THE ROLE OF PERCUTANEOUS TRANSHEPATIC CHOLANGIOGRAPHY, ENDOSCOPIC RETROGRADE CHOLANGIOPANCREATOGRAPHY AND ULTRASONOGRAPHY IN EVALUATION OF OBSTRUCTIVE JAUNDICE

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TABLE OF CONTENTS

CHAPTER 1 LITERATURE REVIEW

ULTRASOUND IN OBSTRUCTIVE JAUNDICE

ENDOSCOPIC RETROGRADE CHOLANGIOPANCREATOGRAPHY

CHAPTER 4 CHOLANGIOGRAPHY: A COMPARATIVE STUDY OF CHRONIC PANCREATITIS AND PANCREATIC CARCINOMA (STUDY III).

CHAPTER 6 GENERAL DISCUSSION AND CONCLUSION.

LIST OF TABLES

LIST OF FIGURES

4 The measurements given by the surgeon and the radiologist for the maximum diameter of the common bile duct in 49 patients at re-evaluation of 76 PTC in the retrospective part of study I.

154

5 Choledocholithiasis confirmed at laparotomy and biopsy. PTC shows a long stricture at the lower part of the common bile duct with moderate dilatation of the proximal ducts. No radiological evidence of choledocholithiasis can be seen, while ultrasound scan of this patient was diagnostic for calculous obstruction.

165

6 The measurements of the maximum diameter of the intrahepatic ducts (IHD), common hepatic ducts (CHD) and common bile ducts (CBD) in benign non-calculous, calculous and malignant obstructions of the biliary system in 147 patients with obstructive jaundice.

193

7 The maximum transverse diameter of the opacified gall-bladders in benign non-calculous, calculous and malignant obstruction of the biliary system in re-evaluation of the cholangiograms of 147 patients with obstructive jaundice.

193

8 Choledocholithiasis. PTC shows a constant filling defect at the lower end of a slightly dilated common duct. The gall-bladder is small.

195

9 Choledocholithiasis. ERCP shows a dilated biliary tract with multiple filling defects.

195

10 Choledocholithiasis. PTC shows a typical downwardly concave meniscus at the lower part of common bile duct with slight dilatation of the proximal biliary ducts.

195

11 Choledocholithiasis. PTC shows complete obstruction of the common bile duct at its lower part, multiple filling defects in the gall-bladder and dilatation of the proximal biliary ducts.

196

12 Choledocholithiasis. PTC shows slightly dilated common bile duct with partial holdup at its lower end. There is a rounded impression in the medial margin of the second part of the duodenum. The gall-bladder is full of stones.

196

13 Benign fibrous stricture. PTC of a 72-year old man shows a very tight stricture at the lower part of the common bile duct with mild dilatation of the proximal biliary ducts. The appearances are very suggestive of a pancreatic head lesion.

196

14 Traumatic stricture in a 72-year old woman who had cholecystectomy 40 years ago followed by exploration of the common bile duct for retained gall stones 9 years latter. PTC shows complete obstruction at the lower end of the common hepatic duct with severe dilatation of the proximal biliary ducts.

197

15 Traumatic stricture in a 30-year old woman due to common bile duct injury and repair during cholecystectomy 5 months ago. PTC shows two strictures of 2&4mm length in the common hepatic duct with moderate dilatation of the proximal biliary ducts. The common bile duct appears normal in calibre and shape.

197

16 Traumatic stricture in a 43-year old man who had biliary surgery 10 months ago. PTC shows complete obstruction of the common bile duct just below the insertion of the cystic duct, shouldering and tracking of the contrast media, and moderate dilatation of the proximal ducts.

197

17 Sclerosing cholangitis. PTC of a 38-year old man shows multiple tight strictures throughout the intra- and extra-hepatic ducts with moderate dilatation of the biliary system including the gall-bladder.

198

18 Sclerosing cholangitis. PTC of a 71-year old man shows irregular dilatation and strictures in the intrahepatic ducts with complete obstruction of the biliary tract at the porta hepatis.

198

19 Duodenal diverticulum. PTC of a 81-year old woman shows dilatation of the common bile duct and an apparent rounded deformity of the medial wall of the second part of the duodenum.

198

20 Duodenal diverticulum. PTC of a 71-year old man shows a distended common bile duct with an apparent filling defect within an associated duodenal diverticulum.

199

21 Cholangiocacinoma. PTC of a 77-year old woman shows a V-shaped obstruction of the right hepatic duct with moderate dilatation of the right intrahepatic ducts.

200

22 Cholangiocarcinoma. PTC of a 77-year old man shows U-shaped obstruction of the common bile duct at its junction with the cystic duct with moderate dilatation of the proximal biliary ducts including the gall-bladder.

200

23 Cholangiocarcinoma. PTC of a 59-years old man shows irregular cut-off obstruction of the common hepatic duct at the porta hepatis with severe dilatation of the proximal intrahepatic ducts.

200

24 Cholangiocarcinoma. PTC of a 73-year old man shows shouldering and complete obstruction of the common hepatic duct at the porta hepatis with severe dilatation of the intrahepatic ducts.

201

25 Cholangiocarcinoma. PTC of a 61-year old man shows a tight stricture 28mm long at the origin of the common hepatic duct, with irregular dilatation of the right intrahepatic ducts; the left intrahepatic system is not visualized. The common bile duct appears normal but the gall-bladder is distended.

201

26 Cholangiocarcinoma. PTC of a 63-year old man shows two strictures in the common hepatic and common bile ducts with severe dilatation of the right intrahepatic ducts and non-opacification of the left intrahepatic system.

201

27 Periampullary carcinoma. PTC of a 68-year old woman shows moderate to severe dilatation of both intra- and extra-hepatic ducts including the gall-bladder (Type II stricture of Caroli).

201

28 Periampullary carcinoma. PTC of a 56-year old man shows moderate dilatation of both intra- and extra-hepatic ducts (Type II stricture of Caroli) with multiple filling defects at the lower part of the common bile duct.

201

29 Metastatic lesions. PTC of a 55-year old man shows very tight and irregular strictures of the intrahepatic ducts and the common hepatic duct, with complete obstruction of the common hepatic duct at its lower end.

202

30 Metastatic lesions. PTC of a 53-year old woman shows a very tight stricture at the lower end of the common bile duct with severe dilatation of the proximal biliary ducts (Type V stricture of Caroli).

202

31 Carcinoma of the gall-bladder. PTC of a 90-year old woman shows a very tight stricture of the common hepatic duct involving the left hepatic duct also, with moderate dilatation of the right intrahepatic ducts and medial dispacement of the common duct and loops of the small intestine by a soft tissue mass in the region of the gall-bladder.

202

32 Chronic pancreatitis. PTC shows type I common bile duct stenosis with dilatation of the proximal ducts and pancreatic calcification. The appearances are pathognomonic of chronic pancreatitis.

226

33 Chronic pancreatitis. ERCP shows mild dilatation of the entire biliary tract as far as sphincter of Oddi (Type II stricture of Caroli). Pancreatic duct shows severe degree of ectasia and marginal irregularity in the tail and body. Mild dilatation of the main pancreatic duct at the head and neck.

227

34 Chronic pancreatitis. ERCP shows hourglass stenosis of the mid common bile duct and slight dilatation of the biliary ducts proximal to the stricture (Type III stricture of Caroli). Pancreatic duct shows severe degree of dilatation, stricturing and ectasia.

228

35 Chronic pancreatitis. ERCP show lateral displacement of the common bile duct with slight proximal dilatation (Type IVa stricture of Caroli). Pancreatic duct was not opacified.

228

40 Pancreatic carcinoma with metastases. PTC shows multiple tight strictures involving both intrahepatic and extrahepatic ducts (unclassified cholangiographic abnormality).

233

41 Pancreatic carcinoma. PTC shows complete obstruction of the common hepatic duct with severe dilatation of the proximal ducts (unclassified cholangiographic abnormality).

233

42 Pancreatic carcinoma. PTC shows irregular tight stricture of the lower common bile duct with moderate dilatation of the proximal ducts and the gall-bladder (Type I stricture of Caroli).

234

43 Pancreatic carcinoma. PTC shows dilatation of the entire biliary system as far as the sphincter of Oddi (Type II stricture of Caroli). A large filling defect in the common hepatic duct most probably is a calculous.

234

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DECLARATION

This thesis has been composed and written entirely by myself and has not been submitted previously for any degree. The studies of which it is a record were conceived and designed by myself. All the work was performed by myself with the exception of chapter 5 (Study IV) which was a combined study involving surgeon, radiologist and pathologist: I was the radiologist involved and carried out all of the radiological assessment single-handed.

Signed:

Date: 7 September 1988

SUMMARY

INTRODUCTION

Owing to the high morbidity and mortality associated with laparotomy on patients with obstructive jaundice (Vellacott and Powell, 1979) and the short life expectance of the patients with malignant obstruction (Sarr and Cameron, 1982; Ubhi & Doran, 1986), there has been a recent swing in the management of patients with malignant biliary obstruction towards stenting the biliary system endoscopically or percutaneously rather than undertaking surgery (Bornman et al. 1986, Speer et al. 1987). Most of these patients underging stenting will not have surgical or histo-pathological confirmation of their disease. Therefore, it is essential to know the accuracy of radiological and imaging investigations, so that one can avoid the pitfall of failing to offer surgery to patients with curable disease. On the other hand, if radiology was sufficiently reliable one could avoid unnecessary laparotomy in patients with unresectable malignant obstruction. Furthermore, the precise diagnosis of the condition seems very important in determining the prognosis and the correct management (Ferrucci et al. 1983).

STUDY I

The work commenced with a retospective appraisal of the diagnostic value, usefulness and complications of percutaneous transhepatic cholangiography (PTC), endoscopic retrograde cholangiopancreatography (ERCP) and ultrasonography of the upper abdomen (US) in 112 patients with obstructive jaundice. This was followed by a prospective evaluation of another 83 patients from the same department. US was considered satisfactory by the radiologist undertaking the procedure in 82% of the attempted scans. The main cause (87%) for unsatisfactory US scans was excessive bowel gas. PTC and ERCP were successful in outlining the biliary system in 96% (131/137) and 80% (72/90) of cases respectively. US and diagnostic ERCP were not associated with any complication. However, therapeutic ERCP was associated with a 19% (10/52) incidence of major complications including five deaths; these figures are comparable with those reported recently in other studies with regard to the palliative biliary stenting (Speer et al. 1987). The use of endoscopic sphincterotomy in young patients with choledocholithiasis who is not considered a high-risk candidate for surgery therefore is not recommended.

On the other hand, PTC was associated with a 6.7% (9/135) major complication rate; this included three deaths, three cases of septicaemia, two cases of severe and repeated attacks of cholangitis, and one symptomatic bile leakage which precipitated an emergency laparotomy. There were no statistically significant differences in the maximum diameters of the common bile duct, common hepatic duct, gall-bladder and intrahepatic ducts in patients who developed complications compared to those who did not following PTC. Furthermore, there were no statistically significant differences regarding the incidence of complications in patients who had PTC alone and those who had PTC combined with percutaneous transhepatic biliary drainage (PTD).

The overall diagnostic accuracy of the successful procedures as based on the original interpretation of the results were 78% for PTC, 84% for ERCP, and 50% for US. The figures are comparable with the results of similar studies (Gibbons et al. 1983;

Gregg & McDonald, 1979; Matzen et al. 1982; Pedersen et al. 1985). However, the essential nature of the investigations in determining the management was for the first time considered in this study. The procedure was considered essential and useful by assessers in 4% and 72% of satisfactory US scans, 7% and 57% of successful PTCs, and 15% and 75% of successful ERCPs, respectively.

This study also showed that there is no statistically significant difference between the diagnostic ability of a specialized pancreatico-biliary surgeon and a gastrointestinal radiologist in reporting cholangiograms. Furthermore, it showed that the diagnostic value of the X-ray reports cannot be improved by using a prepared form with stipulation of the probability of accuracy in interpretation of cholangiograms in comparison with the routine reporting system.

STUDY II

In this part of the thesis, the cholangiographic features associated with different surgical conditions of 147 patients with obstructive jaundice were examined. Complete obstruction of the biliary tract was more frequent with malignant conditions (60/83) than with benign non-calculous conditions (6/21) and choledocholithiasis (26/43). Significantly higher level of the mean total serum bilirubin was found in malignant obstruction (273 ± 19SE), in comparison with choledocholithiasis (128 ± 27SE) and benign non-calculous obstruction (119 ± 33SE). However, there were no statistically significant differences between malignant, benign non-calculous and calculous conditions of the biliary tract regarding the maximum diameters of the intrahepatic ducts, common hepatic duct and common bile duct. Similarly there were no significant differences between the groups in terms of the serum alkaline phosphatase concentration.

The sensitivity and specificity of the cholangiograms for detection of common bile duct stones were 86% (37/43) and 88% (92/104), respectively. The cholangiographic abnormalities found in the common duct in these cases were a constant filling defect in 28 (65%) cases, a downwardly concave meniscus in 8 (19%) cases, and complete obstruction with impaction of stone at the lower end of the common bile duct in 4 (9%) cases. The gall-bladder was shrunken in 38% of the patients with choledocholithiasis, and contained stones in 63%.

The sensitivity and the specificity of the cholangiograms for the detection of benign non-calculous conditions (when interpreted without knowledge of the patients clinical history) were 48% (10/21) and 89% (112/126), respectively. The pitfalls in interpretation the cholangiograms were inability to differentiate sclerosing cholangitis and traumatic strictures of the common duct from cholangiocarcinoma or metastatic lesions; biliary tract obstruction by a duodenal diverticula or an impacted stone from periampullary carcinoma; and chronic pancreatitis from pancreatic carcinoma. However, the diagnostic sensitivity and specificity of the cholangiograms in the differentiation between benign and malignant conditions were 84% (70/83) and 73% (47/64), respectively.

Cholangiocarcinomas showed complete obstruction at the junction of the right and common hepatic duct in two cases, at the common hepatic duct in 8 cases and at the begining of the common bile duct in one case. The appearance of the end of the obstruction was V-shaped in 4 patients, U-shaped in one patient, irregular cut-off in three patients, shouldering in two patients, and a dawnwardly concave meniscus in one patient. The cholangiographic abnormality was stenotic in 7 patients with cholangiocarcinoma; the length of the stenosis ranged from 5-60mm. The disease primaly involved the common hepatic duct in three cases and in 4 cases there were widspread strictures throughout the biliary system.

STUDY III

Cholangiograms of 47 patients with chronic pancreatitis and 53 patients with pancreatic carcinoma, jaundiced or not, were then classified according to the original classification of Caroli (Caroli & Nora, 1952); and the liver function tests were then correlated. The study demonstrated significant differences between chronic pancreatitis and pancreatic carcinoma patients in the following points; (i) the chronic pancreatitis patients were younger, (ii) pancreatic calcifications on plain film were seen only in chronic pancreatitis patients, (iii) the mean maximum diameters of the intra- and extra-hepatic biliary ducts were greater in patients with pancreatic carcinoma, (iv) the cholangiograms were abnormal in 64% of the patients with chronic pancreatitis (these included 67% type I, 3% type II, 10% type III, 10% type

IV and 3% type V, while 17% of patients had biliary abnormalities which could not fit Caroli´s classification) and in all patients with pancreatic carcinoma (these included 17% type I, 7% type II, 4% type III, 66% type V, and 6% non-classified biliary abnormalities), (v) irregularity of stenosis was seen exclusively in patients with pancreatic carcinoma, and (vi) the mean values of the total serum bilirubin, aspartate aminotransferase, alanine aminotransferase and alkaline phosphatase concentration were higher in patients with pancreatic cancer.

STUDY IV

This study was intended to address the significance of the radiological involvement of the biliary tract by chronic inflammatory process of the pancreas. A series of 39 patients underging surgery for chronic pancreatitis, therefore, were investigated for evidence of hepatobiliary disease. In addition to pre-operative assessment by liver function tests, US, ERCP (in 33 patients) and PTC (in 5 patients), peroperative liver biopsy was performed in all cases. Common bile duct stenosis was diagnosed in 16 of the 26 patients with successful cholangiography. Features of extrahepatic biliary obstruction were found on biopsy in 11 of the 39 patients, but no one had evidence of secondary cirrhosis. Five (83%) of the six patients with clinical jaundice had features on biopsy of extrahepatic biliary obstruction as did 8 (67%) of the 12 patients with alkaline phosphatase elevation above twice normal, and 7 (44%) of the 16 patients with radiological common bile duct stenosis.

Study III had shown that 91% (21/23) of chronic patients with elevated serum alkaline phosphatase concentration (over 300 IU/l) had some form of the radiological involvement of the biliary tract by the inflamatory process of the pancreas. However, study IV showed that neither alkaline phosphatase elevation nor common bile duct stenosis radiologically, alone or in combination, were a reliable indication of the need for biliary-enteric bypass surgery. Therefore, pre-operative liver biopsy may be valuable adjunct in the assessment of such patients.

CONCLUSION

The present studies conclude that if US can reliably identify patients with distal common bile duct obstruction there seems to be little to be gained from invasive investigations if patient undergoing surgery, unless surgeon requires a preoperative biliary map. All patients who have unsatisfactory or inconclusive US scan should be investigated by ERCP (PTC when ERCP is contraindicated, failed or not available) in order to avoid unnecessary laparotomy in those with lesions not amenable to surgery and allow one to select appropriate therapy in those with proximal biliary obstruction. Direct cholangiography is not always diagnostic. Abnormalities in the liver function tests, the maximum diameters of the intra- and extra-hepatic ducts, and abnormalities of the gall-bladder can provide useful corroborative evidences to distinguish malignant from benign conditions. Regardless of their accuracy, neither US nor direct cholangiography is without the possibility of error (misleading results were obtained in 10% of cases with US, 9% with PTC and 5% with ERCP). Therefore, it is mandotory to obtain a positive biopsy from the lesion especially in patients who are not undergoing surgery.

INTRODUCTION

The modern imaging methods (ultrasound, computed tomography, endoscopic retrograde cholangiopancreatography, and percutaneous transhepatic cholangiography) have made diagnosis of patients with obstructive jaundice easier and have made the need for diagnostic laparotomy remote. This has paved the way for the use of interventional radiological procedures in the management of patients with "surgical" obstruction in their biliary system (Gibson, 1987). These procedures include percutaneous balloon dilatation of benign bile duct strictures, percutaneous removal of biliary stones, percutaneous pancreatic pseudocyst drainage, preoperative percutaneous transhepatic biliary drainage for patients with severe obstructive jaundice, palliative percutaneous transhepatic biliary drainage or endoprosthesis insertion for patients with unresectable malignancy, endoscopic papillotomy with or without stone extraction for common duct calculi, and endoscopic insertion of an endoprosthesis to relieve jaundice in patients with inoperable biliary or pancreatic cancer. This now means that many patients with surgical benign or malignant obstruction of the biliary system can be spared laparotomy, but only a minority may have histo-pathological proof of their diagnosis. Although the diagnosis of malignant disease can be confirmed by ultrasonically guided percutaneous fine-needle aspiration cytology or biopsy (Lees et al. 1985), the difficulties of biopsy should not be underestimated. Some surgeons have also attempted to confirm the diagnosis cytologically by recovery of bile or pancreatic juices, or by biliary and pancreatic brush cytology. Cameron et al. (1982) stress the difficulties of obtaining an adequate biopsy from small fibrotic cholangiocarcinoma even at laparotomy and believe that cholangiography taken in conjunction with the clinical presentation allows easy and accurate differentiation in the great majority of patients.

Unfortunately, it can be estimated that only about 12-20% of pancreatic and bile duct cancers referred to the specialized centres are potentially resectable and the prospect for patients with cancer of the gall-bladder is even worse (Allen-Mersh & Earlam, 1986; Kummerle & Ruckert, 1984; Sarr & Cameron, 1984).

The resectability rate was less than 5% in all patients registered in England and Wales having pancreatic carcinoma (Allen-Mersh & Earlam, 1986). For every patient undergoing definitive resection of the pancreatic carcinoma, at least 6 to 10 patients receive either no operation, biopsy only or palliative bypass (Brooks & Culebras, 1976, Hermann & Cooperman, 1979). The great majority of patients with unresectable tumour are dead within a year of diagnosis (Ubhi & Doran, 1986) but some attempt at palliation is usually worthwhile. However, biliary bypass in these patients is not without risk and according to collective review it carries a mean operative mortality of 19% with mean duration of survival of only 5.8-6.6 months (sarr & Cameron, 1982). Laparotomy itself in patients with unresectable tumours carries a high mortality rate (39% mortality rate for stage III in comparison with 24% for stage I pancreatic carcinoma), and surgery is more hazardous over the age of 60 years and in the presence of metastasis (Andren-Sanberg & Ihse, 1983; Feduska et al. 1971). These results have highlighted the need to assess alternative methods of palliation in unoperable cancer.

A prospective randomised trail of percutaneous transhepatic biliary endoprosthesis versus bypass surgery for incurable carcinoma of head of pancreas showed that the incidence of postprocedural complications were 33% for percutaneous transhepatic biliary endoprosthesis and 42% for surgery, while the 30 day mortality after percutaneous transhepatic biliary endoprosthesis was 8% as opposed to 20% in patients who had surgical bypass (Bornman et al. 1986). The endoprosthesis patients had a significantly shorter initial hospital stay, and there was no significant differences in survival time. The most recent randomised trail of endoscopic versus percutaneous stent insertion in malignant obstructive jaundice showed that the endoscopic method had a significantly higher success rate for relief of jaundice and a significantly lower 30 day mortality (Speer et al. 1987). Therefore, the authers suggest that when stenting is indicated in elderly and frail patients, the endoscopic method should be tried first, and that the percutaneous method should be reserved for those patients in whom initial endoscopic approach fails.

The principle attraction of endoscopic sphincterotomy are that it avoids the risks associated with general anaesthesia, laparotomy and duodenotomy. Successful endoscopic sphincterotomy is achieved in approximately 90% of patients, and complete clearance of calculi can be expected in about 85% of those with duct stones (Cotton & Vallon, 1981). Furthermore, failed endoscopic sphincterotomy does not jeopardize future abdominal surgery. As well as being quicker and cheaper than surgery, endoscopic sphincterotomy is undoubtedly safer in high-risk patients and those over 60 years of age. However, it is essential to know the accuracy of the radiological and imaging investigations, so that one could avoid the pitfall of simply stenting the biliary system in patients with disease that might be curred by appropriate surgery. On the other hand, one could avoid unnecessary laparotomy in patients with unresectable malignant obstruction who have only a short time to live. Therefore, the aim of the present studies was to examine the diagnostic accuracy and usefulness of percutaneous transhepatic cholangiography, endoscopic retrograde cholangiopancreatography and ultrasonography in patients with obstructive jaundice, and in particular the ability of cholangiography to differentiate between benign and malignant biliary obstruction.

Chapter 1

LITERATURE REVIEW

PERCUTANEOUS TRANSHEPATIC CHOLANGIOGRAPHY

HISTORICAL REVIEW

The first radiological visualization of the biliary tract, following percutaneous puncture of the gall-bladder, was carried out by Burckardt and Mueller in Germany in 1921. In 1937 Huard and Do-Xuan-Hop in Hanoi started blind intrahepatic injection of non-water soluble contrast media (Lipiodol). However, because of the frequent complications, it was performed by or in close cooperation with a surgical team with an operation table set for laparotomy. Since this report appeared in French in an Indochinese bulletin, many surgeons were not aware of it. In 1952 percutaneous transhepatic cholangiography (PTC) was rediscovered by Carter and Saypol, two New York surgeons, who used water soluble contrast medium. They performed preoperative transhepatic puncture of the left hepatic duct under general anaesthesia in a 36-year old woman with obstructive jaundice.

The use of antibiotics and fluoroscopy were important steps in development of PTC. The need to perform PTC just before operation or with the surgeon standing by in case complications developed, was minimised by introduction of the fine flexible Chiba needle (Tsuchiya, 1969). Thereafter PTC made great progress and this was accelerated by a report of 314 successful procedures with only a 2.5% major complication rate, with only one case requiring emergency surgery for bile leakage (Okuda et al. 1974). The popularity of PTC paved the way for many other percutaneous procedures such as percutaneous portal venography, percutaneous transhepatic drainage (PTD) and percutaneous transhepatic insertion of endoprostheses.

Recent development and progress in ultrasonography and endoscopic retrograde cholangio-pancreatography (ERCP) have posed major challenges to PTC in obstructive jaundice. At the same time ultrasound (US) has improved PTC techniques, particularly with regard to determining whether the biliary tree is dilated or not before the procedure and by allowing the needle to be directed through the ultrasonic transducer.

TECHNIQUE OF PERCUTANEOUS TRANSHEPATIC CHOLANGIOGRAPHY

Prior to the performance of PTC, the procedure should be fully explained to the patient and appropriate consent obtained. Most authors recommend commencing a broad spectrum antibiotic 24-48 hours before the procedure and continuing it for 3-5 days afterwards (Goldberg, 1983; Harbin et al. 1980; Okuda et al. 1974). Since bacteraemia resulting from PTC is caused mostly by Escherichia Coli and other Gram-negative organisms, aminoglycosides such as Tobramycin or Gentamycin, or a combination of Ampicillin and Gentamycin are often recommended. Problems with blood coagulation must be defined and appropriate therapy instituted before the procedure. Many authors give vitamin K1 injection routinely in jaundiced patients. Jaundiced patients should be screened for hepatitis B surface antigen (HBs Ag) and appropriate precautions taken if the result is positive. The procedure does not usually need premedication, but some radiologists prescribe Diazepam or Phenobarbitone one hour prior to the procedure.

The patient is placed supine on the fluoroscopic table, made to hold his head with the right arm. The skin on the right lateral lower chest is prepared and draped in the usual fashion. A lead marker may be used on the skin to localise the porta hepatis. This can be done by a line bisecting a sagittal line between the dome of the diaphragm and the duodenal cap (which is usually identified by its air bubble or after insertion of a duodenal tube). Alternatively, ultrasound permits precise localisation of the liver hilus and its surface marking.

Selection of the proper puncture site is important as it may also be the site of placement of a drainage catheter. An intercostal site in the mid axillary line or slightly anterior to it, is chosen for insertion. The needle passes caudal to the inferior portion of the lung, usually in the 7th or 8th right intercostal space. Local anaesthesia is achieved with 1% Lignocaine infiltrated along the course of the needle to the peritoneum. The principle of the technique is to introduce the Chiba needle (15cm long, 0.7mm outer diameter, 0.5mm inner diameter and bevelled angle of 30 degree) from the flank toward an area slightly above the junction of the right and the left hepatic ducts, avoiding the gall-bladder and extrahepatic ducts. A bile duct is sought by injecting water soluble contrast medium rather than by aspirating bile (Okuda et al. 1974). While the patient holds his breath between inspiration and expiration, the needle fitted with a stylet is inserted under fluoroscopic control, passing parallel to the table to an area slightly above the hilum of the liver. Avoidance of puncture in the region of the porta hepatis is important as serious bile leakage may follow extrahepatic puncture of the common bile duct (Harbin et al. 1980). If the first attempt fails, subsequent serial passes are made using small incremeintal angles in a caudal direction (Figure 1) (Mueller et al. 1981). Caudally directed punctures should be more shallow. Ultrasonography has been used also to guide the needle,especially in case of nondilated intrahepatic ducts (1llescas et al. 1986).

After removal of the stylet, the patient is allowed to breathe normally, but not vigorously. Insertion of the needle and removal of the stylet should take less than 5 seconds. Contrast material is injected via a 10 ml syringe attached to the needle with a polythene tube. Under fluoroscopy the needle is very slowly withdrawn while continously injecting small

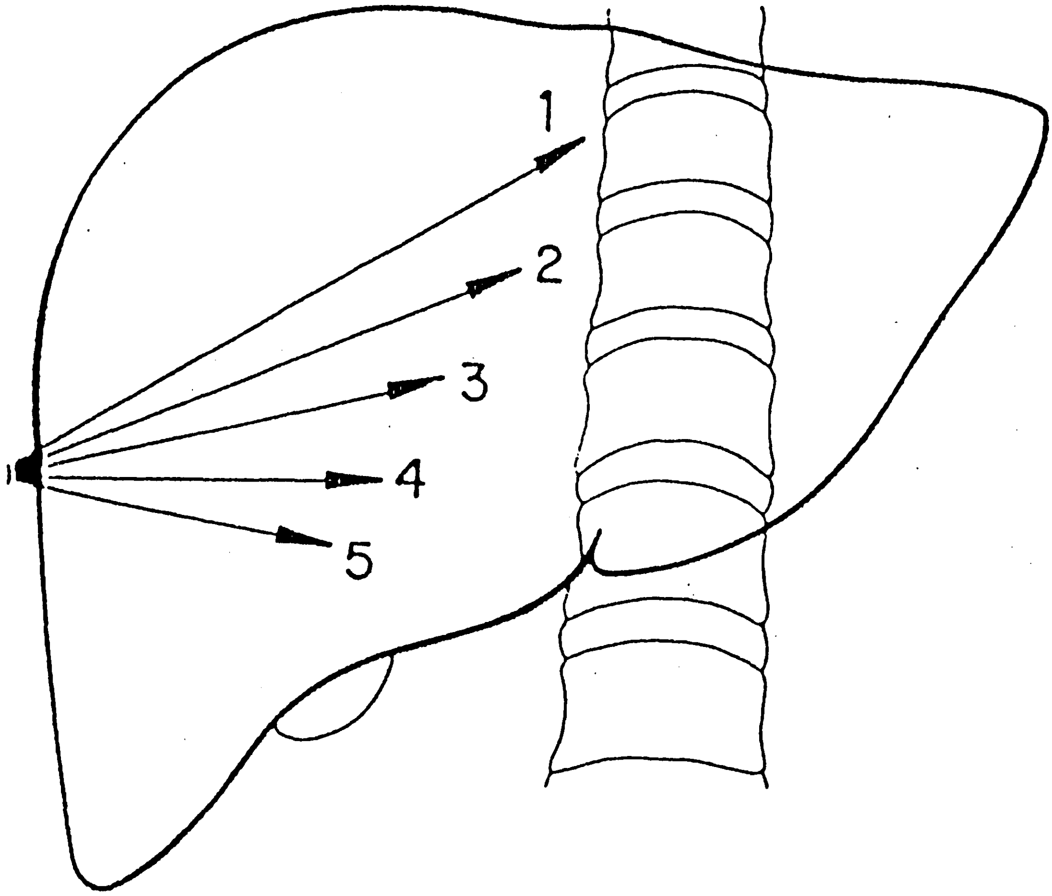

Figure 1 Preferred sequences of needle passes into liver paranchyma during PTC performance (from Mueller et al. 1981).

amounts (0.1-0.2 ml) of contrast with mild hand pressure, trying not to inject more than 5 ml of contrast material in each pass. When the needle is in a blood vessel, the contrast media disappears rapidly, when in the parenchyma or under the capsule it leaves a tract or blush which absorbs slowly and may remain throughout the procedure. If the biliary tree is entered, the contrast material flows slowly towards the hilum. Since the Chiba needle has a small calibre, it occasionally punctures tiny intrahepatic radicles of insufficient size to be recognized during fluoroscopy, yet large enough to carry contrast distally into the common bile duct. In such cases, fluoroscopic screening confined to the region of the needle tip will give the false impression that a negative pass has been made. Hence a brief fluoroscopic scanning over the region of the distal common duct is recommended at the conclusion of each "negative" withdrawal (Ferrucci & Wittenberg, 1977).

If a non-dilated biliary tree is entered, several quick exposures are taken as 10-15 ml of contrast material is rapidly injected. Enough material is injected to fill the biliary tree including if possible the gall-bladder. Okuda et al. (1974) have stressed the importance of removing 50-100 ml of bile before injecting contrast medium into an obviously distended biliary tree. However, many authors find it difficult to remove more than 5 ml of bile (Benjamin et al. 1978; Ferrucci & Wittenberg, 1977). Every effort is made not to overdistend the biliary system. Often it is necessary to move the patient into the left decubitus position, or into the upright, semierect or prone position to cause contrast material to move from dilated dependent posterior branches of the right side. These manoeuvres are essential to opacify the left ductal system and common bile duct, as well as avoid misinterpreting the spurious appearances of obstruction that may result from poor mixing of thick bile and contrast material, particularly at the level of the common hepatic duct. It also helps in opacification of structures such as the gall-bladder and cyst duct, while allowing more precise localisation of the site of obstruction and reducing the amount of contrast material used (Mueller et al. 1981). Radiographs are then obtained of the site of obstruction as well as of any ductal system seen proximal or distal to the obstruction. If the common bile duct is dilated down to the region of the ampulla, administration of 1 mg glucagon intravenously may distinguish functional spasm from pathological obstruction (Mueller et al. 1981). Delayed films taken up to 2 hours later are valuable, particularly if there is obstruction, and sometimes result in late opacification of the gall-bladder (Ferrucci & Wittenberg, 1977). If external drainage is not to be carried out, bile and contrast material are then withdrawn to decompress the biliary system as much as possible,and the needle is finally removed. A wide adhesive tape is placed tightly around the lower chest to immoblize the flank. Biliary aspirates are sent for microbiological studies. When the first attempt has failed to enter a biliary radicle, up to 15-20 passes can be attempted, because a high number of passes is not associated with higher morbidity and does increase the success rate of visualizing a non-dilated biliary tree (Ferrucci & Wittenberg, 1977; Mueller et al. 1982; Pereiras et al. 1977).

The fine-needle technique has an overall success rate in visualization of the biliary system of more than 90%. The rate approaches 100% in patients with dilated ducts and between 70 and 95% in patients with nondilated ducts (Ariyama, 1983; Benjamin et al. 1978; Ferrucci & Wittenberg, 1977; Mueller et al. 1981; Pereiras et al. 1977). Therefore, failure to visualize the biliary tract in experienced hands strongly indicates that the jaundice is non-obstructive and suggests the need to consider liver biopsy (Fraser et al. 1978).

If the information obtained at PTC, particularly in patients with complete extrahepatic obstruction, is not conclusive, hypotonic duodenography can be performed immediately after PTC if the patients condition permits. This may demonstrate the presence or absence of duodenal involvement and clarify the nature of the biliary obstruction (Gourtsoyiannis & Nolan, 1979).

Although PTC with the Chiba needle is accepted universally as a standard method for performing PTC, there may still be a place for the sheathed needle technique, especially if there are dilated intrahepatic ducts and there is a need for preoperative drainage of the biliary tree. This avoids the need for two liver puncture to establish drainage (Russell et al. 1978). This and the fact that inadequate drainage of an obstructed system by a Chiba needle which may result in extravasation of bile through the needle tract and false identification of the level of obstruction have led many workers to try to modify the old sheated needle technique; none have so far developed a better alternative (Andrews & Hawkins, 1984; Andrews et al. 1984).

Other techniques of transhepatic cholangiography

Percutaneous transcholecystic cholangiography

The main advantages of this technique are that it is easy to perform, has no significant major complications, is less painful, is a valuable alternative to transhepatic cholangiography for opacification of non-dilated bile ducts and has proved useful for both diagnostic and therapeutic purposes (Illescas et al. 1986; Teplick et al. 1986).

Percutaneous transjugular transhepatic cholangiography

The procedure is said to be easy, relatively safe, and carrys a good success rate. However, a high rate of Gram-negative septicaemia has been reported with some fatalities so that this approach is only of historical importance (Elias, 1976).

Open minilaparotomy

A diagnostic procedure has been recommended which involves opening the peritoneum through a 4-5 cm midline sub-xiphoid incision under local anaesthesia. The liver and the adjacent structures can be directly inspected. In addition to cholangiography and needle liver biopsy, the "minilaparotomy" allows manometry and venography of the portal system (Elias, 1976). However, this procedure has not proved popular.

INDICATIONS AND CONTRAINDICATIONS TO PTC

Indications

Our understanding of PTC suggests that its current indications are the need for;

1- direct visualization of the biliary tract in patients with clinical obstructive jaundice.

2- delineation of the anatomy of the biliary tract after surgery. PTC is particularly useful when there is clinical evidence of partial obstruction (Goldberg, 1983). It is the primary method for evaluation of biliary-enteric anastomoses, demonstrates biliary anatomy in great detail and can be used regardless of the site of the anastomosis or prior gastric surgery (Gold & Price, 1980). Plain radiography of the upper abdomen can demonstrate gas in the bile ducts indicating that a communication exists with digestive tract, but it does not necessarily indicate that the biliary anastomosis is wide enough to allow unimpended flow. Conversely, lack of identifiable gas in the bile ducts does not necessarily imply that the biliary anastomosis inadequate.

Intravenous cholangiography can be extremely difficult to interpret in post-operative patients and is now seldom used. Barium reflux cholangiography is not always possible in that barium may not reflux from gastrointestinal tract through the surgical anastomosis. Even if barium does gain access to the bile ducts significant diseases such as calculi, communicating abscess and fistula can be missed because of the dense filling and the overlying barium filled stomach and duodenum. ERCP is an alternative in many patients but requires highly trained endoscopist and appropriate equipment.

3- identification of surgical disease in patients with non-dilated ducts (Mueller et al. 1982; Okuda et al. 1974). Such patients may include those with a history of biliary colic in whom US and oral cholecystography have proved negative. PTC may also be of value in conditions such as sclerosing cholangitis in which ductal patency can be determined when other techniques have failed. PTC can also be used to study the lower portion of the common bile duct in patients with pancreatic head lesions. It must be remembered that neither intravenous cholangiography (IVC) nor US are satisfactory for the study of the lower common bile duct, although ERCP is frequently a viable alternative to PTC.

4- as an intial examination before percutaneous biliary drainage (PTD) or other interventional procedures. Appropriate therapeutic decisions can be made from the results of PTC (Mueller et al. 1982).

Conta-indications

The contra-indications to PTC are few and all are relative. The risk of bleeding is high in patients with a bleeding diathesis; such abnormalities must be corrected or the technique should be avoided if they cannot (Harbin et al. 1980; Lintott, 1985). Previous allergic reaction to iodinated contrast media is a contra-indication to PTC, though if the information is essential, PTC can be done under corticosteroid cover (Goldberg, 1983). Very poor general condition and/or deep jaundice are regarded as relative contra-indications to PTC. PTC can be carried out under general anaesthesia in children, the mentally disordered and in very uncooperative patients.

High fever or continous fever (above 38 C) was once considered to be a contra-indication, but cholangitis with sepsis is no longer a contra-indication in that PTD may be life saving (Okuda et al. 1974; Lintott, 1985), particulary if endoscopic approaches have failed. Although ascites is not an absolute contra-indication to PTC, it can interfere with because the liver is displaced from the abdominal wall so that the distance traversed by the needle is increased. Also the liver is less fixed in position, making it more difficult to puncture it perpendicular to the capsule, thus increasing the likehood of bleeding. Therefore, paracentesis should precede the procedure (Lintott, 1985). Severe anaemia, marked distortion of the intrahepatic biliary ducts by metastatic disease and HBs Ag positivity have been regarded by some as relative contra-indications for PTC.

COMPLICATIONS OF PERCUTANEOUS TRANSHEPATIC CHOLANGIOGRAPHY

The use of a large sheathed-needle PTC in 2464 collected cases reported between 1960-1977 carried an overall major complication rate of approximately 5% (which included 3.5% bile leakage and 1.8% intraperitoneal haemorrhage) with a 0.8% mortality rate (Harbin et al. 1980). The literature contains conflicting reports on the complication rate of Chiba-needle PTC. Most authors agree that the procedure is safer than the sheathed-needle technique. However, major complications including bile peritonitis, haemorrhage, septic shock and even death occasionally occur. In a large multi-centre survey in the USA dealing with 2005 Chiba needle procedures, the overall major complication rate was 3.4% (Harbin et al. 1980).

Regarding the need for the immediate surgery after Chiba-needle PTC, if a dilated biliary system is demonstrated, there are three schools of thought. At one extreme it was suggested that laparotomy should be undertaken within a few hours (Elias, 1976; Juler et al. 1977). At the other end of the spectrum, most authors now agree that while surgical facilities should be available, urgent laparotomy is rarely required (Benjamin et al. 1978; Ferrucci & Wittenberg, 1977; Robert et al. 1980). An intermediate school suggests that laparotomy should be performed at the earliest convenient opportunity, usually within three days (Gibbons et al. 1983).

The following factors may affect the complication rate following Chiba-needle PTC:-

1- As the number of needle passes increases so does patient discomfort, but interestingly this does not increase the number of significant complications (Mueller et al. 1981; Mueller et al. 1982).

2- The experience of the radiologist may affect success rate but does not seem to be an important factor affecting the incidence of complications (Harbin et al. 1980).

3- Broad-spectrum antibiotics and correction of any clotting defect are generally thought to reduce the chance of cholangitis, septicaemia and bleeding (Harbin et al. 1980; Mueller et al. 1982).

4- Vigorous breathing and movement during the procedure increases the risk of bleeding (Juttijudata et al. 1984; Okuda et al. 1974).

5- Bile aspiration and drainage of a dilated biliary tract reduces the risk of troublesome bile leakage (Denning et al. 1981).

6- Although there is no controlled study in the literature, it has been suggested that avoidance of extrahepatic puncture of the biliary system and an early surgery following demonstration of a dilated ducts is beleived by some to reduces the complication rate (Harbin et al. 1980; Mueller et al. 1981; Mueller et al. 1982).

7- Post-procedural close supervision and observation, including routine chest X-ray, allows early detection of any complication and to promopt institution of appropriate treatment.

8- Generally, patients with ascites, cholangitis and obstruction with infection are more likely to have complications following PTC (Mueller et al. 1982).

9- Nearly all the complications are encounted in patients with surgical problems (extrahepatic biliary obstruction), particularly those with dilated ducts due to gall-stones (Harbin et al. 1980; Okuda et al. 1974).

10- Patients with vascular lesions such as hepatocellular carcinoma are more prone to bleeding after PTC (Lee et al. 1984).

<u>The main major and minor complications following Chiba-needle PTC are:-</u>

1- Death

Introduction of the Chiba needle appears to have reduced the reported mortality rate of PTC from 0.4% to 0.2% (Drake & Beal, 1965; Harbin et al. 1980). The causes of death in these cases were often related to the need to perform emergercy surgery because of intraperitoneal haemorrhage or sepsis, and most of the patients died as a result of post-operative complications or septic shock. The relative safety of modern PTC technique is affirmed by Ariyama (1983), who had only three (0.1%) deaths after 2745 PTC procedures. However, this was not the case with more recent single institution studies where a death rate of upto 7% has reported (Baumgartner et al. 1987).

2- Sepsis

Fever and chills may be accompanied by hypotension, a positive blood culture and severe prostration. Fever not acompanied by hypotension, a positive blood culture or severe prostration is common as a manifestation of transient bacterimia during PTC (Okuda et al. 1974). Septicaemia is diagnosed when fever is accompanied by hypotension and positive blood culture. Sepsis is the most frequent major complication of Chiba-needle PTC and is almost entirely limited to patients with biliary tract obstruction (Okuda et al. 1974). The overall reported incidence of septicaemia associated with PTC is about 2-3 % (Harbin et al. 1980; Kreek & Balint, 1980).

Sepsis following PTC is the result of infected bile entering the blood stream via direct communications between the biliary canaliculi and the liver sinusoids in patients with biliary obstruction.

lt has been shown that bile is infected in 71-90 % of patients with common duct stones and 25-36 % of patients with malignant biliary obstruction (Keighley, 1977; Keighley et al. 1974). Blood stream contamination may also occur via the needle tract as it traverses both bile ducts and veins. Sepsis-related shock occuring within hours of the procedure is produced primarily by release of endotoxin rather than bacterial seeding of the blood per se.

Prophylactic use of broad-spectrum antibiotics, meticulous asepsis, and surgical or radiological decompression of the obstructed biliary ducts are crucial for preventing septicemia (Mueller et al. 1982). Antibiotics, however, will not prevent sudden endotoxaemia caused by organisms forced out of the bilary tract and into the blood stream during cholangiography. Thus some patients with infected bile may experience endotoxic shock shortly after PTC despite adequate prophylactic antibiotic administration (Keighley et al. 1973).

When septicaemia is diagnosed in a patient after PTC, vigorous treatment includes repeated blood cultures for aerobic and non-aerobic organisms, correction of hypotension and anaemia, broad-spectrum antibiotics and symptomatic support.

3- Bile leakage

The incidence of symptomatic bile leakage following Chiba-needle PTC is about 1-3% (Harbin et al. 1980; Kreek & Balint, 1980). A small amount of blood-stained bile is found in the peritoneal cavity at laparotomy following PTC in most patients with extrahepatic biliary obstruction. This rarely results in any abnormalities of the pulse, blood pressure or temperature. When the leakage becomes symptomatic (with 150-200 ml of bile in the peritoneal cavity) there is abdominal pain and tenderness. Pain may be referred to the right shoulder. As peritonitis becomes established more signs and symptoms appear and the sepsis must be treated vigorously with antibiotics and emergency laparotomy. A 40% incidence of symptomatic bile leakage following fine needle PTC was reported in small series (Juler et al. 1977).

Methods of reducing the incidence of bile leakage after PTC include immediate surgical or radiological decompression of the biliary system if the extrahepatic ducts are obstructed or if the pressure in the system exceeds 35 cm of water, aspiration of as much bile as possible after completion, and avoidance of over-distension of the biliary system and extrahepatic puncture of the biliary tract (Mueller et al. 1981; Mueller et al. 1982).

4- Haemorrhage

(i) Subcapsular haematoma is an occasional complication of PTC but is generally clinically silent and has no serious consequences. It is usually diagnosed only if the patient undergoes surgery.

(ii) Intraperitoneal haemorrhage is a major complication in about 0.3-0.4 % of PTCs conducted with the Chiba needle. Although it does not cause death directly it may precipitate emergency surgery especially when a coagulation disorder is present (Harbin et al. 1980; Kreek & Balint, 1980). Intraperitoneal bleeding should be suspected when there is continous right upper quadrant distress and a drop in haematocrit. Latter the patient may develop signs of shock and/or peritoneal irritation. The bleeding may cease with blood transfusion, but if laparotomy is required, bleeding can be controlled by suturing the tear in the liver capsule.

(iii) Haemobilia means haemorrhage from the liver parenchyma into the biliary ducts. It is an unusual complication of PTC, it is reported incidence varying from 0% to 4%, probably because the condition is usually self-limited and associated with a minimal discomfort (Cahow et al. 1977).

5- Chest complications

The pleural reflection in the costophrenic sulcus has its highest point anteriorly behind the xiphoid process, and then sinks to its lowest level at the level of the 10th rib in the mid axillary line. The reflection then passes virtually horizontally posteriorly, crossing the 11th and 12th ribs and ending medially beneath the 12th rib at the level of L1. Despite the fact that most punctures in 8th, 9th or even 10th intercostal spaces traverse the pleura, diaphragm and peritoneum to reach the liver (but pass below the lung), the incidence of pleural complications is less than 0.2%. The reported chest complications of Chiba-needle PTC are pneumothorax, tension pneumothorax, haemothorax and hepatobronchial fistula (Harbin et al. 1980; Okuda et al. 1974; Wild et al. 1980).

6- Radiation

Every patient undergoing PTC and the radiologist performing it will receive some radiation.

The dose depends upon the total fluoroscopy time, number of exposures, technique of radiography and use of protective measures. The average absorbed dose of radiation per examination for a radiologist permorming PTC within the 14 minutes average screening time is about 4-5 mRad for his forehead and neck, 55 mRad for the eye lens, 55 mRad for the right hand, 150 mRad for the left hand and less than 1 mRad for the rest of his body if covered by apron; for the assisting nurse the dose is less than 10% of these values (Gustafsson & Lunderquist, 1981). Therefore, the greatest contribution in all cases comes from exposure of the unshielded head and neck, and the registered dose on the film dosimeter (worn under the apron) gives an incomplete picture of the risk to the personnel.

The following measures should be taken to reduce the radiation hazards both for the patient and working staff:

(i) reducing fluoroscopy time to a minimum; this can be assisted by using a Video-disc recorder.

(ii) reducing the number of X-ray exposures.

(iii) stepping back from the patient during the exposure time.

(iv) wearing a protective lead apron. A 0.25mm thick apron reduces the exposure to radiation to 10%, while a

0.5mm thick apron reduces it to 1% only.

(v) use of lead barriers, protective glasses and reduction in the number of persons in the examination room during exposure.

(vi) coning down the radiation beam and protecting other parts of the patient by lead shields (Fraser et al. 1978).

(vii) limiting the number of the PTC procedures performed by any radiologist per year.

(viii) use of rare-earth screens (ultra-fast screens) to reduce the radiation dose required during each exposure.

7- Contrast material reactions

The incidence of drug reactions was reported to be only 0.15% (three in a total of 2005 procedures) and no deaths were attributable to this cause (Harbin et al. 1980). The severity of reaction varies from mild urticaria to severe anaphylactic shock, depending on previous sensitization of the patient and the route of entrance of the contrast to the circulation. Urticaria is usually transient and does not need any specific treatment apart from stopping further drug injection. Systemic anaphylaxis is potentially fatal if not treated promptly by intravenous hydrocortisone and subcutaneous adrenaline.

8- Miscellaneous complications

(i) Transient right upper quadrant and epigastric pain of varying intensity but usually alleviated by analgesics, is very common after PTC. lt must be differentiated from pain refelecting major complications (Berk et al. 1982). However, sometimes can be very severe and obviates the procedure to be abandont or performed under general anaesthesia, especially when PTD is also required (Lukes et al. 1985).

(ii) Transient vasovagal attacks may occur during insertion of the needle, especially following gall-bladder puncture (Lukes et al. 1985; Pereiras et al. 1977).

(iii) Arteriovenous fistula is a very infrequent complication of Chiba-needle PTC, probably because of the small calibre of the Chiba needle. lt is usually symptomless and is only diagnosed if the procedure is followed by angiography. Persistence of an arteriovenous fistula may cause some parenchymal changes and phlebosclerosis along the portal venous branches receiving arterial blood, but signs of portal hypertension are unusual (Okuda et al. 1978).

(iv) Needle bending during the procedure has been reported especially when a firm, neoplastic or cirrhotic liver is punctured, but clinical sequelae or needle breakage have not been reported (Harbin et al. 1980).

INTERPRETATION AND USEFULNESS OF PTC

PTC permits direct visualization of the biliary tract in order to detect the presence or absence of obstruction, and the site and probable nature of any obstruction present.

Presence of obstruction

PTC determines the presence or absence of obstruction of the biliary system in nearly 100% of cases when the procedure is successful as verified by the final diagnosis as confirmed by laparotomy, autopsy or liver biopsy (Juttijudata et al. 1986; Pedersen et al. 1985). The diameter of the common bile duct is affected by the injection pressure of the contrast, radiographic magnification and premedication. The calculated upper limit for the diameter of the normal common bile duct is 10-11 mm (Niederau et al. 1984).

Site of obstruction

The ability of PTC to define the site of obstruction accurately is between 90-100 % (Gibbons et al. 1983; Juttijudata et al. 1986; Pedersen et al. 1985). Interpretation of the level of block can be affected by incomplete filling of an obstructed biliary tree containing thick inspissated bile or failure of proper mixing of the contrast with stagnant bile. To avoid misinterpretation as much bile as possible is aspirated before injection of contrast media. Movement of the patient during the procedure, including putting him in semierect or upright position is recommended as is repeated fluoroscopic examination and taking films at intervals of up to three hours. Care must be taken to ensure sharp delineation of the obstruction, preferably with some flow of contrast material beyond it and this can be aided by combining PTC with hypotonic duodenography (Gourtsoyiannis & Nolan, 1979).

Nature of obstruction

The accuracy of PTC in determining the precise cause of obstruction, as verified by biopsy, autopsy or laparotomy findings, ranges between 87% and 96% (Gibbons et al. 1983; Juttijudata et al. 1986). In a total of 106 patients evaluated by both PTC and US recently, the former had an overall sensitivity of 93% in determining the cause of obstruction, with a predictive value of 78% in benign non-calculous obstruction, 97% in malignant obstruction and 100% in calculous obstruction (Pedersen et al. 1985).

THE CHOLANGIOGRAPHIC ABNORMALITIES

BENIGN OBSTRUCTION

Benign obstructions are characterised by the following features (Fleming et al. 1972; Goldberg, 1983);

(i) benign strictures have smoothly tapered margins with smooth contour, are concentric to the proximal dilatation and are usually only a few centimetres in length.

(ii) with complete obstruction due to an impacted stone, the distal end of the contrast column may be indented by the stone, producing a downwardly concave meniscus sign.

(iii) intraductal filling defects can be due to stones, mucous or polypoid tumours. Unless impacted, stones may move with a change in the patients position but do not change their shape (which is usually, but not always, rounded). On the other hand, mucus may change shape and is usually elongated. Debris tends to be amorphous and sometimes diffuse, giving a double contrast appearance to the cholangiogram.

The following are descriptions of the cholangiographic abnormalities found in some common benign conditions:-

Chronic pancreatitis

In about 30% of patients with chronic pancreatitis diagnosed by ERCP, plain radiographs of the abdomen reveal diffuse pancreatic calcification; when calcification is present, the diagnosis of chronic pancrwatitis is almost certain (Goldberg, 1983).

The intrapancreatic portion of the common bile duct is often involved by chronic pancreatitis. The incidence of abnormalities of the biliary tract is not related to the age or sex of the patient, but it is significantlly related to the severity of the disease. The changes are more common in severe cases of chronic pancreatitis (69%) than in minor forms of the disease (28%) as assessed by the morphological changes on ERCP (Guien, 1979). Cholangitis, obstructive jaundice, chronic abdominal pain, and secondary liver cirrhosis may result from stenosis of the lower common bile duct in chronic pancreatitis (Gregg et al. 1981; Scott et al 1977). The overall reported incidence of biliary tract abnormalities associated with chronic pancreatitis, demonstrated by PTC, ERCP, or operative cholangiography, is about 44% (Siegel et al. 1979; Wisloff et al. 1982). The pancreatic and bile ducts are not always involved to the same degree, so that both ductal systems should be visualized for accurate diagnosis (Sahel, 1986).

Although Petrozza & Dutta (1985) found at least twofold elevation of serum alkaline phosphatase concentration in 14 of their 15 patients with chronic pancreatitis and abnormalities of biliary tract as demonstrated by direct cholangiography, this reliability of serum markers was not reflected in other studies. For example, Wisloff et al. (1982) Found an elevated total serum bilirubin in only 50% of their cases with chronic pancreatitis and abnormatities of the biliary tract.

The two characteristic changes in the common bile duct which may be found in chronic pancreatitis are:

1- Displacement (abnormalities of course)

It is caused by enlargement of the head of the pancreas. The duct appears rigid and may be displaced laterally or medially. In some cases, the bile duct appears straightened so that the involved segment demonstrates a striking "pipe-stem" appearance, an appearance seen best on cine recordings of the injection phase of the cholangiography. Displacement of the common bile duct may also be caused by a pseudocyst in the head of the pancreas. In such cases, the smooth out line of the narrowed duct suggests a benign process (Fleming et al. 1972; Freeny & Lawson, 1982; Lang, 1974).

2- Stenosis of the intrapancreatic portion of the common bile duct

Stenosis occurs in more advanced cases of chronic pancreatitis as a result of periductal fibrosis. Although complete obstruction is rare, dilatation of the proximal extrahepatic and intrahepatic ducts may be due to increased resistance of the flow through the narrowed segment. A patient with greatly dilated ducts is more likely to have stone obstruction, carcinoma of the head of the pancreas, or primary ductal carcinoma rather than a benign stricture (Fleming et al. 1972). The maximum diameter of the dilated portion of the common bile duct noted in chronic pancreatitis was between 6-28mm in the series reported by Petrozza and Dutta (1985).

Different types of strictures of the common bile duct have been described in chronic pancreatitis, the commonest is a stricture with an elongated tubular smooth margin, tapering gradually throughout the intrapancreatic portion of the common bile duct (Petrozza & Dutta, 1985; Wilsoff et al. 1982). According to the original classification of the structural changes of the common bile duct by Caroli & Nora (1952) and subsequently of Sarles et al. (1958), both the type I and type III strictures are pathognomonic of chronic pancreatitis. On the other hand, type IV and type V strictures can be seen in chronic pancreatitis as well as in pancreatic carcinoma (Figure 2).

Type I stricture of Caroli

This stricture is characteristic of calcified chronic pancreatitis, but is pathognomonic of chronic pancreatitis even when calcification is not present. It is present more often in severe cases of chronic pancreatitis than in mild cases. It is a diffuse longitudinal stricture of the retropancreatic and intrapancreatic portion of the common bile duct. The retropancreatic narrowing is progressive and conical, while the intrapancreatic stricture, which measures 40-60mm, can assume many shapes. It may be rectilinear and uniformly narrowed or irregular and made up of many

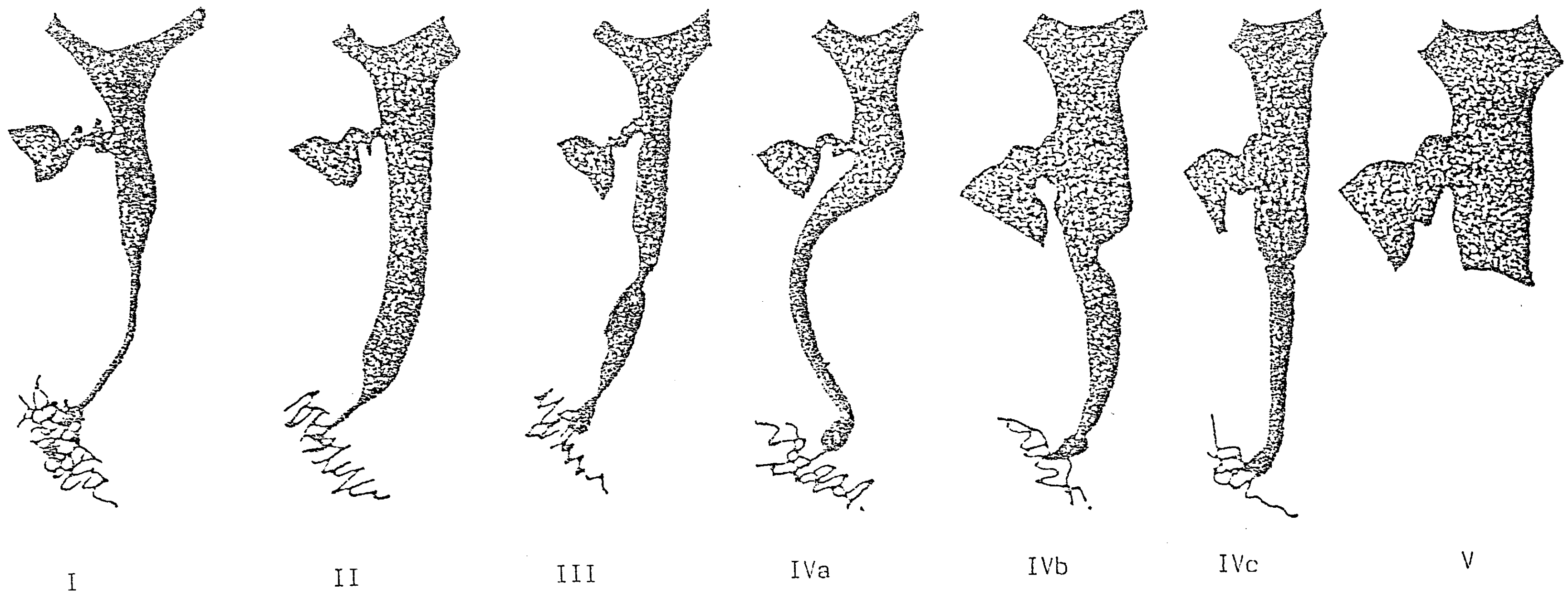

Figure 2 Diagram showing classification of bile duct stenosis according to Caroli and Nora (1952). Type I (long retropancreatic stenosis) and type III (hourglass stricture) are characteristic of chronic pancreatitis. Type II (dilatation of the main bile duct, stricture of the sphincter of Oddi) is typical of ampullary lesions. Type IV is symptomatic of either cyst (a) or cancer (b and c). Type V reflects cancer of the pancreas; when the stricture is impassable, the diagnosis of chronic pancreatitis may be eliminated (from Sarles & Sahel, 1978).

segments. The narrowing is always incomplete, and is frequently associated with dilatation of the proximal biliary tree, but only moderately. Type I stricture has been reported to be constitute 40-66% of common bile duct abnormalities reported in the literature (Engelhom et al. 1976; Guien, 1979; Guien & Camatte, 1971).

Type II stricture of Caroli

This stricture is a dilatation of the entire biliary tract as far as the sphincter of Oddi, and is the picture produced by "odditis" or on occasion by periampullary carcinoma; it is not seen in primary chronic pancreatitis.

Type III stricture of Caroli

This stricture is a very localised annular constriction in the mid common bile duct at the upper border of the pancreas; it is as if the duct was surrounded by a cuff from 2cm to 4cm long. It is a slender waisted stricture with an hour-glass appearance. At ERCP there is a failure of the duct to distend, while the inferior portion of common bile duct and papilla are normal. It is much less common than type I stricture. It is also typical of calcified chronic pancreatitis and occurs more frequently with severe disease than with mild disease. It forms 15% (range: 3-33%) of the common bile duct abnormalties seen in chronic pancreatitis (Engelhom et al. 1976; Fleming et al. 1972; Guien, 1979; Guien & Camatte, 1971; Sarles et al. 1965; Wisloff et al. 1982).

Type IV stricture of Caroli

This is a localised lateral or medial compression of the lower portion of the common bile duct, and is a common finding in chronic pancreatitis, cysts and pancreatic cancer. Even and smooth lateral compression with deviation of the bile duct, the lower part of which is normal, suggests chronic pancreatitis. On the other hand, a long compression, bowed and arched round a mass, favours a cyst. Retrograde dilatation is usually present, while distally the common bile duct is of normal calibre and the papilla is normal. This type of stricture is seen in only 4-6% of cases of chronic pancreatitis (Engelhom et al. 1976; Guien & Camatte, 1971; Sarles et al. 1958).

Type V stricture of Caroli

This is a complete stenosis of the common bile duct at the upper border of the pancreas shown by preoperative cholangiography but occasionally the stenosis may be opacified from below by ERCP.

Retrograde dilatation of the bile duct is the rule. It is highly charactaristic of pancreatic cancer, but it also found in 2% of cases of chronic pancreatitis (Engelhom et al. 1976; Freeny & Lawson, 1982).

The radiological appearances of the lower common bile duct in chronic pancreatitis either remain unchanged or progress spontaneously by an increase in the calibre of the hepatic duct above the stricture; that is type III stenosis evolves towards the appearance of a type I stricture and then becomes progressively more marked. After pancreaticojejunostomy, type III strictures can disappear whereas type I strictures may occasionally improve or remain unchanged (Freeny & Lawson, 1982; Sarles et al. 1958; Sarles et al., 1965).

The gall-bladder is usually normal in chronic pancreatitis. When it is abnormal, the most typical appearance is of an atonic enlarged gall-bladder which is slow to empty (Sarles et al. 1958). Gall-bladder stones are very unusual in chronic pancreatitis (Guien & Camatte, 1971).

Choledocholithiasis

Stones in the bile duct may remain asymptomatic for many years, and sometimes may pass spontenously into the duodenum. However, the complications of choledocholithiasis in addition to obstructive jaundice include cholangitis, pancreatitis, hepatic abscesses, secondary biliary cirrhosis with portal hypertension, and fistulas to the duodenum or colon.

Despite the fact that only 15% of co mmon duct or intrahepatic biliary stones are sufficiently opaque to be recognized on plain film, one should always obtain a scout film prior to opacification of the biliary tree to search for abnormalities such as calcification, air, and foreign body, all which might cause confusion if only post-injection radiographs are obtained. The entire biliary tree should be opacified during cholangiography. Although stones are most frequently extrahepatic, as many as 16-25% can be intrahepatic (Larsen et al. 1976). The cholangiographic picture in choledocholithiasis is usually that of a downwardly concave meniscus sign and in many instances, multiple radiolucent filling defects can be seen in dilated proximal segments. Impacted stones may produce a meniscus which is upwardly concave if contrast is instilled from below at ERCP. Multiple obliquities should be obtained to confirm the presence of the meniscus in all projections and so differentiate stone from polypoid tumour. The latter will be adherent to the wall in at least one projection. Polypoid tumours frequently expand the duct, whereas stones do not (Ligourt & Canard, 1983). The differential diagnosis must include blood clot, admixture defect, and air bubbles. The latter are usually round and smooth whereas stones are seldom perfectly round and smooth. A patient with greatly dilated ducts is more likely to have stone obstruction, pancreatic carcinoma or primary ductal carcinoma than a benign stricture (Fleming et al. 1972); but it is well recognized that stones may be present in normal calibre ducts (Larsen et al. 1976). In Western countries, stones are rarely found in the bile ducts alone and not in the gall-bladder. The incidence of choledocholithiasis in patients after cholecystectomy is 2 to 10 per cent (Teplick, 1981).

The pseudocalculous defect is a peculiar radiographic appearance that mimics a stone at the lower end of the common bile duct. It is an anatomical variation probably due to prominence or unusual arrangment of the smooth muscle fibres of the sphincter of Oddi. During contraction these muscle fibres bulge into the common bile duct, simulating a radiolucent stone. There is no obstruction to bile flow and no proximal ductal dilatation. Antispasmodics do not change the X-ray appearance (Martin et al. 1986; Mujahed & Evans, 1972).

Sclerosing cholangitis

Sclerosing cholangitis affects mainly the intrahepatic ducts with extension into the common hepatic duct. It is unusual for the extrahepatic ducts to be involved without intrahepatic involvement; if this appears to be the case, underfilling or another diagnosis must be suspected (Chen & Goldberg, 1984). The basic lesion is composed of inflammation and fibrosis of the bile ducts, so its distinctive radiographic appearance consists of ductal stiffening and irregularity with multiple sites of beading and stenosis with a predilection for bifurcations. Small out pouchings (diverticula), sometimes associated with 1-2mm length band-like strictures, are more frequent in the extrahepatic ducts and are practically pathognomonic (MacCarty et al. 1983). There is often diminished branching of the intrahepatic radicles, resulting in a "pruned tree" configuration. Marked dilatation proximal to a stricture is quite uncommon and if present should suggest other diseases, since the diffuse fibrosis in sclerosing cholangitis usually prevents significant dilatation (Teplick, 1981).

Traumatic strictures

Stenosis due to trauma or surgical intervention may involve any part of the common duct but usually occurs in the prepancreatic segment of the common bile duct and is characteristically short and smooth (Goldberg, 1983). About 60 per cent of iatrogenic strictures develop during the first post operative week. The remaining 40 per cent are not symptomatic until months or even years after surgery (Teplick, 1981).

Suppurative cholangitis

Multiple tiny contrast-filling cavities, resembling bunches of grapes, connected with biliary tree are typical of suppurative cholangitis. This radiographic demonstration is associated with very poor prognosis (Fleming et al. 1972).

MALIGNANT OBSTRUCTION

Malignant obstruction due to carcinoma of pancreas, bile duct or periampullary region, or to metastatic lesions, hepatoma and lymphomas, is characterised by one or more of the following features (Fleming et al. 1972; Goldberg, 1983);

(i) abrupt termination of the bile duct.

(ii) appearance of an "apple core lesion" is almost pathognomonic of carcinoma.

(iii) a polypoid defect, due to growth of tumour in the obstructed duct, may be seen either at the end of the contrast column or as an irregular lateral filling defect.

(iv) the opacified end of the duct is often irregular in contour and may have a rat-tail appearance, but it may be eccenteric or ulcerated and can sometimes produce a downwardly convex meniscus.

(v) with incomplete malignant obstruction, the strictures are irregular and have abruptly narrowing margins; they are often several centimeters in length.

(vi) multiple strictures suggest a malignant aetiology, although they may be due to sclerosing cholangitis.

(vii) deviation of the common duct from its expected course may be an accompaniment of carcinoma of pancreas, carcinoma of the gall-bladder or malignant lymph node enlargement.

(viii) displacement and distortion of the intrahepatic biliary ducts are usually seen with hepatoma or metastatic lesions.

The following are description of the cholangiographic abnormalities found in some common malignant conditions:

Carcinoma of the head of pancreas

Regardless of its cholangiographic appearance, any complete or near-complete stricture/obstruction in the mid or distal common duct is highly suspicious for carcinoma of the head of the pancreas. With complete obstruction, the pancreatic segment of the common bile duct demonstrates a conical cutoff with a thin, tail-like caudal projection, or the caudal margin of the obstructed segment is convex, or there is a true shouldering at the cut off point. A nipple or beak at the point of obstruction is especially characteristic of carcinoma of the pancreas. These appearances are usually associated with marked dilatation of the intra and extrahepatic ducts. With incomplete obstruction due to pancreatic carcinoma, there is usually a long, irregular stricture of the intrapancreatic and retroduodenal portion of the common bile duct.

Proximal biliary dilatation is obviously related to the degree of obstruction and delayed films may show a large gall-bladder (Fleming et al. 1972; Goldberg, 1983; Lang, 1974). Carcinoma of the pancreas can produce biliary tract obstruction at higher levels and may block the common hepatic duct at any level up to the porta hepatis by virtue of direct extension or nodal compression. Less commonly, the intrahepatic ducts are obstructed by liver metastases.

Carcinoma of the ampulla of Vater

In obstruction due to periampullary carcinoma, the cholangiogram shows dilatation of the proximal ducts with a complete conical cut off or bi-convex lower margins of the termination of the common bile duct (Guien, 1979). With partial obstruction there are either irregular filling defects or encasment and stenosis at the lower end of the common bile duct mimicking inflamatory diseases of the head of pancreas. Local expansion of the duct at the level of the mass when present is a very helpful feature which favours the diagnosis of ampullary carcinoma rather than calculous obstruction. Some patients with periampullary cancer also have associated stones in their proximal common duct (Lang, 1974).

Cholangiocarcinoma

Cholangiocarcinoma can be manifested by several cholangiographic pictures which include; (i) a focal lesion at the bifurcation which often grows into the duct as a filling defect, (ii) infiltration of the porta hepatis with complete obstruction of right or/and left ductal system, or (iii) involvment of several intrahepatic branches along with irregular narrowing of extrahepatic ducts. Many of these radiographic features may be simulated by sclerosing cholangitis and occasionally by advanced cirrhosis (Goldberg, 1983). The pancreatic and retropancreatic common bile duct is usually normal in cholangiocarcinoma (Lang, 1974), unless the cancer arises from the lower portion of the extrahepatic biliary system.

Bile duct carcinoma has been classified cholangiographically as obstructive, stenotic, or protruberant (Ligoury & Canard, 1983). Abrupt occlusion of the biliary system is present in the majority of patients, although delayed or upright films may allow sufficient contrast material to trickle beyond the obstruction. The point of obstruction may have a bluntly tapered (V-shaped or U-shaped), rat-tail, smooth, or irregular appearance. The stenotic type is depicted as a strictured, rigid lumen with irregular margins and prestenotic dilatation. The stenosis may be long or short. Diffuse sclerosing cholangiocarcinoma causes widespread stricturing throughout the biliary tree, resembling sclerosing cholangitis. Clues to the correct diagnosis include absence of diverticula in the extrahepatic biliary tree, more severe disease in the extrahepatic biliary tree and prominent dilatation of ducts. The protruberant type appears as an intraluminal filling defect usually with irregular margins attached at one point to the wall.

Carcinoma of the gall-bladder

Gall-bladder cancer causes displacement and various degree obstruction of the common duct by multinodular masses located close to the porta hepatis and the origin of the cystic duct. The pancreatic and retroduodenal portion of the common bile duct are normal and there is usually associated gall-bladder stones (Lang, 1974).

Metastatic lesions in the liver

Metastases to the liver from cancer elsewhere produces non specific displacement and stretching of the intrahepatic ducts (Lang, 1974), which is sometimes very difficult to differentiate from sclerosing cholangitis or cholangiocarcinoma.

ULTRASONOGRAPHY IN OBSTRUCTIVE JAUNDICE

Over the past decade the quality of ultrasound (US) apparatus has improved so rapidly that the technique has become generally accepted as a useful method for evaluating the biliary system. Since the examination is quick and noninvasive, it is a useful screening procedure for patients thought to have obstructive jaundice. The clinical advantages of US in the differential diagnosis of jaundice are well established.

TECHNIQUE AND USEFULNESS

To scan the biliary tree, the patient is examined in a fasting state to obtain physiological dilatation of the gall-bladder. The frequency used is 2.25-3.5 MHz in most adults and 5 MHz in most childern. The transducer is placed immediately below the xiphisternum, with the scanning arm arranged in the median plane. Using high gain, a slow paramedian scan is performed. Similar scans are made at least every centimetre to the right and left of the midline.

Oblique scans and then transverse scans are also performed. Usually the patient is asked to hold the breath in full inspiration. In a small number of patients, such subcostal scanning may be impossible, and intercostal scanning must be used. Again, scans are performed in paramedial, oblique and transverse plane.

The gall-bladder

Most commonly the gall-bladder is found in contact with the visceral surface of the right lobe of the liver anterior to the right kidney. The most common cause of non visualization of gall-bladder is disease which renders the wall incapable of physiological distention such as chronic cholecystitis. Thus the presence of a small gall-bladder with or without stones indicates stone obstruction. A dilated stone-free gall-bladder often reflects malignant distal obstruction, but it may be a consequence of benign obstruction (Eyre-Brook et al. 1983). The gall-bladder was visualized on ultrasonography in 80% of a total of 662 collected cases studied between 1972-1977 (Anderson & Harned, 1977). With verification of the final diagnosis by direct cholangiography, surgical and/or histopathological findings, the value of US for as a mean of determining the presence or absence of gall-bladder stones is claimed to be 89-96% in satisfactory scans (Anderson & Harned, 1977; Hershman et al. 1986).

Intrahepatic ducts

The intrahepatic biliary tree usually has a lumen of only about 1mm on US examination. Since the axial resolution of the US beam is 1mm, any separation between the walls of the biliary tree exceeding 1mm means that it must be regarded as dilated (Taylor et al. 1979). With verification of the diagnosis by direct cholangiography, the ability of US to detect the presence or absence of intrahepatic biliary dilatation is 90-93% (Haubek et al. 1981; Trought et al. 1980), the corresponding figure is 97% in cases with obstruction of the extrahepatic ducts and 84% in cases without obstruction (Haubek et al. 1981).

Common duct

The common bile duct is usually seen on longitudinal section by taking multiple sections in the plane of the inferior vena cava. It is usually visualized as a small tube of about 4mm (range: 2-6mm) in diameter passing deep to the head of the pancreas. Despite improved equipment and technique, ultrasonographic detection of the cause of common bile duct obstruction remains difficult.

With verification of the US diagnosis by direct cholangiography, surgery or autopsy in patients with obstructive jaundice in recent reports, US can detect the level of obstruction in the biliary tract in 90-95% satisfactory scans (Gibson et al. 1986; Haubek et al. 1981; Laing et al. 1986; Pedersen et al. 1985). The ability of US to detect the cause of obstruction depends largely upon the experience of the operator, the technique used, the US equipment and the nature of the obstruction, and figures of between 23% and 88% have been reported in this context (Eyre-Brook et al. 1983; Gibson et al. 1986; Haubek et al. 1981; Honickman et al. 1982; Pedersen et al 1985). The same is true with regard to the correct detection of the level of obstruction, therefore, some authors have reported figures as low as 27-33% in this context (Gibbons et al. 1983; Honickman et al. 1982). The diagnostic sensitivity of US for detection of common bile duct stones ranges between 13% to 75% with a specificity of nearly 100% (Cronan, 1986; Cronan et al. 1983; Eyre-Brook et al. 1983; Laing et al. 1984; Pedersen et al. 1985). The diagnostic sensitivity of US is 77% in cases with dilated extrahepatic biliary ducts and only 12% in cases with nondilated ducts (Cronan, 1986). The diagnostic sensitivity and specificity of US for the detection of choledocholithiasis in postcholecystectomy patients are 45% and 97% respectively (O'connor et al. 1986). Cronan (1986) analysed 110 cases of choledocholithiasis proved surgically or by endoscopy, stones detected sonographically varied in size from 2mm to 18mm. Acoustic shadowing was exhibited by 31 of the 43 stones (72%) and nonshadowing was observed in 12 (28%). Hamilton et al. (1982) found that the diameter of the common bile duct alone is of limited value in the investigation of presence or absence of common bile duct stones, because of the great overlap between the diameter of the groups with and without duct stones.

Ultrasound of other organs

US is useful for scanning structures related to the biliary system such as the pancreas, liver, right kidney, aorta and para-aortic lymph nodes. This allows detection of the extent of the disease and its resectability in case of malignant obstruction. In predicting tumour resectability, US proved correct in 71% of patients in one reported series, in comparison with a figure of 42% for computed scanning and 58% for direct cholangiography (Gibson et al. 1986).

Abnormal pancreatic US is significant and usually (94%) indicates disease, whereas a normal pancreatic US does not exclude pancreatic disease, this is especially true in patients with suspected chronic pancreatitis (Lawson, 1978). The accuracy of US in differentiating the normal from abnormal pancreas is between 72-87% in satisfactory scans (Cotton et al. 1980; Doust & Pearce, 1976; Gowland et al. 1981; Lawson, 1978).

Intraoperative ultrasound

In an evaluation of intra-operative B-mode biliary tree and pancreatic US in 50 patients undergoing cholecystectomy for gall-bladder stones, US was as accurate as pre-operative cholangiography, and the decision to explore the biliary duct on the basis of US findings was correct in 49/50 cases; a decision made on X-ray findings (operative cholangiography) was correct in 46/47 cases (Lane & Glazer, 1980).

Fine-needle ultrasound guided pancreatography and biopsy

Ultrasonically guided percutaneous puncture of organs and pathological lesions is now possible for diagnostic and therapeutic purposes. The procedure is simple to perform, virtually without hazard, and causes very little discomfort to the patient. The high resolution of real-time sonography and the recent development of a real-time biopsy transducer, which permits visualization of the needle tip, have allowed ultrasonically-guided percutaneous puncture of the pancreatic duct and percutaneous pancreatography. The examination is performed on a fluoroscopic table. The dilated pancreatic duct is localised with the real-time biopsy transducer and a standard 23-gauge (0.7mm) PTC needle is guided into the duct. Aspiration of pancreatic fluid confirms the intraductal location of the needle, and 60% iodinated contrast material is then injected using fluoroscopic monitoring. Although the procedure has received minimal attention and use, it may be helpful in selected cases, particularly for preoperative evaluation of obstructed ducts that cannot be opacified by ERCP (Freeny & Lawson, 1982).

PITFALLS OF ULTRASOUND

Despite the fact that US is non-invasive, relatively cheap and a very reliable mean of detecting gall-bladder stones, biliary US is not an easy investigation to interpret and modern grey-scale equipment and an experienced operator are mandatory. It remains a poor tool for detecting common duct stones (O´Connor et al. 1986; Pedersen et al. 1985).

There can be a high rate of technical failure (unsatisfactory US scans) in depicting the entire course of the common bile duct. In one study (Frederic et al. 1983) this was 11% (52/430). The main factors leading to failure of US scanning are excessive bowel gas, obesity, ascites and an uncooperative patient (Berk et al, 1982; Eyre-Brook et al. 1983).

ULTRASONOGRAPHY IN PANCREATITIS AND PANCREATIC CANCER

Pathological US findings are generally consistent with pancreatic disease, but a normal US findings does not exclude a pancreatic disease. This is particularly true in chronic pancreatitis, where the false-negative result may be frequent (Lawson, 1978). Moderate and severe forms of chronic pancreatitis are well seen by US, but mild forms may be missed. There is no differences in the frequency of sonographic abnormalities between chronic pancreatitis patients with and without clinical and biochemical evidences of pancreatic insufficiency (Alpern et al. 1985). Hessel et al. (1982), in a prospective study involving 279 patients, found a sensitivity and specificity of 69% and 90% for US in detecting an abnormal pancreas, respectively. The diagnostic sensitivity of US to detect pancreatic head masses is 47% (Eyre-Brook et al. 1983). Its sesitivity and specificity in one study (Cotton et al. 1980) were 86% and 90% for diagnosis of chronic pancreatitis and pancreatic carcinoma, respectively. However, this was not the case with all reported studies in the literature. Hessel et al. (1982) found that satisfactory US scans had a sensitivity of 56% in detecting pancreatic lesions and identifying it is malignant or inflammatory, whereas Walls et al. (1975) and Cotton et al. (1980) claimed that US has an accuracy of 80-87% in the differentiation between pancreatic carcinoma and other lesions. On the other hand, Ferrucci et al. (1979) and Gowland et al. (1981) reported 25% and 55% sensitivity in diagnosis of chronic pancreatitis by US, respectively.

The most common ultrasonic features of chronic pancreatitis are shown in Table 1. Usually two or more features must be present to allow diagnosis of chronic pancreatitis. In general, the antero-posterior diameter of the head of the normal pancreas measures 20-25mm, the body 15-20mm, and the tail 10-15mm.

Table 1 Sonographic findings in chronic pancreatitis.

Features	Otte, 1986 (n = 70)	Alpern et al. 1985 (n = 77)
Heterogeneous reflectivity	75%	53%
Local heterogenous enlargement	41%	41%
Cysts	31%	21%
Calcifications	29%	40%
Dilated pancreatic duct	23%	20%
Dilated biliary duct	3%	19%

The size of the pancreas varies with the age, relatively large in childhood and small in the elderly. The pancreas in chronic pancreatitis may be normal, focally or diffusely enlarged, or small and atrophic. These changes generally correlate with the activity and chronicity of the inflammatory process. Diffuse enlargement is seen most often during the early stages of the disease, and focal enlargement or gland atrophy are more common in the late or advance stages (Alpern et al. 1985; Freeny & Lawson, 1982). The normal parenchyma of the pancreas is homogenous, with an echogenicity equal to or slightly greater than that of the nondiseased liver. Chronic pancreatitis is most often characterised by increaesd or heterogenous echo pattren. Non-homogenous enlargement of the pancreas is far more significant and almost stands as a single sonographic sign of chronic pancreatitis. In the other hand, most pancreatic carcinomas are detected as hypoechoic masses enlarging the gland or deforming its contour. However, focal pancreatitis without pseudocyst is indistinguishable from duct cell carcinoma.

Calcifications are usually seen as very echogenic bright foci within the prarenchyma and typify advanced chronic pancreatitis. As in other organs only larger stones produce acoustic shadows.

Demonstration of the normal pancratic duct is the single most important criterion of adequate visualization of the pancreas. The pancreatic duct appears as an echo free tubular structure bounded by echogenic walls and completely surrounded by parenchyma. US allows visualization of the normal pancreatic duct in about 60-85% of normal person, and the normal pancreatic duct has a diameter of 0.8-2mm (Otte, 1986). A dilated pancreatic duct (internal diameter greater than 2-3mm) is probably the most specific ultrasonographic parameter of pancreatic disease. Although a dilated pancreatic duct is virtually always abnormal and indicates the presence of pancreatic disease, the reverse is not always true.

Pseudocysts are often seen in acute or chronic pancreatitis. They may be identified with a high degree of accuracy by US if they are larger than 3cm in diameter (Sarti & King, 1980). Small sonolucent pseudocysts of chronic pancreatitis are difficult to differentiate from tumour necrosis (Freidman et al. 1987). US is highly accurate in the detection of dilated bile ducts due to pseudocysts within the head of the pancreas or enlargement of the head due to chronic inflammation or cancer, and thus may provide important information in patients with pancreatic disease (Alpern et al. 1985).

All the morphological changes detected by US (Table 1), excluding the calcifications, are variously present in pancreatic carcer. Neither the calibre nor the morphology of the duct therefore can differentiate reliably between inflammatory and neoplastic disease of the pancreas (Freeny & lawson, 1982). Definite diagnosis is only possible when there is liver metastasis, invasion of portal veins and/or retropancreatic or hailar lymph node enlargement is detected in addition to the pancreatic mass. The following criteria may be of some help in differentiation between pancreatic carcinoma and chronic pancreatitis; (i) in case of chronic pancreatitis the enlargement of the gland is generally diffuse, the echo pattern is uneven, and the dilatation of the main pancreatic duct is irregular, (ii) in case of pancreatic carcinoma the enlargement is localised, the structure is hypoechoic, and the dilatation of the main pancreatic duct is more regular, (iii) calcifications are nearly always pathognomonic for chronic pancreatitis, and (iv) presence of liver metastasis suggests the diagnosis of cancer. In doubtful cases, however, the only way to establish a correct diagnosis is to perform a fine-needle ultrasound-giuded biopsy of the pancreas.

ENDOSCOPIC RETROGRADE CHOLANGIOPANCREATOGRAPHY

The development of the modern flexible fibreoptic endoscope in the late 1960s has led to the introduction of numerous therapeutic and diagnostic procedures. Endoscopic retrograde cholangio-pancreatography (ERCP) was first reported in the United state (McCune et al. 1968), and soon established itself as an extremely useful tool for visualizing the bile duct in difficult cases of jaundice (Elias, 1976; Kasugai et al. 1972). Although ERCP was introduced as a purely diagnostic procedure, recent technical advances in instrumentation have added a therapeutic dimension.

Attainment of proficiency in ERCP requires considerable practice, and published rates of success often omit consideration of the learning phase. In a large survey of 10,435 attempts at ERCP in USA, the failure rate in cannulation of the ampulla was 15% for those who had performed 200 or more procedures, whereas in less experienced hands the failure rate was 62% (Bilbao et al. 1976).

INDICATIONS AND USEFULNESS OF ERCP

The principal application for ERCP is in the evaluation of suspected pathology in the pancreas or biliary system. In addition to outlining both systems the technique allows biopsy, brushing, and aspiration of material from the biliary or pancreatic ducts, while papillotomy and/or common bile duct stone removal and stenting of the biliary system are more recent extensions of the procedure. The indications and usefulness of ERCP may be considered under four headings:

Obstructive jaundice of unknown aetiology

This indication is identical to that for PTC, as mentioned earlier in this chapter. In fact disagreement exists about whether to use ERCP or PTC for primary biliary tract problems. Matzen et al. (1982) in a randomized trial of 52 consecutive patients with clinically suspected obstructive jaundice achieved the diagnosis in 91% by ERCP and in 69% by PTC ($P<0.05$). Therefore, they suggested ERCP as an initial examination for patients with obstructive jaundice and PTC as the complementary method if necessary. Furthermore, diagnostic ERCP is not contraindicated in the presence of ascites, coagulation defects, hydatid liver disease or liver abscess, nor is its success diminished by sclerosis of the intrahepatic ducts. In addition, useful information can be obtained from upper gastrointestinal endoscopy, biopsy, pancreatography, and cytology.

<u>Pancreatic diseases</u>

Suspected pancreatic disease, particularly in chronic pancreatitis.

1- An accurate diagnosis of chronic pancreatitis can usually be made on the basis of the ERCP findings. Caletti et al. (1982) in a large survey involving 1,411 cases of chronic pancreatitis diagnosed on characteristic clinical features and presence of at least two of the following; (i) abnormal pancreatic function tests, (ii) calcification on the plain radiograph of the abdomen, (iii) abnormal pancreatic ultrasonography, (iv) abnormal CT scan, or (v) positive histo-pathology. They reported normal pancreatograms in 19.4% (229/1179) of successful ERCP examinations.

Pancreatograms are abnormal in about 80-85% of cases with chronic pancreatitis, and these abnormalities include:

(i) Dilatation of the main pancreatic duct is the most common finding in moderate and severe pancreatitis.

However, since the diameter increases with age, interpretation of border line changes may be difficult. In this situations, consideration of several additional parameters may be useful (Sahel, 1986);

A- when ductal calibre is increased, the uniform tapering pattern is maintained in normal persons, but is lost in patients with chronic pancreatitis.

B- in patients with chronic pancreatitis, ductal dilatation invariably is increased with additional changes of pancreatitis, such as ectasis of the lateral side branches and ductal calcifications.

(ii) Ectasia or clubbing of the lateral side branches is the earliest finding in chronic pancreatitis. Frequently the junction of the side branches with the main pancreatic duct appears to be slightly pinched or narrowed (Kasugai et al. 1972).

(iii) Irregularity of the wall of the main pancreatic duct also is an early finding in chronic pancreatitis (Freeny & Lawson, 1982).

(iv) Stenosis of the main pancreatic duct is common in moderate and severe chronic pancreatitis. The stenoses may be focal or multifocal and usually are associated with ductal dilatation, producing the morphological changes described as "chain-of-lakes" or "string-of-pearls". The periampullary portion of the main pancreatic duct is often a site of stenosis (Kasugai et al. 1972; Freeny et al. 1976).

(v) A coarse, acinar pattern is common in severe chronic pancreatitis. But the pattern should be considered as a minor or ancillary finding of the chronic pancreatitis only when associated with other features. As an isolated findings, it may be due to artefact of over-filling or due to aging process (Kasugi et al. 1972; Freeny & Lawson, 1982).

(vi) Pancreatic calculi and parenchymal calcifications are pathognomonic of chronic pancreatitis and may be seen on plain films, US, or CT. During ERCP, ductal calculi are seen as filling defects within the pancreatic ducts and may cause obstruction. Non-opaque calculi must be distinguished from air bubbles inadvertently introduced during injection of the contrast material (Freeny & Lawson, 1982; Sahel, 1986).

(vii) Pancreatic pseudocysts and fistulae may be visualized during ERCP. Cysts are encounted in about 20% of cases of chronic pancreatitis. They can be filled with contrast medium, as they communicate with the main pancreatic duct in approximately 60% of cases, or appear as a regular compression of the main pancreatic duct or side branches or as a complete obstruction of the pancreatic duct (Sahel, 1986).

2- A variety of abnormalities of the pancreas and biliary tree such as biliary tract stones, pancreas divisum, annular pancreas, ampullary stenosis, sclerosing cholangitis and choledochal cyst, may be associated with chronic pancreatitis. These ductal abnormalities, which are mostly amenable to surgery, can be demonstrated by ERCP.

3- Preoperative evaluation of the pancreatic and biliary tract anatomy prior to surgery has led to considerable improvement in the management of patients with chronic pancreatitis.

(i) The appropriate procedure may be selected prior to surgery. For example, lateral pancreaticojejunostomy may be indicated when there is a diffusely dilated pancreatic duct, whereas pancreaticoduodenal resection may be indicated if the disease is confined to the head of the pancreas, or subtotal or total pancreatectomy may be preferred if diffuse pancreatic ductal sclerosis and obliteration are demonstrated.

(ii) Patients who are more likely to benefit from surgery may be selected by ERCP, while in some cases laparotomy may be avoided.

4- Complictions of the chronic pancreatitis preoperatively such as common bile duct stenosis (which may be treated to prevent hepatic and biliary complications), pancreatic ascites and fistula may all be detected by ERCP.

5- Despite the advent of more sophisticated techniques, ERCP is today still the prime diagnostic tool for the assessment of the morphological severity of pancreatic disease (Kasugai et al. 1972; Sarner & Cotton, 1984). Although several classifications have been established, the morphological diagnosis of the chronic pancreatitis at early stages is often difficult. The diameter of the pancreatic duct can be increased with aging and the microcysts can be seen in the elderley. The proposed classifications of ERCP appearances in chronic pancreatitis are shown in Tables 2-4.

6- Differentiation between chronic pancreatitis and pancreatic carcinoma. ERCP generally has an accuracy rate of 80-90% in the diagnosis of both pancreatic carcinoma and chronic pancreatitis, with high degree of reliabilty (Caletti et al. 1982; Gilinsky et al. 1986; Reuben & Cotton, 1979). In some cases the findings may be equivocal, and additional studies, such as

Table 2 Criteria for endoscopic pancreatography diagnosis of chronic pancreatitis (Kasugai et al. 1972)

	Minimal	Moderate	Advanced
Main pancreatic duct			
Tortuosity	-	+	+++
Dilatation and stenosis	-	+	+++
Obstruction	-	-	+
Cyst formation	-	-	+
Calculi	-	-	+
Branches and fine pancreatic duct			
Irregular distribution	+	++	+++
Dilatation	+	++	+++
Stenosis and obstruction	+	++	+++
Cystic dilatation	-	+	+++
Calculi	-	-	+
Acini			
Coarse opacification	-	-	+
Size of the pancreas			
Diminished	-	-	+

Table 3 "Cambridge" classification of chronic pancreatitis (Sarner & Cotton, 1984)

Grading	Enoscopic retrograde pancreatography		US & CT
1 Normal	Quality study visualising whole gland without abnormal features.		
2 Equivocal	Less than three abnormal branches.	One sign only.	Main duct enlarged (< 4mm). Gland enlagment (up to 2 Normal) Irregular head/body countour Cavities (< 10mm) Irregular ducts Focal pancreatitis Duct wall echo increased Parenchymal hetrogericity
3 Mild	More than three abnormal branches.	Two or more signs.	
4 Moderate	Abnormal main duct and branches.		
5 Marked	All above with one or more of: Large cavities (> 10mm) Gross gland enlargment (> 2*N) Intraductal filling defects or calculi Duct obstruction, stricture or gross irregularity Contiguous organ invasion		

If pathological changes are limited to 1/3 of the gland or less they are classified as focal.

Table 4 Revised classification of chronic pancreatitis (from Jones et al. 1988).

	Endoscopic retrograde pancreatography		Ultrasound
1 Normal	Visualisation of entire duct system with uniform filling of side branches without acinar opacification		Visualisation of entire gland and demonstration and measurement of main pancreatic duct
2 Equivocal	Less than 3 abnormal branches	Less than 2 abnormal signs	Main duct enlarged (less than 4 mm) Gland enlarged (up to twice normal) Cavities (less than 10 mm) Irregular ducts Focal reduction in parenchymal echogenicity Echogenic foci in parenchyma Increased or irregular echogenicity of wall of main duct Irregular contour to gland particularly focal enlargement
3 Mild	More than 3 abnormal branches	2 or more abnormal signs	
4 Moderate	Abnormal main duct and branches		
5 Marked	Large cavities (greater than 10 mm Intraduct calculi Duct obstruction with stricture Gross irregularity of main pancreatic duct		Large cavities (greater than 10 mm) Calculi Duct obstruction (greater than 4 mm) Major duct irregularity Gross enlargements (greater than 4 mm) Contiguous organ invasion

angiography or percutaneous pancreatic biopsy may be required. However, most investigators agree that if carcinoma and chronic pancreatitis coexist, it is virtually impossible to make a specific radiological diagnosis. Similarly, the diagnosis may be equally difficult to make at the operating table, even when a wedge-resection biopsies are submitted for frozen-section evaluation. The following findings may help to distinguish pancreatic carcinoma from chronic pancreatitis at ERCP (Caletti et al. 1982; Freeny & Lawson, 1982; Kruse et al. 1978; Sarles et al. 1958):

(i) Chronic pancreatitis characteristically produces diffuse changes of the main duct and lateral side branches consisting of dilatation, marginal irregularities, and short stenoses. Carcinoma, on the other hand, usually causes a focal abnormality, most often complete ductal obstruction or a long area of irregular encasement.

(ii) Although ductal obstruction may be a feature of both pancreatitis and carcinoma, however, complete obstruction of the main pancreatic duct is uncommon feature of chronic pancreatitis (Kruse et al. 1978). The following specific features may aid in differentiation.

A- In chronic pancreatitis, the ductal segment between the ampulla and the point of obstruction usually shows characteristic changes of dilatation and side branch ectasia and clubbing. In carcinoma, this ductal segment is usually normal.

B- The obstructed terminus is usually rounded or blunt in chronic pancreatitis and irregular or eccentric in carcinoma.

C- In chronic pancreatitis, correlation of plain films with the ERCP may show the obstruction to be secondary to an impacted calculous.

(iii) As mentioned earlier in this chapter, common bile duct abnormalities when associated with the carcinoma of the head of pancreas are usually of the type V stricture of Caroli. In contrast, chronic pancreatitis usually causes type I or type III strictures of Caroli (Caroli & Nora, 1952; Sarles et al. 1958).

(iv) Although obstruction and proximal dilatation of the CBD may associated with both chronic pancreatitis and cancer, but is more marked in carcinoma than in chronic pancreatitis (Guien, 1979).

(v) Lactoferrin concentration in pancreatic juice , obtained during ERCP cannulation of the pancreatic duct, is increased in patients with chronic pancreatitis but normal in patients with pancreatic carcinoma (Fedail et al 1978).

Abdominal pain

Unexplained severe abdominal pain of suspected biliary or pancreatic origin may be investigated by ERCP, particulary when other non invasive investigations were negative.

Therapeutic use of ERCP

Therapeutic indications include endoscopic biliary stenting (to provide preoperative relief of the common bile duct obstruction or palliative therapy in inoperable patients) and endoscopic papillotomy with or without stone extraction.

CONTRAINDICATIONS FOR ERCP

Contraindication to ERCP are few and all are relative. These include oesophageal stenosis, gastric outlet obstruction, thoracic aortic aneurysm and severe pulmonary disease. ERCP should be avoided in patients with hypersensitivity to contrast media or known Australia antigen positive hepatitis. Acute cholangitis is a relative contraindication unless a stone in the common bile duct is thought to be the cause, in which case the stone may be removed during the procedure. At one time it was believed that ERCP should not be performed during and within four weeks of an episode of acute pancreatitis or in the known presence of a pseudocyst (Bilbao et al. 1976; Evans, 1983). Although this is no longer the case in some patients thought to have gall stone associated acute pancreatitis, when ERCP can be used to outline the biliary system and perform endoscopic papillotomy with or without stone extraction.

TECHNIQUE OF ERCP

A close rapport between endoscopist and radiologist is required to obtain the best possible radiographic record. The examination must be performed in a room containing high quality radiographic equipment and which is large enough to accommodate all neccessary apparatus and personnel. A conventional screening unit with an under-couch tube is preferrable to an over-couch remote control unit, which may cause excessive radiation exposure to the endoscopist. The table top should be capable of being tilted from the upright to at least a 15° headdown position. The X-ray tube should have a small focal spot (0.3-0.6mm) and high MaS and KV facility. An overcouch tube is required for delayed films.

The basic endoscopic equipment consists of a side viewing endoscope, such as the Olympus BJIT; together with its cold light source, suction apparatus, balloon catheter, nasobiliary cather and cannulation catheters. Dormia baskets, sphincterotomy knives, stents and guidewires, and a diathermy unit should be available to allow therapeutic techniques to be performed after the diagnostic procedure. A lignocaine spray is required for pharyngeal anaesthesia and syringes of various size should be included on the trolley. Drugs available should include pethidine, Omnopon, atropine, diazepam (diazemuls) and Buscopan. A suitable contrast media such as Conray 280 or metrizamide should be to hand. Resuscitation equipment should always be available in case of cardio-respiratory collapse.

The patient should be reassured by prior explanation of the procedure. A chest X-ray and barium examination of the oesophagus and stomach are desirable in the way to exclude an aortic aneurysm and oesophageal or gastric outlet obstruction. However, this is rarely fessible in practice. The patient is starved for six hours prior to the examination.

The patient lies on the fluoroscopy table. A Butterfly needle is used to provide an intravenous line into the arm. Sedation is provided by diazemuls or opiates. The onset of ptosis and dysarthria usually indicates adequate sedation. Intravenous atropine or Buscopan is given immediately before the examination to control salivation. One dose of intravenous prophylactic antibiotic such as Gentamycin is usually given to cover the procedure. Plain radiographs of the hepatobiliary area are obtained to assess radiographic factors and will also show the presence of pancreatic calcifications. Endoscopy is then performed in the left lateral position. The stomach is insufflated, the pylorus is identified and negotiated, and the duodenal bulb is inspected before paralytic ileus is obtained by intravenous hyoscine-n-butyl bromide or glucagon. It is necessary to obtain an en face view of the papilla in order to cannulate it. Once cannulation has obtained, 1-2 ml of the contrast medium is slowly injected under fluoroscopic control. The field size should be kept to a minimum to obtain maximum detail. Reflux of contrast medium into the duodenum indicates failure of cannulation and requires repositioning of the cannula. If the pancreatic duct is opacified, slow injection of contrast medium proceeds under constant fluoroscopic control. Radiographs are obtained when the pancreatic duct is delineated to its tail. The pressure of injection should be sufficient to fill but not over-distend the pancreatic or biliary ducts. The injection is stopped when lateral branches of the pancreatic duct are seen or when the patient complains of pain. The patient is gently turned as necessary so that the endoscope does not obscure ductal detail on further radiographs. Having obtained radiographs of the ductal system, the instrument is retracted into the stomach and over-couch films of the pancreatic area are obtained in prone oblique and antero-posterior positions. These radiographs must be quickly obtained as contrast medium is very rapidly evacuated from the normal ductal system.

Cholangiography is often more difficult to attain than pancreatography. Once the common bile duct has been cannulated, the contrast medium is injected under fluoroscopic control until there is adequate filling of the biliary tree. The normal pancreatic duct volume is of the order of 2-5 ml whereas 8-12 ml are required to fill the normal biliary tract. Much larger volumes may be required to demonstrate the biliary system adequately if there is free filling of the gall-bladder. Great care must be taken not to introduce air bubbles as these may cause diagnostic difficulties. With the cannula in situ, under-couch radiographs are obtained in left lateral and left anterior oblique projections. The endoscope is removed as soon as there is adequate opacification of the biliary system and over-couch radiographs are taken of the biliary tract. Delayed radiographs, including erect views, may be required to assess fully the biliary system. Video recording of both pancreatic duct and common bile duct is useful documentation. The patient should be nursed in the lateral position in the immediate post-procedure phase, until there is full return of pharyngeal sensation.

COMPLICATIONS OF DIAGNOSTIC ERCP

The hazards and complications of ERCP include those of upper gastrointestinal endoscopy in addition to complications which specifically result from cannulation of the ductal system, premedication, and radiation exposure.

Hazards of endoscopy

1- Inhalation of vomit may occur and cause aspiration pneumonia. This risk is minimized by keeping the patient in the prone or prone oblique position throughout the examination.

2- Perforation of the pharynx, oesophagus, stomach or duodenum is possible during endoscopy. However, perforation of the duodenum is more likely with ERCP than with simple endoscopy.

3- Cardiac arrhythmias; patients undergoing upper gastrointestinal endoscopy may develop different types of cardiac arrhythmias especially patients with previous heart diseases, elderly patients and patients with chronic obstructive lung disease. Fatal cardiac complications following upper gastrointestinal endoscopy have been reporeted (Mandelstam et al. 1976).

4- An acute abdomen may be simulated due to the forcible introduction of a large volume of air into the stomach.

5- Cross-infection is always possible with an inadequately sterilized endoscope.

6- Bleeding from oesophageal varices has been reported in one case (Bilbao et al. 1976).

Hazards unique to ERCP

The major hazards of diagnostic ERCP are the precipitation of an attack of acute pancreatitis or the introduction of infection into the biliary or pancreatic system. The complication rate of diagnostic ERCP in experienced hands is of the order of 2-3%, with mortality rate of 0.1-0.2% (Bilbao et al. 1976; Cotton, 1977). These complication rates were inversely related to the experience of the endoscopists (Bilbao et al. 1976).

1- Hyperamylasaemia

Hyperamylasaemia is a frequent occurence after pancreatography. Skude et al. (1976) reported pathologically high pancreatic serum amylase values (mean increase of 5 times over control) in 60% of patients having ERCP. The higher levels of amylase were associated with extensive opacification; however, patients have rarely developed clinical pancreatitis. Hyperamylasaemia and pain has been associated more with ionic contrast media such as Isopaque 350 and Urografin 60 than with non-ionic contrast media such as metrizamide (Osnes et al. 1977), although this was not confirmed in other studies (Hamilton et al. 1982; Hannigan et al. 1985).

Laferla et al. (1985) randomised 92 patients undergoing ERCP to receive single intravenous bolus of aprotinin as opposed to placebo immediately before the procedure. Blood samples were taken for pancreatic serum amylase levels immediately before and after the ERCP and at 4 hours lat er. They found a signifigant reduction in the incidence of abnormal serum amylase values (>330 IU/l) in the immediate post ERCP samples in patients receiving aprotinin, while there were no significant reductions in the 4-hour sample. Therefore, they suggest that a single bolus injection of aproptinin has a transient inhibitory effect on ERCP-induced hyperamylasaemia, and could be useful prophylactically especially when parenchymal opacification is seen at the time of examination.

2- Pancreatitis

The incidence of clinical pancreatitis with severe abdominal pain is about 1% in large studies (Bilbao et al. 1976; Cotton, 1977). Clinical pancreatitis is more common following acinar filling (Ruppin et al. 1974) and/or when the renal tract is opacified after ERCP (Roszler & Campbell, 1985). It is likely that infection plays only a minor role in the pathogenesis of acute pancreatitis after ERCP (Brandes et al. 1981; O'Connor & Axon, 1983). Radiologists have an important role in monitoring the extent of filling of the pancreatic duct by fluoroscopy during the injection of contrast medium so that over-injection and acinar filling are avoided. They should also be aware of the possibility and significance of renal tract opacification.

3- Infection

The second major hazard of diagnostic ERCP is infection of the biliary and pancreatic ducts. Pancreatic abscess occurred in 25 (0.3%) of the 8681 cases reported by Bilbao et al. (1976) and there was a mortality rate of 20% in those 25 cases. They reported no complications in 91% of ERCP procedures performed on 193 patients with pseudocysts. Most authorities agree that ERCP in the presence of pseudocyst should be reserved for those patients scheduled for surgery and the examination performed as a pre-operative investigation (Cotton, 1977). Indeed, ERCP is not indicated as the method for diagnosing the presence of a pseudocyst, the investigations of choice being ultrasound or computed tomography.

Cholangitis, with a reported incidence of 0.8% and a 10% mortality; was the second most common complication and most common cause of death in the survey by Bilbao et al. (1976). Cotton (1977) quotes a review of ten European centres with a 0.4% incidence of cholangitis in 9000 patients with an overall mortality of less than 0.1%. The onset of cholangitis may be early, within 12 hours, or delayed for several days. It is not entirely clear whether cholangitis is due to endogenous organisms already present, particularly in an obstructed duct system, or is a result of infection introduced from contaminated endoscopes and accessories. The high incidence of cholangitis in the presence of obstruction has already been noted (Bilboa et al. 1976). While Low et al. (1980) isolated a strain of Pseudomonas aeruginosa from the bile of 14 patients in 101 endoscopies; these micro-organisms could not be detected after more vigorous cleansing and disinfection of the endoscope. Despite the number of cases of cholangitis reported, the incidence of bacteraemia appears to be low (0-2%) (Dutta et al. 1983; Low et al. 1980).

The most important factors in the prevention of septic complications of ERCP are meticulous attention to disinfection of endoscopes and accessories (Low et al. 1980), prompt relief of obstruction or stasis by endoscopic or surgical methods (David et al. 1975), the appropriate use of prophylactic antibiotics (Axon &

Cotton, 1983), and limiting the amount of contrast medium injected into poorly draining ducts.

4- Radiation exposure in ERCP

X-ray irradiation during ERCP is low (about 10% of that employed for infusion cholangiography). However, cumulative X-ray damage to the fibre bundles of the endoscope eventually occurs. Many factors influence radiation exposure in diagnostic ERCP. In a prospective study over a three-year period, van Husen et al. (1984) showed a remarkably shorter X-ray screening time in endoscopic retrograde pancreatography (ERP) compared with endoscopic retrograde cholangiography (ERC), and in younger patients compared with the older age group. In endoscopic sphincterotomy the average fluoroscopic time was about one minute longer than in purely diagnostic ERCP. In contrast to diagnostic ERC, there was an appreciable reduction of radiation exposure in endoscopic sphincterotomy with time, reflecting the growing experience of the endoscopic team.

5- Sedation

As many of the patients refered for ERCP are jaundiced, they are more susceptible to sedative drugs used as premedication. Diazepams (diazemuls), the most commonly used drugs for sedating patients undergoing ERCP, cause mild respiratory depression, but can occasionally induce severe respiratory depression. Excessive dosage can result in stupor or coma. Extra caution should be taken when using sedatives in patients with hepatic insufficiency, cardiopulmonary disease or those already receiving sedative drugs.

6- Drug reaction

Endoscopists and radiologists should be alert to the posibility of drug reaction occuring as a result of ERCP. Moreira et al. (1985) performed ERCP in 16 patients with previous history of minor reaction to contrast medium after intravenous administration. None of these patients developed any signs of adverse reactions. However, a severe contrast medium reaction with hypotensive collapse had been reported in 1 of 2000 ERCP procedures, ten minutes after pancreatic duct injection (Gmelin et al. 1977).

Chapter 2

EVALUATION OF PERCUTANEOUS TRANSHEPATIC CHOLANGIOGRAPHY ENDOSCOPIC RETROGRADE CHOLANGIOPANCREATOGRAPHY AND ULTRASONOGRAPHY IN OBSTRUCTIVE JAUNDICE (STUDY I)

AIM OF THE STUDY

The aim of this study was to evaluate the diagnostic values, usefulness and complications of percutaneous transhepatic cholangiography (PTC), endoscopic retrograde cholangiopancreatography (ERCP), and ultrasonography (US) in the evaluation of patients with obstructive jaundice.

PATIENTS AND METHODS

Retrospective part of study I

All the patients undergoing PTC and/or ERCP from the University Department of Surgery Glasgow Royal Infirmary (GRI) between January 1st 1981 and December

31st 1985 were identified by personal search through the unit´s discharge summary cards. Cholangiograms of 112 patients, who had PTC and/or ERCP as an investigation for obstructive jaundice diagnosed on the basis of clinical and labarotory data, were available for review at the Radiology Department GRI.

Investigations

The original X-ray reports of these 112 cholangiograms were scrutinised. The patients case notes were then obtained from the Records Department of GRI and the following data were abstracted; (i) the radiologists conclusion regarding the presence or absence of biliary obstruction, the level of the obstruction, suggested cause or causes of this obstruction, measurements (if given) for the diameters of the common hepatic duct, common bile duct and the gall-bladder, and presence or absence of stones in the gall-bladder or the involvement of the latter by a tumour, (ii) any complications related to the PTC and/or ERCP, and whether the procedure had precipitated emergency surgery, (iii) whether external biliary drainage had been combined with diagnostic cholangiography (and its duration), and whether placement of an internal biliary stent, papillotomy, stone extraction, biopsy or any other procedures had accompanied PTC, US or ERCP, and (iv) the final diagnosis of the patient and whether it is based upon biopsy, autopsy, laparotomy findings or endoscopy, or on clinical grounds including the results of all available investigations.

Comparison

Of the total of 112 patients in the study, 100 patients had their final diagnosis based on histopathological, surgical or endoscopic (in the case of common bile duct stones) findings. From the above data the diagnostic value and the usefulness of the performed investigations (PTC, ERCP & US) in determining the management and the outcome of these 100 patient were classified on the basis of the three following criteria. This classification was based upon the fact that during the period of the study US was the first line investigation undertaken by the unit followed by ERCP or PTC as appropriate. The diagnostic values and usefulness of PTC, US and ERCP were then compared.

1- Performance and success of the procedure.

It was noted whether the investigation was attempted or not, and whether it failed or was successful in visualizing the biliary system in the case of PTC and ERCP, and satisfactory or not in the case of US.

2- Diagnostic value of the procedure.

It was considered diagnostic when the cholangiographic and/or pancreatographic, or ultrasonic pictures were considered typical of what proved to be the correct final diagnosis. It was considered misleading when the cholangiographic or the ultrasonic pictures had misled the radiologist and the surgeon regarding the actual diagnosis before surgery or the performance of other investigations. The investigation was considered inconclusive when it was not diagnostic but at same time it was not misleading.

3- The usefulness of the procedure in determining the management of the patient.

The procedure was considered essential when no other relevant investigations had achieved the correct diagnosis preoperatively particularly if one or more of the performed investigations had been misleading. It was also considered essential when the investigation was the only diagnostic tool available for use in that specific condition such as assessment of biliary patency by PTC after hepaticojejunostomy or gastric surgery, use of ERCP in the diagnosis and management of frail patients with choledocholithiasis, and use of US in patient too ill to undergo any other form of investigations. lt was considered <u>useful</u> when it was helpful in the management of the patient whether diagnostic or not. The investigation was considered <u>useless</u> ; (i) when the procedure was misleading, (ii) when the procedure was inconclusive and no extra information was obtained which was of help in the management of patient, and (iii) when the procedure was diagnostic in the case of ERCP and PTC but the diagnosis had already made by US and the procedure did not provide additional information helpful in the management of the patient. It was considered <u>therapeutic</u> when the investigation was used in treatment as in preoperative biliary drainage after PTC, papillotomy and stone extraction during ERCP, and ultrasonically guided drainage of pseudocysts of the pancreas.

Re-evaluation of PTC

A consultant radiologist experienced in the performance and interpretation of PTC and a consultant surgeon with an interest in pancreato-biliary surgery were then asked to report on the cholangiographic films of the first 87 patients in this study all of whom had undergone PTC. The assessers were not given access to clinical data, results of other investigations or the final diagnosis. Their findings were noted on the form shown in Appendix 1. Of the 87 patients, 11 were excluded from further consideration because the final diagnosis had been based only on clinical findings. The results obtained from re-evaluation of the cholangiograms by the surgeon and the radiologist of the remaining 76 patients, who had had final diagnosis proved by pathology, and/or surgical or endoscopic (in the cases with common bile duct stones) findings, were then compared with the data obtained from case notes and the original X-ray reports of the cholangiograms. Note was taken of the following points; (i) the suitability of the cholangiograms for reporting (determined technically satisfactory or not), (ii) the accuracy of assessors opinions regarding the presence or absence of obstruction, the level of the obstruction, and the nature of the obstruction in the biliary system, (iii) the measurements of the maximum diameters of the common hepatic duct and common bile duct when given, (iv) the statements regarding the size of the gall-bladder and presence or absence of gall-bladder stones, and (v) the next step suggested in the management of the patient after re-evaluation of the cholangiogram.

Prospective part of study I

All patients admitted to the University Department of Surgery GRI with obstructive jaundice of obscure aetiology diagnosed on the basis of clinical and labarotory data, between 1st January 1986 and 31st December 1987, were identified by daily visit to the wards belonging to the above department. Then a monthly check of the unit´s discharge summary cards was carried out personally to identify any cases of obstructive jaundice who had escaped detection by the first method.

Investigations

During the two-year period any patient who fulfilled the criteria for this part of the study was followed until he or she was discharged from hospital, and note was made of any subsequent admissions. The findings and the diagnostic value and usefulness of PTC, ERCP, and US reports (which were evaluated and classified in the same way as in the retrospective part of this study) were noted on the form in Appendix 2.

Comparison

The final diagnosis was considered proved when it was based on biopsy report, laparotomy findings, autopsy, or the endoscopic observation of the passage of stone for the diagnosis of choledocholithiasis. From the total of 83 patients with obstructive jaundice included in this part of the study, 11 patients were excluded because their diagnosis was made on a clinical basis only. The diagnostic values and the usefulness of PTC, ERCP, and US of the remaining 72 patients with proven diagnosis were then compared.

The ability of the original radiological reports of PTC, ERCP and US to define the presence or absence of biliary obstruction and its level level, and their ability to define the cause of obstruction were obtained and compared. The investigations were also compared in terms of their complication rate and therapeutic value.

Statistics

In both parts of the study an "Apple lle" personal computer was used to create a personal filing system and to perform all statistical analysis. Chi-square test, Fisher's exact probability test, and paired and unpaired Student's T-tests were used to define the differences between groups as appropriate. The differences between groups were considered statistically significant when the possibility of their arising by random sampling error was less than 1 in 20 ($P<0.05$). The definitions of the statistical terms used in the chapter are listed in Appendix 3.

RESULTS

<u>Retrospective part of study I</u>

Of the 112 patients included in the study, 62 were men and 50 were woman; their mean age was 66 years (range: 30-86). The final diagnoses of these patients are shown in Table 5.

Ultrasound

Ultrasound was considered unsatisfactory by the radiologist undertaking the procedure in 14 cases. Excessive bowel gas was the cause of unsatisfactory scanning in 13 cases and a previous right hepatectomy in one case. Therefore, satisfactory scans were obtained in 83 of 97 cases (86%) in whom US was attempted. The procedure was combined with fine-needle biopsy of a pancreatic mass in two cases without complications.

ERCP

ERCP was successful in cannulation of the papilla of Vater in 26 of the 32 cases (81%) in whom ERCP was attempted, but cholangiograms were obtained in only 23 cases (72%). The procedure was combined with papillotomy in 7 cases, papillotomy and stone

Table 5 The final diagnosis in 112 patients in the retrospective part and in 83 patients in the prospective part of study I.

Diagnosis	no. patients	Diagnosis based on biopsy	lap.	autopsy	end.	clin.
<u>Retrospective study</u>						
Pancreatic cancer	42	33	6	0	0	3
Cholangiocarcinoma	14	6	4	2	0	2
Metastatic lesions	5	5	0	0	0	0
Ampullary cancer	4	3	0	1	0	0
Choledocholithiasis	22	0	13	0	9	0
Chronic pancreatitis	5	1	4	0	0	0
Benign stricture	7	6	7	0	0	0
Cholestatic jaundice	5	0	0	0	0	5
Sclerosing cholangitis	3	2	3	1	0	0
Duodenal diverticulae	2	2	2	0	0	0
Acute cholecystitis	1	0	1	0	0	0
Cholangitis	1	0	0	0	0	0
Passed stone	1	0	0	0	0	1
Subtotal	112	58	37	4	9	12
<u>Prospective study</u>						
Pancreatic carcinoma	20	14	3	1	--	2 ERCP
Cholangiocarcinoma	15	5	1	2	--	7 ERCP
Metastatic lesions	3	2				1 Clin
Ampullary carcinoma	4	4				
Gall-bladder cancer	1			1		
Choledocholithiasis	32		10		22	
Chronic pancreatitis	5	3	2			
Benign strictures	1		1			
Cholestatic jaundice	2	1				1 Clin
Subtotal	83	29	17	4	22	11
Total	195	87	54	8	31	23

Lap, laparotomy; End, endoscopy; Clin, clinical findings.

extraction in one case, and biopsy of the papilla in 2 cases. In a total of 32 attempted ERCPs, there were no immediate or late complications attributed to the procedure.

PTC

Percutaneous transhepatic cholangiography was successful in outlining the biliary system in 100 of the 103 cases (97%) in whom it was attempted. In three cases (two of whom had cholangiocarcinoma while one had chronic pancreatitis) who had dilated intrahepatic ducts demonstrated by ultrasound, the biliary tree could not be opacified. All patients undergoing PTC had dilated intrahepatic ducts (maximum diameter >4mm) except for 6 patients. Of these 6 patients with non dilated ducts, 3 had drug-induced cholestasis, one had cholangiocarcinoma, one had acute cholecystitis, and in one case the ultrasonic diagnosis of choledocholithiasis was not confirmed. Percutaneous transhepatic biliary drainage (PTD) was combined with PTC in 14 cases treated early in the series and in whom the general condition of the patient did not allow early surgery, and was instituted as palliative treatment of malignancy in three patients.

Complications of PTC

In the total of 103 attempts at PTC, 12 patients (11.6%) developed some form of complication (Table 6):

1- Deaths attributable to PTC.

A 77-year old man with jaundice, hypertension, chronic renal failure and chronic obstructive airway disease, developed acute renal failure following the demonstration of cholangiocarcinoma by PTC and died within three days. An 84-year old man with periampullary carcinoma had PTC on 26.01.1984 and cholecystoduodenostomy was undertaken on 31.01. 1984 because of his obstructive jaundice and very poor general condition. He deteriorated and died within 24 hour of operation. Autopsy attributed death to a subdiaphragmatic abscess following PTC and haemorrhage from operation site.

2- Major complications of PTC.

A 71-year old man who had choledocholithiasis, underwent emergency laparotomy on the 4th day after PTC because of abdominal pain. A large amount of bile stained fluid was recovered from the peritoneal cavity and obvious infected subhepatic and subphrenic

Table 6 The major and the minor complications experienced by 103 patients undergoing PTC with and without drainage (PTD) in the retrospective part of study I.

	Biliary obstruction	
	Malignant (n = 63)	Benign (n = 40)
PTC only		
no. patients	49	37
no. complications	6 (12.2%)	4 (10.8%)
	*septicaemia	*septicaemia
	*deaths (2)	*bile leakage
	bile leakage (2)	bile leakage
	ileus	drug reaction
PTC with drainage		
no. patients	14	3
no. complications	1 (7.1%)	1 (33.3%)
	pleural effusion	*septicaemia
Total complication rate	11.1%	12.5%
Major complication rate	4.8%	7.5%

* indicates major complication.

collections were drained. Three men aged 43,71&83 years who had traumatic stricture of the common bile duct, choledocholithiasis and pancreatic carcinoma, respectively, developed fever and positive blood cultures in the 24 hours following PTC. All of them responded to the conservative treatment and recovered so that definitive but non-emergency surgery could be undertaken.

3- Minor complications of PTC.

A 69-year old woman with pancreatic head carcinoma had PTC followed by PTD for 5 days. She developed right sided bile stained pleural effusion diagnosed on chest X-ray and confirmed by pleural aspiration. Although she did not require treatment for this complication; she died within 24 hours of palliative cholecystojejunostomy and gastroentrostomy undertaken 5 days after PTC. The death was not attributed to PTC.

Iodine reaction in a 83-year old woman, in whom jaundice was attributed to liver cirrhosis, was manifested by continous vomiting which led to PTC being abandoned before proper visualization of the biliary system. She responded to medical management.

A 35-year old woman and 77-year old man who had pancreatic carcinoma and a 37-year old man with chronic pancreatitis had more than 2 litres of bile stained fluid found in the peritoneal cavity at subsequent laparotomy; they did not have any symptoms or signs attributed to bile leakage preoperatively.

A 75-year man with pancreatic carcinoma had developed abdominal distention and vomiting following PTC. Plain film of the abdomen showed multiple gas filled loops of intestine with no evidence of a subdiaphragmatic gas shadow. The appearances were attributed to a degree of paralytic ileus after PTC, which responded to conservative management.

All patients who had developed major complications (3 septicaemic shock, 2 deaths and one symptomatic bile leakage) had dilated intrahepatic ducts on PTC. However, there was no significant difference in the mean diameters of intrahepatic ducts, common hepatic duct, common bile duct and the gall-bladder (measured personally to the nearest millimetre) of patients who had complications and those who did not following PTC (Table 7).

Table 7 Comparison of biliary tract diameters in 103 jaundiced patients who had and who did not have complications following PTC with or without drainage (PTD) in the retrospective part of study I.

Maximum diameter mean ± SD (mm)	No complication (no = 91)	Complications (n = 12)	P-value	DF
Intrahepatic ducts	10 ± 4	11 ± 3	>0.1	89
Common hepatic duct	22 ± 9	21 ± 7	>0.8	74
Common bile duct	21 ± 10	26 ± 10	>0.1	69
Gall-bladder	46 ± 16	54 ± 11	>0.15	42

DF, degrees of freedom.

The overall complication rate associated with PTC alone and PTC combined with PTD were 11.6% and 11.8%, respectively, and there were no statistically significant difference between the two groups (Table 6).

Re-evaluation of PTC

In the re-evaluation of the cholangiograms of 76 patients, who had their final diagnosis confirmed by biopsy, autopsy, laparotomy or endoscopic (in the case of choledocholithiasis) findings by the surgeon and the radiologist the following points were observed:-

1- The cholangiograms were considered to be satisfactory technically in 91% (69/76) by the surgeon and in 93% (71/76) by the radiologist.

2- The diagnostic accuracy of the opinion of the surgeon and radiologist regarding the presence or absence of obstruction in the biliary system were 97% (74/76) and 99% (75/76), respectively.

3- The surgeon and the radiologist agreed precisely about the level of obstruction in 79% (60/76) cases. Regarding their statements of upper (porta hepatis and common hepatic duct) or lower (common bile duct and ampullary region) duct obstruction, they agreed in 94%

of the cases (Table 8). In one patient with a final histopathological diagnosis of sclerosing cholangitis, the surgeon stated that there was no obstruction in the biliary system while the radiologist considered that there were multiple obstructions. In one patient with drug-induced jaundice both regarded the examination as unsatisfactory for any comment. In two cases with pancreatic carcinoma and in one case with cholangiocarcinoma, all had complete obstruction of the biliary tract to the flow of the contrast material with non visualization of the gall-bladder; the surgeon stated that the obstruction was in the common hepatic duct (70-90% probability) while the radiologist stated that the obstruction was in the common bile duct (100% probability). In a patient with choledocholithiasis and previous cholecystectomy and choledochoduodenostomy the surgeon and the radiologist considered that the level of the obstruction was at the common hepatic duct (80% probability) and periampullary level (100% probability), respectively.

4- There were no significant differences between the surgeon and the radiologist regarding the accuracy of their statements about the nature of obstruction in the biliary tract, as verified by the final diagnosis (Table 9). The sensitivity of the surgeon's and the

Table 8 Opinions of the surgeon and the radiologist regarding presence or absence of obstruction and its level in the biliary system in re-evaluation of the cholangiograms of 76 patients in the retrospective part of study I.

SURGEON

upper		lower						RADIOLOGIST	
PH	CHD	CBD	PAM	Mult.	Ind.	No.	Total		
4	2						6	PH	Upper
1	7						8	CHD	Upper
	3	37	1				41	CBD	lower
	1	7	8				16	PAM	lower
				1		1	2	Multiple	
					1		1	Ind.	
						2	2	No.	
5	13	44	9	1	1	3	76	Total	

PH, porta hepatis; CHD, common hepatic duct; CBD, common bile duct; PAM, periampullary; Ind, indeterminate; No, no obstruction.

Table 9 Opinions of the surgeon and the radiologist regarding the nature of obstruction in the biliary tract, as based on re-evaluation of the cholangiograms of 76 patients who had a proven diagnosis, in the retrospective part of study I.

1- Neoplastic conditions.

SURGEON

Neop	Stone	Ben.	Ind	Total	RADIOLOGIST
43	2			45	Neoplasm
	2			2	Stone
3				3	Benign non-calculous
	1			1	Indeterminate
46	5	0	0	51	Total

2- Choledocholithiasis.

SURGEON

Neop.	Stone	Ben.	Ind	Total	RADIOLOGIST
1				1	Neoplasm
	10			10	Stone
				0	Benign non-calculous
				0	Indeterminate
1	10	0	0	11	Total

3- Benign non-calculous conditions.

SURGEON

Neop	Stone	Ben.	Ind	Total	RADIOLOGIST
4				4	Neoplasm
				0	Stone
		10		10	Benign non-calculous
				0	Indeterminate
4	0	10	0	14	Total

radiologist´s statements in malignant obstruction were 90% (46/51) and 88% (45/51) respectively, whereas, the specificity of their statements was 80% (20/25). The sensitivity of both the surgeon´s and the radiologist´s statements in cases of choledocholithiasis and benign non-calculous obstruction in the biliary tract were 91% (10/11) and 71% (10/14), respectively. The specificity of the surgeon and the radiologist opinion were 92% (60/65) and 97% (63/65) for detection of common bile duct stones, respectively.

5- The surgeon and the radiologist measured the diameter of the common hepatic duct in 53 cases and the common bile duct in 49 cases. Although, they gave precisely the same figure for the diameter of the common hepatic duct in 6 patients and for the diameter of the common bile duct in 7 patients, the mean of the differences between them in measuring common hepatic duct and common bile duct are 0.2mm and 0.3mm, respectively. The differences in measuring the diameters of the common hepatic duct and common bile duct in each individual cases are shown in Figure 3 and Figure 4, respectively.

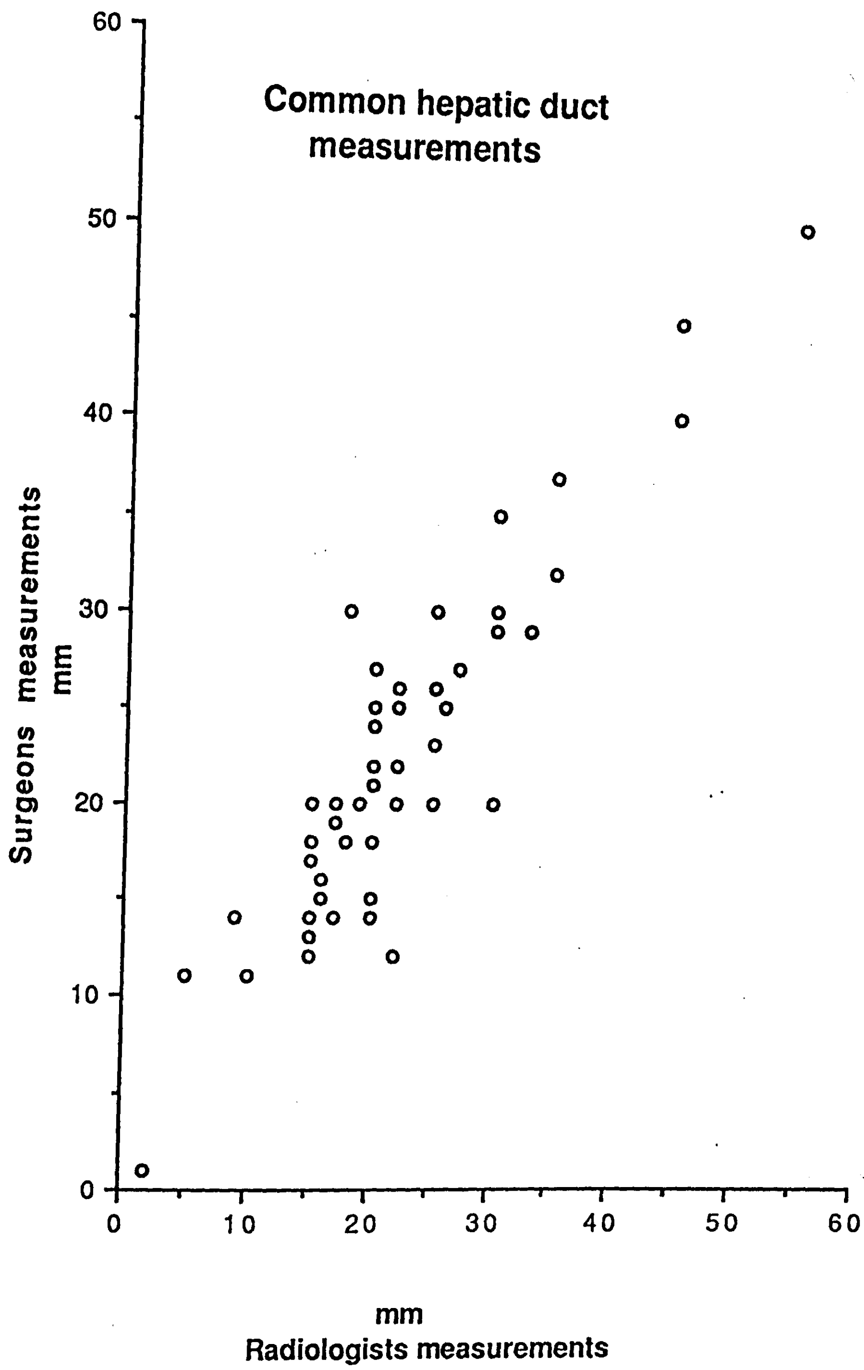

Figure 3 The measurements given by the surgeon and the radiologist for the maximum diameter of the common hepatic duct in 53 patients at re-evaluation of 76 PTC in the retrospective part of study I.

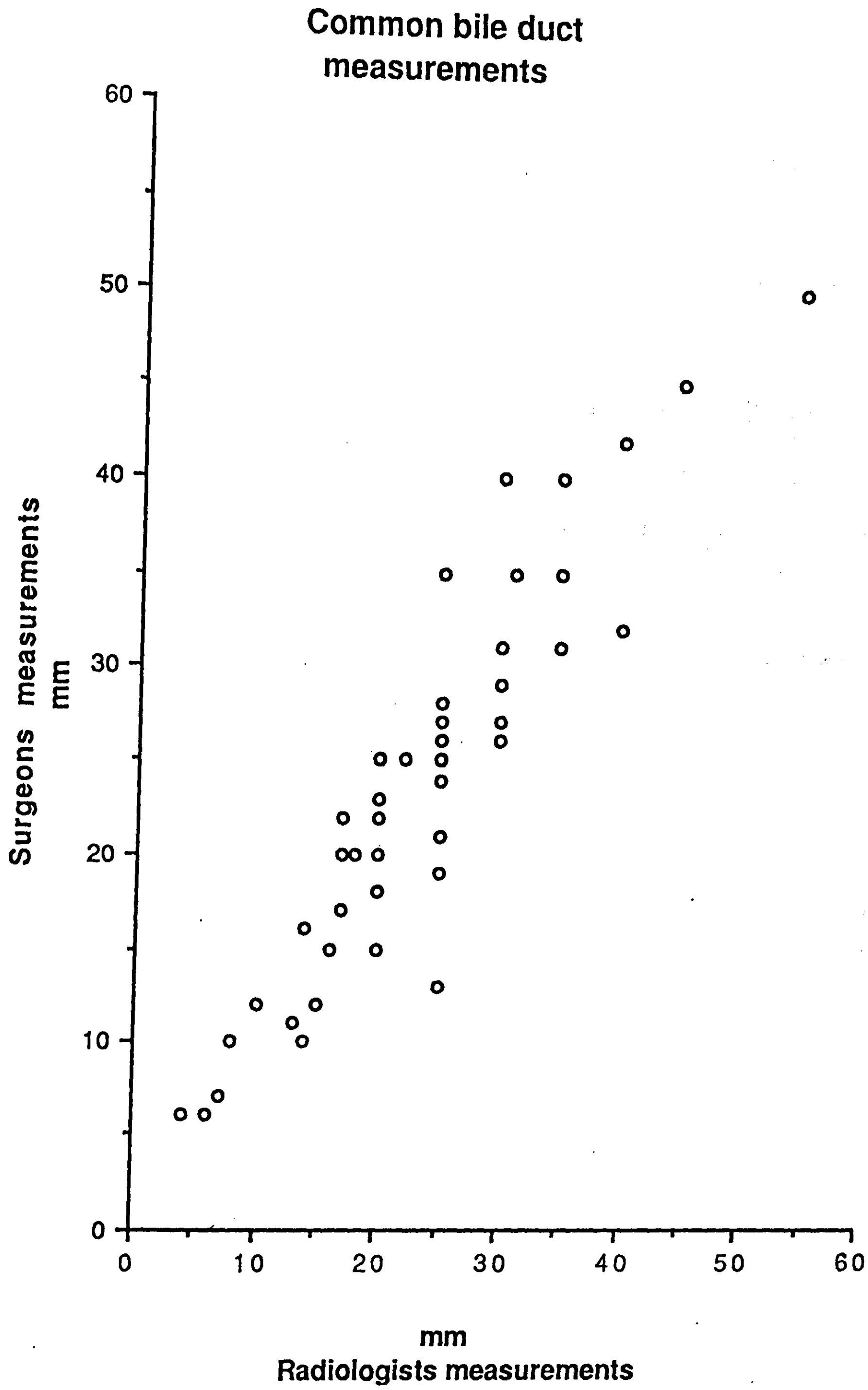

Figure 4 The measurements given by the suegeon and the radiologist for the maximum diameter of the common bile duct in 49 patients at re-evaluation of 76 PTC in the retrospective part of study I.

6- Table 10 shows the maximum transverse and longitudinal diameters of the gall-bladder measured to the nearest millimetre when classified as normal, shrunken or distended. This classification was based upon the assessment given in the original radiological reports of the cholangiograms of 44 patients who had their gall-bladder opacified. The surgeon and the radiologist were agreed in their assessments of the gall-bladder size only in 27 (61%) out of these 44 cases at re-evaluation of their cholangiograms (Table 11).

7- In 21 patients (who had a proven diagnosis of cholelithiasis at surgery) the diagnostic sensitivity of the radiologist´s opinion regarding the presence of gall-bladder stones was 76%, and that of the surgeon was 24% (Table 12).

8- Table 13 shows that there was no differences between the surgeon and the radiologist in suggesting a proper treatment (48 vs 50) or suggesting the need for further investigations (28 vs 26) in 76 jaundiced patients based upon re-evaluation of their cholangiograms. However, when the treatment option was suggested, the radiologist was more in favour of the surgical

Table 10 The maximum diameters of the gall-bladder measured to the nearest millimetre when classified as normal, shrunken or distended in the retrospective part of study I.

Classification	Transverse diameter mean $\pm$ SD (mm)	Longitudinal diameter mean $\pm$ SD (mm)
Distended (no = 35)	53 $\pm$ 9	127 $\pm$ 23
Shrunken (no = 7)	16 $\pm$ 6	27 $\pm$ 12
Normal (no = 2)	32 $\pm$ 8	78 $\pm$ 19

Table 11 Opinions of the surgeon and the radiologist regarding the size of the gall-bladder during the re-evaluation of the cholangiograms of 76 patients with obstructive jaundice in the retrospective part of study I.

1- Distended gall-bladder (> 40mm in transverse diameter).

SURGEON Dist.	Nor.	Shr.	Ind.	Total	RADIOLOGIST
21	4	1	2	28	Distended
	1		2	3	Normal
1				1	Shrunken
			3	3	Indeterminate
22	5	1	7	35	Total

2- Normal size gall-bladder (25-40mm in transverse diameter).

SURGEON Dist.	Nor.	Shr.	Ind.	Total	RADIOLOGIST
1				1	Distended
			1	1	Normal
				0	Shrunken
				0	Indeterminate
1	0	0	1	2	Total

3- Shrunken gall-bladder (<25mm in transverse diameter).

SURGEON Dist.	Nor.	Shr.	Ind.	Total	RADIOLOGIST
		1		1	Distended
	1			1	Normal
			4	4	Shrunken
			1	1	Indeterminate
0	1	1	5	7	Total

Table 12 The ability of the surgeon and the radiologist to detect gall-bladder stones during re-evaluation of the cholangiograms of 21 patients who had a proven cholelithiasis at surgery in the retrospective part of study I.

SURGEON

No stone	Stone seen	Not seen	Total	RADIOLOGIST
1			1	No stone
7	4	5	16	Stone seen
	1	3	4	Gall-bladder not seen
8	5	8	21	Total

Table 13 The next step suggested by the surgeon and the radiologist in the management of 76 patients after re-evaluation of their cholangiograms in the retrospective part of study I.

SURGEON: Treatment				or Investigation				RADIOLOGIST
Lap.	Pap.	St.	PTD	ERCP ±	US ±	L-Bx	Total	
22	8	3		9	5		47	Laparotomy
								Papillotomy
1							1	Stent
				1	1		2	PTD
5	5	4		7	1	2	24	ERCP ± biopsy
				1			1	US ± biopsy
						1	1	Liver biopsy
28	13	7		18	7	3	76	Total

Lap, laparotomy; Pap, endoscopic papilotomy; St. endoscopic stenting; PTD, percutaneous transhepatic drainage; ERCP ± , endoscopic retrograde cholangiopancreatography with or without biopsy; US ± , ultrasound with or without fine needle aspiration biopsy; L-Bx, liver biopsy.

treatment (47/50), while the surgeon was more in favour of non-surgical management of the patient such as endoscopic papillotomy (20/48), and there was a significant statistical differences between them in this aspect ($P<0.001$).

Comparison of investigations

Comparison of percutaneous transhepatic cholangiography, endoscopic retrograde cholangio-pancreatography and ultrasonography of the upper abdomen in their diagnostic values and usefulness in determining the management of 100 patients, who had their final diagnosis based on biopsy, laparotomy, autopsy or endoscopy (in the case of choledocholithiasis), are shown in Table 14. In these 100 patient, PTC opacified the biliary system in 88 of the 91 patients and ERCP in 20 of the 30 patients, whereas, ultrasound was considered as satisfactory in 75 of the 88 patient having examination attempted. Both PTC and ERCP were diagnostic in 80% of the successful procedures, while US was diagnostic in only 45% of the satisfactory scans. The diagnostic sensitivity of the satisfactory ultrasound scans was 29% (6/21) in calculous obstruction, 50% (24/48) in malignant and 67% (4/6) in benign non-calculous

Table 14 The diagnostic value and usefulness of successful PTC and ERCP procedures, and satisfactory US scans in 172 jaundiced patients who had a proven final diagnosis in the retrospective and prospective parts of study I.

	Diagnostic value				Usefulness			
	Diag.	Mis.	Inc.	TS	Ess.	Uf.	Ul.	Th.
Retrospective								
PTC								
Benign conditions	21	7	5	33	3	14	16	3
Malignant conditions	49	0	6	55	3	29	23	9
Total	70	7	11	88	6	43	39	12
ERCP								
Benign conditions	14	2	0	16	4	6	6	8
Malignant conditions	2	0	2	4	0	3	1	0
Total	16	2	2	20	4	9	7	8
US								
Benign conditions	10	5	12	27	1	11	15	0
Malignant conditions	24	5	19	48	1	32	15	0
Total	34	10	31	75	2	43	30	0
Prospective								
PTC								
Benign conditions	4	3	0	7	1	3	3	0
Malignant conditions	17	0	4	21	1	12	8	2
Total	21	3	4	28	2	15	11	2
ERCP								
Benign conditions	25	1	3	29	4	18	7	22
Malignant conditions	10	0	2	12	1	10	1	7
Total	35	1	5	41	5	28	8	29
US								
Benign conditions	15	1	8	24	1	21	2	0
Malignant conditions	13	2	10	25	2	20	3	0
Total	28	3	18	49	3	41	5	0
Retrospective and prospective								
PTC								
Benign conditions	25	10	5	40	4	17	19	3
Malignant conditions	66	0	10	76	4	41	31	11
Total	91	10	15	116	8	58	50	14
ERCP								
Benign conditions	39	3	3	45	8	24	13	30
Malignant conditions	12	0	4	16	1	13	2	7
Total	51	3	7	61	9	37	15	37
US								
Benign conditions	25	6	20	51	2	32	17	0
Malignant conditions	37	7	29	73	3	52	18	0
Total	62	13	49	124	5	84	35	0

Ess, essential; Diag, diagnostic; Mis, misleading; Inc, inconclusive; Th, therapeutic; Uf, useful; Ul, useless; TS, total number of successful procedures.

conditions, whereas, the specificity was 37% (10/27) in determining the presence or absence of malignant obstruction and 56% (30/54) in detecting common bile duct stones (Table 15A). The diagnostic sensitivity of successful ERCPs was 100% (10/10) in calculous obstruction, 50% (2/4) in malignant and 67% (4/6) in benign non-calculous conditions, whereas, the specificity was 88% (14/16) in determining the presence or absence of malignant obstruction and 80% (8/10) in detecting common bile duct stones.

Finally, the diagnostic sensitivity of successful PTCs was 87% (13/15) in calculous obstruction, 89% (49/55) in malignant and 44% (8/18) in benign non-calculous conditions, whereas, the specificity was 64% (21/33) in determining the presence or absence of malignant obstruction and 86% (63/73) in detecting common bile duct stones.

Ultrasound was considered essential in two cases. In the first case, a male patient of 72 years of age had cholangiocarcinoma proved by percutaneous ultrasonic guided needle biopsy. ERCP was not attempted and PTC was considered useless, because it was inconclusive and the quality of the films were

Table 15A Diagnostic value of the original reports of successful PTC and ERCP procedures, and satisfactory US scans in 100 jaundiced patients (who had a proven final diagnosis) in different surgical conditions in the retrospective part of study I.

	PTC reports M	B	C	In.	Total
Malignant	49	-	-	6	55
Benign non-calculous	5	8	-	5	18
Calculous	2	-	13	-	15
Total	56	8	13	11	88

	ERCP reports M	B	C	In.	Total
Malignant	2	-	-	2	4
Benign non-calculous	2	4	-	-	6
Calculous	-	-	10	-	10
Total	4	4	10	2	20

	US reports M	B	C	In.	Total
Malignant	24	-	5	19	48
Benign non-calculous	2	4	-	19	6
Calculous	3	-	6	12	21
Total	29	4	11	31	75

M, malignant conditions; B, benign non-calculous conditions; C, calculous obstruction; In, inconclusive.

Table 15B Diagnostic value of the original reports of successful PTC and ERCP procedures, and satisfactory US scans in 72 jaundiced patients (who had a proven final diagnosis) in different surgical conditions in the prospective part of study I.

	PTC reports M	B	C	In.	Total
Malignant	17	-	-	4	21
Benign non-calculous	1	1	-	-	2
Calculous	2	-	3	-	5
Total	20	1	3	4	28

	ERCP reports M	B	C	In.	Total
Malignant	10	-	-	2	12
Benign non-calculous	1	1	-	3	5
Calculous	-	-	24	-	24
Total	11	1	24	5	41

	US reports M	B	C	In.	Total
Malignant	13	1	1	10	25
Benign non-calculous	-	3	-	1	4
Calculous	-	1	12	7	20
Total	13	5	13	18	49

M, malignant conditions; B, benign non-calculous conditions; C, calculous obstruction; In, inconclusive.

Table 15C Diagnostic value of the original reports of successful PTC and ERCP procedures, and satisfactory US scans in 172 jaundiced patients (who had a proven final diagnosis) in different surgical conditions in the retrospective and prospective parts of study I.

	PTC reports M	B	C	In.	Total
Malignant	66	-	-	10	76
Benign non-calculous	6	9	-	5	20
Calculous	4	-	16	-	20
Total	76	9	16	15	116

	ERCP reports M	B	C	In.	Total
Malignant	12	-	-	4	16
Benign non-calculous	3	5	-	3	11
Calculous	-	-	34	-	34
Total	15	5	34	7	61

	US reports M	B	C	In.	Total
Malignant	37	1	6	29	73
Benign non-calculous	2	7	-	1	10
Calculous	3	1	18	19	41
Total	42	9	24	49	124

M, malignant conditions; B, benign non-calculous conditions; C, calculous obstruction; In, inconclusive.

poor. Since the lesion was thought to be inoperable on the basis of US and CT scan, the patient was discharged home for terminal care. In this case US had saved the patient from unnecessary operation. The second case was a 60 year old female with choledocholithiasis proved later at laparotomy and biopsy. PTC in this case was misleading in that it suggested pancreatic tumour (Figure 5) and ERCP had not attempted. In this case US avoided the patient undergoing palliative stenting in the mistaken belief that biliary obstruction was due to pancreatic cancer.

ERCP was considered essential in 4 cases. Two patients aged 75 & 84 years with choledocholithiasis were considered too ill to undergo any form of therapy apart from endoscopic papillotomy. Two patients had obstructive jaundice due to duodenal diverticula and in both PTC was misleading (lesions diagnosed as periampullary tumour) and US was considered useless in that it was inconclusive. These two cases with diverticula have been reported in detail elsewhere (Hasan et al. 1988).

In 6 patients, all of them had a proven final diagnosis at laparotomy and biopsy, PTC was considered essential. In two patients with choledocholithiasis

Figure 5 Choledocholithiasis confirmed at laparotomy and biopsy. PTC shows a long stricture at the lower part of the common bile duct with moderate dilatation of the proximal ducts. No radiological evidence of choledocholithiasis can be seen, while ultrasound scan of this patient was diagnostic for calculous obstruction.

aged 60 and 69 years and one patient with cholangiocarcinoma aged 73-year, ERCP failed to cannulate the ampulla, whereas ultrasound was useless in that it was inconclusive. Two patients with pancreatic carcinoma aged 62 and 69 years and a patient with choledocholithiasis aged 71-year, ultrasound examinations were misleading in that it suggested stone obstruction in the two cancer patients and pancreatic mass in the patient with choledocholithiasis. ERCP was attempted but failed to cannulate the ampulla in one patient with pancreatic carcinoma and it was not attempted in the other two patients.

Prospective part of study I

A total of 83 jaundiced patients entered the study, 38 were men and 45 were women. The age of the patients ranged from 32 to 92 years and their mean age was 69 years. Table 5 shows that seventy-two patients had a proven diagnosis. All patients in this part of the study had dilated intrahepatic ducts on ultrasonography and/or direct cholangiography, and they had a mean serum bilirubin level of 238 $\pm$ 32(SE) μmol/l and mean serum alkaline phosphatase concentration of 1397 $\pm$ 173(SE) IU/l on addmision. Normal values for total serum bilirubin and serum alkaline phosphatase concentration in our laborotory are 3-22 μmol/l and

80-280 IU/l, respectively.

Ultrasound

Ultrasonography of the upper abdomen was attempted in 75 patients. It was considered unsatisfactory in 17 cases (22%). The main causes for unsatisfactory scans, as stated by the radiologist undertaking the procedure were excessive bowel gas in 14 patients, ascites in one patient, and previous biliary-enteric anastamosis and presence of gas in the biliary system in 2 patients.

PTC

Percutaneous transhepatic cholangiography was attempted on 34 patients. It was successful in outlining the biliary system in 31 (91%) cases; all had dilated intrahepatic ducts demonstrated by US. In one patient with cholangiocarcinoma, PTC was combined with PTD for 11 days after an attempt at percutaneous stenting of the biliary system failed. In another patient who had pancreatic carcinoma, percutaneous stenting was successful as a palliative treatment without any complication. In a female of 88 years with cholangiocarcinoma, endoscopic and percutaneous routes were combined to stent the biliary system when endoscopic stenting alone had failed. She developed repeated attacks of cholangitis and septicaemia and died within 6 weeks. At autopsy multiple intraperitoneal abscess were discovered. The last two patients who had successful stenting procedures were excluded from further statistical analysis with regard to the complications associated with PTC.

In total of 31 attempts of PTC without biliary drainage or stenting, 4(13%) patients developed some form of complication following the procedure. Two patients with pancreatic carcinoma aged 53 & 62 years developed two episodes of cholangitis which were treated successfully by antibiotics. A male patient aged 87-year who also had pancreatic carcinoma developed bilateral pleural effusion and a small right pneumothorax following PTC, the condition responded successfully to conservative management. Finally, a 90-year old woman who had carcinoma of the gall-bladder and cholelithiasis, developed severe attack of cholangitis and Gram-negative septicaemia and died on the 5th day following PTC. Autopsy attributed the cause of death to septicaemia and hepato-renal failure (she had had normal blood urea and creatinine on addmision and no history of renal problems).

ERCP

Endoscopic retograde cholangiopancreatography was successful in obtaining cholangiography in 49 of the 58 cases in whom ERCP was attempted (85%). It failed in 9 cases, in 4 due to duodenal distortion or obstruction by the tumour, in two patients only the pancreatic duct was cannulated, in one case the contrast refluxed when injected into the biliary ducts and in two cases the ampulla could not be cannulated without obvious cause.

ERCP was combined with a diagnostic or a therapeutic procedure in 42 patients (72%). It was successfully combined with sphincterotomy (with or without biopsy) in 15 cases, sphincterotomy with Dormia basket stone extraction in 12 cases, and sphincterotomy with biliary stenting in 15 cases. Sphincterotomy failled in further three patients.

ERCP was not associated with any complication in 16 patients in whom the procedure was not combined with papillotomy. In the remaining 42 patients who had ERCP and papillotomy, complications developed in 17 cases (40%; Table 16). Major complications which required active treatment developed in 10 cases (24%), five of whom died as a result. Hyperamylasaemia (mean

Table 16 Details of the 17 patients who developed complications following ERCP combined with endoscopic papillotomy in the prospective part of study I.

Name	Age	Sex	Diagnosis	Other procedures	Complications and notes
VR**	74	F	Cholang.	stent	*Cholangitis
JM	85	F	Cholang.	stent	Hyperamylasaemia
MM	92	F	Pancreatic cancer	stent	Hyperamylasaemia
EB	68	M	Cholang.	stent	Hyperamylasaemia
EB	78	F	Cholang.	stent	Duodenal perforation
FM	76	F	Cholang.	stent	*Oesophageal bleeding
MY**	88	F	Cholang.	stent	Hyperamylasaemia
					*Cholangitis
					*Septicaemia
					*Abdominal abscess
MO	85	M	Ampullary cancer	stent	Hyperamylasaemia
IM	85	F	Choled.	stone extraction	Hyperamylasaemia
AS	87	M	Choled.	stone extraction	*Respiratory arrest
CC**	72	F	Choled.	stone extraction	*Acute pancreatitis
CK	66	M	Choled.	no	*Rectal bleeding
DF**	67	M	Choled.	no	*Cholangitis
					*Bleeding
RD	76	F	Choled.	no	*Septicaemia
MM**	78	F	Choled.	no	Hyperamylasaemia
					*Perforation
					*Septicaemia
JT	64	M	Choled.	no	Hyperamylasaemia
IP	46	F	Benign stricture	no	Hyperamylasaemia
					*Cholangitis

Cholang, cholangiocarcinoma; Choled, choledocholithiasis.
* Indicates a major complications.
** Indicates patients who died as a result of complications.

serum amylase of 2346 IU/l on the first few days after the procedure) developed in 9 of the cases (21%), but none of them required treatment for this complication which was regarded as "biochemical" rather than "clinical" acute pancreatitis.

Comparison of investigations

In the 72 patients, who had a proven final diagnosis, the satisfactory US scans were obtained in 49 of the 64 patients having the examination, and the biliary system is successfully opacified in 28 of the 31 patients by PTC and in 41 of the 50 patients by ERCP. The comparison of successful PTC, ERCP and US in terms of their diagnostic values and usefulness in the management of these 72 patients are shown in Table 14.

The ability of US in defining the presence or absence of biliary tract obstruction in satisfactory scans was 88% (43/49), and its diagnostic accuracy in determining the nature of obstruction in the biliary system was 57% (28/49). The sensitivity of satisfactory ultrasound scans was 60% (12/20) in choledocholithiasis, 75% (3/4) in benign non-calculous and 52% (13/25) in malignant conditions, whereas, the specifity was 67% (16/24) in determining the presence or absence of malignant obstruction and 59% (17/29) in detecting common bile duct stones (Table 15B). In the case of unsatisfactory scans, the diagnostic accuracy of US in determining the presence or absence of the biliary tract obstruction was 67% (10/15), and for determining the nature of the obstruction was zero.

PTC was successful in determining the presence or absence of obstruction in the biliary system in 27 out of 28 successful procedures (96%), and its diagnostic accuracy in determining the cause of obstruction was 75% (21/28). The diagnostic sensitivity of successful PTC procedures was 60% (3/5) in calculous obstruction, 81% (17/21) in malignant and 50% (1/2) in benign non-calculous conditions, whereas, the specificity was 57% (4/7) in determining the presence or absence of malignant obstruction and 83% (19/23) in detecting common bile duct stones.

The ability of ERCP to determine the presence or absence of obstruction in the biliary system was 100%, and its diagnostic accuracy in determining the cause of obstruction was 85% (35/41). The diagnostic sensitivity of successful ERCPs was 100% (24/24) in calculous obstruction, 83% (10/12) in malignant and 20% (1/5) in benign non-calculous conditions, whereas, the specificity was 86% (25/29) in determining the presence or absence of malignant obstruction and 71% (12/17) in detecting common bile duct stones.

Ultrasound was considered essential in three patients. In one patient with choledocholithiasis and another with pancreatic carcinoma (proven later at laparotomy and biopsy), both PTC and ERCP failed to visualize the biliary system and US was the only diagnostic investigation. The third case was a 65-year old woman with pancreatic carcinoma in whom ERCP failed to cannulate the papilla and PTC was regarded diagnostically useless in that it was inconclusive.

In two cases, a 67-year man with choledocholithiasis and a 70-year woman with pancreatic carcinoma proven later at laparotomy and biopsy, PTC was regarded as an essential investigation in determining management. In both cases, US was a useless investigation in that it was inconclusive and ERCP failed to cannulate the biliary system.

ERCP was considered essential in five cases. In four patients (aged 72,77,82 and 88 years) with choledocholithiasis, ERCP proved to be both a diagnostic and therapeutic procedure. These patients were considered too ill to undergo any form of therapy apart from endoscopic papillotomy. The fifth case was an 85-year old lady with pancreatic carcinoma proven later at laparotomy and biopsy; US in this case was misleading in that it suggested choledocholithiasis and PTC was not attempted.

DISCUSSION

In the present study, PTC more consistently produced successful cholangiograms (96%; 131/137) compared with ERCP (80%; 72/90), and satisfactory ultrasound scans produced in 82% (141/172) of the attempted cases. These figures are comparable to those reported previously (Eyre-Brook et al. 1983; Matzen et al. 1982; Mueller et al. 1981).

Ultrasound

Ultrasound did not have any complication even in two cases who had fine-needle biopsy in the present study. The main cause of unsatisfactory scans in this study was the presence of excessive bowel gas as reported previously (Eyre-Brook et al. 1983). This rendered the scan unsatisfactory in no less than 27 of the 31 unsatisfactory procedures. Ascities, previous right hepatectomy and presence of gas in the biliary system due to previous entero-biliary anastomosis were the causes of the unsatisfactory US scanning in the remaining 4 cases.

Percutaneous transhepatic cholangiography

Although PTC has become a relatively less common procedure in our hospital, it is relatively quick, inexpensive, and may be more widely available at smaller institutions where reliable endoscopic capabilities lacking. Unfortunately, it has also a high associated morbidity and mortality in that the overall complication rate of PTC in our study is 12% (16/135) although this is well below the rate of 29% and 32% reported by Baumgartner et al. (1987) and Nilsson et al. (1983), respectively. Although in a large American multicentre survey dealing with 2005 PTC procedures carried out with the Chiba-needle where the overall major complication rate was 3.4% (Harbin et al. 1980), the major complication rate of 6.7% (9/135) in the present series is comparable with the 6.3% rate reported in recent series from single institutions (Table 17).

All patients in the present study had prophylactic antibiotics before PTC, but sepsis was still the most frequent complication 5% (7/135) and resulted in the death of two patients. The overall reported incidence of septicaemia associated with PTC in the literature is about 2-3% (Harbin et al. 1980).

Table 17 Complications associated with fine-needle PTC in the present study in comparison with previous reports.

	no. patients	Complications total	major	minor
Harbin et al. 1980				
Survey report	2005	nc	68 (3.4%)	nc
Previous reports	1591	nc	50 (3.1%)	nc
Total	3596	nc	118 (3.3%)	nc
Recent series				
Kreek & Balint, 1980	322	102	33 (10.2%)	69
Wild et al. 1980	65	6	3 (4.6%)	3
Robert et al. 1980	40	nc	3 (7.5%)	nc
Mueller et al. 1981	450	nc	22 (4.9%)	nc
Gibbons et al. 1983	111	10	5 (4.5%)	5
Nilsson et al. 1983	237	76	15 (6.3%)	61
Juttijudatta et al. 1984	276	nc	17 (6.2%)	nc
Pedersen et al. 1985	114	nc	3 (2.6%)	nc
Baumgartner et al. 1987	58	17	nc	nc
Subtotal	1615*	nc	101 (6.3%)*	nc
Present study	135	16	9 (6.7%)	7

nc, not clearly reported.
* 58 patients in the study by Baumgartner et al. (1987) are excluded from analysis because the number of patients developed major complications is not clear.

Again Baumgartner et al. (1987) found positive septic complications in 9% (5/58) of their patients with one death due to hepatic abscess. The third death in the present study was due to acute renal failure in a frail old patient who had chronic renal failure in addition to obstructive jaundice. Although acute renal failure following PTC has been reported previously in patients with normal renal function (Kone et al. 1986), one can still recommend an alternative investigation in patients with chronic renal failure.

Bile leakage has found in 3% (4/135) patients following PTC in the present study, but only one patient had symptomatic leakage and required an early laparotomy. The introduction of the Chiba-needle technique has reduced the incidence of symptomatic bile leakage following PTC to 1-2% in comparison with 3-4% for the older sheathed-needle technique (Harbin et al. 1980; Kreek & Balint, 1980). However, some workers still report an incidence of bile leakage in their series of up to 40% (Juler et al. 1977).

Baumgartner et al. (1987) and McPherson et al. (1982) found that morbidity and mortality were increased when percutaneous drainage was added to PTC. The present study does not show any differences between patients who had PTC only and those had additional drainage (Table 6) although the number of patients having PTD may be too small to allow firm conclusion in this context.

Endoscopic retrograde cholangiopancreatography

ERCP affords a broader diagnostic approach than PTC or US. In the present study, ERCP was not associated with any complication in 38 patients who had ERCP without papillotomy or other diagnostic or therapeutic procedures. The reported complication rate of diagnostic ERCP in experienced hands is of the order of 2-3%, with a mortality rate of 0.1-0.2% (Bilbao et al. 1976; Cotton, 1977).

A prospective multicentre study reported 80 complications in 721 patients undergoing endoscopic sphincterotomies (11%) with 9 deaths (Frost, 1984). The present study has a 19% (10/52) major complication rate when ERCP was combined with sphincterotomy. This figure should be interpreted with caution. Firstly, in 15 out of 52 patients sphincterotomy was followed by stenting of the biliary system, and the most recent reported complication rate of palliative stenting of the biliary tract is 19% (7/37) (Speer et al. 1987). Secondly, the figure only includes the patients who had jaundice, and it does not include all patients undergoing endoscopic sphincterotomy in this department.

Diagnostic values

The overall diagnostic accuracy of the successful procedures in this study are 78% for PTC, 84% for ERCP, and 50% for the satisfactory US scans (Table 14). The reported accuracy of PTC in determining the precise cause of obstruction in the light of the final diagnosis as verified by biopsy, laparotomy or autopsy, ranges between 87-96% (Gibbons et al. 1983; Juttijudata et al. 1986; Pedersen et al. 1985). In a randomized trail of 52 consecutive patients with clinical obstructive jaundice, the diagnosis was achieved in 91% by ERCP and 69% by PTC (Matzen et al. 1982).

The ability of US to detect the cause of obstruction depends largely upon the experience of the operator, the technique used, the US equipment and the nature of the obstruction in the biliary system. Therefore, the reported diagnostic value of US ranges between 29-88% (Eyre-Brook et al. 1983; Gibbons et al. 1983; Gibson et al. 1986; Gregg & McDonald, 1979). Table 15C shows that the present study has a diagnostic sensitivity of 44% (18/41) for the detection of the common bile duct stones, which is better than the figure of 13-38% reported in most previous studies (Eyre-Brook et al. 1983, Pedersen et al. 1985) and comparable with the figure of 45% (13/29) for the detection of retained stones in post-cholecystectomy patients (O´Connor et al. 1986). Furthermore, the predictive value of ultrasound in the present study was 75% (18/24) for detection of common bile duct stones, and 88% (37/42) for determining the presence or absence of malignant obstruction in the biliary system.

Comparison

All reported studies have compared the diagnostic accuracy (Table 18), complication rate or success rate of PTC, US, and ERCP. None of them have mentioned the usefulness or essential nature of these investigations in determining the management of the patients (Gregg et al. 1979; Matzen et al. 1982; Pederson et al. 1985). The present study shows (Table 14) that in spite of PTC and ERCP being diagnostic in 91 and 51 patients, respectively, the diagnosis had already made by US in 25 and 5 cases, respectively. Furthermore, ERCP and PTC did not provide information which could have been of use in determining

Table 18 Accuracy of ultrasound, PTC and ERCP in determining the correct cause of obstruction in the biliary system in the present study in comparison with the similar studies reported previously.

	US	PTC	ERCP
Gold et al. 1979	7/19 (37%)	19/19 (100%)	---
Gregg & McDonald, 1979	28/56 (50%)	---	50/56 (89%)
Wild et al. 1980	13/46 (28%)	29/46 (63%)	---
Matzen et al. 1982	---	20/29 (69%)	32/35 (91%)
Gibbons et al. 1983	27/93 (29%)	97/111 (87%)	---
Pedersen et al. 1985	74/114 (65%)	106/114 (93%)	---
Subtotal	149/328 (45%)	271/319 (85%)	83/91 (91%)
Present study	62/124 (50%)	91/116 (78%)	51/61 (84%)
Total	211/452 (47%)	362/435 (83%)	134/152 (88%)

the management of the patients when added to that already obtained from US. Therefore, the usefulness of PTC and ERCP in the management of the patients drops to 57% (66/116) and 75% (46/61), respectively. On the contrary, US was useful in 72% (89/124) of cases despite being diagnostic in only 50% (62/124). Although US did not diagnose the cause of obstruction in the biliary tract in 26 out of 89 patients in whom the procedure was considered useful; it was successful in defining the presence or absence of obstruction, and the level of obstruction in some cases. Regarding the essential nature of the investigations in determining the management of the patients, the study shows (Table 14) that ERCP is more frequently essential (15%) than PTC (7%) and US (4%).

<u>Re-evaluation of PTC</u>

The study also concludes that there are no differences between an expierenced surgeon and radiologist in reporting cholangiograms regarding the dignostic value of their reports (Table 9) or in suggesting further investigation (Table 13). Furthermore, the study demonstrates that no improvement can be obtained regarding the diagnostic value of the cholangiographic reports, by introducing a prepared form for reporting the cholangiograms with added probability and desirability percentage statements as seen in Appendix 1. There were no significant differences between the diagnostic value of the original X-ray reports (Table 14&15) and that given by the surgeon and the radiologist in the re-evalution of the 76 cholangiograms in the retrospective part of this study (Table 9).

Chapter 3

EVALUATION OF CHOLANGIOGRAMS IN OBSTRUCTIVE JAUNDICE (STUDY II).

AIM OF THE STUDY

The aims of this study were to describe the specific cholangiographic features of different surgical conditions which cause jaundice and to evalute the diagnostic value of these cholangiograms with particular reference to their ability to differentiate between benign and malignant conditions.

PATIENTS AND METHODS

Cholangiograms

The cholangiograms of all patients with surgical obstructive jaundice in the retrospective and prospective parts of study I (Chapter 2), who had a final diagnosis based on operative findings, biopsy, autopsy or endoscopy (in the case of common bile duct stones) were reviewed, without reference to the final diagnosis, history or information in the original X-ray reports. Data were collected on the form shown in Appendix 4. The cholangiograms were regarded as satisfactory when the common bile duct, the common hepatic duct, both the right and left hepatic ducts, and some of the intrahepatic ducts were opacified or there were clear indications of an obstructive lesion within them. Using a simple plastic ruler graded in millimetres the maximum diameter of the left or right hepatic duct after its first intrahepatic division (first generation of the intrahepatic ducts) was measured to the nearest millimetre (the higher value was taken). The state of the intrahepatic ducts was classified as normal (no dilatation) when the maximum diameter was <5mm (Hamilton et al. 1982), mild or slight dilatation when the maximum diameter was 5-7mm, moderate dilatation when the maximum diameter was 8-12mm, and gross or severe dilatation when the maximum diameter was >12mm. The maximum diameters of the common hepatic duct, common bile duct and the transverse and longitudinal diameters of of the gall-bladder were then measured to the nearest millimetre. 1t was noted whether the gall-bladder was visualized and whether it appeared to be distended, involved by tumour or contain gall stones. The gall-bladder was considered distended when its transverse diameter was more than 40mm. It was considered shrunken when its transverse diameter was less than 25mm. The figures between these two values (25-40mm) were regarded normal. The presence or absence of complete or partial obstruction ot the flow of contrast material into the duodenum was noted as was the level of any obstruction. The most likely cause of obstruction was then classified as malignant, calculous or benign non-calculous obstruction. In case where there was more than one possibility, the cause was recorded as inconclusive.

Biochemistry

The final diagnosis of these patients was then identified from their case-notes and the values of the total serum bilirubin and serum alkaline phosphatase concentration in the same day prior to cholangiography were noted. The normal values for the total serum bilirubin level and serum alkaline phosphatase concentration in our laboratory are 3-22 µmol/l and 80-280 lU/l, respectively.

Comparison

The cholangiograms were then analyzed and compared with regard to the following criteria:-

1- Statistical significance of the degree of dilatation of the intrahepatic ducts, commom hepatic duct, common bile duct and the gall-bladder in different groups separated according to the ultimate diagnosis.

2- Shape of the obstructing lesion when completely outlined.

3- Shape of the lower end of the opaque colomn when obstruction was incomplete.

4- Course of the extrahepatic ducts.

5- Consistency or inconsistency in the calibre of the intrahepatic ducts.

6- The diagnostic value of the cholangiograms and in particular their ability to differentiate between benign and malignant conditions.

7- In each specific surgical condition the cholangiographic features were studied to find the frequency of their occurence and these were compared with the incidence of abnormalities reported in the literature.

8- Unusual cholangiographic features and abnormalities were identified.

Statistics

An "Apple IIe" personal computer was used to create personal filing system and to perform all statistical analysis including Chi-square test, paired and unpaired Student's T-tests, and Fisher's exact probability test as appropriate. The differences between groups were considered statistically significant when the probability of their arising by random sampling error was less than 1 in 20 ($P<0.05$). The definitions of the statistical terms used in the chapter are listed in Appendix 3.

RESULTS

The cholangiograms of 147 patients who had surgical obstructive jaundice, with mean total serum bilirubin level of 220 µmol/l and mean serum alkaline phosphatase concentration of 1259 IU/l, were reviewed. All cholangiograms were suitable for review although in eight patients the cholangiograms were not technically very satisfactory. In three of these eight patients the intrahepatic ducts and in two the extrahepatic ducts were not opacified clearly, in two the quality of available films were poor, and in one extravasation of the contrast media had resulted in blurring of the films. However, all of 147 cholangiograms were still included in the study.

The clinical and biochemical, and radiological findings of these 147 patients are summarised in Table 19 and Table 20, respectively. Patients with benign non-calculous conditions were younger (mean age 54 years) in comparison with patients having choledocholithiasis (mean age 68 years) or malignant obstruction (mean age 73 years; $P<0.001$). There was no statistically significant difference between the three groups regarding the maximum diameters of the

Table 19 Comparison of clinical and biochemical findings of 147 jaundiced patients having benign non-calculous, calculous and malignant obstruction of the biliary system.

	Nature of the obstruction in the biliary system			
	Benign non-calculous	Calculous	Malignant	Total
Age (mean ± SD)	54 ± 15	73 ± 10	68 ± 12	67
Sex (m/f)	12/9	22/21	45/38	79/68
Final diagnosis				
	CP: 11	43	CA-P: 51	
	DD: 2		CH: 18	
	SC: 2		P-AM: 8	
	TS: 6		MET: 5	
			CA-GB: 1	
Diagnosis based on				
biopsy	13	---	61	74
laparotomy	8	20	18	46
autopsy	--	---	4	4
endoscopy	--	23	--	23
Biochemical tests (mean ± SE)				
Alk phos (IU/l)	1141 ± 194	1101 ± 172	1334 ± 92	1259
Bilrubin (μmol/l)	119 ± 33	128 ± 27	273 ± 19	220

CP, chronic pancreatitis; DD, duodenal diverticula; SC, sclerosing cholangitis; TS, traumatic stricture; CA-P, pancreatic carcinoma; CH, cholangiocarcinoma; P-AM, periampullary carcinoma; MET, metastatic lesions; CA-GB, carcinoma of the gall-bladder; Alk phos, serum alkaline phosphatase concentration.

Table 20 Comparison of the radiological findings of benign non-calculous, calculous and malignant conditions of the biliary system in 147 patients with obstructive jaundice.

	Nature of the obstruction			
	Benign non-calculous	Calculous	Malignant	Total
Type of cholangiography				
PTC/ERCP	15/6	19/24	73/10	107/40
Degree of obstruction				
Partial/Complete	15/6	17/26	23/60	55/92
Maximum diameter (mean & SD)				
Intrahepatic ducts (mm)	9 ± 4	9 ± 4	10 ± 3	10
Common hepatic duct (mm)	20 ± 10	21 ± 10	23 ± 8	22
Common bile duct (mm)	20 ± 9	21 ± 10	22 ± 9	21
Gall-bladder (mm)	47 ± 11	34 ± 10	54 ± 14	47
Gall-bladder				
Visualised	8	24	50	82
Not visualized	6	13	30	49
Removed	7	6	3	16
Distended	5	7	39	51
Shrunken	0	9	1	10
Contain stones	2	15	11	28

intrahepatic ducts, common hepatic duct and common bile duct, and the value of serum alkaline phosphatase concentration (unparied T-test).

On the other hand, a significantly higher value of the total serum bilirubin level was recorded in patients with malignant conditions ($P<0.001$), and the maximum transverse diameter (mean & SD) of the gall-bladder was significally larger in malignant obstruction (54 $\pm$ 14mm) than in benign non-calculous and calculous obstruction together (38 $\pm$ 12mm; $P<0.01$). However, there was a considerable overlap between the groups in terms of the maximum diameter of the intrahepatic ducts, common hepatic duct, common bile duct, and the transverse diameter of the gall-bladder in patients with benign non-calculous, calculous and malignant conditions (Figures 6&7).

Choledocholithiasis

The diagnostic sensitivity and specificity of the cholangiograms in detection of stones in the common bile duct without reference to the patient's present or past clinical history, were 86% (37/43) and 88% (92/104), respectively (Table 21).

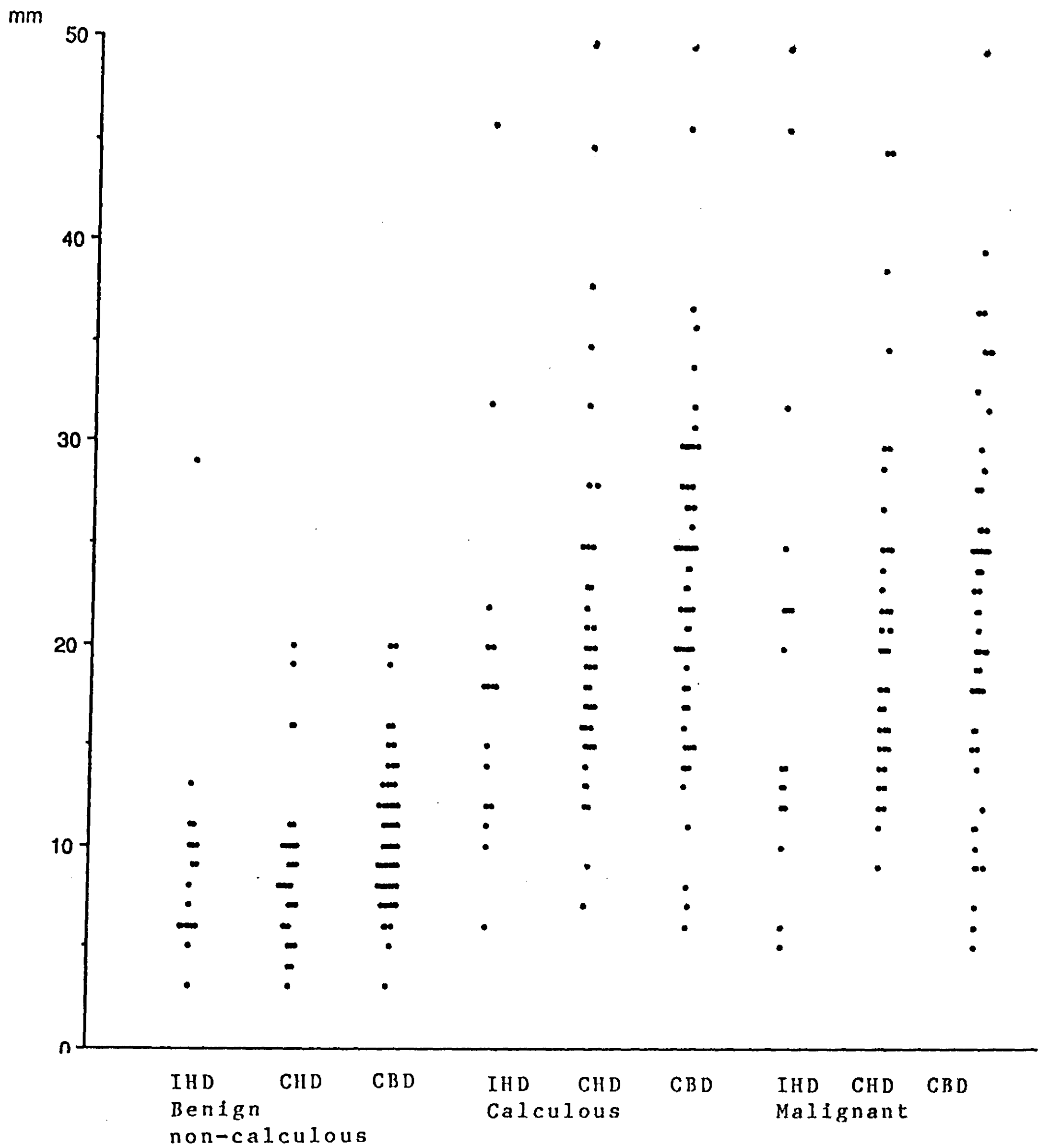

Figure 6 The measurements of the maximum diameter of the intrahepatic ducts (IHD), common hepatic ducts (CHD) and common bile ducts (CBD) in benign non-calculous, calculous and malignant obstructions of the biliary system in 147 patients with obstructive jaundice.

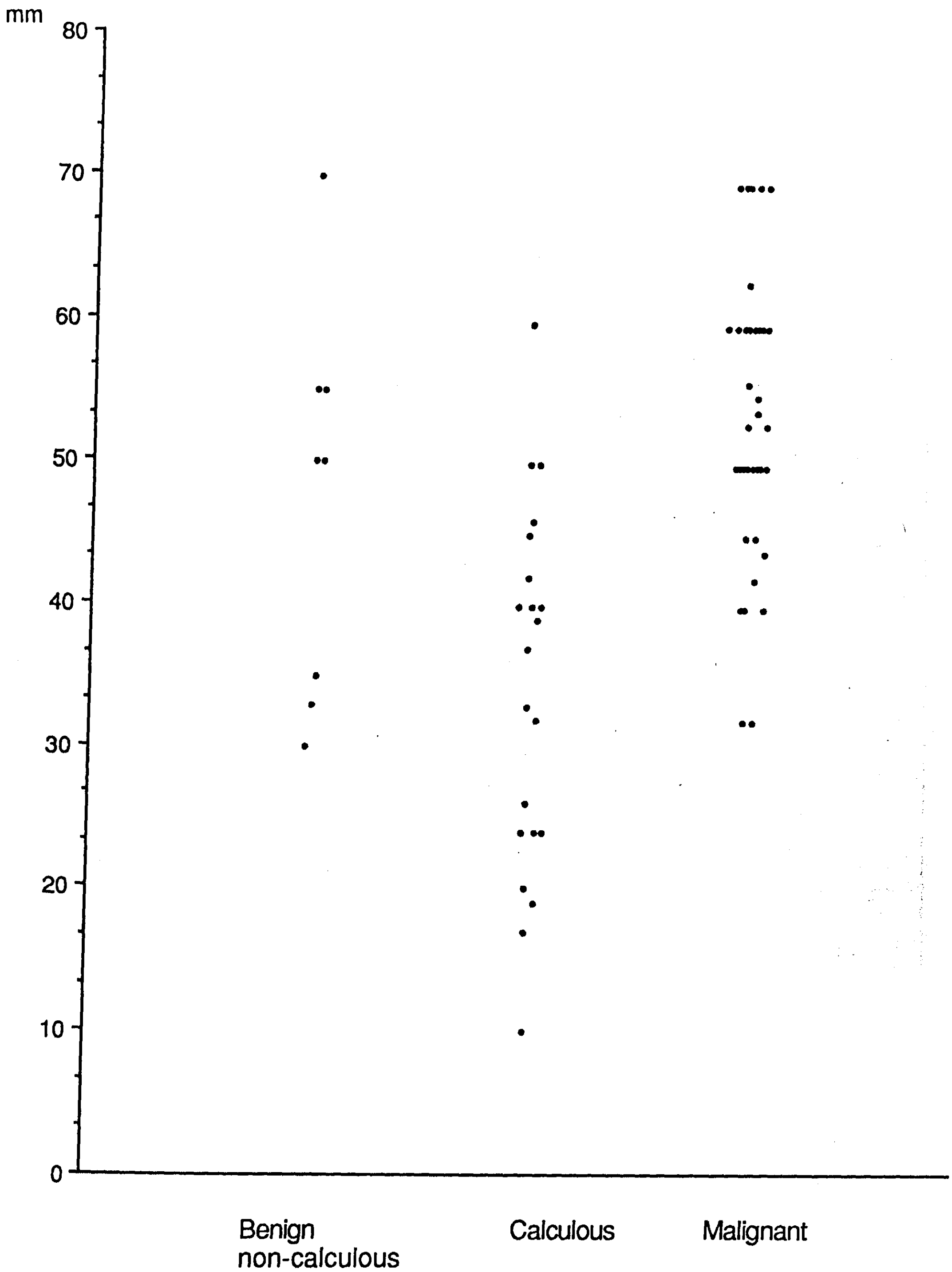

Figure 7 The maximum transverse diameter of the opacified gall-bladders in benign non-calculous, calculous and malignant obstruction of the biliary system in re-evaluation of the cholangiograms of 147 patients with obstructive jaundice.

Table 21 The diagnostic value of the cholangiograms of 147 jaundiced patients with different surgical conditions.

Final diagnosis	no. cases	Nature of obstruction			
		N	C	B	Inc.
Neoplasm	83	70	3	3	7
Calculous	43	2	37	1	3
Benign non-calculous	21	9	0	10	2
Total	147	81	40	14	12

N, neoplasm; C, calculous; B, benign non-calculous; Inc, inconclusive.

The cholangiographic abnormality seen was a constant filling defect in the lower common bile duct in 28 cases (Figure 8). In 6 of these 28 patients the biliary tree was impacted almost completely with stones (Figure 9). In eight cases the cholangiographic abnormality was a downwardly concave meniscus at the lower part of the common bile duct with complete obstruction to the flow of contrast media into the duodenum (Figure 10). In four patient, stones impacted at the lowest part of the common bile duct showing no filling defect or meniscus sign (Figure 11); this and complete obstruction of the biliary system resulted in inability to rule out the possibility of periampullary carcinoma as the cause of obstruction in two cases. However, all of these four cholangiograms had also radiolucent filling defects in the proximal segments of the dilated duct system, and two cholangiograms showed stones in the gall-bladder. In furthure two patients, the cholangiograms showed dilated ducts extending down to the ampulla (Type II stricture of Caroli) with no evidence of filling defects or meniscus (Figure 12). The gall-bladder was full of small gall stones in the first case and it was not opacified in the second. The cholangiographic features of these two patients were more infavour of malignant than calculous obstruction. Finally, the cholangiogram of one patient showed a

Figure 8 Choledocholithiasis. PTC shows a constant filling defect at the lower end of slightly dilated common duct. The gall-bladder is small.

Figure 9 Choledocholithiasis. ERCP shows a dilated biliary tract with multiple filling defects.

Figure 10 Choledocholithiasis. PTC shows a typical downwardly concave menisus at the lower part of common bile duct with slight dilatation of the proximal biliary ducts.

Figure 11 Choledocholithiasis. PTC shows complete obstruction of the common bile duct at its lower part, multiple filling defects in the gall-bladder and dilatation of the proximal biliary ducts.

Figure 12 Choledocholithiasis. PTC shows slightly dilated common bile duct with partial holdup at its lower end. There is a rounded impression in the medial margin of the second part of the duodenum. The gall-bladder is full of stones.

smooth tapering of the common bile duct to a stricture at its lower end with moderate proximal dilatation of the duct system (Type I stricture of Caroli), an appearance which is usually regarded as peculiar to chronic pancreatitis (Figure 5, Chapter 2).

benign non-calculous conditions

The accuracy of the cholangiograms for the diagnosis of the benign non-calculous conditions, without knowledge of the previous clinical history of the patients was 48% (10/21), whereas, the positive and negative predictive values were 71% (10/14) and 93% (112/121) respectively (Table 21).

1- Chronic pancreatitis

In 11 patients who had chronic pancreatitis, the cholangiograms showed appearances consistent with that diagnosis in 10 cases. The cholangiogaphic abnormalities associated with chronic pancreatitis will be discussed in detail in the succeding chapters.

2- Benign strictures

In a 72-year old man who did not have history of any previous biliary surgery, the cholangiographic appearance was very suggestive of a lesion in the pancreatic head (figure 13). Histo-pathological

Figure 13 Benign fibrous stricture. PTC of a 72-year old man shows a very tight stricture at the lower part of the common bile duct with mild dilatation of the proximal biliary ducts. The appearances are very suggestive of a pancreatic head lesion.

examination revealed a fibrous stricture with no evidence of chronic pancreatitis or pancreatic malignancy. The remaining five cases had had a history of previous cholecystectomy with or without exploration of the common bile duct, and their stricture proved to be benign at laparotomy and biopsy. The cholangiograms of these patients showed complete obstruction or a very tight short stricture of the common hepatic duct with moderate to severe dilatation of the proximal segments of the biliary tract (Figures 14-16).

3- Sclerosing cholangitis

In the two patients ultimately thought to have sclerosing cholangitis, the cholangiogram of the first case showed moderate dilatation of both intrahepatic and extrahepatic ducts including the gall-bladder, with multiple tight strictures in the biliary tract (Figure 17). The second case had a very tight stricture at the bifurcation of the left and right hepatic ducts with numerous filling defects in moderately dilated intrahepatic ducts, giving the appearances of tumour emboli (Figure 18). However, both cholangiograms showed diminished branching of the intrahepatic ducts and a "pruned tree" configuration usually regarded as peculiar to sclerosing cholangitis.

Figure 14 Traumatic stricture in a 72-year old woman who had cholecystectomy 40 years ago followed by exploration of the common bile duct for retained gall stones 9 years later. PTC shows complete obstruction at the lower end of the common hepatic duct with severe dilatation of the proximal biliary ducts.

Figure 15 Traumatic stricture in a 30-year old woman due to common bile duct injury and repair during cholecystectomy 5 months ago. PTC shows two strictures of 2&4mm length in the common hepatic duct with moderate dilatation of the proximal biliary ducts. The common bile duct appears normal in calibre and shape.

Figure 16 Traumatic stricture in a 43-year old man due to biliary surgery one year ago. PTC shows complete obstruction of the common bile duct just below the insertion of the cystic duct, shouldering and tracking of the contrast media, and moderate dilatation of the proximal ducts.

Figure 17 Sclerosing cholangitis. PTC of a 38-year old man shows multiple tight strictures throughout the intra- and extra-hepatic ducts with moderate dilatation of the biliary system including the gall-bladder.

Figure 18 Sclerosing cholangitis. PTC of a 71-year old man shows irregular dilatation and strictures in the intrahepatic ducts with complete obstruction of the biliary tract at the porta hepatis.

4- Duodenal diverticula

Two patients were found at laparotomy to have duodenal diverticuli responsible for their jaundice; malignant change was excluded on histo-pathological examination of periampullary region biopsy in both cases. Both cholangiograms showed dilatation of the intrahepatic and extrahepatic biliary tract (maximum diameters 15&16mm), with delay in the passage of contrast into the duodenum. The cholangiogram of the first patient showed an apparent rounded deformity of the medial wall of the second part of the duodenum (Figure 19). The cholangiogram of the second patient showed an irregularly narrowed lower end of the common bile duct which opened into a diverticulum containing a filling defect (Figure 20). Details of these two patients are discussed elsewhere (Hasan et al. 1988).

Malignant conditions

The sensitivity and specificity of cholangiograms in this study with regard to the presence or absence of malignant obstruction in the biliary system were 84% (70/83) and 75% (48/64), respectively (Table 21). The positive and negative predictive values of these cholangiograms in determining the presence or absence of malignant

Figure 19 Duodenal diverticulum. PTC of a 81-year old woman shows dilatation of the common bile duct and an apparent rounded deformity of the medial wall of the second part of the duodenum.

Figure 20 Duodenal diverticulum. PTC of a 71-year old man shows a distended common bile duct with an apparent filling defect within an associated duodenal diverticulum.

conditions were 86% (70/81) and 89% (48/54), respectively.

1- Pancreatic head carcinoma

Fifty-one patient had a proven final diagnosis of pancreatic cancer. In three patients, the cholangiograms were inconclusive; since it was impossible to rule out the possibility of chronic pancreatitis as the cause of the obstruction. In two patients, the cholangiograms were misleading; in both there was smooth and gradual narrowing of the common bile duct into a sticture at its lower end (Type I stricture of Caroli) which was very suggestive of chronic pancreatitis. The cholangiographic appearances were diagnostic in 46 patients and will be discused in detail in Chapter 4.

2- Cholangiocarcinoma

The cholangiograms were diagnostic in 16 out of 18 patients with cholangiocarcinoma. The cholangiograms showed complete obstruction to the flow of the contrast media in 11 cases. The obstruction was at the junction of the right and common hepatic duct in two cases, at the common hepatic duct in eight cases, and at the begining of the common bile duct in one case. The appearance of the end of the obstruction was

V-shaped in four, U-shaped in one, an irregular cut-off in three, and shouldering in two cases (Figures 21-24). In one case the end of the obstruction showed the typical dawnwardly concave meniscus of stone obstruction. All of these obstructions were associated with moderate to severe proximal dilatation.

The obstruction in the biliary tract was incomplete in seven cases. The length of the stenosis ranged from 5mm to 60mm. The disease primarily involved the common hepatic duct in three cases (Figure 25), while in four cases there were widspread strictures throughout the biliary tree (Figure 26).

The cholangiographic appearance was inconclusive in one case and misleading in another in that it suggested stone in the common bile duct as the cause of the obstruction. However, both had poor quality films and most of the biliary ducts were not opacified clearly.

3- Periampullary carcinoma

The cholangiograms were diagnostic in 6 of the 8 patients with periampullary carcinoma, and the cholangiographic picture was one of a biliary system which is dilated down to the lower end of the common

Figure 21 Cholangiocacinoma. PTC of a 77-year old woman shows a V-shaped obstruction of the right hepatic duct with moderate dilatation of the right intrahepatic ducts.

Figure 22 Cholangiocarcinoma. PTC of a 77-year old man shows U-shaped obstruction of the common bile duct at its junction with the cystic duct with moderate dilatation of the proximal biliary ducts including the gall-bladder.

Figure 23 Cholangiocarcinoma. PTC of a 59-years old man shows irregular cut-off obstruction of the common hepatic duct at the porta hepatis with severe dilatation of the proximal intrahepatic ducts.

Figure 24 Cholangiocarcinoma. PTC of a 73-year old man shows shouldering and complete obstruction of the common hepatic duct at the porta hepatis with severe dilatation of the intrahepatic ducts.

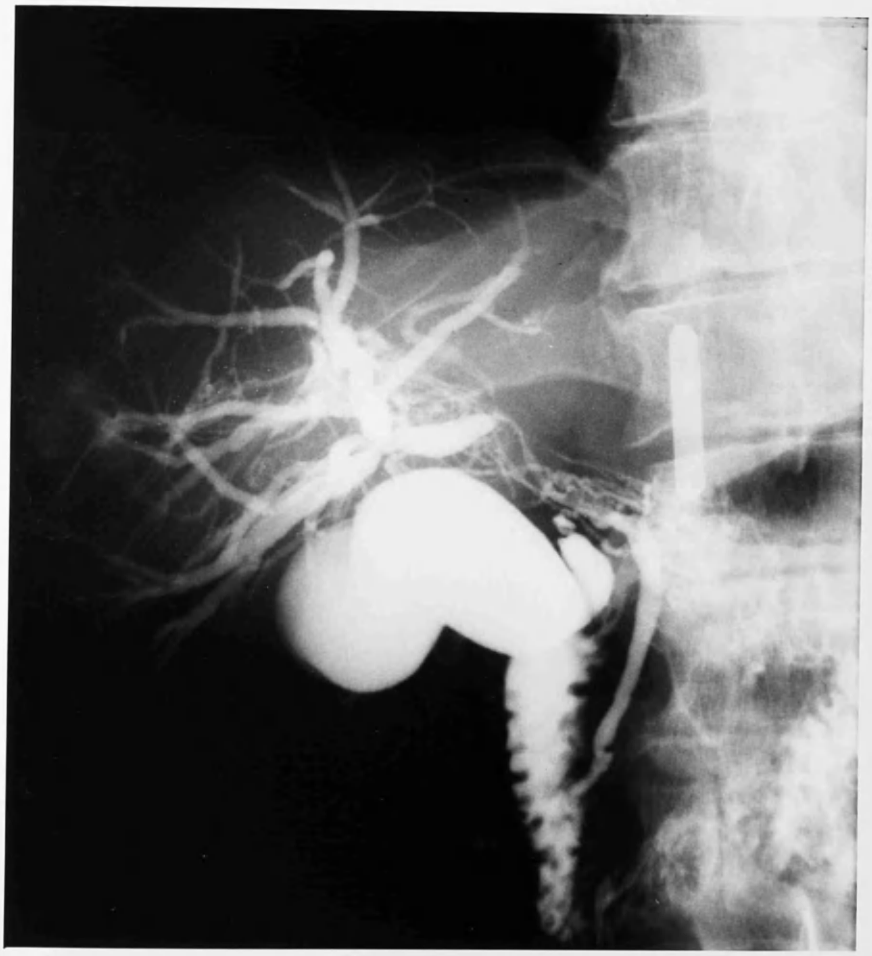

Figure 25 Cholangiocarcinoma. PTC of a 61-year old man shows a tight stricture 28mm long at the origin of the common hepatic duct, with irregular dilatation of the right intrahepatic ducts; the left intrahepatic system is not visualised. The common bile duct appears normal but the gall-bladder is distended.

Figure 26 Cholangiocarcinoma. PTC of a 63-year old man shows two strictures in the common hepatic and common bile ducts with severe dilatation of the right intrahepatic ducts and non-opacification of the left intrahepatic system.

bile duct including the gall-bladder (Figure 27). In three of these 6 patients this abnormality was associated with multiple filling defects proximal to the obstruction (Figure 28). The cholangiographic appearances were misleading in two cases. In the first case, ERCP showed a dilated and tortous pancreatic duct with smooth and gradually tapered common bile duct at its lower end which was very suggestive of chronic pancreatitis. In the second case, the cholangiographic appearance was one of irregular cut-off of the common bile duct at its upper part with moderate to severe dilatation of the proximal biliary ducts. This and none visualization of the gall-bladder and multiple filling defects in the dilated ducts were very suggestive of gall stone obstruction.

4- Metastatic lesions

In two patients the metastatic lesions in the porta hepatis and liver parenchyma presented as multiple irregular strictures and dilatations in the biliary tree (Figure 29). In furthure two patients, metastases around the common duct gave a cholangiographic picture very similar to that of pancreatic head carcinoma (Figure 30). The cholangiographic appearance was misleading in one case; it showed a typical downwardly concave meniscus of

Figure 27 Periampullary carcinoma. PTC of a 68-year old woman shows moderate to severe dilatation of both intra- and extra-hepatic ducts including the gall-bladder (Type II stricture of Caroli).

Figure 28 Periampullary carcinoma. PTC of a 56-year old man shows moderate dilatation of both intra- and extra-hepatic ducts (Type II stricture of Caroli) with multiple filling defects at the lower part of the common bile duct.

Figure 29 Metastatic lesions. PTC of a 55-year old man shows very tight and irregular strictures of the intrahepatic ducts and the common hepatic duct, with complete obstruction of the common hepatic duct at its lower end.

Figure 30 Metastatic lesions. PTC of a 53-year old woman shows a very tight stricture at the lower end of the common bile duct with severe dilatation of the proximal biliary ducts (Type V stricture of Caroli).

stone obstruction at the begining of the common bile duct with moderate dilatation of the proximal biliary ducts.

5- Carcinoma of the gall-bladder

In one case the histo-pathological examination of the gall-bladder confirmed the presence of carcinoma and gall stones. The cholangiographic appearances were of a very tight stricture 37mm long involving the common hepatic duct and extending into the left hepatic duct, a soft tissue mass in the region of the gall-bladder stretching and medially displacing the lower end of the common duct and jejunal loops, non opacification of the gall-bladder, and moderate dilatation of the right intrahepatic biliary ducts (Figure 31).

Figure 31 Carcinoma of the gall-bladder. PTC of a 90-year old woman shows a very tight stricture of the common hepatic duct involving the left hepatic duct also, with moderate dilatation of the right intrahepatic ducts and medial dispacement of the common duct and loops of the small intestine by a soft tissue mass in the region of the gall-bladder.

DISCUSSION

The aims of direct cholangiography prior to surgery are to differentiate between intrahepatic and extrahepatic cholestasis, determine the level and extent of lesion and identify the nature of the obstruction. However, I believe that with availability of non-invasive and simpler methods such as US, the first two aims can be achieved without recourse to direct cholangiography. Direct cholangiography, therefore, should be reserved as a mean of identifying the cause of obstruction in the biliary system, and if required, to provide a map of the biliary system prior to surgery. The overall ability of direct cholangiography to identify the cause of the obstruction in this study was 80% (117/147); but if unsatisfactory scans were excluded the sensitivity rises to 84% (117/139). The accuracy of direct cholangiography in determining the cause of obstruction as verified by biopsy, autopsy or/and laparotomy, varies between 69% to 96% in the literature (Gibbons et al. 1983; Juttijudata et al. 1986; Matzen et al. 1982; Pedersen et al. 1985). Pedersen et al. (1985) in a prospective study of 114 consecutive jaundiced patients comparing PTC with US, reported a diagnostic accuracy of 93% (106/114) for direct cholangiography as verified by laparotomy or autopsy. The diagnostic sensitivity and specificity of PTC in their study were 94% (85/90) and 88% (21/24) for malignant conditions, 78% (7/9) and 95% (100/105) for benign non-calculous conditions, and 93% (14/15) and 97% (96/99) for choledocholithiasis, respectively. Furthermore, in a prospective study which included direct cholangiography of 102 patients with obstructive jaundice, Matzen et al. (1981) found a 92% sensitivity and 89% specificity in identifying the presence or absence of malignant conditions, and a 96% sensitivity and 98% specificity for the presence or absence of calculi in the common duct. The present study has a sensitivity and specificity of 84% and 75% for malignant conditions, 48% and 89% for benign non-calculous conditions, and 86% & 88% for choledocholithiasis, respectively (Table 21). However, the lower diagnostic value of direct cholangiography in the present study in comparison with the previous two studies can be explained by the lack of information regarding patients clinical history and results of other investigation during the re-evaluation of cholangiograms (Fleming et al. 1972; Reuben et al. 1978; Silvis et al. 1976).

There was a significantly higher level of mean total serum bilirubin prior to direct cholangiography in patients with malignant obstruction (273 μmol/l) than in patients with benign non-calculous obstruction (119 μmol/l) or choledocholithiasis (128 μmol/l; P<0.001). This can partly be explained by the fact that complete obstruction of the biliary tract was more frequent in patients with malignant conditions (72%) than in patient with benign non-calculous conditions (29%) and choledocholithiasis (60%; Table 20). Fleming et al. (1972) and Goldberg (1983) have also observed that complete obstruction of the biliary tract is more frequent with malignant conditions. Therefore, in the absence of a history of previous biliary surgery or the usual cholangiographic features of stone obstruction (filling defect and meniscus sign), any complete or near complete obstruction of the biliary ducts must be highly suspicious for a malignant condition regardless of the cholangiographic appearances.

It has been found by others that patients with greatly dilated ducts are more likely to have stone obstruction or malignant conditions in the biliary system rather than benign non-calculous conditions (Fleming et al. 1972). However, the present study did not demonstrate any statistically significant difference between patients with choledocholithiasis, benign non-calculous and malignant conditions with regard to the maximum diameters of the intrahepatic ducts, common hepatic duct and common bile duct (Table 20). Both the study by Fleming et al. (1972) and the present study demonstrate that the extent of overlap between the three groups is so great (Figure 6) that measurement of bile duct calibre cannot separate patients with malignant obstruction from patients with choledocholithiasis or benign non-calculous conditions. Measurement of bile duct diameter by ultrasound are therefore of limited value in determining the cause of jaundice. A similar observation has been previously reported in connection with the investigation of post-cholecystectomy patients for retained common duct stones (Hamilton et al. 1982).

The maximum transverse diameter (mean & SD) of the gall-bladder was significantlly larger in malignant conditions (54 $\pm$ 14mm) than in choledocholithiasis (34 $\pm$ 10mm) or benign non-calculous conditions and choledocholithiasis together (38 $\pm$ 12mm; $P<0.01$). Although, Figure 7 shows some overlap in the maximum transverse diameter of the gall-bladder in patients with benign non-calculous, calculous and malignant obstructions, it also shows that patients with a contracted gall-bladder are unlikely to have malignant or even benign non-calculous obstruction of the biliary tract. But the opposite is not true, patients with dilated gall-bladder could have calculous, benign non-calculous or malignant causes of obstruction. This was also the case with the study by Eyre-Brook et al. (1983) who found that 19 patients with a small gall-bladder containing multiple stones had gall stone jaundice while 57 of 61 patient with a dilated stone-free gall-bladder had malignant distal obstruction as verified at laparotomy and biopsy. Patients with choledocholithiasis had also higher incidence of gall stones in their gall-bladder 63% (15/24) in comparison with patients having benign non-calculous 25% (2/8) and malignant 22% (11/50) causes of obstruction in the present study.

Choledocholithiasis

Choledocholithiasis complicates the course of approximately 15% of cholecystectomy patients and 3-4% of post-cholecystectomy patients (Coehlo et al. 1984). Common duct stones can originates in the gall-bladder and then pass into the commmon bile duct via the cystic duct or on a rare occasion develop primarily in the intrahepatic or extrahepatic ducts. Common duct stones can remain free, or can obstruct partially, completely or intermittently. All of our patients were jaundiced and this means they had either partial or complete obstruction. Impacted stones produced smooth and downwardly concave meniscus in 19% (8/43) of our patients with choledocholithiasis (Figure 10); this appearance has been described by others (Fleming et al. 1972; Lang, 1974). However, the meniscus sign was also observed in patients with metastatic lesions, cholangiocarcinoma and chronic pancreatitis in the present study. The meniscus sign, therefore, is highly suggestive of choledocholithiasis but it is neither common nor pathognomonic for stone obstruction.

A filling defect at the lower common bile duct was the most common cholangiographic abnormality in patients with choledocholithiasis in the present study (65%). However, there are many points to be considered in these patients before making the diagnosis of stone obstruction; (i) intraductal filling defects, apart from polypoid tumours, can be produced by free stones, mucus or debris, and air bubbles. Unless impacted, stones may move with a change in the position of the patient but do not change shape, whereas mucus may change shape (Fleming et al. 1972). Air bubbles can be extremely difficult to distinguish from stones; they are usually rounded and smooth whereas stones are seldom perfectly rounded and smooth (Friedman et al. 1987), (ii) "pseudocalculous sign" is a term used to denote a cholangiographic illusion that appears as a filling defect in the distal common bile duct when spot films are exposed during a contractile phase of choledochal sphincter activity (Martin et al. 1986). It can mimic radiographically an impacted stone in the distal common bile duct. Therefore, its delineation is critical to avoid unnecessary instrumentation of the common duct. The pseudocalculous sign occurs only in the distal end of the common bile duct, it may be smooth or irregular and it fills the entire lumen of the duct without dilating it. The lower border of a pseudocalculous defect cannot be delineated and it usually merges with the wall of the intramural portion of the common bile duct. Bile can usually pass into the duodenum, and the defect is not manifested by pain or cramp (Martin et al. 1986; Mujahed & Evans, 1972), and (iii) finally, the presence of stones in the common duct does not mean that they are the cause of the obstruction in the biliary tract. Four of our 8 patients with periampullary carcinoma had a number of coincidental gall stones in the common duct (Figure 28). This observation has been substantiated by others, notably in patients with periampullary carcinoma (Lang, 1974) and hepatocellular carcinoma (Lee et al. 1984).

Benign strictures

All of our patients with benign stricture had had previous biliary tract operations except for one 72 year old man in whom the stricture was due to benign fibrous tissue of unknown cause as proved later at laparotomy and biopsy. This observation has also been reported previously (Fleming et al. 1972; Silvis et al. 1976). This highlights the importance of knowing the clinical history of patients in interpretation and reporting of cholangiograms, as the cholangiographic features were very suggestive of malignant obstruction in the absence of previous history of biliary surgery (Figures 14&15). However, the present study included three patients who had had previous cholecystectomy and despite this their stricture in the biliary tract turned out to be malignant (Table 20). On the other hand, in one patient with a traumatic stricture of the common duct (as proved later by no evidence of malignancy at laparotomy and biopsy), the cholangiographic features were very suggestive of malignant stricture in spite of knowing that the patient having had previous biliary surgery (Figure 16).

Duodenal diverticula

The great majority of duodenal diverticula are asymptomatic incidental findings even in jaundiced patients. However, they are reported as causing obstructive jaundice due to anatomical distortion of the common bile duct, diverticulitis or enterolith formation (Landor & Fulkerson, 1966; McSherry & Glenn, 1970; Neil & Thompson, 1965; Willox & Costopoulos, 1969). These two cases in the present study (Figures 19&20) illustrate that cholangiographic appearances mimicking periampullary tumour can be associated with such diverticula and highlight the need for endoscopic biopsy in all patients thought radiologically to have periampullary lesions. Before such diverticula can be considered as a cause of biliary obstruction it is suggested that the following criteria should be fulfilled (Hasan et al. 1988); (i) the presence of the diverticulum should be confirmed endoscopically or radiologically, (ii) the patient should have had at least one episode of obstructive jaundice documented clinically, biochemically and radiologically, and (iii) no other causes of obstruction should be demonstrated. lt is particularly important to exclude the presence of gallstones and an arbitary follow-up period of, say, 2 years might be used to exclude occult neoplasia of the periampullary area.

The exact cause for obstructive jaundice in these two patients with duodenal diverticula remains speculative, but both required laparotomy because of gall-bladder inflammation and though no gallstones were recovered, it is conceivable that earlier passage of calculi through the papilla of Vater could cause inflammation and obstruction. Leese et al. (1986) have emphasized the clinical and biochemical similarities between patients with non-neoplastic periampullary "pseudotumour" and those with periampullary neoplasm. Like these authors, I would recommend avoidance of laparotomy if at all possible when endoscopic biopsy does not confirm neoplasia in the patients with periampullary obstruction. The recent availability of endoscopic sphincterotomy may now allow the jaundice to resolve. If such patients do come to laparotomy, radical surgery must not be undertaken unless open biopsy and frozen section examination confirms the presence of cancer (Hasan et al. 1988).

Sclerosing cholangitis

Sclerosing cholangitis affects mainly the intrahepatic ducts with extension into the common hepatic and common bile duct in some patients. Its distinctive radiographic appearance on cholangiography consists of ductal stiffening and irregularity with multiple sites of beading and stenosis with a predilection for the bifurcations (Chen & Goldberg, 1984). In the present study, two patients had sclerosing cholangitis proved at laparotomy and biopsy. The cholangiographic appearance of the first patient was inconclusive (Figure 17) in that it was impossible to rule out the possibility of sclerosing cholangiocarcinoma as the cause of obstruction. In the second case, the cholangiographic features were very suggestive of cholangiocarcinoma (Figure 18). Furthermore, sclerosing cholangiocarcinoma may be difficult to exclude even after negative histology and cytology. However, diffuse stricturing favours sclerosing cholangitis, as do band-like strictures and diverticula or pseudodiverticula in the extrahepatic ducts (MacCarty et al. 1983). Marked dilatation proximal to a stricture is quite uncommon with sclerosing cholangitis and if present should suggest a different aetiology. A "pruned tree" configuration of the intrahepatic ducts favours sclerosing cholangitis (Teplick, 1981). Finally, because of the cholangiographic and histological dificulties in differentiatating cholangitis from cholangiocarcinoma, one must conclude that carcinoma can be ruled out in these cases only by long term follow-up.

Cholangiocarcinoma

PTC and ERCP are still the best diagnostic methods available for detecting bile duct neoplasms. From a diagnostic stand point; it is important to know whether or not previous biliary surgery has been performed (Clemett, 1983), so that one can exclude the possiblity of traumatic stricture (Figure 15). PTC has the advantage over ERCP of being able to delineate the intrahepatic duct anatomy in cases of complete obstruction in or around the porta hepatis as for example in case of Klatskin tumour (which is an irregular stricture at the bifurcation with prestenotic dilatation; one or both of the left and right hepatic ducts may be affected in addition to the proximal common hepatic duct). Other entities that may produce a similar cholangiographic appearances to the Klatskin type tumour are metastatic lesions (Figure 29), lymphomas and hepatocellular carcinoma (Friedman et al. 1987; Ligoury & Canard, 1983).

Bile duct carcinoma has been classified cholangiographically as either obstructive, stenotic or protuberant (Ligoury & Canard, 1983). The obstructive type is the most frequent, occuring in about 70% (11 of the 18 patients or 61% in the present study) of cases and appearing as a U-shaped, V-shaped, rat-tail stricture which can be smooth or irregular. In the present study (Figures 21-24), a V-shaped appearance was the most frequent (36%; 4/11), and more common than an irregular cut-off termination (27%; 3/11), shouldering (18%; 2/11), U-shaped (one patient) or dawnwardly concave menisus appearance (one patient). The stenotic type is depicted as strictured rigid lumen with irregular margins and prestenotic dilatation, and was observed in 39% (7/18) of the patients in the present study. The length of the stenosis may be long or short and ranged from 5 to 60mm in the present study. The stricture was single and involved the hepatic duct in three patients (Figure 25), and there were widespread strictures and dilatations in 4 patients (Figure 26) which caused difficulty in differentiation from sclerosing cholangitis (Figure 17). The clue to the correct diagnosis is an absence of diverticula in the extrahepatic ducts (Chen & Goldberg, 1984) and a lack of prominent dilatation of the biliary ducts (Teplick, 1981). The protuberant type appears as an intraluminal filling defect usually with irregular margins attached at one point to the wall. The duct is often widened in the region of the mass (Ligoury & Canard, 1983). This type was not observed in the present study.

Metastatic lesions

Metastases to the liver from carcinoma elsewhere produced non-specific dilatation and stretching of the intrahepatic and extrahepatic ducts in two of the patients in the present study (Figure 29) and the appearance was very difficult to be differentiate from cholangiocarcinoma (see cholangiocarcinoma). ln another two patients, complete and near-complete stenosis of the lower common bile duct with severe dilatation of the proximal biliary tract gave a cholangiographic appearance (Figure 29) suggestive of pancreatic carcinoma (see Chapter 4). ln the fifth patient with metastatic obstruction, a typical downwardly concave meniscus appearance at the common bile duct was characteristic of stone obstruction in other words the PTC was misleading. Therefore, direct cholangiography may allow one to suspect the presence of metastatic lesions but ultrasound and CT scan are better method of diagnosis. lt is also found that US is superior to ERCP for diagnosis of focal hepatic disease and cholelithiasis (Frederic et al. 1983).

Carcinoma of the gall-bladder

Lang, (1974) has reported medial dispacement of the common duct by what appeared to be an extrinsic mass in all of his four patients with carcinoma of the gall-bladder. He found funnel-shaped attenuation of the common duct located close to the porta hepatis and the origin of the cystic duct in two of his patients, while the other two showed near-complete obstruction of the common duct by multinodular masses at the level of the porta hepatis. The cholangiographic appearance in the only case of carcinoma of the gall-bladder in the present study was therefore very suggestive of the correct diagnosis (Figure 31).

Periampullary carcinoma

Classically, periampullary carcinoma is often an irregular polypoid intraductal mass partially obstructing the very distal common bile duct (Freidman et al. 1987). This appearance was not observed in any of our 8 biopsy-proven patients. However, periampullary carcinoma can present as an irregularly tapered stricture or as a squared off flattened termination. Local expansion of the duct at the level of the mass when present is a very helpful feature, favouring carcinoma over stone obstruction (Ferrucci et al. 1983).

In one study (Lang, 1974) carcinoma of the ampulla of Vater was correctely suggested on the basis of PTC in 6 of 9 biopsy-proven patients, with three false-negative diagnoses (inflammatory stenosis or oedema of the papilla) and one false-positive diagnosis (proven subsequently to be inflammatory stenosis). These results are comparable with that of the present study in that periampullary carcinoma was diagnosed on the basis of direct cholangiography in 6 of the 8 patients, with 2 false-negative diagnoses (chronic pancreatitis and choledocholithiasis) and 4 false-positive diagnoses (2 cases of duodenal diverticula and 2 choledocholithiasis). Therefore, ERCP may be a better diagnostic tool than PTC in the diagnosis of periampullary carcinoma and carries the advantage of visual inspection and biopsy.

Chapter 4

CHOLANGIOGRAPHY: A COMPARATIVE STUDY OF CHRONIC PANCREATITIS AND PANCREATIC CARCINOMA (STUDY III)

AIM OF THE STUDY

Differentiation of pancreatic carcinoma from chronic pancreatitis remains difficult in some patients even at laparotomy and when wedge-resection biopsies are submitted for frozen-section evaluation. The fact that pancreatic carcinoma and chronic pancreatitis can coexist makes evaluation even more difficult (Reuben et al. 1978). Attempts to aid differentiation between chronic pancreatitis and pancreatic carcinoma preoperatively have centered on the radiological appearances of the pancreatic duct and pancreatic function tests such as measurement of Lactoferrin (Fedail et al. 1978; Frick et al. 1982; Multigner et al. 1980; Rohramann et al. 1976). Although many studies have provided a detailed description and classification of cholangiographic features in both chronic pancreatitis and pancreatic carcinoma (Caroli &

Nora, 1952; Freeny & Lawson, 1982; Guien, 1979; Petrozza & Dutta, 1985), a specific study of the cholangiographic differentiation between chronic pancreatitis and pancreatic carcinoma with sufficient number of patients has not been reported (Kruse et al. 1978; Rohramann et al. 1974). Therefore, the aim of the present study was to assess any points of difference between chronic pancreatitis with abnormalities of the biliary tract and pancreatic carcinoma in term of their cholangiographic features and associated liver function abnormalities.

PATIENTS AND METHODS

All the patient with final diagnosis of chronic pancreatitis or pancreatic carcinoma in their discharge report from the University Department of Surgery Glasgow Royal Infirmary between the 1st of January 1981 and the 31st December 1987, regardless of whether the patient was jaundiced or not, were identified by personal search of the Unit´s discharge summary cards. Fourty-seven patients with chronic pancreatitis and 53 patients with pancreatic carcinoma had percutaneous transhepatic cholangiography (PTC) or endoscopic retrograde cholangiopancreatography (ERCP) available for review at Radiology Department. The cholangiograms and case notes of these patients were reviewed and re-evaluated to obtain the data shown in Appendix 5 when possible.

Radiology

The cholangiographic abnormalities were categorised according to Caroli´s classification (Caroli & Nora, 1952; Sarles et al. 1958). When the bile duct abnormality did not fit any type of Caroli´s classification (see Figure 2, chapter 1), the abnormality was regarded as unclassified. The length of the stenosed part of the common bile duct was measured from the point when it started to narrow from its normal diameter to the end of the stenosis. In cases with severe or complete stenosis of the common bile duct and no opacification of the duodenum, the length of the stenosis was impossible to measure. The maximum diameter of the right or left hepatic duct following its first intrahepatic division (first generation of the intrahepatic ducts) was measured to the nearest millimetre. The ducts which measured 4mm or less regarded as normal (Hamilton et al. 1982). The gallbladder was considered normal when its transverse diameter was between 25 and 40mm; figures less than 25mm were regarded as shrunken and those above 40mm as distended.

Biochemistry

The values for total serum bilirubin, serum alkaline phosphatase concentration, serum albumin, serum amylase, serum creatine, serum aspartate transaminase (AST), and serum alanine transaminase (ALT) of these patients were obtained from the case notes. The results of tests performed on the same day as cholangiography were taken where possible or the closest test to the procedure was taken within the preceding seven days. Biochemical tests performed after cholangiography were not taken in the basis that PTC and ERCP may affect their values. The normal value in our laboratory for the total serum bilirubin is 3-22 µmol/l, serum alkaline phosphatase concentration 80-280 IU/l, serum albumin 35-55 g/l, serum amylase 70-300 IU/l, serum creatinine 40-130 µmol/l, AST 12-48 IU/l and ALT 3-55 IU/l.

Clinical/biochemical/radiological correlation

The types of cholangiographic abnormality found in re-evaluation of the cholangiograms of patients with chronic pancreatitis and pancreatic carcinoma were then compared for their relation with the age and sex of patient, presence of plain film pancreatic calcifications, size of the gall-bladder, maximum diameters of the intra- and extra-hepatic ducts, and laboratory data.

Comparison

The patients with chronic pancreatitis and pancreatic carcinoma were compared for; (i) the incidence of the bile duct abnormality associated with the disease, (ii) types of cholangiographic abnormalities, (iii) the maximum diameters of the intrahepatic ducts, proximal common duct and the gall-bladder, (iv) presence or absence of plain film pancreatic calcifications, and (v) the values of serum bilirubin, serum alkaline phosphatase, serum amylase, serum albumin, serum creatinine, AST and ALT.

Statistics

An "Apple IIe" personal computer was used to create personal filing system and to perform all statistical analysis including Chi-square test, Fisher's exact probability test, and paired and unpaired Student's T-test as appropriate. The differences between groups were considered statistically significant when the probability of their arising by random sampling error was less than 1 in 20 ($P<0.05$). The definitions of the statistical terms used in the chapter are listed in Appendix 3.

RESULTS

A total of 100 patients were included in the study, they comprised 61 men and 39 women and they had a mean age of 57 years (range: 21-92). Table 22 shows that the diagnosis of the pancreatic carcinoma was based on pancreatographic and ultrasonographic findings in three patients who were considered too ill for any intervention. All patients with chronic pancreatitis had had clinical features of the disease but only 11 of them were jaundiced; 37 patients of these patients had undergone surgery but only 22 patients had biopsy. Therefore, chronic pancreatitis was diagnosed on the pancreatographic findings in eight cases, surgical findings in addition to pancreatographic features in fifteen cases, and plain film pancreatic calcification in a further two cases.

All the 53 patients with pancreatic carcinoma had PTC apart from seven cases who had ERCP. Of the 47 patients with chronic pancreatitis, forty patients had ERCP and seven had PTC. All the cholangiographic films reviewed were technically satisfactory. The plain film which accompanied these cholangiograms showed pancreatic calcifications in 15 (32%) of the 47 patients with chronic pancreatitis, but none of the

Table 22 The clinical, biochemical and radiological data of 100 patients with chronic pancreatitis or pancreatic carcinoma.

	Carcinoma (no = 53)	Pancreatitis (no = 47)
Mean age (range)	68 (32-92)	46 (21-72)
Sex (m/f)	29/24	32/15
Diagnosis based on		
biopsy	48	22
autopsy	2	0
laparotomy	0	15
other means	3 (ERCP & US)	10 (8 ERCP & 2 calcifications)
Cholangiograms		
PTC/ERCP	46/7	7/40
Normal/Abnormal	0/53	17/30
Pancreatic calcification	0	15

patients with pancreatic carcinoma (or the combination of cancer with chronic pancreatitis) showed calcifications.

Chronic pancreatitis

Thirty of the 47 chronic pancreatitis patients (64%) were considered to have stenosis of the lower common bile duct. These included 20 (67%) type I, three (10%) type III, three (10%) type IV, and there was one case each of type II and type V stricture. Two patients (7%) had unclassified cholangiographic abnormalities which proved to be the result of the presence of common duct stones in addition to 20mm strictures at the lower end of common bile duct (proved at laparotomy and biopsy to be due to chronic pancreatitis in that no evidence of malignancy). None of them were jaundiced and both had normal liver function tests.

Type I stricture

A diffuse longitudinal and smooth stricture of the intrapacreatic and retropancreatic portion of the common bile duct, measured 41 $\pm$ 16mm (mean & SD) and assuming many shapes, was the most frequent finding (Figure 32). The mean of the maximum diameters of the intrahepatic and extrahepatic ducts associated with

Figure 32 Chronic pancreatitis. PTC shows type I common bile duct stenosis with dilatation of the proximal ducts and pancreatic calcification. The appearances are pathognomonic of chronic pancreatitis.

this type of cholangiographic abnormality was 7mm (range: 4-13) and 18mm (range: 7-46), respectively. The gall-bladder was opacified in 11 patients; it was considered normal in 6 patients and distended in 5 patients. All opacified gall-bladders were free from gall stones.

Type II stricture

The cholangiogram (Figure 33) showed mild dilatation of the entire biliary tract as far as the sphincter of Oddi (The maximum diameters of the intrahepatic and extrahepatic ducts were 6mm and 12mm, respectively).

Type III stricture

All type III strictures showed single annular stricture in the mid common bile duct at the upper border of the pancreas (Figure 34); the length of the strictures were 10, 20 & 50mm. The mean of the maximum diameters of the intrahepatic and extrahepatic ducts associated with this type of cholangiographic abnormality were 5mm and 16mm respectively, while the inferior portion of common bile duct and papilla were normal. The gall-bladder was normal in two patients and was not opacified in one patient.

Figure 33 Chronic pancreatitis. ERCP shows mild dilatation of the entire biliary tract as far as sphincter of Oddi (Type II stricture of Caroli). Pancreatic duct shows severe degree of ectasia and marginal irregularity in the tail and body. Mild dilatation of the main pancreatic duct at the head and neck.

Figure 34 Chronic pancreatitis. ERCP shows hourglass stenosis of the mid common bile duct and slight dilatation of the biliary ducts proximal to the stricture (Type III stricture of Caroli). Pancreatic duct shows severe degree of dilatation, stricturing and ectasia.

Type IV stricture

The cholangiograms of two patients showed lateral and medial compressions of the lower portion of the common bile duct with a large radius in one (Figures 35&36). There was proximal dilatation of both intahepatic and extrahepatic ducts (Table 23); the gall-bladder was normal in one and not opacified in another. One of these two patients was jaundiced. The cholangiogram of the third patient (Figure 37) showed that the lower portion of the common bile duct had failed to distend at ERCP and appeared slightly irregular and compressed from outside, with considerable dilatation of the intrahepatic ducts (9mm), proximal common duct (24mm) and the gall-bladder (51mm). The cholangiographic picture was type IVc, which is said to be peculiar to pancreatic carcinoma (Sarles & Sahel, 1978). At laparotomy, a large mass was seen in the head of the pancreas; beacuse of the difficulty in differentiating between chronic pancreatitis and pancreatic carcinoma, the patient had a cholecystojejunostomy and gastroentrostomy. Tru-Cut biopsies of the head of the pancreas showed evidence of chronic pancreatitis only and no malignant disease.

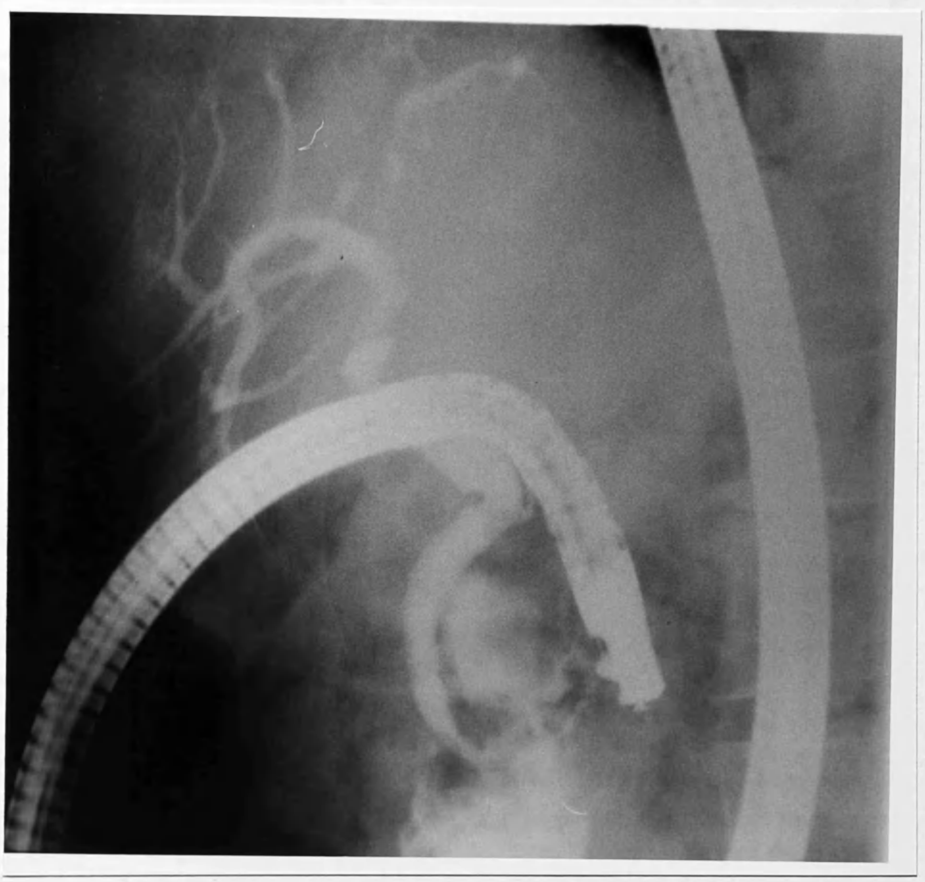

Figure 35 Chronic pancreatitis. ERCP show lateral displacement of the common bile duct with slight proximal dilatation (Type IVa stricture of Caroli). Pancreatic duct was not opacified.

Figure 36 Chronic pancreatitis. ERCP shows medial displacement of the common bile duct (Knee-bent appearance) with slight dilatation of the proximal ducts (Type IVb stricture of Caroli). Only short segment of the panceatic dut was opacified.

Table 23 The radiological and biochemical data in 30 chronic pancreatitis patients with abnormal cholangiograms and 53 pancreatic carcinoma patients with similar cholangiographic abnormalities (Caroli classification).

	Caroli classification of cholangiograms					
	I	II	III	IV	V	Un.
1- Frequency of the types of cholangiographic abnormalities						
carcinoma:	17%	7%	4%	0%	66%	6%
pancreatitis:	67%	3%	10%	10%	3%	7%
2- Maximum diameter of the intrahepatic ducts (mean)						
carcinoma:	8mm	10mm	9mm	---	10mm	12mm
pancreatitis:	7mm	6mm	5mm	7mm	NA	6mm
3- Maximum proximal common duct diameter (mean)						
carcinoma:	25mm	27mm	17mm	---	26mm	23mm
pancreatitis:	18mm	12mm	16mm	18mm	12mm	14mm
4- Total serum bilirubin μmol/l (mean)						
carcinoma:	278	268	353	---	266	336
pancreatitis:	61	6	131	30	23	15
5- Serum alkaline phosphatase concentration IU/l (mean)						
carcinoma:	1669	1203	1303	---	1315	1791
pancreatitis:	715	350	788	420	580	192
6- Serum aspartate transaminase concentration IU/l (mean)						
carcinoma:	137	160	185	---	125	81
pancreatitis:	47	29	43	32	32	37
7- Serum alanine transaminase concentration IU/l (mean)						
carcinoma:	210	133	309	---	176	145
pancreatitis:	42	32	53	43	22	25

Un, unclassified; NA, not available.

Figure 37 Chronic pancreatitis. ERCP shows straightening and slight extrinsic compression of the wall of the common bile duct (Type IVc stricture of Caroli). Mild dilatation of the main pancreatic duct in the head and body.

Type V stricture

ERCP of a 59-year old man showed very tight stricture at the pancreatic duct and lower common bile duct with severe dilatation of both pancreatic and bilary system (Figue 38); diagnosis of chronic pancreatitis was established at laparotomy in that biopsy showed chronic inflammation with no signs of malignancy.

The incidence of the abnormalities of the biliary tract associated with chronic pancreatitis had no relation with the age or sex of patient, or the presence or absence of the pancreatic duct calcification. Furthermore, Table 23 shows that there were no significant statistical differences between different cholangiographic abnormalities associated with chronic pancreatitis regarding the maximum diameters of the intrahepatic and extrahepatic ducts, or the mean values of the liver function tests (unpaired T-test). On the other hand, there were significant differences between chronic pancreatitis patients with normal and abnormal cholangiograms (Table 24) regarding the mean values of the total serum bilirubin level ($P<0.02$), serum alkaline phosphatase concentration ($P<0.001$), AST ($P<0.001$), and ALT

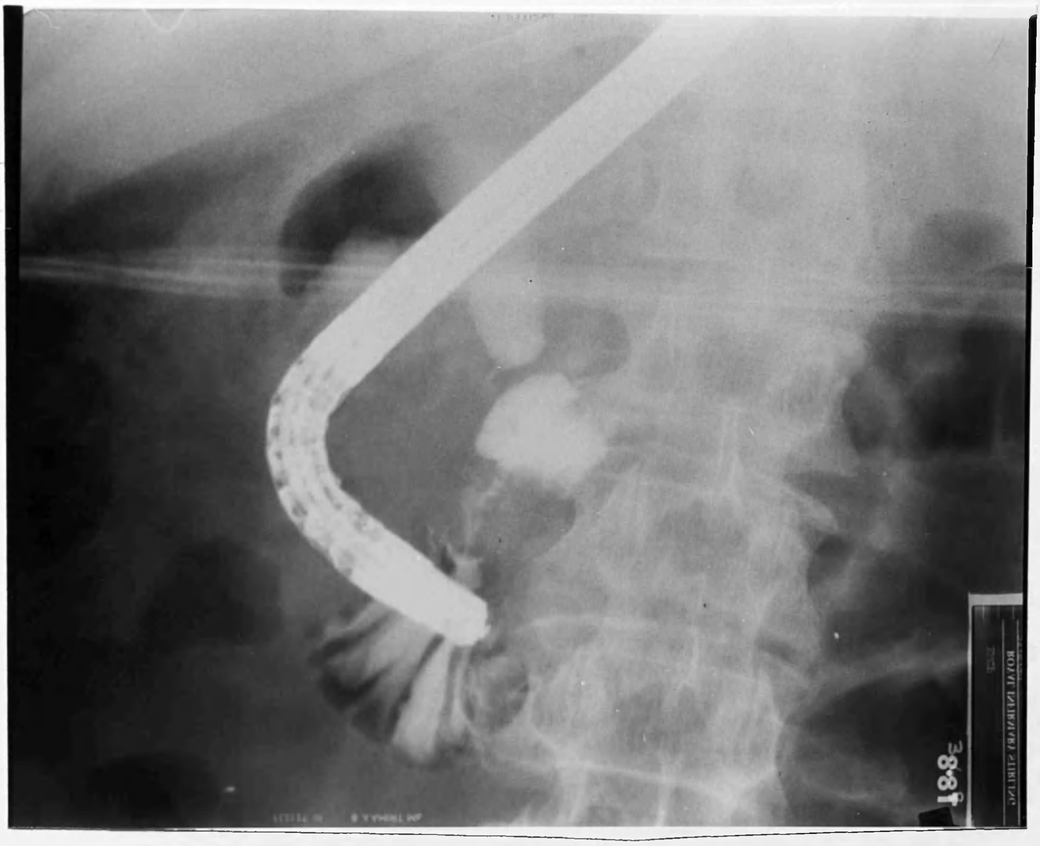

Figure 38 Chronic pancreatitis. ERCP shows very tight stenosis of both main pancreatic duct and lower common bile duct (double-duct sign), with severe dilatation of both ducts proximally (Type V stricture of caroli).

Table 24 Comparison of radiological and biochemical criteria in 47 chronic pancreatitis patients with normal and abnormal cholangiograms.

	Cholangiograms			
	normal (no = 17)	abnormal (no = 30)	P-value	DF
Age (mean & SD)	46 ± 11	49 ± 11	NS	
Sex (m/f)	11/6	21/9	NS	
Maximum diameter (mean & SD)				
Intrahepatic ducts (mm)	3 ± 1	7 ± 3	<0.001	41
Proximal common duct (mm)	8 ± 2	16 ± 8	<0.001	46
Gall-bladder				
visualized	12	16		
not visualized	5	14		
contain stone	0	0		
normal size	10	9		
distended	2	7		
diameter (mean & range)	35mm(22-45)	41mm (25-58)	NS	27
Biochemistry (mean & SE)				
serum bilirubin μmol/l	12 ± 3	65 ± 21	<0.02	43
alkaline phospatase IU/l	228 ± 23	1650 ± 107	<0.001	43
aspartate transaminase IU/l	21 ± 3	42 ± 6	<0.001	42
alanine transaminase IU/l	26 ± 3	44 ± 5	<0.01	42
serum amylase IU/l	913 ± 346	316 ± 64	<0.1	42
serum creatinine μmol/l	78	73	NS	41
serum albumin g/l	39	35	NS	42

NS, not significant.

(P<0.01); and the maximum diameters of the intrahepatic and extrahepatic ducts (P<0.001). However, as shown in Figure 39, normal liver function does not exclude radiological involvement of the biliary tree by the inflamatory process. Since only 23% (7/30) of the chronic pancreatitis patients who had abnormal cholangiograms had a serum bilirubin greater than 50 μmol/l, 70% (21/30) had an elevated serum alkaline phosphatase concentration over 300 IU/l, and 31% (9/29) had AST and 24% (7/29) had ALT over the normal values. Thirty percent (9/30) of the patients with chronic pancreatitis and abnormal cholangiograms had all liver function tests normal. On the other hand, 91% (21/23) of the chronic pancreatitis patients with elevated serum alkaline phosphatase concentration (over 300 IU/l) had abnormal cholangiograms in comparison to the figure of 41% (9/22) for patients with normal alkaline phosphatase concentrations (Figure 39). All chronic pancreatitis patients having combination of serum bilirubin level (>50 μmol/l) and elevated alanine transaminase (>55 IU/l) or serum alkaline phosphatase concentration (>300 IU/l) had some abnormality of the biliary tract.

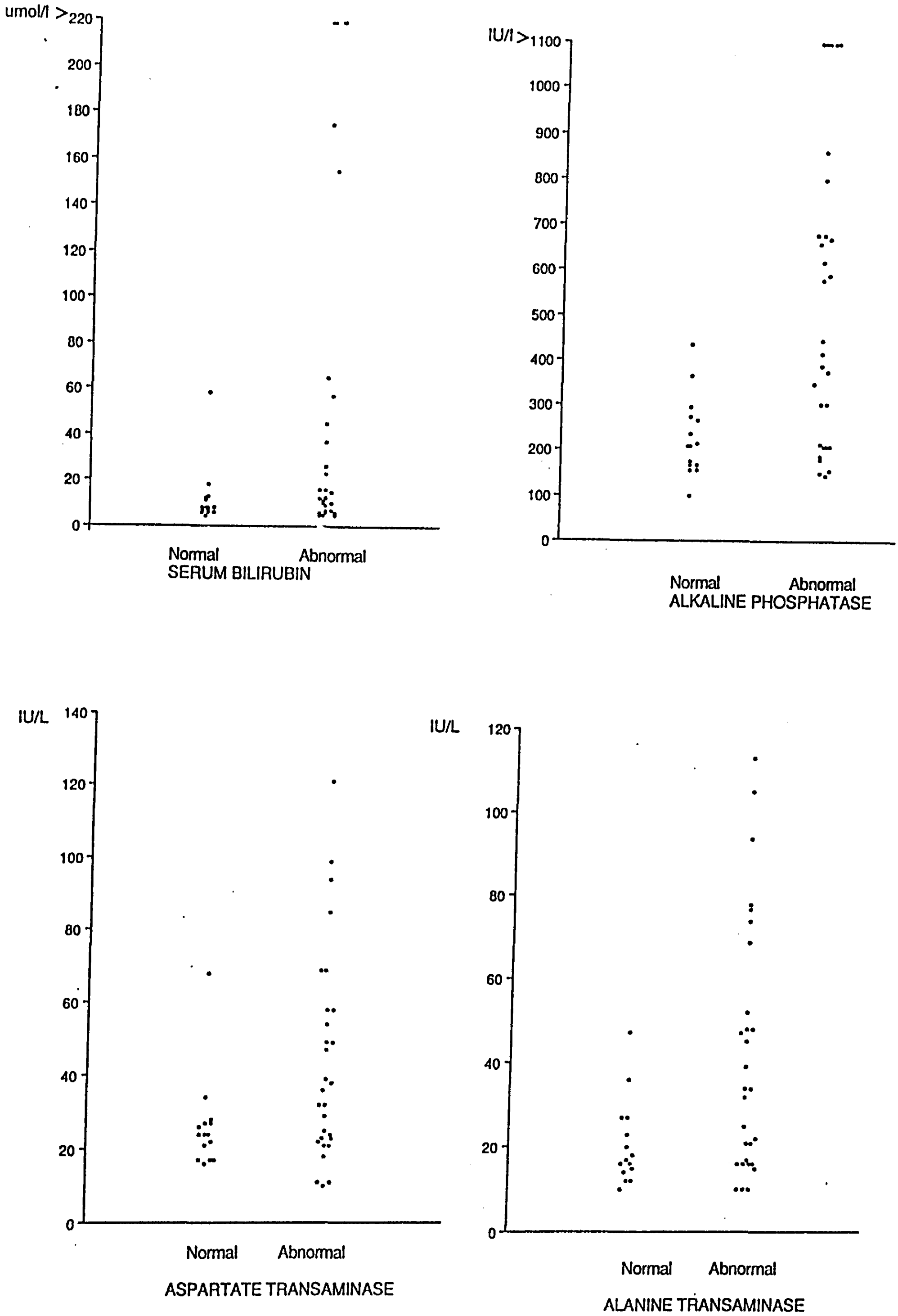

Figure 39 Diagram showing the value of the total serum bilirubin, serum alkaline phosphatase concentration, serum aspartate transaminase and serum alanine transaminase levels in 47 chronic pancreatitis patients with normal or abnormal cholangiograms.

Pancreatic carcinoma

All of the 53 patients with pancreatic carcinoma had some form of cholangiographic abnormality; this included 66% (35/53) type V, 17% (9/53) type I, 7% (4/53) type II, and 4% (2/53) type III stricture. Three female patients (6%) aged 60, 70 & 80 years had unclassified cholangiographic abnormalities because they had biopsy proven metastatic lesions in the porta hepatis and/or liver parenchyma (Figure 40&41).

Type I stricture

The cholangiograms showed longitudinal strictures at the lower common bile duct which measured 54 $\pm$ 10mm (mean & SD). The strictures assumed many shapes, and were irregular in 6 patients (Figure 42) and smooth in three. The mean of the maximum diameters of the intrahepatic and extrahepatic ducts associated with this type of cholangiographic abnormality were 8mm (range: 6-10) and 25mm (range: 18-37), respectively. The gall-bladder was opacified in 8 patients; it was considered distended (the mean of the maximum transverse diameter was 56mm) in 88% (7/8) patients and contained a stone in one patient.

Figure 40 Pancreatic carcinoma with metastases. PTC shows multiple tight strictures involving both intrahepatic and extrahepatic ducts (unclassified cholangiographic abnormality).

Figure 41 Pancreatic carcinoma. PTC shows complete obstruction of the common hepatic duct with severe dilatation of the proximal ducts (unclassified cholangiographic abnormality).

Figure 42 Pancreatic carcinoma. PTC shows irregular tight stricture of the lower common bile duct with moderate dilatation of the proximal ducts and the gall-bladder (Type I stricture of Caroli).

Type II stricture

The cholangiograms showed dilatation of the entire biliary tree, including the gall-bladder in two patients who had their gall-bladder opacified, as far as the sphincter of Oddi (Figure 43). The mean of the maximum diameters of the intrahepatic and extrahepatic ducts associated with this type of cholangiographic abnormality were 10mm (range: 6-12) and 25mm (range: 16-35), respectively.

Type IV stricture

Two patients had their cholangiograms showed a single annular and short (1-2mm) stricture in the mid common bile duct (Figure 44). The maximum diameters of the intrahepatic and extrahepatic ducts above these strictures were 9mm and 17mm respectively, while the inferior portion of the common bile duct and papilla were normal. The gall-bladder was of normal size and contained a gall stone in one patient, but was not opacified in the second patient.

Type V stricture

Thirty-five patients had type V cholangiographic abnormality, which is characteristic finding in pancreatic carcinoma. The cholangiograms showed complete obstruction of the lower portion of the common

Figure 43 Pancreatic carcinoma. PTC shows dilatation of the entire biliary system as far as the sphincter of Oddi (Type II stricture of Caroli). A large filling defect in the common hepatic duct most probably is a calculous.

Figure 44 Pancreatic carcinoma. PTC shows a short annular constriction at the mid portion of the common bile duct with slight dilatation of the proximal ducts and normal common bile duct below the stricture (Type III stricture of Caroli).

bile duct at PTC or very tight stenosis, ranged between 13 to 50mm in length, opacified from below at ERCP (Figure 45). The mean of the maximum diameters of the intrahepatic and extrahepatic ducts proximal to the obstruction were 10mm (range: 6-20) and 26mm (range: 13-50), respectively. The mean of the transverse diameter of the 27 visualized gall-bladders was 55mm (range: 42-90). The gall-bladder was considered distended in 85% (23/27) patients, shrunken in one patient and normal size (mean=37mm) in three patients; and it contained stones in three patients but all had distended gall-bladder.

All the patients with pancreatic carcinoma (except for two) were jaundiced and had an elevated serum alkaline phosphatase (>300 IU/l), total serum bilirubin (>50 μmol/l), and AST and ALT over their normal values. The mean values (± SE) of the biochemical tests were total serum bilirubin 276 ± 21 μmol/l, serum alkaline phosphatase concentration 1400 ± 195 IU/l, AST 129 ± 11 IU/l, ALT 168 ± 20 IU/l, serum albumin 34 ± 2 g/l, serum amylase 286 ± 60 IU/l and serum creatinine 83 ± 6 μmol/l. However, Table 23 shows that there was also no statistically significant difference between different cholangiographic abnormalities associated with pancreatic carcinoma with

Figure 45 Pancreatic carcinoma. PTC shows complete obstruction of the common bile duct at its mid portion with dilatation of the proximal ducts and the gall-bladder (Type V stricture of Caroli).

regard to the maximum diameters of the intrahepatic and extrahepatic ducts, or the mean values of the liver function tests (unpaired T-test).

On histopathological examination of the pancreas, six patients had both pancreatic cancer and chronic pancreatitis diagnosed (Figure 46). The details of these patients are shown in Table 25. However, first biopsy of the pancreas of these patients showed evidence of chronic pancreatitis; only at subsequent laparotomies and biopsies or autopsy (in one case) was pancreatic carcinoma diagnosed.

Comparison

Table 26 demonstrates the points of difference between pancreatic carcinoma and chronic pancreatitis patients with cholangiographic abnormalities. Patients with chronic pancreatitis were younger ($P<0.001$); they had significantly lower levels of the total serum bilirubin ($P<0.001$), serum alkaline phosphatase concentration ($P<0.001$), AST ($P<0.001$) and ALT ($P<0.01$). The cholangiograms of patients with pancreatic carcinoma showed significantly greater maximum diameters of the intrahepatic ducts ($P<0.001$), proximal common duct ($P<0.05$) and the gall-bladder

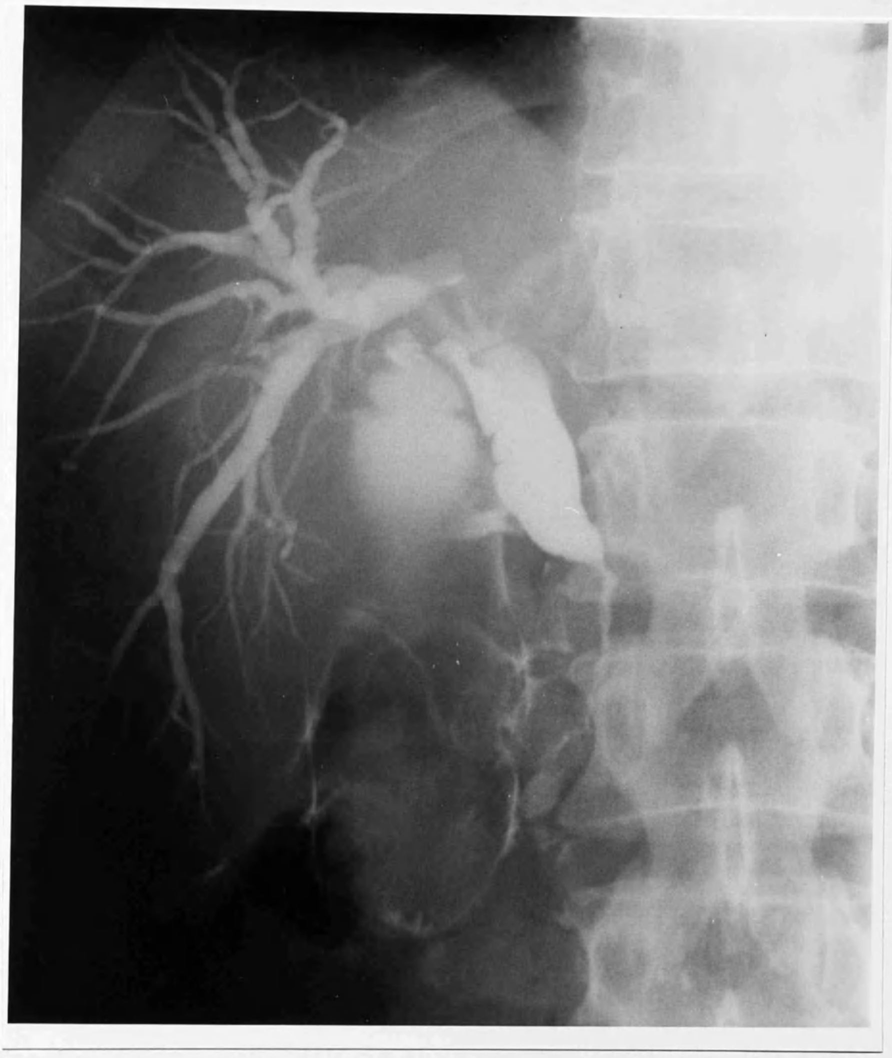

Figure 46 Pancreatic carcinoma and chronic pancreatitis. PTC shows long, irregular and tight stricture involving the mid and lower parts of the common bile duct with moderate dilatation of the proximal ducts and severe dilatation of the gall-bladder.

Table 25 Details of the 6 patients who had both pancreatic carcinoma and chronic pancreatitis on the histopathological examination of the pancreas.

	Patients						
	CT	DE	EH	JS	MG	TM	All cases
Sex	m	m	f	m	f	m	4m/2f
Age in years	66	57	69	32	60	54	56
Maximum diameter (mm)							
Intrahepatic ducts	8	9	8	7	NA	10	8
Common hepatic duct	17	20	20	17	37	21	22
Common bile duct	24	20	25	20	37	21	25
Gall-bladder	--	55	50	44	60	70	56
Cholangiographic abnormalities							
Type (Caroli):	I	I	I	V	I	I	---
Stenosis length (mm)	70	50	45	60	NA	55	56
Total serum bilirubin (μmol/l)	260	115	357	170	440	160	250
Serum alkaline phosphatase (IU/l)	600	1610	2133	610	3500	1460	1652
Aspartate transaminase (IU/l)	141	66	250	44	199	181	147
Alanine transaminase (IU/l)	260	156	354	48	147	510	246

NA, not available.

Table 26 The differentiation points observed between 30 chronic pancreatitis patients having abnormalities of the biliary tract and 53 patients with pancreatic carcinoma.

	Carcinoma (no = 53)	Pancreatitis (no = 30)	P-value	DF
Age (mean & SD)	68 ± 12	49 ± 11	0.001	81
Pancreatic calcifications	0	43% (13/30)		
<u>Caroli classification</u>				
Type I				
no. cases	9	20		
shape:	6 irregular 3 smooth	20 smooth		
stenosis length (mm)	54 ± 10SD	41 ± 16SD	<0.01	28
Type II	4	1		
Type III	2	3		
Type IV	0	3		
Type V	35	1		
Unclassified	3	2		
<u>Maximum diameter</u> (mean & SD)				
Intrahepatic ducts	10 ± 3mm	7 ± 3mm	<0.001	73
Proximal common duct	25 ± 8mm	16 ± 8mm	<0.05	80
<u>Gall-bladder</u>				
visualized	37	16		
diameter (mm)	55 ± 12SD	41 ± 10SD	<0.001	41
contain stones	7 cases	0		
distended	32 (86%)	7 (44%)		
<u>Biochemistry</u> (mean & SE)				
Serum bilirubin μmol/l	276 ± 21	65 ± 21	<0.001	78
Alkaline phosphatase IU/l	1400 ± 105	650 ± 107	<0.001	78
Aspartate transaminase IU/l	129 ± 11	44 ± 5	<0.001	77
Alanine transaminase IU/l	168 ± 20	42 ± 6	<0.001	77
Serum amylase IU/l	286 ± 60	316 ± 64	NS	60
Serum albumin g/l	34 ± 2	35 ± 3	NS	70
Serum creatinine μmol/l	83 ± 6	73 ± 6	NS	65

DF, degrees of freedom; NS, not significant.

($P<0.001$). On the other hand, it is shown in Figure 47 that there is a large degree of overlap between chronic pancreatitis and pancreatic carcinoma patients with regard to the maximum diameters of the intra- and extra-hepatic ducts. Finally, the biochemical differences in groups of patients with identical cholangiographic abnormalities are shown in Table 23.

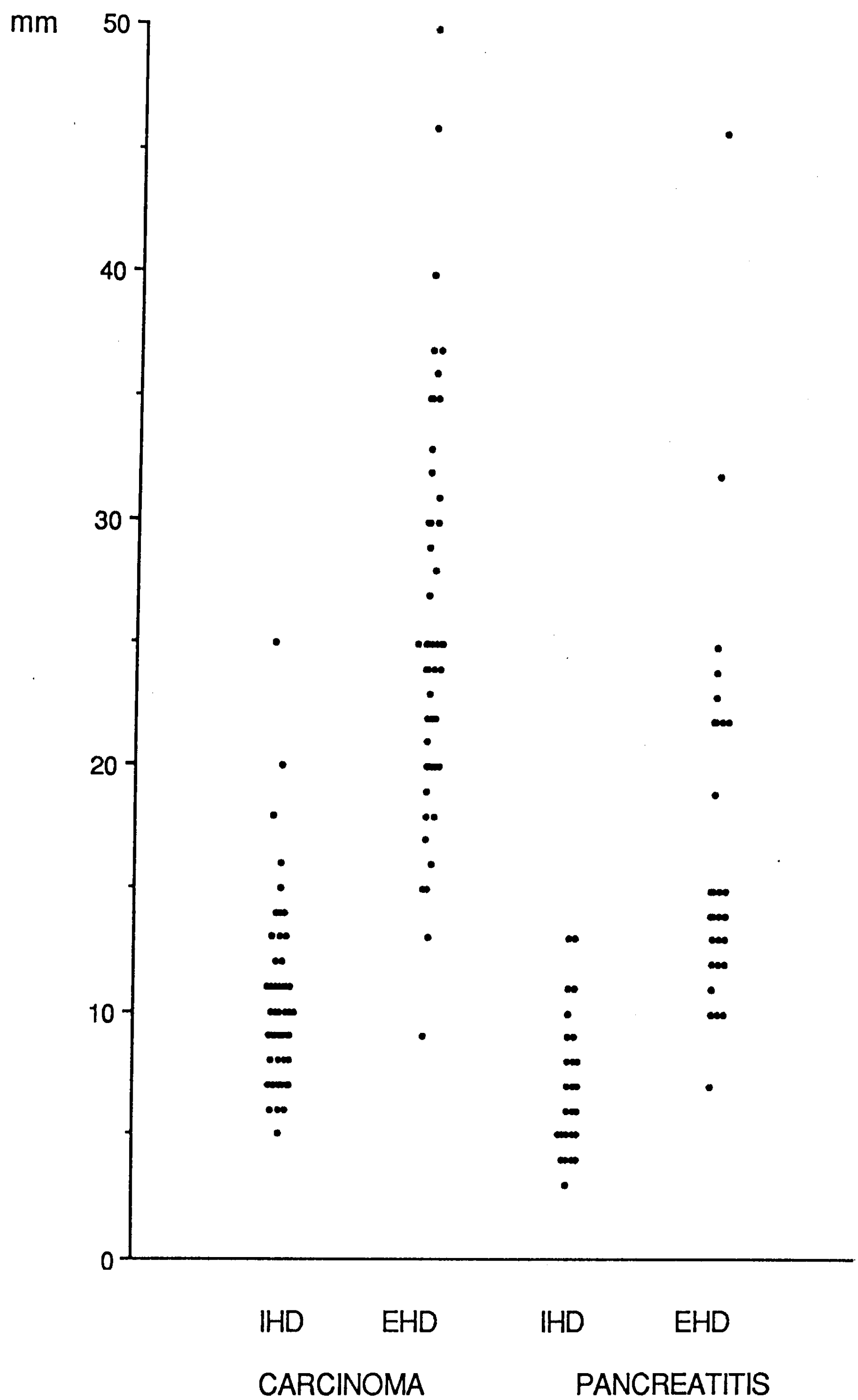

Figure 47 Diagram showing distribution of the maximum diameters of the intrahepatic (IHD) and extrahepatic (EHD) ducts measured to the nearest millimetre proximal to the obstruction/stenosis caused by pancreatic carcinoma and chronic pancreatitis.

DISCUSSION

Chronic pancreatitis

A higher incidence of the abnormalities of the lower common bile duct in patients with chronic pancreatitis has been observed in this study in comparisom with previous reports (Table 27). The incidence of common bile duct stenosis in our 47 chronic pancreatitis patients was almost identical to the figure 63% reported by Sarles et al. (1965) in a series of 100 patients with chronic calcifying pancreatitis. Our patients must have had chronic pancreatitis of sufficient severity to warrant direct cholangiography and this may explain the high incidence of bile duct abnormality. Since bile duct abnormalities are found more commonly on ERCP in severe chronic pancreatitis (69%) than in mild cases (28%; Guien, 1979) this may also account for the different incidence reported in previous series (Table 27). However, the present study demonstrates that the frequency of the Caroli types of cholangiographic abnormalities associated with chronic pancreatitis are comparable with those of previous reports. Type I and type III strictures (Figures 32&34) were seen in 67% and 10% of the abnormal cholangiograms respectively; figures which are comparable with 40-66% for type I and

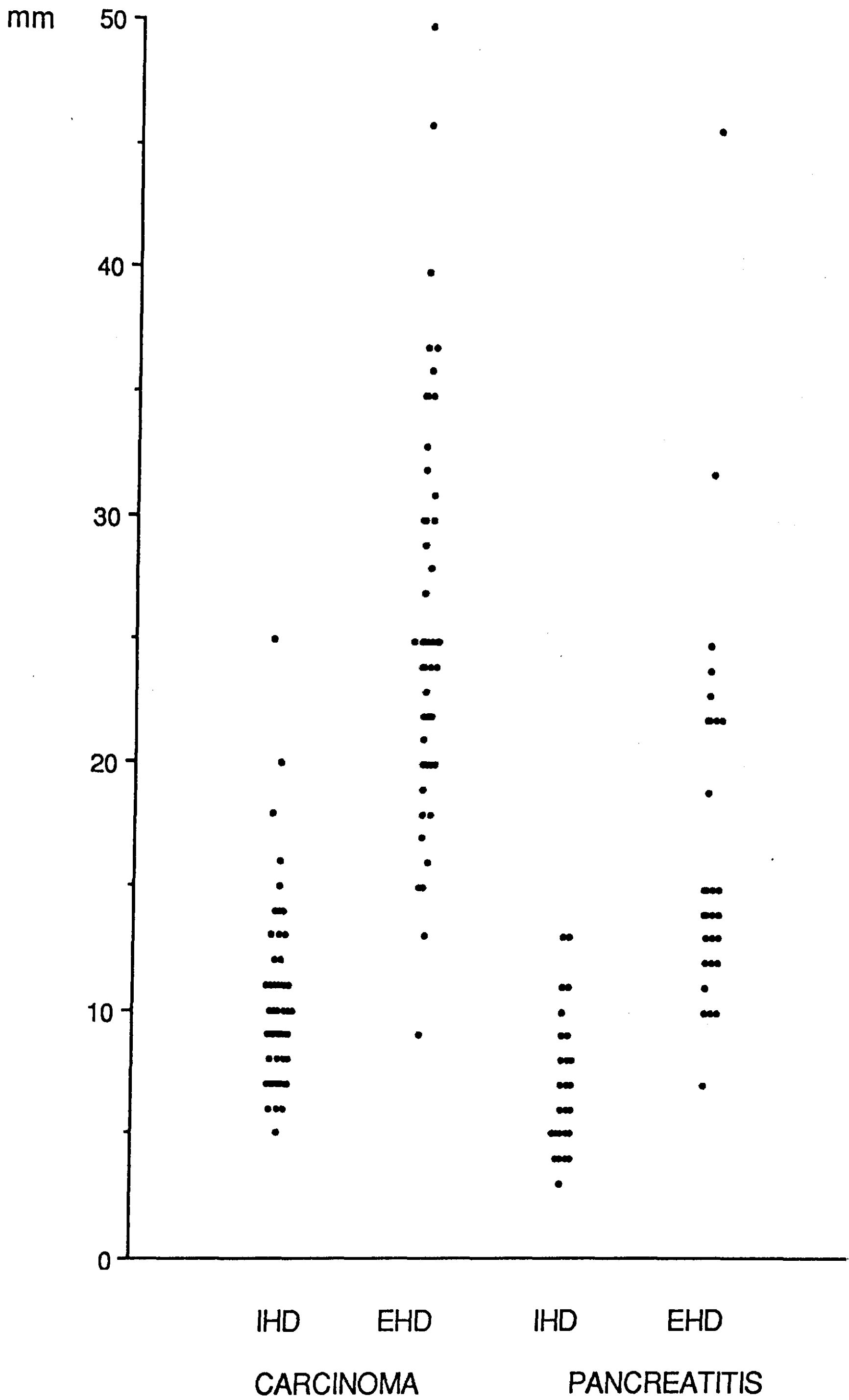

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Table 27 The incidence of abnormalities of the biliary tract associated with chronic pancreatitis in the present and previous studies.

Study	no. cases	Abnormal cholangiograms number	Abnormal cholangiograms incidence
Englholm et al. 1976	179	99	59%
Gregg et al. 1981	21	19	90%
Guien & Camatte, 1971	162	100	61%
Petrozza & Dutta, 1985	151	15	9%
Sarles et al. 1965	100	63	63%
Scott et al. 1977	38	11	30%
Siegel et al. 1979	27	12	44%
Wisloff et al. 1982	79	36	46%
Subtotal	757	355	47%
Present study	47	30	64%
Total	804	385	48%

3-15% for type III strictures reported by others (Engelhom et al. 1976; Guien 1979; Guien & Camatte, 1971; Sarles et al. 1965; Wisloff et al. 1982). Although type II, type IV, and type V strictures are not usual cholangiographic findings in chronic pancreatitis, the observed incidence in the present study (Table 23) are also comparable with the range of 2-6% reported previously (Engelhom et al. 1976; Freeny & Lawson, 1982; Guien & Camatte, 1971; Sarles et al. 1958). Two of the chronic pancreatitis patients in the present study had stones in their common bile duct which resulted in atypical cholangiographic abnormalities. However, Gregg et al. (1981) found common bile duct stones in four of their 19 patients with chronic pancreatitis.

The reported figures for the mean maximum diameter of the common duct proximal to obstruction in chronic pancreatitis patients are 11 to 13mm (range: 6-28) (Gregg et al. 1981; Petrozza & Dutta, 1985; Sarles et al. 1965). The diameters are narrower than the 18mm found in the present study. Furthermore, the length of the stenotic part in the study by Gregg et al. (1981) (range: 4-30mm, mean 15mm) was shorter in comparison with the present study (range: 10-75mm, mean 41mm).

Gall-bladder stones are relatively unusual in chronic pancreatitis (Guien & Camatte, 1971); Sarles et al. (1965) found gall-bladder stones in only two of their series of 100 patients with chronic pancreatitis. The present study did not find gall stones in the gall-bladder of the 28 patients who had their gall-bladder opacified at direct cholangiography; this was also the case in the 54 patients with chronic calcifying pancreatitis reported from Brazil (Dani et al. 1974).

All the patients with chronic pancreatitis who had an elevated total serum bilirubin , also had elevated serum alkaline phosphatase concentrations. On the other hand, only 48% (11/23) of the cases with elevated serum alkaline phosphatase concentration had an elevated total serum bilirubin level. Therefore, serum alkaline phosphatase concentration is a better index for the radiological involvement of the biliary tract by the inflammatory process. Lesser degrees of stenosis may produce no symptoms or signs but may still be suggested by elevations in serum alkaline phosphatase concentration, a finding observed previously (Snape et al. 1976). Figure 39 shows that 91% of the patients with elevated serum alkaline phosphatase concentration (>300 IU/1) and 100% of the patients with elevated ALT, regardless of the level of total serum bilirubin or presence or absence of clinical jaundice, had some form of abnormality of the biliary tract. Therefore, persistent abnormality of the liver function tests should alert the clinician to the possibility of common bile duct stenosis and biliary radiology should then be mandatory.

The study has demonstrated that an elevated serum alkaline phosphatase concentration is present in 70% and an elevated total serum bilirubin level is present in 23% of chronic pancreatitis patients with abnormal cholangiograms (Figure 39). These figures are well below the 93% figure for elevated serum alkaline phosphatase concentration reported by Petrozza & Dutta (1985) and the 50% elevated total serum bilirubin level reported by Wisloff et al. (1982). Therefore, the present study demonstrates that direct cholangiography is still the best method to define involvement of the biliary tract by chronic pancreatitis. However, the significance of asymptomatic radiological stenosis of the common bile duct associated with chronic pancreatitis is not clear (this will be discussed in chapter 5).

The present study has showed that there are no significant biochemical differences can be demonstrated between different types of the cholangiographic abnormalities (Caroli classification) associated with chronic pancreatitis (Table 23). Therefore, the classification cannot predict the severity of the disease and extent of involvment of the bilary tree, or help in selecting patients who are in need of a biliary bypass operation. Furthermore, although the pattern of bile duct abnormality in association with chronic pancreatitis and other pancreatic diseases have been carefully documented (Caroli & Nora, 1952; Guien, 1979), the criteria for determining the presence of common bile duct stenosis appear imprecise (see Figure 2, chapter 1). Type I stenosis is most frequently encountered in chronic pancreatitis but it need not be associated with any dilatation of the proximal biliary tree. While there should be no dispute about severe obstruction, minimal changes in the biliary tree may be difficult to evaluate and label correctly, particularly if radiological assessment has depended on the relatively poor quality radiograms obtained at cholecystography or intravenous cholangiography. Evaluation of biliary tree stenosis should be based on cholangiograms obtained by ERCP or PTC. Furthermore, stenosis might be more accurately defined if the definition was restricted to radiological narrowing of the common bile duct to less than a certain diameter, or to narrowing which results in defined dilatation of the proximal biliary tree. Only when such a definition is agreed can we hope to rationalise our understanding of the extent of the problem and its treatment.

Pancreatic carcinoma

Kruse et al. (1978) have reported biliary tract abnormalities in 93% of their patients with pancreatic carcinoma. The figure from the present study (Table 22) must be interpreted with caution, since the study has only included patients with pancreatic carcinoma who had had some form of direct cholangiography preoperatively.

Forty (75%) of 53 patients with pancreatic carcinoma in the present study showed complete or near-complete obstruction of the biliary tract (35 type V, 4 type II and 1 unclassified stricture). Although a rat-tailed obstruction is deemed typical in pancreatic carcinoma, the configuration of the terminus may be smoothly and symetrically tapered, conical, or only slightly eccentric and irregular. A nipple or beak at the point of obstruction or non-specific rounded appearance are quite common (Friedman et al. 1987).

Therefore no matter what its cholangiographic appearances, any complete or near complete stricture/ obstruction in the mid or distal common duct is highly suspicious for carcinoma of the head of the pancreas.

Type V stricture formation was observed in 47 (60%) of 78 pancreatic carcinoma patients by Guien (1979), and type I stricture in 8 (14%) of 57 patients by Guien & Camatte (1971), figures which are comparable with those of the present study (Table 23). However, five of the 9 cancer patients who had type I cholangiographic abnormalities actually had combination of both pancreatic carcinoma and chronic pancreatitis however the strictures were tighter, longer and irregular in shape (Figure 46). Although all these patients had clinical features of chronic pancreatitis and were jaundiced, their radiological and biochemical datas were more in favour of primary malignant obstruction (Table 25).

Rarely, metastatic disease near the head of the pancreas causes common bile duct obstruction or encasement that is indistinguishable from primary pancreatic malignancy (see Figure 29, Chapter 3). Carcinoma of the pancreas, on the other hand, can produce biliary obstruction at the level of the common hepatic duct or at any level upto porta hepatis by virtue of direct extension or nodal compression (Figure 41). Furthermore, intrahepatic ducts compression is produced by liver metastasis from pancreatic carcinoma without stenosis of the common bile duct (Figure 40). These cholangiographic abnormalities have also been observed by other workers (Friedman et al. 1987).

Comparison of chronic pancreatitis and pancreatic carcinoma

From 40 successful ERCP in 43 (biopsy-proven) pancreatic carcinoma patients, the diagnosis of carcinoma on the basis of pancreatic duct stenosis or obstruction is suggested in 30 patients and on the basis of common bile duct stenosis or obstruction in 7 patients of whom 5 had normal pancreatograms (Silvis et al. 1976). These authors reported that both ducts were abnormal in only 19 of the 40 patients. Therefore, the degree of involvement of pancreatic duct and bile ducts is not always of similar importance in patients with pancreatic carcinoma. The same is true with in patients with chronic pancreatitis (Sahel, 1986). This stresses the usefulness of visualization of both duct system for accurate diagnosis and evaluation of chronic pancreatitis and pancreatic carcinoma.

This is the first reported study which has concentrated on the cholangiographic differences of chronic pancreatitis and pancreatic carcinoma with a relatively large number of patients. Table 26 shows that patients with chronic pancreatitis are younger than their fellows with pancreatic carcinoma. Patients with pancreatic cancer have greater dilatation of the intrahepatic and extrahepatic biliary ducts which is also reported previously (Guien, 1979). However, Figure 47 shows that there is a large degree of overlap regarding the maximum diameters of the intrahepatic and extrahepatic ducts proximal to the obstruction between chronic pancreatitis and pancreatic carcinoma patients. In individual cases the measurement of the biliary ducts diameter (such as by ultrasound) therefore of limited value in differentiation. None of the six cases with chronic pancreatitis and pancreatic cancer and of the 47 cases with carcinoma of the pancreas only in this study had pancreatic calcifications on plain films. Therefore, the present study supports previous reports in suggesting that presence of pancreatic calcification strongly excludes pancreatic carcinoma (Freeny & Lawson, 1982).

Table 26 shows that chronic pancreatitis patients had shorter length of common bile duct stenosis (P<0.01) and as reported previously, irregularity of the stenotic part of the common bile duct was exclusively seen in the cancer group (Kruse et al. 1978). The absence of a transitional zone and presence of an abrupt boundary between the stenosis and the resulting dilatation are more in favour of cancer than pancreatitis in which the entrance to the narrowing is gradul (Guien, 1979). It has been suggested that tumours arising in the head of the pancreas often cause similar abnormalities of the both the main pancreatic duct and contiguous common bile duct, such as obstruction or encasement "double-duct sign" (Freeny et al. 1976). However, the double duct sign is not pathognomonic of pancreatic carcinoma. The present study and that of Gilinsky et al. (1986) demonstrated double duct signs in patients with chronic pancreatitis as diagnosed at laparotomy and biopsy (Figure 38).

The present study agrees with others (Caroli & Nora, 1952) that a distended gall-bladder is more frequent with pancreatic carcinoma (86%); the gall-bladder may be distended in chronic pancreatitis (44%) but usually to a lesser extent (48 $\pm$ 6mm) than in pancreatic carcinoma (57 $\pm$ 12mm).

Non-specific ductal changes may render a definitive diagnosis impossible. While some workers have experienced no difficulty in differentiating chronic pancreatitis from pancreatic carcinoma on ERCP (Freeny et al. 1976; Rohrmann et al. 1974), the present study like others (Caletti et al. 1982; Frick et al 1982; Silvis et al. 1976) could not always make the distinction on cholangiographic appearances. The morphological appearances are sometimes similar and both conditions may co-exist. Type I and type III are typical findings in chronic pancreatitis (Figures 32&34), however, they can also be found in patients with pancreatic carcinoma (Figures 42&44). It is then difficult to differentiate between the two conditions. On the other hand, type V stricture which is specific to the pancreatic carcinoma (Figure 45), can also be difficult to differentiate when it associated with chronic pancreatitis (Figure 38). However, the present study demonstrated significant differences between chronic pancreatitis and pancreatic carcinoma patients regading the associated biochemical changes in patients who had the same types of the cholangiographic abnormalties (Table 23); this could be of some help in making the correct diagnosis.

Most investigators agree that if carcinoma and chronic pancreatitis co-exist, it is virtually impossible to make a specific radiologic diagnosis (Reuben et al. 1978). A distended gall-bladder, tighter and longer stenosis of the common bile duct, greater dilatation of the biliary duct system proximal to stenosis, and high values of total serum bilirubin, AST, ALT, and serum alkaline phosphatase concentration should make surgeons think of the possibility of underlying pancreatic cancer when patient presents with clinical features of chronic pancreatitis (Tables 25&26, Figure 46).

In spite the fact that both the present study and the study by Kruse et al. (1978) observed that patients with pancreatic carcinoma have a greater dilatation of the biliary system proximal to the stricture, irregularity of the stricture of the common bile duct is exclusively seen in patients with pancreatic carcinoma and the cancer group have higher levels of the associated liver function tests. However, these findings are not pathognomonic and the present study found a large degree of overlap between the two conditions with regard to the maximum diameters of the intra- and extra-hepatic ducts (Figure 47) and the values of the liver function tests. Therefore, a safe differentiation between chronic pancreatitis and pancreatic carcinoma in an individual patient cannot exclusively rely on cholangiography, but should be based upon histopathological examination of the lesion.

CHAPTER 5

HEPATOBILIARY COMPLICATIONS OF CHRONIC PANCREATITIS (STUDY IV)

AIM OF THE STUDY

Common bile duct stenosis is a well recognised complication of chronic pancreatitis but its incidence, significance and natural history is uncertain. Study III has addressed the first issue (see chapter 4) and found that direct cholangiography is the most sensitive method to detect the involvement of the biliary tract by the inflammatory process. The present study was intended to address the significance of the radiological stenosis of the common bile duct by correlating the biochemical, radiological and histological sequelae of this complication in an unselected, consecutive group of patients undergoing surgery for chronic pancreatitis.

PATIENTS AND METHODS

Thirty-nine consecutive patients undergoing surgery for chronic pancreatitis between 1st January 1984 and 31st January 1987 in Glasgow Royal Infirmary had peroperative liver biopsy performed. The patients comprised 32 males and 7 females with a median age of 42 years (range 27-72 years). Chronic pancreatitis was considered secondary to alcohol abuse in 30 patients (77%), pancreas divisum in one and polyarteritis nodosa in one. No definite aetiological factor could be established in the remaining 7 patients although one had gallstones at the time of diagnosis of chronic pancreatitis and one had hypercalcaemia although primary hyperparathyroidism was not confirmed. Eight patients (21%) had previously undergone pancreatic surgery but none had undergone a previous biliary-enteric bypass. Five had previously undergone cholecystectomy. The indications for surgery during the index admission included obstructive jaundice in 6 patients and the presence of a cyst or pseudocyst in 7. In the remainder, pain, inadequately controlled by narcotic analgesics, was the predominant indication for surgery. The median duration of symptoms prior to surgery was 36 months, ranging from 2 weeks (in one patient with jaundice) to 14 years.

Pre-operative assessment

Pre-operative assessment in all patients included routine liver function tests and ultrasound scan of the pancreas, liver and biliary tree. Radiology of the biliary tree was attempted pre-operatively in 38 of the 39 patients, at the time of endoscopic retrograde cholangiopancreatography (ERCP) in 33 and by percutaneous transhepatic cholangiogram (PTC) in 5. In those patients judged to have a common bile duct stenosis based on the presence of a persistent narrowing of a portion of the duct, this was categorised according to the classification of Caroli and Nora (1952). Both type I stenosis (long retropancreatic stenosis) and type III stenosis ("hourglass-type" narrowing of the mid common bile duct at the upper border of the pancreas) are considered characteristic of chronic pancreatitis (see Figure 2, chapter 1). Stricture at the sphincter of Oddi (type II) is typical of periampullary lesions. Type IV stenosis (medial or lateral compression with deviation of the common bile duct) may be associated with chronic pancreatitis, cyst or carcinoma, while the type 5 stenosis (complete occlusion of the duct at the upper border of the pancreas) is characteristic of pancreatic cancer. The cholangiograms were assessed by the author who was unaware of the clinical details, and the stenosis length and maximum diameter of the duct above the stenosis were measured.

Surgery

Fourteen patients underwent formal pancreatic resection (distal pancreatectomy-9, pancreaticoduodenectomy-2 and total pancreatectomy-3). Two of the patients undergoing distal pancreatectomy had the duct in the pancreatic remnant drained by pancreaticojejunostomy. Eight patients underwent longitudinal pancreaticojejunostomy without resection. Three patients had a transduodenal sphincteroplasty with removal of stones from the pancreatic duct (Hansell et al. 1986) and one patient with pancreas divisum had accessory duct sphincteroplasty. Five patients underwent cystogastrostomy, and one had needle aspiration of multiple cysts in the head of the pancreas. One patient had pancreatic biopsy alone. Six patients (15%) had a biliary-enteric bypass performed comprising cholecystjejunostomy in 3 (one with additional pancreaticojejunostomy), choledochojejunostomy in 2 (one with pancreaticojejunostomy and one with gastrojejunostomy) and choledochoduodenostomy in one.

Liver histology

The liver biopsy was usually taken from the right lobe, using the Tru-Cut biopsy needle (Travenol Laboratories, Illinois, USA). The biopsies were processed by standard means and sections routinely stained with haematoxylin and eosin, Masson's trichrome, Gordon and Sweets' reticulin and PAS/diastase. Where appropriate Perls' iron stain and Shikata's orcein stain were performed. The biopsies were examined by an independent pathologist (Professor RNM MacSween) unaware of the patients' clinical details. Following the initial morphological assessment clinico-pathological correlations were examined and the final morphological diagnoses agreed.

Statistics

Statistical analysis of the differences between groups of patients was performed by the Mann-Whitney U test. The differences between groups were considered statistically significant when the probability of their arising by random sampling error was less than 1 in 20 ($P < 0.05$). The definitions of the statistical terms used in the chapter are listed in Appendix 3.

RESULTS

Biochemistry

Six patients (15%) were clinically jaundiced prior to surgery (mean serum bilirubin concentration 156 μmol/l, normal range 3-22 μmol/l). Serum alkaline phosphatase concentration was elevated in 19 patients (49%) with 12 (31%) having an elevation greater than twice the upper limit of normal. Serum aspartate transaminase concentration was elevated in 12 patients (31%) but in only 3 patients was the elevation greater than twice normal. Alanine transaminase concentration was elevated in 11 patients (28%), and in 4 patients this elevation was greater than twice normal.

Radiology

Biliary radiology was obtained in 26 patients (67%). Sixteen of these 26 patients (62%) were considered to have stenosis of the lower common bile duct. Diameters of the bile duct above the stenosis in these 16 patients ranged from 7 to 25mm (mean 15mm) and the stenosis length varied from 10 to 70mm (mean 36mm). The remaining 10 patients all had normal biliary radiology with maximum duct diameters ranging from 5 to 15mm (in a patient following cholecystectomy). The mean duct diameter in these patients was 9mm and was significantly different from those with a stenosis ($p < 0.001$). Twelve patients were considered to have type I biliary stenosis and there was one case each of types II, III, IV and V.

Histology

Twenty-three liver biopsies were considered to show non-specific features; 5 of these had minimal fatty infiltration, increased lipofuscin deposition and nuclear polypliody; 18 showed reactive changes of varying degree comprising Kupffer cell hyperplasia, increased numbers of intra-sinusoidal mononuclear cells including occasional ceroid-laden macrophages, and a mild, often focal infiltration of mononuclear cells in the portal tracts. In 11 patients the biopsy showed histological features consistent with biliary tract disease. In 7 patients there was cholestasis with mild portal tract changes comprising oedema, cholangitis and increased prominence of marginal bile ducts. In one patient there was cholestasis and more severe portal tract changes comprising oedema, cholangitis, marginal duct proliferation, cholangiolitis and some portal fibrosis. In 3 biopsies there were features of a secondary sclerosing cholangitis with fibro-obliterative lesions affecting interlobular bile ducts; in all 3 biopsies there was portal fibrosis and in two there were superimposed features of an acute cholangitis with a moderately intense peri-ductal and portal tract neutrophil polymorph infitrate.

The remaining five patients comprised two cases of mild perivenular scarring (possibly residual to alcohol-induced injury), one case each of alcoholic hepatitis, resolving acute hepatitis (possibly of drug or viral aetiology) and cirrhosis (possibly of alcohol aetiology in that there was a previous clinical history of alcohol abuse although the biopsy did not show features of a superimposed alcoholic hepatitis).

Biochemical/radiological/histological correlations

All 6 jaundiced patients had bile duct stenosis. Of the 26 patients with a pre-operative cholangiogram, 10 (71%) of the 14 patients with an elevated serum alkaline phosphatase concentration (including all 9 with an elevation greater than twice normal) had radiological evidence of bile duct stenosis. Alkaline phosphatase concentrations were also elevated in 4 patients found radiologically to have a normal common bile duct. Nine (90%) of those with an elevated aspartate transaminase level and 8 (89%) of those with an elevation in serum alanine transaminase concentration had bile duct stenosis demonstrated.

Seven (44%) of the 16 patients with common bile duct stenosis exhibited histological features of extrahepatic biliary obstruction (Table 28) as did 5 (83%) with clinical jaundice, 8 (67%) with alkaline phosphatase elevation greater than twice normal and 6 (67%) of the 9 patients with both alkaline phosphatase elevation greater than twice normal and common bile duct stenosis. The maximum common bile duct diameters (mean & SD) were similar whether histological features of extrahepatic biliary obstruction was present or not (17 $\pm$ 4mm vs. 14 $\pm$ 6mm) but the mean stenosis length was longer (44 $\pm$ 23mm vs. 29 $\pm$ 12mm) the difference, however, failing to reach statistical significance. The senstivities and specificities of each parameter for predicting the presence of extrahepatic obstruction on liver biopsy are shown in Table 29.

Surgery

The presence of jaundice was the major indication for biliary-enteric bypass and 4 of the 6 patients jaundiced pre-operatively underwent either biliary-enteric bypass (in 3) or pancreaticoduodenectomy (as pancreatic carcinoma could not be excluded) in one. All 3 patients had bile duct stenosis but only 3 had histological features of extrahepatic obstruction on biopsy, the fourth having alcoholic hepatitis. The two remaining jaundiced patients did not have a biliary-enteric bypass performed (see below).

Table 28 Biochemical, histological and operative data on 16 patients with radiologically demonstrated common bile duct stenosis.

Patients	Bilirubin (μmol/l)	Alkaline phospatase (IU/l)	Liver histology	Operation
AD	175	680	EHO-severe	Cystogastrostomy
BG	155	2080	EHO/SSC	Cholecystojejunostomy
JSw	185	670	EHO/SSC	Choledochoduodenostomy
CL	335	660	EHO	Cholecystojejunostomy
TW	57	1470	EHO	Transduodenal sphincteroplasty
WMcA	67	1100	Alc Hep	Pancreatico-duodenectomy
EMcC	26	4100	EHO	Cholecystojejunostomy/ Pancreaticojejunostomy
MH	11	680	Cirrhosis	Choledochojejunostomy/ Gastrojejunostomy
MHy	10	1070	NSR	Choledochojejunostomy/ Pancreaticojejunostomy
AA	23	380	Hepatitis	Distal pancreatectomy
JC	10	210	NSR	Pancreaticojejunostomy
JS	12	190	NSR	Pancreaticojejunostomy
LF	8	150	EHO	Transduodenal sphincteroplasty
MM	11	245	NSR	Transduodenal sphincteroplasty
RR	6	160	NSR	Cyst aspiration
RS	12	205	NSR	Cystogastrostomy

EHO, extrahepatic biliary obstruction; SSC, secondary sclerosing cholangitis; AIc Hep, alcoholic hepatitis; NSR, non-specific reactive changes.
(Normal-bilirubin <22 μmol/l, alkaline phosphatase <280 IU/l)

Table 29 Analysis of parameters predicting the presence of extrahepatic biliary obstruction on liver biopsy in 39 patients with chronic pancreatitis.

Parameter	SN	SP	Predictive values positive	Predictive values negative
Jaundice	45%	96%	83%	82%
Alkaline phospatase	91%	68%	53%	95%
Alkaline phospatase (>2N)	73%	86%	67%	89%
Aspartate transaminase	64%	82%	58%	85%
Alanine transaminase	55%	82%	55%	82%
Common bile duct stenosis*	87.5%	50%	44%	90%

SN, sensitivity; SP, specificity.
* Only on 26 patients with successful cholangiogram.

Three other non-jaundiced patients with common bile duct stenosis and an elevated alkaline phosphatase concentration pre-operatively also had a biliary-enteric bypass performed. Only one of these patients had histological features of extrahepatic biliary obstruction on liver biopsy; one had cirrhosis and the other non-specific features.

Outcome

Three of the 6 patients having biliary-enteric bypass had an uncomplicated postoperative recovery and none have since developed recurrent jaundice or cholangitis with a follow-up of at least 6 months. Two patients undergoing cholecystjejunostomy developed recurrent jaundice at 2 months and 2 years postoperatively. Cholangiography in both patients showed a non-functioning biliary-enteric anastomosis, one having developed biliary debris and the other gallstones in the common bile duct. Both have since undergone Roux-en-Y choledochojejunostomy and currently remain free of symptoms. The sixth patient had a choledochoduodenostomy but developed further pain and 5 months later underwent pancreaticojejunostomy. Biopsies of the pancreatic head had, on both occasions, shown chronic pancreatitis. He remained syptomatic and has since undergone pancreaticoduodenectomy when histology showed a small, unsuspected pancreatic carcinoma with surrounding pancreatitis.

Three of the other 10 patients with radiological bile duct stenosis were jaundiced; one underwent pancreaticoduodenectomy and remains well but 2 others who did not have biliary-enteric bypass developed postoperative biliary complications. One developed a bile leak after cholecystectomy, transduodenal sphincteroplasty and exploration of the pancreatic duct. Leakage from the cystic duct stump was demonstrated by fistulography but this settled on conservative treatment. The other patient, an alcoholic, had presented late with advanced biliary obstruction and haemorrhage into a large pseudocyst. Liver function improved during a period of percutaneous biliary drainage. He underwent cystogastrostomy but without biliary-enteric bypass. His biliary obstruction was not relieved by drainage of the pseudocyst and he died one month later from liver failure. Of the remaining 7 patients with common bile duct stenosis, two have had further pain and are to undergo pancreatic surgery, one has died of a myocardial infarction and 4 others remain well. None have had any symptoms related to the biliary tree.

DISCUSSION

The incidence of common bile duct stenosis reported in the literature varies widely (see Table 27, chapter 4) and is difficult to evaluate due to differences in patient selection and the diagnostic criteria used to define chronic pancreatitis and common bile duct stenosis. Radiological evidence of common bile duct stenosis was found by Sarles et al. (1965) in 65% of a series of 100 patients with chronic calcifying pancreatitis. The lowest incidence of common bile duct stenosis (4%) was reported from a large series of 1262 patients (Aranha et al. 1984). These patients were not screened biochemically or radiologically for the presence of common bile duct stenosis and this figure represents the small proportion of patients with clinically apparent common bile duct obstruction; it undoubtedly underestimates the true incidence of common bile duct stenosis. Bile duct abnormalities are found more commonly in severe chronic pancreatitis, as assessed by ERCP, than in mild cases (69% vs. 28%) (Guien, 1979) and this may also account for the different incidence reported in various series.

The incidence of common bile duct stenosis in the 26 evaluable patients was high at 62% which is comparable to the figure 64% found in the study III (Table 27) and almost identical to that reported by Sarles et al. (1965). All 39 patients in the present study had chronic pancreatitis of sufficient severity to warrant surgery and this may explain the high incidence of bile duct abnormality. However, because 13 of the 39 patients in the present study did not have biliary radiology this figure must be interpreted with caution. None of these 13 patients had been jaundiced, although 5 had alkaline phosphatase elevations which, in 3 of them, exceeded twice the upper limit of normal. On liver biopsy 3 of these 13 patients showed features of extrahepatic obstruction. This suggests that the total number of patients with common bile duct stenosis in this series may have been between 19 (49%) and 21 (54%) of the total group of 39 patients and could be higher. Therefore at least half the patients coming to surgery for chronic pancreatitis may have some degree of biliary obstruction with important implications for treatment.

Jaundice in an alcoholic may be diagnosed as alcoholic hepatitis or cirrhosis when unsuspected extrahepatic biliary obstruction is the cause (Warshaw et al. 1976) and conversely hepatocellular disease may mimic the biochemical features of extrahepatic biliary obstruction (Phillips & Davidson, 1957). Despite alcohol being the putative aetiological factor in 77% of our patients the incidence of significant alcoholic liver disease (5%) was small and an infrequent cause of biochemical derangement compared with Bradley and Salam's (1978) experience.

The results of the present study study show that, even in the presence of radiological stenosis of the common bile duct, liver enzyme abnormalities do not always reflect extrahepatic biliary obstruction, the presence of which may only be confirmed by liver biopsy. All but one of the 11 patients with histological features of extrahepatic biliary obstruction had abnormal liver function tests. Therefore, even in the presence of radiological common bile duct stenosis, normal liver function tests suggest that extrahepatic biliary obstruction is unlikely and that liver biopsy and biliary bypass surgery are not indicated.

The role of surgery in anicteric patients with common bile duct stenosis who manifest persistent alkaline phosphatase elevation is more controversial. Sarles and Sahel (1978) consider that these patients, because they have a more dilated proximal bile duct, may have more prolonged bile duct obstruction than those who present with jaundice. Biliary-enteric bypass may be considered in such patients to prevent secondary biliary cirrhosis which, although a rare complication in most series, was reported in 10% of one series of 50 patients undergoing peroperative liver biopsy (Leger et al. 1972). In another series an incidence of 29% was recorded in 24 patients with common bile duct stenosis complicating chronic alcoholic pancreatitis, these patients have been detected by screening a larger group for persistent alkaline phosphatase elevation (Afroudakis & Kaplowitz, 1981). It is probable that biliary cirrhosis usually develops over many years in neglected or unsuspected biliary obstruction but rapid progression from cholestasis to biliary cirrhosis over the space of a year has been documented (Warshaw et al. 1976). Secondary biliary cirrhosis was not seen in any of the 39 patients. Portal tract fibrosis, a finding which others have observed commonly (Afroudakis & Kaplowitz, 1981) was present in 4 cases in the present study. In 3 of these 4 patients there were fibro-obliterative lesions of the interlobular bile ducts indicating the development of a secondary sclerosing cholangitis. In these 3 cases we would envisage a greater liklihood of progressive cholestatic liver disease, which in the absence of fully adequate biliary drainage, would result in secondary biliary cirrhosis.

Jaundice was the indication for surgery in 6 of the 39 patients in the present study. Whereas, three patients had a biliary-enteric bypass performed for serum alkaline phosphatase elevation in association with common bile duct stenosis but only one had features of extrahepatic biliary obstruction on biopsy. Isolated elevation of alkaline phosphatase was, therefore, a less common indication for biliary-enteric bypass than jaundice and less specific for the presence of extrahepatic biliary obstruction.

Of the 6 patients undergoing biliary-enteric bypass, 2 of the 3 treated by cholecystjejunostomy had recurrent jaundice. While cholecystjejunostomy may be adequately palliative in obstruction due to pancreatic carcinoma it is inappropriate in chronic pancreatitis. Others have reported similar problems (Gregg et al. 1981).

Persistent abnormality of the liver function tests in patients with chronic pancreatitis should be prompt ultrasound scan and full radiological assessment of the biliary tree. Persistent jaundice in the presence of radiological common bile duct stenosis is a strong indication for biliary-enteric bypass but pre-operative liver piopsy is suggested in those with isolated elevation of alkaline phosphatase. There is no place for routine biliary-enteric bypass during surgery for chronic pancreatitis.

Chapter 6

GENERAL DISCUSSION AND CONCLUSION

ULTRASOUND

Ultrasound plays the pivotal role in the evaluation of jaundiced patients by differentiating obstructive from nonobstructive jaundice. When the US diagnosis is compared to that made using direct cholangiography, the ability of US to detect the presence or absence of intrahepatic biliary dilatation is 93% (Trought et al. 1980); the corresponding figure is 97% in patients having extrahepatic obstruction and 84% in those with intrahepatic cholestasis (Haubek et al. 1981). Although it has been suggested that intrahepatic biliary dilatation is a reliable indicator of obstruction (Haubek et al. 1981), O´Connor et al. (1986) found dilated intrahepatic biliary ducts in only 5 of their 29 patients with choledocholithiasis. This given a 83% false negative rate if the diagnosis of biliary obstruction was based soley on finding dilated intrahepatic ducts on US. Conversely, patients who have obstruction of only one of the two major intrahepatic ducts (or segmental ductal obstruction) leading to segmental intrahepatic biliary dilatation will not be jaundiced although they will usually have other biochemical abnormalities (Myracle et al. 1981). Non-dilatation of the intrahepatic ducts does not exclude dilatation in other parts of the biliary tree; it is well recognised that the distal common duct alone may dilate while the proximal ducts remain normal, in keeping with La Place's law. Sequential scanning of the biliary tree in monkeys with surgical common bile duct ligation has confirmed these clinical observations (Shawker et al. 1981). In this animal model, dilatation of the gall-bladder and distal common duct occurs at about 24 hours. Dilatation progresses proximally with intrahepatic ducts becoming affected at about one week. Bilirubin elevation is first detected within 48-72 hours. After release of the obstruction, dilatation resolves in reverse order with the distal common duct being the last to return to normal at 30-50 days. This suggests that dilated intrahepatic ducts should probably be regarded as a late sign of established biliary obstruction. Furthermore, if the extrahepatic ducts are normal when the intrahepatic ducts are dilated, the obstruction is probably located at porta hepatis, where lymphadenopathy or cholangiocarcinoma is usually the cause.

In 100 normal persons evaluated by US at the University of British Columbia, the maximum diameter of extrahepatic duct was 4mm (Cooperberg et al 1980). Although a small number of patients have extrahepatic duct wider than 4mm without obstruction following cholecystectomy, it has been suggested that a diameter of 5mm or more should be regarded abnormal and justifying further investigations (Cross et al. 1983; Cooperberg et al. 1980). However, most authors regard a maximum diameter of 7mm or more as a definite indicator of obstruction (Baron et al. 1982; Haubek et al. 1981). Furthermore, patients may have common bile duct dilatation without obstruction or jaundice (Weinstein & Weinstein, 1980). It has been suggested that age, chronic inflammation, and prolonged obstruction act to destroy the elastic recoil of the duct wall, resulting in persistent dilatation after spontaneous or surgical relief of previous obstruction (Ferrucci et al. 1983). Conversely, there are patients with obvious jaundice due to surgical obstruction who have a nondilated biliary system (Muhletaler et al. 1980; Trought et al. 1980). Beinart et al. (1981) reported a 9% incidence of a nondilated but obstructed biliary system in a series of 150 PTCs. Explanations for this phenomenon include acute obstruction without time to dilate, a ball-valve effect, and periductal tumour growth or scarring preventing dilatation (Friedman et al. 1987).

In the present study, the sensitivity of satisfactory US scans in determining the presence or absence of biliary tract obstruction was 88%, a figure which is comparable with the results of previous studies (Baron et al. 1982; Haubek et al. 1981; Trought et al. 1980). Therefore, when no obstruction is seen in the biliary system on sonography, nonobstructive jaundice is usually considered to be the diagnosis. But if the clinical suspicion of obstruction is sufficiently high, direct cholangiography should still be performed. This has been emphazised particularly in patients with persistent evaluation of the serum alkaline phosphatase concentration (Mueller et al. 1981).

A wide range of accuracy has been reported with regard to the correct determination of both the level and cause of biliary dilatation, based on US findings. At one extreme are the reports by Haubek et al. (1981) and Koenigsberg et al. (1979), who used US findings to determine correctly the level of dilatation in 95% (35/37) and 94% (30/32) of patients; the precise cause was defined in 68% (25/37) and 81% (26/32) of patients, respectively. However, eight of 44 patients with obstruction in the first study did not have definite proof of the final diagnosis, and 7 patients in whom US failed to determine the presence or absence of obstruction in the biliary system were excluded from their analysis. The second study was a retrospective series of 32 selected patients with surgically proven biliary obstruction and all had satisfactory scans. At the opposite extreme are the more recently published reports by Honickman et al. (1983) and Baron et al. (1982), who predicted the correct level of dilatation from US scans in only 27% (17/62) and 60% (24/40) of patients, and the correct cause in only 23% (14/62) and 38% (18/47) respectively. However, not all of their patients had proper proof of the final diagnosis and they included in their analysis a large number of unsatisfactory scans. In contrast to this discouraging trend, the present study found a 50% (62/124) accuracy in US diagnosis of the cause of obstruction in the biliary system. The positive and negative predictive values of satisfactory US scans in the present study are 75% and 92% respectively for detection of common bile duct stones and 88% and 79% for determining the presence or absence of malignant obstruction in the biliary system (Table 15C).

Although, Gibson et al. (1986) reported that the cause of obstruction was correctly detected by US in 88% of patients (57/65), by CT in 63% (32/51) and by direct cholangiography in 89% (51/57) as proved later at laparotomy and histo-pathology, US generally is less reliable than PTC or ERCP in identifying the cause of obstruction and the present study confirms this general view (Table 18). The following are some factors believed to be responsible for the low diagnostic accuracy of US scans in comparison with direct cholangiography:

Technical failures

There can be a high rate of technical failure (unsatisfactory scans) in depicting the entire course of the common duct due to overlying bowel gas, obesity, ascites, or previous bypass operations. Frederic et al. (1983) had an 11% (52/430) incidence of technical failures, whereas, the present study had 18% (28/152) unsatisfactory scans, mainly (87%) as a result of excessive bowel gas. The incidence of unsatisfactory US scans, however, can be minimised by repeated examination of the patient and by using special scanning techniques (Laing et al. 1986).

The diagnostic value of the unsatisfactory US scans in the present study is zero. Therefore, when dilated intrahepatic ducts are seen on sonography but the distal common duct is obscured, direct cholangiography is strongly recommended to establish the cause of the obstruction.

Nature of the obstruction

In the present study there were no statistically significant differences in the overall diagnostic value of US scans when patients with different causes of obstruction were compared (Chi-squared test). The diagnostic sensitivity of US scans in determining the cause of obstruction was 44% (18/41) in calculous obstruction, 70% (7/10) in benign non-calculous obstruction, and 51% (37/73) in malignant conditions (Table 15C). However, this was not the case with other reported studies (Pedersen et al. 1985) and there are many points which need to be highlighted in this context:

1- The most common problem with abdominal ultrasonography is failure to detect calculi in the common duct. The sensitivity of ultrasound for detection of common duct stones in the present study was 44% (18/41), which is even higher than the figure of 13-38% reported previously with regard to the normal practice with real-time US scanning (Cronan et al. 1983; Cross et al. 1983; Einstein et al. 1984; Eyre-Brook et al. 1983; Pedersen et al. 1985). This is because the obstructing common duct stones frequently lodge in the distal retroduodenal common duct and are often obscured by overling bowel gas. Furthermore, the surrounding bile pool is small or nonexistent, adding to the difficulty in detection when stones are present in normal-sized ducts (Dewbury & Smith, 1983; Friedman et al. 1987; O´Connor et al. 1986).

O´Connor et al. (1986) found that the demonstration of common duct dilatation (>6mm) on sonography had a predictive value of 71% (25/35) for the presence of stones, and a nondilated duct had a predictive value of 83% (20/24) for their absence. Most authors agree with the results of the present study in that demonstration of dilated ducts is an insufficient basis for the diagnosis of choledocholithiasis because; (i) the diameter of a normal choledochus varies from 4mm to 17mm on US (Bruneton et al. 1981), (ii) a great degree of overlap in diameters of the intrahepatic and extrahepatic ducts opacified in post-cholecystectomy patients with and without retained stones has been demonstrated by ERCP (Hamilton et al. 1982), (iii) in one study (Cross et al. 1983), the majority of post-cholecystectomy patients (57%) with duct dilatation did not have choledocholithiasis, and finally (iv) a stone can partially or intermittently obstruct the biliary system without dilating it (Mueller et al. 1982). It should be stressed that a normal calibre of common duct has been found in 30-36% of patients with choledocholithiasis (Cronan et al. 1983; Laing & Jeffrey, 1983). Furthermore, in contrast to stones in the gall-bladder, only 60-80% of stones in the common duct give rise to acoustic shadows (Cronan, 1986, Einstein et al. 1984; Parulekar & McNamara, 1983). Therefore, it is necessary to demonstrate a definite echogenic focus within the common duct for the diagnosis of choledocholithiasis. However, in the light of the less than perfect detectability of common duct stones, it has been suggested that post-cholecystectomy patients with elevated serum alkaline phosphatase level should have ERCP despite normal sonography (Friedman et al. 1987).

Sonography is generally considered a relatively insensitive mean of detecting common duct stones (Coelho et al. 1984; O´Connor et al. 1986). Cronan (1986) analysed 110 patients having choledocholithisis proven surgically or by endoscopy. He obtained a sensitivity of 55% with preoperative US and the stones detected sonographically varied in size from 2mm to 18mm. Furthermore, reports using transverse scanning of the intrapancreatic portion of the common bile duct and erect or semierect positioning in addition to the traditional parasagittal scans gave an improved sensitivity of 75% for common duct stones (Laing et al. 1984). Other helpful manoeuvres include longitudinal coronal views with the patient in various degrees of left posterior obliquity, filling the antrum and duodenum with water, and occasionally Trendelenburg positioning to allow distal common duct stones to sink to more accessible proximal positions (Friedman et al. 1987). Using these maneuvers Laing et al. (1986) detected common duct stones in 80% (33/41) of patients with choledocholithiasis. In the present study the positive and negative predictive values of satisfactory US scans for the detection of the common bile duct stones are 75% (18/24) and 92% (47/51), respectively (Table 15C). Furthermore, the predictive value of satisfactory scans for the detection of the common bile duct stones has improved from 55% (6/11) in the rerospective part of the study I to 92% (12/13) in the prospective part of the study. In one reported evaluation of intra-operative B-mode biliary tree and pancreatic US in 50 patients undergoing cholecystectomy for gall-bladder stones, US correctly diagnosed common duct stones in 98% (49/50) patients (Lane & Glazer, 1980).

Even when the diagnosis of choledocholithiasis is successfully made sonographically, more stones are often present at surgery than are shown by sonography, and the stone seen on US is often not the obstructing stone (Parulekar & McNamara, 1983; O´Connor et al, 1986). Furthermore, detection of common duct stones in jaundiced patients cannot be interpreted as evidence for choledocholithiasis as the cause of the obstruction; biliary stasis by itself leads to stone formation, and results of the present study II confirm previous reports that choledocholithiasis can co-exist even with malignant obstructions (Lee et al. 1984; Pedersen et al. 1985). Therefore, the point of obstruction should be identified clearly and a mass searched for in all such cases before making a firm diagnosis of choledocholithiasis on sonography.

2- Small periampullary tumours are not seen on sonography (Friedman et al. 1987). As neither the degree of dilatation of the biliary system in jaundiced patients (Table 18) nor biochemical abnormalities (Leese et al. 1986) aid in differentiation of benign from malignant conditions, any obstruction seen at the ampullary region on ultrasound with no apparent calculus or mass (particularly if the pancreatic duct is also dilated) is probably due to periampullary carcinoma and endoscopic biopsy is indicated.

3- Pancreatic neoplasm may be hard to distinguish from inflammatory masses by ultrasound (Frederic et al. 1983). Definite diagnosis is possible when there is liver metastasis, invasion of portal veins and/or retropancreatic or hilar lymphadenopathy in addition to a pancreatic mass. Most pancreatic duct cell carcinomas are detected on sonography as hypoechoic masses enlarging the gland or deforming its contour. However, focal pancreatitis without pseudocyst is indistinguishable from duct cell carcinoma unless shadowing echogenicities (calcifications) are present. Furthermore, small sonolucent pseudocysts in chronic pancreatitis are difficult to differentiate from tumour necrosis (Freidman et al. 1987). Lack of a clinical history of pancreatitis or alcohol abuse, greater dilatation of the intra- and extra-hepatic ducts, and higher levels of the liver function tests are highly suspicious for pancreatic carcinoma when a non-calcified solid mass is detected (Table 26). The diagnostic sensitivity and specificity of US in diagnosis of pancreatic head carcinoma in a small study of 27 patients were 74% & 94%, respectively (Classen & Phillips, 1984). The specific sensitivity of US for the diagnosis of chronic pancreatitis varies from 55% to 86%, and its specificity is about 90% (Cotton et al. 1980; Foley et al. 1980; Gowland et al. 1981). Part of this variability is due to different imaging techniques and whether patients are in clinical remission or exacerbation. Hessel et al. (1982) stated that CT is the method of choice for detecting pancreatic abnormalities and defining their nature and extent. They believed that sonographic accuracy in cases of carcinoma is a significant problem, whereas Foley et al. (1980) in a small series of 40 patients with suspected pancreatic disease found ERCP to be the most accurate method in evaluation of pancreatic malignancy. However, in young patients where the incidence of carcinoma is low or for followup examinations when the extent of disease has been evaluated by CT or ERCP, high-resolution US is very useful and capable of demonstrating the changes of chronic pancreatitis.

4- Infiltrative cholangiocarcinoma may mimic an inflammatory or traumatic stricture. Abrupt termination of the common duct usually indicates malignancy or a calculus whereas smooth tapering is associated with a benign stricture (Jones et al. 1983). However, the key to successful differentiation of cholangiocarcinoma from choledocholithiasis or benign stricture on sonography is the demonstration of a mass either within or surrounding the ducts at the point of obstruction. This is usually not possible especially in distal cholangiocarcinomas which are often obscured by bowel gas. However, cholangiocarcinoma should be suspected when abrupt obstruction is seen and no stone or mass is demonstrable, especially if a normal pancreas is well-depicted. When masses have been seen, they have been discribed as persistent intraluminal echoes without shadowing (Subramanyam et al. 1984). The sonographic differential diagnosis of an intraluminal nonshadowing mass include nonshadowing calculi, uncommon benign tumours such as adenoma, gall-bladder or hepatocellular carcinoma extending into the duct, blood clot, or sludge. Sonographic demonstration of dilatation of intrahepatic ducts without any evidence of extrahepatic duct dilatation should raise the suspicion of a Klatskin tumour, with or without the demonstration of small tumour in the porta hepatis (Subramanyam et al. 1984).

Experience

Cross et al. (1983) and O´Connor et al. (1986) did not find a significant learning effect when US was used to determine the cause of obstruction in the biliary system in their series of 90 patients undergoing ERCP and 70 post-cholecystectomy patients, respectively. Our sonographic ability to define the cause of obstruction in the biliary tract improved from 45% (34/75) in the retrospective part to 57% (28/49) in the prospective part of study I (Table 14). This improvement is more obvious with regard to the detection of common duct stones as the diagnostic sensitivity of US increased from 29% (6/21) to 60% (12/20) in the same period (Table 15A&B). Furthermore, the positive and negative predictive values of US in determining the presence or absence of malignant obstruction in the biliary system increased from 90% (26/29) and 67% (10/15) in the retrospective part to 100% (13/13) and 89% (16/18) in the prospective part of the study I, respectively. A similar learning effect has been also observed by Laing & Jeffrey (1983) in a comparative study of US and ERCP or surgery in 53 patients. They found an increase in sensitivity of US in the diagnosis of duct stones from 15% (3/20) in the early period to 50% (6/11) in the later period. Furthermore, when special scanning techniques were used by three staff radiologists in 135 consecutive patients undergoing sonography in 15 month period at San Francisco General Hospital, US indicated the level of dilatation in 92% (101/110) and suspected the correct cause in 71% (78/110) of cases with subsequently proven biliary dilatation (Laing et al. 1986). As a result of this special scanning approach, no study was deemed to be technically unsatisfactory. The same is true with the most recent reported experience of Hammersmith Hospital, London. In 66 patients with bile duct obstruction proved on the basis of surgical findings and cytological or histological evidence, US correctly diagnosed the level of obstruction in 95% (62/65), and the cause of obstruction in 88% (57/65) of patients (Gibson et al. 1986). However, these figures are exceptional and achieved only in large specialized centres.

DIRECT CHOLANGIOGRAPHY (PTC AND ERCP)

The results of study I have confirmed previous reports that PTC more consistently produces successful cholangiograms (96% or 131/137) compared with ERCP (80% or 72/90) (Elias et al. 1976; Ertan et al. 1981; Matzen et al. 1982). Satisfactory US scans of the biliary system in the present study were obtained in 82% (124/152) of the attempted procedures. The figure is also comparable to those reported previously (Eyre-Brook et al. 1983; Gold et al. 1979).

In the present study, neither ultrasound nor diagnostic ERCP were associated with any complications, whereas PTC and therapeutic ERCP were associated with 6.7% (9/135) and 19% (10/52) incidence of major complications, respectively. A wide range of incidence has been reported with regard to the major and minor complications associated with fine-needle PTC. At one extreme is the report by Harbin et al. (1980) in a large American multicentre survey dealing with 2005 PTC procedures carried out with the Chiba-needle where the overall major complication rate was 3.4%. These authors, however, did not include in their review of previous studies many reports which had demonstrated higher incidence of complications following PTC such as the reports by Fraser et al. (1978), Juler et al. (1977) and Tsuchiya (1969). Furthermore, multicentre studies have many disadvantages (Kreek & Balint, 1980); (i) there is no control over the accuracy of the data obtained, (ii) there is no assurance that consecutive cases were reported, and (iii) there is no insight into whether or not any biases related to case reporting may have occured. At the opposite extreme are more recent studies in the literature by Baumgartner et al. (1987) and Nilsson et al. (1983), who reported a total complication rate of 29% (17/58) and 32%(76/237), respectively. A chronological review of the literature suggests that complications associated with fine-needle PTC have increased in recent years in comparison with earlier reports (Table 17). This increase and the wide range of differences between reported series with regard to the complication rate of fine needle PTC can be attributed to several factors:

1- Aetiology of obstruction.

Study I has demonstrated that the incidence of complications atrributable to PTC are not related to the aetiology of obstruction (Table 6) nor to the maximum diameters of the intrahepatic ducts, common hepatic duct, common bile duct or the gall-bladder

(Table 7). Many authors, however, report that complications following PTC are more frequent in patients having greater dilatation of the biliary system and in patients with choledocholithiasis (Kreek & Balint, 1980; Mueller et al. 1981; Okuda et al. 1974). Furthermore, one study (Juttijudata et al. 1984) found that the incidence of bile leakage is directly proportional to the size of the intrahepatic ducts, especially, in patients with malignancy of the pancreatico-hepaticobiliary system.

2- Methods of determining the complications.

Many complications cannot be detected unless the patient undergoes laparotomy or angiography; such complications include asymptomatic bile leakage, arteriovenous fistula or haemobilia (Cahow et al. 1977; Okuda et al. 1978).

3- Experience of the operator.

Harbin et al. (1980) found that the experience of the radiologist does not seem to be an important factor affecting the incidence of the complications of PTC. The increase in the complication rate associated with fine-needle PTC in recent reports (Baumgartner et al. 1987; Nilsson et al. 1983) can be explained partly by the unpopularity of PTC in recent years as the investigation for patients with obstructive jaundice in many centres (92% vs 41% in the rerospective and prospective parts of study I, respectively). Eventually this leads to lack of experience in performing the procedure among junior radiologists. This has been reflected in our hospital by a slight drop in the successful rate of opacification of the biliary system at PTC from 97% (100/103) in the retrospective part of the study I to 91% (31/34) in the prospective part of the study. On the contrary, the success rate of ERCP in obtaining cholangiograms has increased from 72% (23/32) to 85% (49/58) in the same period. In contrast to this discouraging increase in the complication rate associated with PTC, there is no statistically significant difference with regard to the total complication rate of PTC in the retrospective (11.7% or 12/103) and prospective (12.5% or 4/32) parts of study I (Chi square test). In a previous series of 46 patients reported from this hospital, Benjamin et al. (1978) reported septicaemia in two of their patients (one of them died), pyrexia of >38°C in two patients without positive blood culture, and small collection of bile or blood over the dome of the liver was found at laparotomy in several patients. Furthermore, the major complication rate of 6.7% associated with PTC in the present study is comparable with the 6.3% rate reported in recent series (Table 17).

4- Difference in the statistical analysis of the complication rate of PTC.

This is a major factor responsible for the large differences observed between many studies with regard to the reported figures of the complication rate associated with PTC (Table 17).

5- Prophylactic antibiotics.

Prophylactic antibiotics are considered crucial for preventing septicaemia by many authors and their use is recommended 24 hours before the procedure (Harbin et al. 1980; Mueller et al. 1982). In spite of the use of prophylactic antibiotics to cover PTC, sepsis was the most frequent complication (5% or 7/136) in our hospital and resulted in two deaths in study I and one death in the study reported by Benjamin et al. (1978).

Although the death rate attributable to PTC in large multicentre studies is 0.1-0.2% (Ariyama 1983; Harbin et al. 1980), this was not the case with single institution studies where a death rate of up to 7% has been reported (Baumgartner et al. 1987). The death rate in the present study (2%) following PTC has not changed in our hospital from that reported 10 years ago (Benjamin et al. 1978).

Bile leakage was discovered during laparotomy in 3% (4/135) of our patients following PTC, but only one had symptomatic leakage requiring early laparotomy. The intoduction of the Chiba-needle technique has generally reduced the incidence of symptomatic bile leakage following PTC to 1-2% in comparison with a 3-4% incidence for the old sheathed-needle technique (Harbin et al. 1980). A 40% incidence of symptomatic bile leakage was reported in a small series of 30 patients undergoing fine-needle PTC (Juler et al. 1977). The results of the present study confirm previous reports that bile leakage is exclusively seen in patients with extrahepatic obstruction (Harbin et al. 1980). These authors have also reported that in one third of their patients with bile leakage, the extrahepatic biliary tract had been punctured. One of our patients who developed bile leakage had PTC performed by accidental puncture of the gall-bladder. It has been suggested that the needle should be always directed superior to the porta hepatis (Figure 1), and whenever puncture of the extrahepatic biliary tract is recognised in a patient with biliary obstruction, early surgery should be seriously considered (Harbin et al. 1980; Mueller et al. 1981).

Haemorrhage was not problem in our hospital as a complication of PTC, but it has been reported previously (Kreek & Balint, 1980; Nilsson et al. 1983; Okuda et al. 1974). In one study (Juttijudata et al. 1984) hemoperitoneum was found to have a direct association with trauma and movement of the patient during the procedure.

In contrast to the reports of Baumgartner et al. (1987) and McPherson et al. (1982), who found an increased morbidity and mortality when percutaneous drainage was added to PTC, the present study does not show any differences with regard to the complications between patients who had PTC only and those had percutaneous drainage (PTD) added (Table 6). However, the number of patients having PTD may be too small to allow firm conclusions in this context.

Many authors in non-randomised and retrospective studies from different centres around the world reported that routine use of preoperative biliary drainage to lower the bilirubin level to less than 10mg% improves surgical mortality (Denning et al. 1981;

Nakayama et al. 1978). However, many recent controlled trials have failed to show any improvement in surgical mortality following preliminary perctaneous drainage (McPherson et al. 1984; Norlander, 1982; Pitt et al. 1985). Furthermore, total hospital stay was significantly longer in the patients who were drained before surgery (Pitt et al. 1985). Permanent drainage, can of course, be established with percutaneous catheters or percutaneously inserted endoprostheses for patients judged not to be surgical candidates. The most recent randomised trial of endoscopic versus percutaneous stent insertion in malignant obstructive jaundice showed that the endoscopic method had a significantly higher success rate for relief of jaundice and a significantly lower 30 day mortality (Speer et al. 1987).

Direct cholangiography is very important in the differentiation of benign from malignant obstruction, in particular in patients undergoing percutaneous or endoscopic procedures to relieve biliary tract obstruction. In the present study, the diagnostic accuracy of direct cholangiography in differentiation of benign from malignant obstruction is 80-86% (Tables 9,14,15&21), a figure which is comparable with those reported in previous series (Berk et al. 1982; Gibbons et al. 1983; Matzen et al. 1981; Pedersen et al. 1985). In a randomized trail of 52 consecutive patients with clinical obstructive jaundice, the diagnosis was achieved in 91% by ERCP and 69% by PTC (Matzen et al. 1982). The accuracy of PTC and ERCP in the present study I were 78.4% (91/116) and 83.6% (51/61) in determining the correct cause of obstruction in the biliary system, respectively. However, if the inconclusive results are excluded from statistical analysis, the accuracy rises to 90% (91/101) for PTC and 94.4% (51/54) for ERCP (Table 14).

Abnormalities of the gall-bladder can provide useful corroborative evidence of common bile duct obstruction and consideration of these findings may well reduce the error in diagnostic accuracy of the investigations. Study II has demonstrated that the maximum diameter of the gall-bladder (mm) is significantly larger in malignant conditions ($54 \pm 14SD$) than in benign conditions ($38 \pm 12SD$; $P<0.01$); patients with choledocholithiasis also have higher incidence of gall-bladder stones (63%; 15/24) in comparison with patients having benign non-calculous obstruction (25%; 2/8) and malignant obstruction (22%; 11/50). Furthermore, Figure 7 shows that contracted gall-bladder is seen exclusively in patients with choledocholithiasis, whereas patients with dilated gall-bladder could have stone, benign non-calculous blockage or malignant obstruction. This has been also observed previously by Eyre-Brook et al. (1983) who found that 57 of 61 patients with dilated stone-free gall-bladders on cholangiography had malignant distal obstruction, while all 19 patients with a small gall-bladder containing multiple stones had calculous obstructive jaundice. This highlights the importance of correct reporting of the cholangiograms. Unfortunately, there were significant differences between the reports of the first radiologist and the statements of the second radiologist and the surgeon in the re-evaluation of the cholangiograms (Table 11) with regard to gall-bladder size in the retrospective part of study I. Therefore, one can strongly suggest that measuring transverse and longitudinal diameters of the gall-bladder is the best way of reporting cholangiograms; the size of gall-bladder can then be usefully classified as normal, shrunken or distended (Table 10).

The present study also found that jaundiced patients with malignant obstruction have a significantly higher total serum bilirubin level prior to direct cholangiography than patients with benign obstruction (P<0.001; Table 19). This can partly be explained by the fact that complete obstruction of the biliary system was more frequent in patients with malignant than in patients with benign conditions (Table 20). Furthermore, the present studies conclude that the maximum diameter of intra- and extra-hepatic ducts alone cannot reliably differentiate benign from malignant obstruction (Table 20; Figrures 6,47). Therefore, in the absence of a history of previous biliary surgery or the usual cholangiographic features of calculous obstruction, any complete or near complete obstruction in the biliary system must be highly suspicious for a malignant condition regardless of the cholangiographic appearances. The present study has also confirmed previous reports with regard to the importance of a proper clinical history in determining the correct nature of obstruction in the biliary system, particularly in the differentiation of benign traumatic strictures from common duct carcinomas (Clemett, 1983; Fleming et al. 1972; Silvis et al. 1976; Reuben et al. 1978).

However, even when malignancy is diagnosed or excluded by direct cholangiography, a precise diagnosis of the condition is sometimes very important in determining the prognosis and the correct steps in management, particularly in malignant disease (Ferrucci et al. 1983). The cholangiographic abnormalities of some common benign and malignant conditions, therefore, have been discribed and compared in chapters 3 and 4.

In 6 of the 8 patient with periampullary carcinoma in the study II, the cholangiographic appearance (Figures 27&28) consisted of dilatation of the entire biliary system down to the ampulla (Type II stricture of caroli; see Figure 2). However, this cholangiographic abnormality was also observed in two patients with duodenal diverticula (Figures 19&20), in six patients with choledocholithiasis (Figures 11&12), in four patients with pancreatic carcinoma (Figure 43) and in one patient with chronic pancreatitis (figure 33). The cholangiographic appearances mimicking periampullary tumour, therefore, can be associated with both benign and malignant conditions. Furthermore, Leese et al. (1986) have emphasized the clinical and biochemical similarities between patients with non-neoplastic periampullary "pseudotumours" and those with periampullary neoplasm. This highlights the need for endoscopic biopsy in all patients thought radiologically to have periampullary carcinoma.

Study III showed that similar cholangiographic abnormalities can be associated with both chronic pancreatitis and pancreatic carcinoma. However, the study also demonstrated significant differences between the two conditions with regard to the associated biochemical changes (Table 26) even in patients who had identical cholangiographic appearances (Table 23). Furthermore, the study showed that patients with chronic pancreatitis are younger than their fellows with pancreatic carcinoma, chronic pancreatitis patients have a shorter length of the stenosis of common bile duct, and irregularity of the stenosis is exclusively seen in patients with pancreatic carcinoma (Table 26). A distended gall-bladder is more frequent with cancer (86%); the gall-bladder may be distended in chronic pancreatitis (44%) although to a lesser extent (45mm) than in pancreatic carcinoma (57mm). However, study III concludes that in an individual patient, differentiation of chronic pancreatitis from pancreatic carcinoma cannot exclusively rely on cholangiography but should be confirmed by histo-pathological examination of the lesion.

Study III also demonstrated that 91% of the patients with elevated serum alkaline phosphatase concentration (>300 IU/1) and 100% with elevated alanine transaminase (>55 IU/1), regardless of the level of total serum bilirubuin, had some form of radiological abnormality of the biliary tract (Figure 39). Therefore, persistent abnormality of the liver function tests should alert the clinician to the possibility of common bile duct stenosis and ultrasound scan and biliary radiology should then be mandatory. The patients in the studies III and IV must have chronic pancreatitis of sufficient severity to warrant direct cholangiography and this may explain the high incidence of radiological stenosis of the common bile duct (62-64%) in comparison with the mean figure of 47% reported in previous series (Table 27). Although study III had found that direct cholangiography is the most sensitive method for detection of common bile duct involvement by the inflammatory process in chronic pancreatitis, study IV found that even in the presence of radiological common bile duct stenosis normal liver function tests suggest that histopathological evidence of extrahepatic biliary obstruction is unlikely and therefore that liver biopsy and bypass surgery is not indicated. On the other hand, persistent jaundice in the presence of radiological common bile duct stenosis is a strong indication for biliary-enteric bypass, although pre-operative liver biopsy is suggested in those with isolated elevation of alkaline phosphatase.

There is no place for routine biliary-enteric bypass during surgery for chronic pancreatitis.

COMPARISON OF THE INVESTIGATIONS

The diagnostic accuracy of the successful procedures in study I are comparable with that reported in similar previous studies (Table 18). To the best of my knowledge, no study in the literature has been concerned with the essential nature of investigations in determining management of the patient. Study I concludes that ERCP is more frequently essential (15% or 9/61) than PTC (7% or 8/116) and US (4% or 5/124). This highlights the importance of each investigation in determining the management of individual. The present study, therefore, confirms previous reports that ERCP, PTC and US are not subsitutes for each other, and should not be used in comparative and competive ways but as complementary methods (Matzen et al. 1982; Mueller et al. 1981). However, proper selection of investigations in each specific condition and in each individual patient are very important and further study is needed to confirm and expand present knowledge in this context (Frederic et al. 1983; Lee et al. 1984).

Although US generally is not as good as ERCP or PTC in pinpointing the exact level and cause of obstruction (Table 18), both PTC and ERCP are unpleasant for the patient and are associated with a significant morbidity and mortality (Tables 6 and 16; Baumgartner et al. 1987; Bilbao et al. 1976). The diagnostic yield of US is superior to that of ERCP for focal hepatic disease and for gall-bladder lithiasis (Frederic et al. 1983), and superior to that of direct cholangiography for the diagnosis of metastatic lesions (see Chapter 3). Hershman et al. (1986) found that US accurately predicted gall-bladder stones in 96% (194/203) of patients with stones confirmed at laparotomy, and was unhelpful due to technical difficulties in 11 patients. Even in a district general hospital, US was found to be 84% accurate in detecting gall-bladder stones (Walker, 1981). In pancreatic disease, although the diagnostic score of ERCP is superior, US is the specific complementary investigation for the demonstration of pseudocysts and secondary abscess formation (Frederic et al. 1983). US can provide more preoperative information about structures related to the biliary system such as the pancreas, liver, right kidney, aorta and para-aortic lymph nodes (Baron et al. 1982). This allows the procedure to be useful in determining the management of the patient even when it is not diagnostic (Table 14) by differentiation of obstructive fron non-obstructive jaundice, identification of the level of obstruction in the biliary system, allowing ultrasonic guided fine-needle biopsy, and providing information with regard to the condition of related organs. Nonoperative assessment of resectability has become important in recent years because of the advent of percutaneous and endoscopic palliative techniques for biliary drainage. US appears to be a useful non-invasive investigation for detection of tumour resectability. It was correct in 71% of patients, in comparison with 42% for CT scanning and 58% for direct cholangiography, as verified by laparotomy (Gibson et al. 1986). US has also high predictive value (83%) in the distinction between malignant and benign obstruction, but the diagnostic sensitivity is poor (50%; Table 15C), partly due to a high number of inconclusive and technically unsatisfactory examinations; this has been substantiated by others (Pedersen et al. 1985). Finally, US can be essential in management despite availability of other sophisticated and invasive investigations, as was the case with 4% (5/124) of our patients having satisfactory scans (Table 14).

The present study with its 88% diagnostic sensitivity has confirmed previous reports that US is a reliable tool for the distinction between obstructive and non-obstructive jaundice (Baron et al. 1982; Haubek et al. 1981). The main aim of direct cholangiography, therefore, should be to identify the cause of obstruction and to provide a map of the biliary system. However, ultrasound may be sufficient preoperative investigation when it is diagnostic for the level and cause of obstruction (Gibson et al. 1986). But even then, the information provided by direct cholangiography can be vital in determining management. For example, it may show the exact length of duct available for possible surgical biliary bypass. Cholangiograms can identify surgical obstructive disease in patients with biliary obstruction not detected clinically (no evidence of jaundice) or/and sonographically (no evidence of dilated ducts) as in patients with sclerosing cholangitis, ampullary stenosis and non obstructing stones (Mueller et al. 1982).

During evaluation of the cholangiograms of 76 patients who had a proven final diagnosis in study I, there was no statistically significant differences with regard to the diagnostic value of the statements of an experienced radiologist and surgeon (Table 9). However, a second opinion can sometimes be vital in determining management. In ultrasound, the quality of the stored images is frequently inferior to that of the real-time display and the amount of information stored within these images can present only a tiny fraction of the information presented to the operator during the examination. Therefore, it is difficult to obtain a second opinion from another radiologist or a surgeon as is the case with direct cholangiography. It is also difficult for a third party to determine when a technically inadequate study has been performed.

On the other hand, ERCP affords a broader diagnostic approach and higher success rate. ERCP depicts the pancreatic duct as well as the biliary tree, so that in cases in which pancreatic disease may be the cause of the biliary obstruction, ERCP may provide significant extra diagnostic information when compared to PTC. Mucosal abnormalities in the stomach, duodenum, and ampullary region that can be revealed by ERCP are occasionally relevant in the jaundiced patient. The overall diagnostic sensitivity of ERCP in the present study was 100% (34/34) in calculous obstruction, 75% (12/16) in malignant and 45% (5/11) in benign non-calculous conditions, whereas, its specificity was 87% (39/45) in determining the presence or absence of malignant obstruction and 74% (20/27) in detecting common bile duct stones. Table 15C shows that the positive predictive value for successful ERCP procedures is 100% (34/34) in calculous obstruction and 80% (12/15) in malignant obstruction, whereas the negative predictive value is 100% in both conditions. Furthermore, diagnostic ERCP did not associate with any complication in the present study. However, ERCP is relatively more expensive, more time-consuming, and far more technically demanding than PTC, with information obtained being directly proportional to the skill of the examiner (Anacker et al. 1977).

In contrast, PTC is generally quicker, less expensive, has a comparable diagnostic value with that of ERCP (Table 18), and may be more widely available at smaller institutions. The overall diagnostic sensitivity of PTC in the present study was 80% (16/20) in calculous obstruction, 87% (66/76) in malignant and 45% (9/20) in benign non-non calculous conditions, whereas, its specificity was 62% (25/40) in determining the presence or absence of malignant obstruction and 84% (81/96) in detecting common bile duct stones. Table 15C shows that the positive and negative predictive values for successful PTC procedures are

100% (16/16) and 95% (81/85) in calculous obstruction, and 87% (66/76) and 100% (25/25) in malignant obstruction, respectively. Furthermore, in the presence of total obstruction or previous biliary-enteric anastomosis, PTC often gives more useful information than ERCP regarding the site, nature and degree of the obstruction. Its success is dependent on the experience of the radiologist and the degree of biliary dilatation. Unfortunately, it has also a higher associated morbidity and mortality (Table 17).

Many authors consider PTC to be the procedure of choice when ducts are dilated on sonography or CT, and ERCP to be the procedure of choice in patients with nondilated ducts where obstruction is still a possibility (Benjamin et al. 1978; Ferrucci & Wittenberg, 1977; Lintott, 1985; Mueller et al. 1981). Owing to the progressive increase in the success rate of opacification of the biliary system by ERCP (72% vs 85% in the rerospective and prospective parts of study I, respectively); comparable diagnostic accuracy (84% vs 78%) of ERCP and PTC respectively; the high mortality and morbildity associated with PTC in the present and previous studies (Table 17); and increased availability of endoscopic fascilities in most centres, ERCP is recommended as the first choice investigation in jaundiced patients with dilated and nondilated biliary ducts in patients where surgical obstruction cannot be excluded by US. This view has been previously expressed by Matzen et al. (1982) who found a significantly higher diagnostic accuracy for ERCP (91%) in comparison with PTC (69%). However, it has been also recommended for patients with post-cholecystectomy problems, in patients in whom upper gastrointestinal pathology is suspected, and when there is suspicion of pancreatic disease (Blumgart, 1978; Blumgart et al. 1977; Cross et al. 1983).

One can conclude the present studies by suggesting that in the presence of obstructive jaundice one should proceed directly to surgery in uncomplicated young patients when ultrasound reveals a picture typical of obstruction of the distal common bile duct whether due to calculi or tumour. If ultrasound can reliably identify patients with distal common bile duct obstruction there seems to be little to be gained from invasive investigations unless the surgeon is intending to manage the patient by percutaneous or endoscopic procedures. The use of sphincterotomy in the young patient who is not considered a high-risk candidate for surgery is not recommended because of the high (19% or 10/52) complication rate associated with the procedure.

Endoscopic sphincterotomy, however, is ideal for elderly patients either prior to or after cholecystectomy since it obviates the morbidity and mortality associated with major abdominal surgery. Regardless of their accuracy, neither US nor direct cholangiography (PTC & ERCP) are without the possibility of error (Table 14). Therefore, it is mandatory to obtain a positive biopsy (through ultrasonic fine-needle aspiration or percutaneous and endoscopic biopsy and cytology) before proceeding to any form of non-operative management of the patient.

Since precise diagnosis is very important in determining the prognosis and correct management (Ferrucci et al. 1983), all patients who have unsatisfactory or inconclusive ultrasound scans should be investigated by ERCP. PTC should be considered if ERCP fails, is inconclusive, or is contra-indicated or when endoscopic facilities are not available; PTC may also be necessary in patients with previous hepatico-enterostomy. Direct cholangiography may avoid unnecessary laparotomy in those with lesions not amenable to surgery and allow one to select appropriate therapy in those with proximal biliary obstruction. Direct cholangiography, however, is also not always diagnostic. Abnormalities in the liver function tests, the maximum diameters of the intra- and extra-hepatic ducts, and abnormalities of the gall-bladder can provide useful corroborative evidence to distinguish malignant from benign obstruction (Table 19,20&26).

Our study failed to improve the diagnostic yield of direct cholangiography by introducing probability and desirability percentage statements in the reporting form (Appendix 1). There were no statistically significant differences between the diagnostic value of the original interpretation reports of the cholangiograms (Table 14&15) and that of the surgeon and radiologist using the form shown in Appendix 1 (Table 9). However, study II has confirmed previous reports with regard to the importance of the clinical history of the patient in interpretation of cholangiograms, especially in differentiatiation of benign from malignant conditions (Reuben et al. 1978). Since our trial was retrospective and carried out without knowledge of the patients clinical history, a prospective study using a form similar to that shown in Appendix 6 is recommended. Such a study is very likely to result in improvement of diagnostic accuracy and usefulness of US, PTC and ERCP in determining resectability of malignant tumours and in the selection of appropriate surgical procedures prior to laparotomy.

APPENDICES

Appendix 1 The form introduced to be used by the surgeon and the radiologist to note their findings of the re-evaluation of the first 87 percutaneous transhepatic cholangiographys in the retrospective part of study I.

EVALUATION OF THE CHOLANGIOGRAMS

Name of the patient: Date of birth:

Evaluated by: Dr. Date:

Is the examination technically satisfactory? Y N

Is the biliary system dilated? Y N

Maximum diameter of common hepatic duct mm.

common bile duct mm.

Level of the obstruction at (probability 0-100%),

Porta hepatis

Common hepatic duct

Common bile duct

Periampullary

Indeterminate

Nature of the obstruction is (probability 0-100%),

Calculi

Benign non-calculous

Neoplastic

Non-surgical obstruction

Indeterminate

Evaluation of the gall-bladder (if visualized)

Normal

Distended

Shrunken

Contain stones

Other (specify)

Next step suggested is (desirability 0-100%)

US $\pm$ fine needle biopsy

ERCP $\pm$ biopsy or cytology

Liver biopsy

Laparotomy

Papillotomy (endoscopic)

Stenting

Other (specify)

Appendix 2 The form used in the prospective part of study I for evaluation of 83 jaundiced patients.

PROSPECTIVE EVALUATION OF PATIENTS WITH OBSTRUCTIVE JAUNDICE BETWEEN 1st Jan 1986 AND 31 Dec 1987

Identification number: Name:

Date of birth: SEX: Hospital number:

Dates of admision and discharge:

Final diagnosis: Confirmed by:

Short clinical notes:

PERCUTANEOUS TRANSHEPATIC CHOLANGIOGRAPHY

Date of the examination:

Is the examination satisfactory?

X-ray report:

Diagnostic value: 1-essential 2-diagnostic 3-misleading 4-therapeutic 5-useful 6-useless 7-failed 8-not done

Complications:

PTD & duration:

ENDOSCOPIC RETOGRADE CHOLANGIOPANCREATOGRAPHY

Date of the examination:

Is the examination satisfactory?

X-ray report:

Diagnostic value: 1-essential 2-diagnostic 3-misleading
4-useful 5-useless 6-therapeutic 7-failed 8-not done

Complications:

Combined procedures: 1-papilotomy 2-biopsy or cytology
3-stent 4-stone extruction 5-others,specify....

ULTRASOUND

Date of the examination:

Was the examination satisfactory?

Report of the sonologist:

Diagnostic value: 1-essential 2-diagnostic 3-misleading
4-useful 5-useless 6-therapeutic 7-failed 8-not done

Combined procedures:

OTHER INVESTIGATIONS

1-Liver biopsy 2-CT scan 3-Hidda scan

4-Biochemistry, bilirubin..... alkaline phosphatase...

5-Pathology report:

MANAGEMENT AND THE OUT COME OF THE PATIENT;

SUBSEQUENT ADMISSIONS AND FOLLOWUP;

Appendix 3 Definiation of some statistical terms used to report and discus results of all studies.

SAMPLE STATISTICS

The sample <u>mean</u> or average of a set of numbers is a measure of the location of their distirbution. It is defined as the sum of the data values divided by the number of data values.

The <u>standard deviation</u> (SD) is a measure of the variability of the data values about their mean. For normally distirbuted data, roughly 68% of the observations will lie within 1 SD of the mean and 95% within 2 SDs.

The <u>standard error</u> (SE) is a measure of the precision of an estimate. The SE of a sample mean can be calculated as the SD divided by the square root of the sample size.

The <u>degrees of freedom</u> (DF) is one less than the number of observations and is used in preference to sample size.

DIAGNOSTIC TESTS

The sensitivity of a dignostic test measures its ability to identify correctly diseased patients. The specificity measures its ability to identify correctly disease-free patients.

Example

Data from a group of patients whose true disease status is known and whose test results are available can be set out as follow:

		Disease: Yes	Disease: No
Test results	Positive	a	b
	Negative	c	d

From these data, sensitivity and specificity may be estimated as:

Sensitivity = a / (a + c).

Specificity = d / (b + d).

Other terms used in this context include:

Predictive value positive = a / (a + b).

Predictive value negative = d / (c + d).

Accuracy = (a + d) / (a + b + c + d).

Appendix 4 The form used in the study II to evaluate the cholangiographic films of 147 jaundiced patients with different surgical conditions.

Name of the patient:

Age: Sex: Date of birth:

Type of the cholangiography and date of performance:

The maximum diameters of the

Intrahepatic ducts......mm.

Common hepatic duct......mm.

Common bile duct......mm.

Gall-bladder

transverse......mm.

longitudinal....mm.

Is the cholangiogram satisfactory? Y No, why........

Is there obstruction to the biliary system?

No Yes 1-partial

2-complete

Level of the obstruction at;

1-porta hepatis. 2-common hepatic duct.

3-common bile duct. 4-periampulary.

5-other, specify.....

Nature of the obstruction;

1-malignant 2-benign non-calculous

3-calculous 4-others, specify....

Gall-bladder

1-normal 2-distended

3-shrunken 4-contain calculi

5-involved by tumour 6-not visualized

Cholangiographic discription:

Notes:

Appendix 5 The form used in the study IV for evaluation of the cholangiograms and case-notes of 47 patients with chronic pancreatitis and 53 patients with pancreatic carcinoma.

EVALUATION OF CHOLANGIOGRAMS OF PATIENTS WITH CHRONIC PANCREATITIS AND CARCINOMA OF THE PANCREAS

Name: Sex:

Date of birth: Hospital NO:

Type and date of the cholangiogram:

Final diagnosis: Confirmed by:

Maximum diameter of the intrahepatic ducts......mm.

Maximum diameter of the common hepatic duct.....mm.

Maximum diameter of the common bile duct........mm.

Retropancreatic portion of the common bile duct;

Displacement 1-Yes 2-No

a-medially

b-laterally

c-straightening

Stenosis 1-Yes 2-No

a-smooth

b-irregular

Length of the stenosis.........mm.

Type of the stricture (Caroli),

a-Type I

b-Type II

c-Type III

d-Type IV

e-Type V

f-Unclassified

Gall-bladder evaluation:

Maximum diameters......*......mm.

1-normal. 2-contain calculi. 3-shrunken.

4-distended. 5-not visualized. 6-removed.

Liver and pancreatic function tests;

Bilirubin..............μmol/l.

Albumin...................g/l.

Alkaline phosphatase......IU/l.

Serum amylase............ IU/l.

Creatinine.............μmol/l.

Aspartate transaminase....IU/l.

Alanine transaminase......IU/l.

Appendix 6 A form designed to report the interpretation of results of ultrasound, PTC and ERCP in patients with obstructive jaundice in a suggested prospective study to improve the diagnostic accuracy of these investigations.

Patient: Radiologist:

D O B: Date of examination:

Hospital no: Investigation:

Ward no: 1-US 2-PTC 3-ERCP

Clinical history (completed by surgeon or physcian)

Results of performed investigations

Past history

Investigation

Is the examination technically satisfactory? Y N

If no, why.....................................

Are the intrahepatic ducts dilated? Y ....mm N

Are the extrahepatic ducts dilated? Y.....mm N

The level of obstruction at (give probability 0-100%)

intrahepatic

porta hepatis

common hepatic duct

common bile duct

periampullary

indeterminate

Natrure of obstruction (give probability 0-100%)

calculi

benign non-calculous (specify)

malignant (specify)

indeterminate

Evaluation of the gall-bladder(give probability 0-100%)

A- Visualised; diameter..........mm.

1- normal	Y	N
2- distended	Y	N
3- shrunken	Y	N
4- thicken	Y	N
5- calculi	Y	N
6- debris	Y	N
7- involved by tumour	Y	N

8- others (specify)................

B- Not visualized,

1- previous cholecystectomy Y N

2- others (specify)...............

Evaluation of the pancreas (give probability 0-100%)

A- Main pancreatic duct,

1- diameter at head....mm body...mmm tail...mm.

2- obstructed at....mm from ampulla.

3- a stricture of....mm at.... mm from ampulla.

4- multiple strictures.

5- not visualized.

B- Parenchyma,

1- contain cyst of........ .....mm in diameter, location......................................

2- tumour of......mm in diameter, location......................................

C- Side branches,

1- normal.

2- not opacified.

3- abnormal (specify).

D- Inconclusive results (specify)....................

Evaluation of the liver (give probability 0-100%)

A- Size,

1- normal.

2- large.

3- small.

4- indeterminate.

B- Space occuping lesion,

1- absent.

2- present, single or multiple.

3- solid or cystic.

4- primary or metastatic.

C- Pattren of intrahepatic ducts and echo pattren,

1- normal or irregular.

2- increased or decreased.

D- Others (specify).................................

Evaluation of other related structures.

A- kidneys.......................................

B- Lymph nodes...................................

C- Spleen..

D- Blood vessels.................................

E- Others (specify)..............................

Resectability of malignant lesion (probability 0-100)

resectable, why..............................

irresectable

indeterminate

Next-step suggested in management (desirability 0-100%)

A- Further investigations, suggest...................

B- Laparotomy.

C- Endoscopic procedures, suggest...................

D- Palliative treatment, suggest...................

E- Others (specify).................................

REFERENCES

References are cited according to the Vancouver system and the title of the journals abbreviated according to the style used in "Index Medicus" (British Medical Journal 1979; 1: 532-535; British Medical Journal 1988; 296: 401-405).

REFERENCES

Afroudakis A, Kaplowitz N.
Liver histopathology in chronic common bile duct stenosis due to chronic alcoholic pancreatitis.
Hepatology 1981; 1: 65-72.

Allen-Mersh TG, Earlam RJ.
Pancreatic cancer in England and Wales: surgeons look at epidemiology.
Ann R Coll Surg Eng 1986; 68: 154-158.

Alpern MB, Sandler MA, Kellman GM, Madrazo BL.
Chronic pancreatitis: Ultrasonic features.
Radiology 1985; 155: 215-219.

Anacker H, Weiss HD, Kramann B.
Endoscopic retrograde pancreaticocholangiography.
New York: Springer-Verlag, 1977: 25-30.

Anderson JC, Harned RK.
Gray scale ultrasonography of the gall bladder: An evaluation of accuracy and report of additional ultrasound signs.
A J R 1977; 129: 975-977.

Andren-Sanberg A, Ihse 1.
Factors influncing survival after total pancreatectomy in patients with pancreatic cancer.
Ann Surg 1983; 198: 605-610.

Andrews RC, Hawkins IF.
The Hawkins needle-guide system for percutaneous catheterization: 1- Instrumentation and procedure.
A J R 1984; 142: 1191-1195.

Andrews RC, Hawkins IF, Vogel SG.
The Hawkins needle-guide system for percutaneous catheterization: 2- Clinical experience in biliary tract and abscess drainage.
A J R 1984; 142: 1197-1200.

Aranha GV, Priz RA, Freeark RJ, Greenlee HB.
The spectrum of biliary tract obstruction from chronic pancreatitis.
Arch Surg 1984; 119: 595-600.

Ariyama J.
Percutaneous transhepatic cholangiography.
In: Margulis AR & Burhenne HJ, eds. Alimentary tract radiology. 3rd ed. St. Louis: CV Mosby, 1983: 2229-2241.

Ariyama J, Shirakabe H, Ohashi K, Roberts GM.
Experience with percutaneous transhepatic cholangiography using the Japanese needle.
Gastrointest Radiol 1978; 2: 359-365.

Axon ATR, Cotton PB.
Endoscopy & infection.
Gut 1983; 24: 1064-1066.

Baron RL, Stanley RJ, Lee JKT, Koehler RE, Melson GL, Balfe DM, Weyman PJ.
A prospective comparison of the evaluation of biliary obstruction using computed tomography and ultrasonography.
Radiology 1982; 145: 91-98.

Baumgartner F, Williams RA, Wilson SE.
Patient selection and complications of transhepatic cholangiography.
Surg Gynecol Obstet 1987; 165: 199-203.

Beinart C, Efremidis S, Cohen B, Mitty HA.
Obstruction without dilatation: importance in evaluating jaundice.
J A M A 1981; 245: 353-356.

Benjamin IS, Allison MEM, Moule B, Blumgart LH.
The early use of fine-needle percutaneous transhepatic cholangiography in an approch to the diagnosis of jaundice in a surgical unit.
Br J Surg 1978; 65: 92-98.

Berk RN, Cooperberg PL, Gold PR, Rohrmann CA Jr., Ferrucci JT Jr.
Radiography of the bile duct. A symposium on the use of new modalities for diagnosis and treatment.
Radiology 1982; 145: 1-9.

Bilbao MK, Dotter CT, Lee TG, Katon RM.
Complications of endoscopic retrograde cholangiopancreatography (ERCP). A study of 10000 cases.
Gastroentrology 1976; 70: 314-320.

Blumgart LH.
Biliary tract obstruction-new approches to old problems.
Am J Surg 1978; 135: 19-31.

Blumgart LH, Carachi R, Imrie CW, Benjamin IS, Duncan JG.
Diagnosis and management of post-cholecystectomy symptoms: the place of endoscopy and retrograde cholangiopancreatography.
Br J Surg 1977; 64: 809-816.

Bornman PC, Harries-Jone EP, Tobias R, Van Stiegmann G, Terblanche J.
Prospective controlled trial of transhepatic biliary endoprosthesis versus bypass surgery for incurable carcinoma of head of pancreas.
Lancent 1986; i (8472): 69-71.

Brandes JW, Scheffer B, Lorenz-meyer H, Korst HA, Littman KP.
ERCP: Complications and prophylaxis. A controlled study.
Endoscopy 1981; 13: 27-30.

Bradley EL, Salam AA.
Hyperbilirubinemia in inflammatory pancreatic disease: natural history and management.
Ann Surg 1978; 188: 626-629.

Brooks JR, Culebras JM.
Cancer of the pancreas. Palliative operation, Whipple procedure, or total pancreatectomy?
Am J Surg 1976; 131: 516-520.

Bruneton JN, Roux P, Fenart D, Caramella G, Occelli JP.
Ultrasound evaluation of common bile duct size in normal adult patients and following cholecystectomy. A report of 750 cases.
Eur J Radiol 1981; 1: 171-172.

Burckhardt H, Mueller W.
Versuche Uber die punktion der Gallenblase und ihre Rontgendarstellung.
Dtsch. Zschr. Chir 1921; 161:168-197.

Cahow CE, Burrell M, Greco R.
Hemobilia following percutaneous transhepatic cholangiography.
Ann Surg 1977; 185: 235-241.

Caletti G, Brocchi E, Agostini D, Balduzzi A, Bolondi L, Labo G.
Sensitivity of endoscopic retrograde pancreatography in chronic pancreatitis.
Br J Surg 1982; 69: 507-509.

Cameron JL, Broe P, Zuidema GD.
Proximal bile duct tumours. Surgical management with silastic transhepatic biliary stents.
Ann Surg 1982; 196:412-419.

Caroli J, Nora J.
L´ hepatocholedoque dans les pancratites.
IIIe Congres Europeen de Gastroenterologie Bolegne 1952: 609-36.

Carter RF, Saypol GM.
Transabdominal cholangiography.
J A M A 1952; 148: 253-255.

Chen L, Goldberg HI.
Sclerosing cholangitis: broad spectrum of radiographic features.
Gastrointest Radiol 1984; 9: 39-47.

Classen M, Philip J.
Endoscopic retrograde cholangiopancreatography (ERCP) and endoscopic therapy in pancreatic disease.
Clin Gastroentrol 1984; 13: 819-842.

Clemett AR.
Radiology of the liver and bile duct.
In: Margulis AR & Burhenne HJ, eds. Alimentary tract radiology, volume 11. 3rd ed. ST Louis: CV Mosby company, 1983: 1371-1433.

Coehlo JC, Buffara M, Pozzobon CE, Altenburg FL, Artigas GV.
Incidence of common bile duct stones in patients with acute and chronic cholecystitis.
Surg Gynecol Obstet 1984; 158: 76-80.

Cooperberg PL, Li D, Wong P, Cohen MM, Burhenne HJ.
Accuracy of common hepatic duct size in the evaluation of extrahepatic biliary obstruction.
Radiology 1980; 135: 141-144.

Cotton PB.
ERCP.
Gut 1977; 18: 316-341.

Cotton PB, Lees WR, Vallon AG, Cottone M, Croker JP, Chapman M.
Gray-scale ultrasonography and endoscopic pancreatography in pancreatic diagnosis.
Radiology 1980; 134; 453-459.

Cotton PB, Vallon AG.
British experience with duodenoscopic sphincterotomy for removal of bile duct stones.
Br J Surg 1981; 68: 373-375.

Cronan JJ.
US diagnosis of choledocholithiasis: A reappraisal.
Radiology 1986; 161: 133-134.

Cronan JJ, Mueller PR, Simeone JF, O'Ccnnell RS, VanSonnenberg E, Wittenberg J, Ferrucci JT Jr.
Prospective diagnosis of choledocholithiasis.
Radiology 1983; 146: 467-469.

Cross BH, Harter LP, Core RM, Callen PW, Filly RA, Shapiro HA, Goldberg HI.
Ultrasonic evaluation of common bile duct stones: prospective comparison with endoscopic retrograde cholangiopancreatography.
Radiology 1983; 146: 471-474.

Dani R, Nogueira CED, Furtado L, Leal S.
Epidemiology and aetiology of chronic calcifying pancreatitis in Belo Horizonte, Brazil.
Rendiconti Gastroenterologie 1974; 6: 153-156.

David JL, Milligan FD, Cameron JR.
Septic complications following endoscopic retrograde cholangiopancreatograpgy.
Surg Gynecol Obstet 1975; 140: 365-367.

Denning DA, Ellison EC, Carey LC.
Preoperative percutaneous transhepatic biliary decompression lowers operative morbidity in patients with obstructive jaundice.
Am J Surg 1981; 141: 61-65.

Dewbury KC, Smith CL.
The misdiagnosis of common bile duct stones with ultrasound.
Br J Radiol 1983; 56: 625-630.

Doust BD, Pearce JD.
Gray-scale ultrasonic proprties of the normal and inflammed pancreas.
Radiology 1976; 120: 653-657.

Drake CT, Beal JM.
Percutaneous Cholangiography.
Arch Surg 1965; 91: 558-563.

Dutta SK, Cox M, William RB, Eisenstat TE, Standiford HC.
Prospective evaluation of the risk of bacteraemia and the role of antibiotics in ERCP.
J Clin Gastroenterol 1983; 5: 325-329.

Einstein DM, Lapin SA, Ralls PW, Halls JM.
The insensitivity of sonography in the detection of choledocholithiasis.
A J R 1984; 142: 725-728.

Elias E.
Progress report: Cholangiography in the jaundiced patient.
Gut 1976; 17: 801-811.

Elias E, Hamlyn AN, Jain S, Long RG, Summerfield JA, Dick R, Sherlock S.
A randomized trial of percutaneous transhepatic cholangiography with the Chiba needle versus endoscopic retrograde cholaniography for bile duct visualization in jaundice.
Gastroentrology 1976; 71: 439-443.

Engelhom L, De Tceuf J, Hermanus A, Struyen J, Cremer M, Deltendu M, Sahel J, Toussaint J, Guien C, Pietri H, Clement JP, Mendes Vieira JN.
Posibilities et limites de la radiologie clasique dans le diagnostic de la pancreatite chronique primitive.
Acta Gastero-Enterolgica Belgica 1976; 39: 405-425.

Ertan A, Kandilci U, Danisoglu V, Aktan H, Payloc Z.
A comparison of percutaneous transhepatic cholangiography and endoscopic retrograde cholangio-pancreatography in post cholecystectomy jaundice.
J Clin Gastroentrol 1981; 3: 67-72.

Evans AF.
Endoscopic retrograde cholangiopancreatography (ERCP).
In: Whitehouse GH, Worthington BS, eds. Techniques in diagnostic radiology. Oxford: Blackwell scientific publications, 1983: 87-94.

Eyre-Brook A, Ross B, Johnson G.
Should surgeons operate on the evidence of ultrasound alone in jaundice patients?
Br J Surg 1983; 70: 587-589.

Fedail SS, Harvey RF, Salmon PR, Read AE.
Radioimmunoassay of lactoferrin in pancreatic juice as a test for pancreatic disease.
Lancet 1978; i (8057): 181-182.

Feduska NJ, Dent TL, Lindenauer SM.
Results of palliative operations for carcinoma of the pancreas.
Arch Surg 1971; 141:66-71.

Ferrucci JT Jr., Adson MA, Mueller PR, Stanely RJ, Stewart ET.
Advances in the radiology of jaundice: a symposium and review.
A J R 1983; 141: 1-20.

Ferrucci JT Jr., Mueller PR, vanSonnenberg E.
Transhepatic cholangiography.
In: Berk RN, Ferrucci JT Jr., Leopold GR, eds.
Radiology of the gall-bladder and bile duct, diagnosis and intervention. Philadelphia: WB Saunders, 1983: 334-345.

Ferrucci JT Jr., Wittenberg J.
Refinements in Chiba needle transhepatic cholangiography.
A J R 1977; 129: 11-16.

Ferrucci JT Jr., Wittenberg J, Black EB, Kirkpatrick RH, Hall DA.
Computed body tomography in chronic pancreatitis.
Radiology 1979; 130: 175-182.

Fleming MP, Carlson HC, Adson MA.
Percutaneous Transhepatic Cholangiography: The differential diagnosis of bile duct pathology.
A J R 1972; 116: 327-336.

Foley WD, Stewart ET, Lawson TL, Geenan J, Loguidice J, Maher L, Unger GF.
Computed tomography, ultrasonography, and endoscopic retrograde cholangiopancreatography in the diagnosis of pancreatic disease: a comparative study.
Gastrointest Radiol 1980; 5: 29-35.

Fraser GM, Cruikshank JG, Sumerling MD, Buist TAS.
Percutaneous transhepatic cholangiography with the Chiba needle.
Clin Radiol 1978; 29: 101-112.

Frederic N, Deltenre M, d´Hondt M, de Reuck M, Hermanus A, Potvliege R.
Comparative study of ultrasound and ERCP in the diagnosis of hepatic, biliary and pancreatic diseases: a prospective study based on a continous series of 424 patients.
Eur J Radiol 1983; 3: 208-211.

Freeny OC, Lawson TL.
Radiology of the pancreas.
NewYork: Springer-Verlag, 1982: 225-305.

Freeny PC, Bilbao MK, Katon RM.
"Blind" evaluation of endoscopic retrograde cholangiopancreatography (ERCP) in diagnosis of pancreatic carcinoma: The "double duct" and other signs.
Radiology 1976; 19: 271-274.

Friedman AC, Sachs L, Birns MT.
Radiology of jaundice including choledocholithiasis and biliary neoplasms.
ln: Friedman AC, ed. Radiology of the liver, biliary tract, pancreas and spleen. Baltimore: Williams & Wilkins, 1987: 497-548.

Frick MP, O-Leary JF, Walker HC Jr., Goodale RL.
Accuracy of endoscopic retrograde cholangiopancreatography (ERCP) in differentiation benign and malignant pancreatic disease.
Gastroentest Radiol 1982; 7: 241-244.

Frost RA.
Prospective multicentre study of British sphincterotomy: intial results and complications (Abstract).
Gut 1984; 25: A549.

Gemelin E, Kramann R, Weiss HD.
Kontrastmittel-zwischenfall bei einer endoskopischen retrograden cholangio-pankreatographie.
Munch Med Wschr 1977; 119: 1439.

Gibbons CP, Griffiths GJ, Cormack A.
The role of percutaneous transhepatic cholangiography and grey-scale ultrasoud in the investigation and treatment of bile duct obstruction.
Br J Surg 1983; 70: 494-496.

Gibson RN, Yeung E, Thompson JN, Carr DH, Hemingway AP, Bradpiece HA, Benjamin IS, Blumgart LH, Allison DJ.
Bile duct obstruction: Radiological evaluation of level, cause, and tumour resectability.
Radiology 1986; 160: 43-47.

Gibson RN.
Interventional radiology of pancreatobiliary tract.
Current Opinion in Gastroenterology 1987; 3: 664-671.

Gilinsky NH, Bornman PC, Girdwood AH, Marks IN.
Diagnostic yield of endoscopic retrograde cholangiopancreatography in carcinoma of the pancreas.
Br J Surg 1986; 73: 539-543.

Gold RP, Casarella WJ, Stern G, Seaman WB.
Transhepatic cholangiography: The radiological method of choice in suspected obstructive jaundice.
Radiology 1979; 133: 39-44.

Gold RP, Price JB.
Thin needle cholangiography as the primary method for the evaluation of the biliary-enteric anastomosis.
Radiology 1980; 136: 309-316.

Goldberg HI.
Percutaneous transhepatic cholangiography and biliary drainage.
In: Sleisenger MH & Fordtran JS, eds. Gastrointestinal Diseases. 3rd ed. Philadelphia: WB Saunders, 1983: 1745-1762.

Gourtsoyiannis NC, Nolan DJ.
Combined fine needle percutaneous transhepatic cholangiography and hypotonic duodenography in obstructive jaundice.
Clin Radiol 1979; 30: 507-512.

Gowland M, Kalantzis N, Warwick F, Braganza J.
Relative effeciency and predictive value of ultrasonography and endoscopic retrigrade pancreatography in diagnosis of pancreatic disease.
Lancent 1981; ii (8239): 190-193.

Gregg JA, Carr-Locke DL, Gallagher MM.
Important of common bile duct stricture associated with chronic pancreatitis.
Am J Surg 1981 ; 141 : 199-203 .

Gregg JA, McDonald DG.
Endoscopic retrograde cholangiopancreatography and grey-scale abdominal ultrasound in the diagnosis of jaundice.
Am J Surg 1979; 137: 611-615.

Guien C, Camatte R.
Valeur diagnostique et etude comparative des signes radiogiques des techniques standard dans les affections du pancreas.
Acta Gastroenterol Belg 1971; 34:115-121.

Guien C.
Radiological examination of the pancreas.
In: Howat HT & Sarles H, eds. The exocrine pancreas.
London: WB Saunders, 1979: 176-226.

Gustafsson M, Lunderquist A.
Personnel exposure to radiation at some angiographic procedures.
Radiology 1981; 140: 807-811.

Hamilton I, Lintott DJ, Rothwell J, Axon ATR.
Metrizamide as contrast medium in endoscopic retrograde cholangiography.
Clin Radiol 1982; 33: 293-295.

Hamilton I, Ruddell WSJ, Mitchell CJ, Lintott DJ, Axon ATR.
Endoscopic retrograde cholangiograms of the normal and post-cholecystectomy biliary tree.
Br J Surg 1982; 69: 343-345.

Hannigan BF, Keeling PWN, Slavin B, Thompson RPH.
Hyperamylasemia after ERCP with ionic and non-ionic contrast media.
Gastrointest Endosc 1985; 31: 109-110.

Hansell DT, Gillespie G, Imrie CW.
Operative transampullary extraction of pancreatic calculi.
Surg Gynecol Obstet 1986; 163: 17-20.

Harbin WP, Mueller PR, Ferrucci JT Jr.
Transhepatic cholangiography: Complications and use patterns of the Fine-needle technique. A multi-instutional survey.
Radiology 1980; 135: 15-22.

Hasan AH, Moule B, Carter DC.
Duodenal diverticula and jaundice: percutaneous transhepatic cholangiography may be misleading.
Br J Surg; 75: 490-491.

Haubek A, Pedersen JH, Burcharth F, Gammelgaard J, Hancke S, Willumsen L.
Dynamic sonography in the evaluation of jaundice.
A J R 1981; 136: 1071-1974.

Hermann RE, Cooperman AM.
Concept in cancer. Cancer of the pancreas.
N Eng J Med 1979; 301: 482-485.

Hershman MJ, Campion KM, Reilly DT.
Can surgeons rely on ultrasonography for gall stones ?
J R Coll Surg Edinb 1986; 31: 35-36.

Hessel SJ, Siegelman SS, McNeil BJ, Sanders R, Adams DF, Alderson PO, Finberg HJ, Abrams HL.
A prospective evaluation of computed tomography and ultrasound of the pancreas.
Radiology 1982; 143: 129-133.

Honickman SP, Mueller PR, Wittenberg J, Simeone JF, Ferrucci JT Jr., Cronan JJ, VanSonnenberg E.
Ultrasound in obstructive jaundice: prospective evaluation of site and cause.
Radiology 1983; 147: 511-515.

Huard P, Do-Xuan-Hop.
La ponction transhepatique des canaux biliares.
Bull Soc Med Chir lndochine 1937; 15: 1090-1100.

Illescas FF, Braun SD, Cohan RH, Bowie JD, Dunnick R.
Ultrasonically guided percutaneous transhepatic cholangiography in the nondilated biliaty tree.
Gastrointest Radiol 1986; 11: 77-80.

Jones SN, Lees WR, Frost RA.
Diagnosis and grading of chronic pancreatitis by morphological criteria derived by ultrasound and pancreatography.
Clin Radiol 1988; 39: 43-48.

Jones TB, Dubuisson RL, Hughes JJ, Robinson AE.
Abrupt termination of the common bile duct: a sign of malignancy identified by high-resolution real-time sonography.
J Ultrasound Med 1983; 2: 345-348.

Juler GL, Conry RM, Fuelleman RW.
Bile leakage following percutaneous transhepatic cholangiography with the Chiba needle.
Arch Surg 1977; 112: 954-958.

Juttijudata P, Chiemchaisri C, Palavatana C.
A prospective study of percutaneous transhepatic cholangiography (PTC) with Chiba needle: morbidity and mortality.
J Med Ass Thailand 1984; 67: 211-215.

Juttijudata P, Palavatana C, Chiemchaisri C, Churnratanakul S.
The accuracy of percutaneous transhepatic cholangiography (P.T.C) using the Chiba needle in the diagnosis of level and cause of cholestasis.
Australas Radiol 1986; 30: 24-29.

Kasugai T, Kuno N, Kobayashi S, Hattori K.
Endoscopic pancreato-cholangiography. I-The normal endoscopic pancreatocholangiography.
Gastroenterology 1972; 63: 217-226.

Kasugai T, Kuno N, Kobayashi S, Hattori K.
Endoscopic pancreato-cholangiography. II-The pathological endoscopic pancreatocholangiography.
Gastroenterology 1972; 63 : 227-234.

Keighley MRB.
Micro-organisms in the bile. A preventable cause of sepsis after biliary surgery.
Ann R Coll Surg Eng 1977; 59: 328-334.

Keighley MRB, Lister DM, Jacobs SI, Giles GR.
Hazards of surgical treatment due to microorganisms in the bile.
Surgery 1974; 75: 578-583.

Keighley MRB, Wilson G, Kelly JP.
Fatal endotoxic shock of biliary tract origin complicating transhepatic cholangiography.
Br J Surg 1973; 3: 147-148.

Kone BC, Watson AJ, Gimenez LF, Kadir S.
Acute renal failure following percutaneous transhepatic cholangiography. A retrospective study.
Arch Intern Med 1986; 146: 1405-1407.

Kreek MJ, Balint JA.
"Skinny needle" cholangiography-Results of a pilot study of a voluntary prospective method for gathering risk data on new procedures.
Gasroenterology 1980; 78: 598-604.

Kruse A, Thommesen P, Frederiksen P.
Endoscopic retrograde cholangio-pancreatography in pancreatic cancer and chronic pancreatitis.
Scand J Gastroenterol 1978 ; 13 : 513-517 .

Kummerle F, Ruckert K.
Surgical treatment of pancreatic cancer.
World J Surg 1984; 8: 889-894.

Laferla G, Gordon S, Watt M, Murray WR.
Role of a protease inhibitor in ERCP induced hyperamylasemia and pancreatitis (Abstract).
Gut 1985; 26: A650-A651.

Laing FC, Jeffrey RB.
Choledocholithiasis and cystic duct obstruction: difficult ultrasonic diagnosis.
Radiology 1983; 146: 475-479.

Laing FC, Jeffrey RB, Wing VW.
Improved visualization of choledocholithiasis by ultrasonography.
A J R 1984; 143: 949-952.

Laing FC, Jeffrey RB, Wing VW, Nyberg DA.
Biliary dilatation: defining the level and cause by real-time US.
Radiology 1986; 160: 39-42.

Lane DJ, Glazer G.
Intra-operative B-mode ultrasound scanning of the extra-hepatic biliary system and pancreas.
Lancet 1980; ii (8190): 334-337.

Landor JH, Fulkerson CC.
Duodenal diverticula. Relationship to biliary tract disease.
Arch Surg 1966; 93: 182-188.

Lang EK.
Percutaneous Transhepatic Cholangiography.
Radiology 1974; 112: 283-290.

Larsen CR, Scholz FJ, Wise RE.
Diseases of the biliary ducts.
Semin Roentgenol 1976; 11: 259-267.

Lawson TL.
Sensitivity of pancreatic ultrasonography in detection of pancreatic disease.
Radiology 1978; 128: 733-736.

Lee NW, Wong KP, Siu KF, Wong J.
Cholangiography in hepatocellular carcinoma with obstructive jaundice.
Clin Radiol 1984; 35: 119-123.

Lees WR, Hall-Craggs MA, Manhire A.
Five years experience of fine-needle aspiration biopsy; 454 consecutive cases.
clin Radiol 1985; 36: 517-520.

Leese T, Neoptolemos JP, West KP, Talbot I, Carr-Locke DL.
Tumours and pseudotumours of the region of the ampulla of Vater: an endoscopic, clinical & pathological study.
Gut 1986; 27: 1186-1192.

Leger L, Lemaigre G, Roseau E, Lenriot JP.
Les lesions hepatiques des pancreatites chroniques 50 observations.
Nouv Presse Med 1972; 33: 2159-2163.

Leukes P, Ceder S, Wibed A, Falk A, Gamklou R.
Evaluation of percutaneous cholangiography and percutaneous biliary drainage in obstructive jaundice.
Eur J Radiol 1985; 5: 267-270.

Ligoury C, Canard JM.
Tumours of the biliary system.
Clin Gastroenterol 1983; 12: 268-285.

Lintott DJ.
Percutaneous Transhepatic Cholangiography.
Clin Gastroenterol 1985; 14: 373-385.

Low DE, Micflicker AB, Kennedy TK, Striver HG.
Infectious complications of endoscopic retrograde cholangiopancreatography. A prospective assessment.
Arch Intern Med 1980; 140: 1076-1077.

MacCarty RL, LaRusso NF, Weisner RH, Ludwig J.
Primary sclerosing cholangitis: findings on cholangiography and pancreatography.

Radiology 1983: 149: 39-44.

Mandelstam P, Sugaw C, Silvis SE, Nebel OT, Rogers BH.
Complications associated with oesophagogastroduodenoscopy and with oesophageal dilatation. An analysis of the 1974 A S G E survey.
Gastrointest Endosc 1974; 23: 16-19.

Martin MB, Kon ND, Ott DJ, Sterchi JM.
Pseudocalculus sign: a pitfall of static cholangiography.
Am surg 1986; 52: 197-200.

Matzen P, Haubek A, Host-chistensen J, Lejerstofte J, Juhl E.
Accuracy of direct cholangiography by endoscopic or transhepatic route in jaundice- a prospective study.
Gastroenterology 1981; 81: 237-241.

Matzen P, Malchow-Moller A, Lejerstofte J, Stage P, Julhl E.
Endoscopic retrograde cholangiopancreatography and transhepatic cholangiography in patients with suspected obstructive jaundice.
Scand J Gasroentrol 1982; 17: 731-735.

McCune WS, Shorb PE, Moscovitz H.
Endoscopic cannulation of the ampulla of Vater: a preliminary report.
Ann Surg 1968; 167: 752-756.

McPherson GAD, Benjamin IS, Habib NA, Bowley NB, Blumgart LH.
Percutaneous transhepatic drainage in obstructive jaundice: advantage and problems.
Br J Surg 1982; 69: 261-264.

McPherson GAD, Benjamin IS, Hodgson HJF, Bowley NB, Allison DJ, Blumgart LH.
Pre-operative percutaneous transhepatic biliary drainage: the results of a controlled trial.
Br J Surg 1984; 71: 371-375.

McSherry CK, Glenn F.
Biliary tract obstruction and duodenal diverticula.
Surg Gynecol Obstet 1970; 130: 829-836.

Moreira VF, Merono E, Larraona JL, Gonzalez JA, Simon MA, Fernadez C, Ruiz de Arbol L.
ERCP and allergic reactions to ionised contrast media (Letter).
Gastrointest Endosc 1985; 31: 293.

Mueller PR, Harbin WP, Ferrucci JT Jr., Wittenberg J, vanSonnenberg E.
Fine-needle transhepatic cholangiography: Reflections after 450 cases.
A J R 1981; 136: 85-90.

Mueller PR, vanSonnenberg E, Simeone JF.
Fine-needle transhepatic cholangiography. Indications and usefulness.
Ann Intern Med 1982; 97: 567-572.

Muhletaler CA, Gerlock AJ Jr., Fleischer AC, James AE Jr.
Diagnosis of obstructive jaundice with nondilated bile ducts.
A J R 1980; 134: 1149-1152.

Mujahed Z, Evans JA.
Pseudocalculus defect in cholangiography.
A J R 1972; 116: 337-341.

Multigner L, Figarella C, Sahel J, Sarles H.
Lactoferrin and albumin in human pancreatic juice: a valuable test for diagnosis of pancreatic disease.
Dig Dis Sci 1980; 25: 173-178.

Myracle MR, Stadalnik RC, Blaisdell FW, Farkas JP, Martin P.
Segmental biliary obstruction: diagnostic significance of bile duct crowding (case report).
A J R 1981; 137: 169-171.

Nakayama T, Ikeda A, Okuda K.
Percutaneous trashepatic drainage of the biliary tract: technoque and results in 104 cases.
Gastroenterology 1978; 74: 554-559.

Neil SA, Thompson NW.
The complications of duodenal diverticula and their management.
Surg Gynecol Obstet 1965; 120: 1251-1258.

Niederau C, Sonneenberg A, Nueller J.
Comarison of the extrahepatic bile duct size measured by ultrasound and by different radiological methods.
Gastroenterology 1984; 87: 615-621.

Nilsson U, Evander A, Ihse 1, Lunderquist A, Mocibob A.
Percutaneous transhepatic cholangiography and drainage-risks and complications.
Acta Radiol (Diagn) 1983; 24: 433-439.

Norlander A, Kalin B, Sundblad R.
Effect of percutaneous transhepatic drainage upon liver function and post-operative mortality.
Surg Gynecol Obstet 1982; 155: 161-166.

O´Connor HJ, Axon ATR.
Gastrointestinal endoscopy: infection and disinfection.
Gut 1983; 24: 1067-1077.

O´Connor HJ, Hamilton 1, Ellis WR, Watters J, Lintott DJ, Axon ATR.
Ultrasound detection of choledocholithiasis: Prospective comparison with ERCP in the postcholecystectomy patients.
Gastrointest Radiol 1986; 11: 161-164.

O´Dwyer JA, Pemberton J, Thompson RP.
Measurments of the endoscopic retrograde cholangiograms
Dig Dis Sciences 1981; 26: 561-564.

Okuda K, Musha H, Nakajima Y, Takayasu K, Suzuki Y, Morita M, Yamasaki T.
Frequency of intrahepatic arteriovenous fistula as a sequela to percutaneous needle puncture of the liver.
Gastroenterology 1978; 74: 1204-1207.

Okuda K, Tanikawa K, Emura T, Kuratomi S, Jinnouchi S, Urabe K, Sumikoshi T, Kanda Y, Fukuyama Y, Musha H, Mori H, Shimokawa Y, Yakushiji F, Matsuura Y.
Nonsurgical, percutaneous transhepatic cholangiography-Diagnostic significance in medical problems of the liver.
Digestive Diseases 1974; 19: 21-36.

Osnes M, Skjennald A, Larsen S.
A comparison of a new non-ionic (metrizamide) and a dissociable (metrizoate) contrast medium in endoscopic retrograde pancreatography (ERCP).
Scand J Gastroenterol 1977; 12: 821-825.

Otte M.
Ultrasound in chronic pancreatitis.
In: Malifertheiner P, Ditchuneit H, eds. Diagnostic procedures in pancreatic disease. Berlin: Springer-Verlag, 1986: 143-148.

Parulekar SG, McNamara MP Jr.
Ultrasonography of choledocholithiasis.
J Ultrasound Med 1983; 2: 395-400.

Pedersen JH, Christensen RF, Juul N, Burcharth F.
Comparison of ultrasonography and transhepatic cholangiography in the evaluation of obstructive jaundice.
R O F O 1985; 143: 41-43.

Pereiras R Jr., Chiprut RO, Greenwald RA, Schiff ER.
Percutaneous Transhepatic Cholangiography with the "Skinny" needle. A rapid, simple, and accurate method in diagnosis of cholestasis.
Ann Intern Med 1977; 86: 562-568.

Petrozza JA, Dutta KS.
The variable appearance of the distal common bile duct stenosis in chronic pancreatitis.
J Clin Gastroentrol 1985 ; 7 : 447-450 .

Phillips GB, Davidson CS.
Liver disease of the chronic alcoholic simulating extrahepatic biliary obstruction.
Gastroenterology 1957; 33: 236-244.

Pitt HA, Gomes AS, Lois JF, Mann LL, Longmire WP Jr.
Does preoperative percutaneous biliary drainage reduce operative risk or increase hospital cost?
Ann Surg 1985; 201: 545-552.

Reuben A, Cotton PB.
Endoscopic retrograde cholangiopancreatography in carcinoma of the pancreas.
Surg Gynecol Obstet 1979; 148: 179-184.

Reuben A, Johnson AL, Cotton PB.
Is pancreatogram interpretation reliable? A study of observer variation and error.
Br J Radiol 1978; 51: 955-962.

Rohramann CA, Silvis SE, Vennes JA.
Evaluation of the endoscopic pancreatogram.
Radiology 1974; 113: 297-304.

Rohramann CA, Silvis SE, Vennes JA.
The significant of the pancreatic ductal obstruction in differential diagnosis of the abnormal endoscopic retrograde pancreatogram.
Radiology 1976; 121: 311-314.

Robert J, Taylor TV, Lee D, Carter DC.
The results of percutaneous transhepatic cholangiography in surgical practice.
J R Coll Surg Edinb 1980; 25: 444-448.

Roszler MH, Campbell WL.
Post-ERCP pancreatitis: Association with urographic visualization during ERCP.
Radiology 1985; 157: 595-598.

Ruppin H, Amon R, Ettl W, Classen M, Demling L.
Acute pancreatitis after endoscopic radiological pancreatography.
Endoscopy 1974; 6: 94-98.

Russell E, Nunez D Jr., Yrizarry J.
A 23-gauge sheahed needle, an alternative in transhepatic cholangiography.
Radiology 1978; 128: 822-823.

Sahel J.
Endoscopic retrograde pancreatography findings and their grading in chronic pancreatitis.
In: Malifertheiner P & Ditchuneit H, eds. Diagnostic procedures in pancreatic disease. Berlin: Spriger-Verlag, 1986: 169-173.

Sarles H, Sahel J.
Progress report: cholestasis and lesions of the biliary tract in chronic pancreatitis.
Gut 1978; 19: 851-857.

Sarles H, Sarles JC, Camatte R, Muratore R, Gaini M, Guien C, Pastor J, Le Roy F.
Observations on 250 confirmed cases of acute pancreatitis, recurring pancreatitis and chronic pancreatitis.
Gut 1965; 6: 545-559.

Sarles H, Sarles JC, Guien C.
Etude des voies biliaire et pancreatiques an cours des pancreatites chroniques.
Arch Mal App Digestif 1958; 47: 664-683.

Sarner M, Cotton PB.
Classification of pancreas.
Gut 1984 ; 25 : 756-759 .

Sarr MG, Cameron JL.
Surgical management of unresectable carcinoma of the pancreas.
Surgery 1982, 91; 123-133.

Sarr MG, Cameron JL.
Surgical palliation of unresectable carcinoma of the pancreas.
World J Surg 1984; 8: 906-918.

Sarti DA, King W.
The ultrasound findings in inflammatory pancreatic disease.
Semin Ultrasound 1980; 1: 178-191.

Scott J, Summerfield JA, Elias E, Dick R, Sherlock S.
Chronic pancreatitis: a cause of cholestasis.
Gut 1977 ; 18 : 196-201 .

Shawker TH, Jones BL, Girton ME.
Distal common bile duct obstruction: an experimental study in monkeys.
J Clin Ultrasound 1981; 9: 77-82.

Siegel JH, Sable RA, Ho R, Balthazar EJ, Rosenthal WS.
Abnormalities of the bile duct associated with chronic pancreatitis.
Am J Gastroenterol 1979 ; 72 : 259-266 .

Silvis SE, Rohrmann CA, Vennes JA.
Diagnostic accuracy of endoscopic retrograde cholangiopancreatography in hepatic, biliary, and pancreatic malignancy.
Ann Intern Med 1976; 84: 438-440.

Skude G, Wehlin L, Maruyama T, Ariyama J.
Hyperamylasaemia after duodenoscopy and retrograde cholangiopancreatography.
Gut 1976; 17: 127-132.

Snape WJ, Long WB, Trotman BW, Marin GA, Czaja AJ.
Marked alkaline phosphatase elevation with partial common bile duct obstruction due to calcific pancreatitis.
Gastroentrol 1976; 70: 70-73.

Speer AG, Cotton PB, Russell RCG, Mason RR, Hatfield ARW, Leung JWC, MacRae KD, Houghton J, Lennon CA..
Randomosed trial of endoscopic versus percutaneous stent insertion in malignant obstructive jaundice.
Lancent 1987; ii (8550):57-62.

Subramanyam BR, Raghavendra BN, Balthazar EJ, Horii SC, Lefleur RS, Rosen RJ.
Ultrasonic features of cholangiocarcinoma.
J Ultrasound Med 1984; 3: 405-408.

Taylor KJW, Rosenfield AT, de Graaff CS.
Anatomy and pathology of the biliary tree as demonstrated by ultrasound.
In: Taylor KJW, ed. Diagnostic ultrasound in gastrointestinal disease. NewYork: Chirchill Livingstone, 1979: 103-121.

Teplick SK
Cholecystitis, calculi, and miscellaneous conditions.
ln: Teplick JG & Haskin ME, eds. Surgical radiology, volume I. Philadelphia: WB Saunders, 1981: 913-962.

Teplick SK, Haskin PH, Sammon JK, Clearfield HR, Borowsky LM, Gambescia RA, Zitomer N, Goldstein RC.
Common bile duct obstruction: assessment by transcholecystic cholangiography.
Radiology 1986; 161: 135-138.

Trought WS, Morgan CL, Jackson DC, Johnsrude IS.
Evaluation of the biliary tree: A comparison of percutaneous transhepatic cholangiography and ultrasonography.
South Med J 1980; 73: 1592-1593.

Tsuchiya Y.
A new safer method of percutaneous transhepatic cholangiography.
Japanese Journal of Gastroenterology 1969; 66: 438-455.

Ubhi CS, Doran J.
Palliation for carcinoma of head of pancreas.
Ann R Coll Surg Eng 1986; 68: 159-162.

van Husen N, Hogemann B, Egen V, Mehnert CI.
Radiation exposure in endoscopic retrograde cholangiopancreatography.
Endoscopy 1984; 16: 112-114.

Vellacott KD, Powell PH.
Exploration of the common bile duct:a comparative study
Br J Surg 1979; 66: 389-391.

Walker TM.
Ultrasound of the gallbladder: experience in a district general hospital.
Br Med J 1981; 282: 1452-1453.

Walls WJ, Gonzallez G, Martin NL, Templeton AW.
B-scan ultrasound evaluation of the pancreas.
Radiology 1975; 114: 127-134.

Warshaw AL, Schapiro RH, Ferrucci JT, Galdabini JJ.
Persistent obstructive jaundice, cholangitis, and biliary cirrhosis due to common bile duct stenosis in chronic pancreatitis.
Gastroenterology 1976; 70: 562-567.

Weinstein BJ, Weinstein DP.
Biliary tract dilatation in the non-jaundiced patients.
A J R 1980; 134: 899-906.

Wild SR, Cruikshank JG, Fraser GM, Copland WA, Grieve DC.
Grey-scale ultrasonography and percutaneous transhepatic cholangiography in biliary tract disease.
Br M J 1980; 281: 1524-1526.

Willox GL, Costopoulos LB.
Entry of common bile and pancreatic duct into a duodenal diverticulum. Cause of pancreaticobiliary disease.
Arch Surg 1969; 98: 447-450.

Wisloff F, Jakobsen J, Osnes M.
Stenosis of the common bile duct in chronic pancreatitis.
Br J Surg 1982; 69: 52-54.