Progress report

ERCP

Endoscopic cannulation of the papilla of Vater was first described in 1968, but its widespread introduction followed the development of new duodenoscopes which became available outside Japan in 1970. Within two years, endoscopic retrograde cholangiopancreatography (ERCP) had been the subject of many enthusiastic reports, not only from Japan, but also from Germany, France, Belgium, Britain, and North America. Five groups were able to review series of more than 200 cases at the European Congress in Paris (1972), with technical success rates close to 90%.

This report concerns progress since the last review in 1972, and is based on personal experience and a burgeoning literature. Discussion of the technical problems of diagnostic ERCP will be followed by consideration of its clinical role and new developments.

Technical aspects

INSTRUMENTATION

Equipment has changed little since the original introduction of the long lateral viewing duodenoscopes (Olympus JFB and Machida FDS). The Olympus instrument has been more popular, largely because of its ready availability. Cannulation is possible with the Machida PFSB swing lens panview instrument, but proved difficult with the ACM F5A gastroduodenoscope; a more specialised ACM instrument will soon be available. Standard adult forward-viewing and oblique lens panendoscopes are not suitable, except when the papilla is approached from below via the afferent loop of a Billroth II partial gastrectomy.

There have been calls for improved instruments, but it is hard to see what changes are desirable; a partial reverse tilt of the lens might be helpful. Irradiation damage is a problem with all instruments. Bundle replacement every 100-200 cases is costly.

Catheter systems have not changed significantly. Graduated tip markings are useful, and metal tip inserts may facilitate cannulation of the minor papilla. Balloon tipped catheters have application in the context of papillotomy, and can be used for long term duct drainage. Manoeuvrable catheters are unnecessary. Methods for leaving a stilette in the catheter during contrast injection improve control and catheter survival, and reduce the possibility of introducing air. Incorporation of a manometer in the injection system has been recommended as a safety feature.

MEDICATION

The choice of sedation has never been critical, and most experts use little, especially in elderly patients. Duodenal ileus is helpful, and intermittent intravenous injections of hyoscine N-butyl-bromide (Buscopan, 20-40 mg)
Cannulation Methods and Success

The basic method for reaching the papillary region is established. Whether it is appropriate to perform formal gastroduodenoscopy en route depends upon the patient and clinical context. For cannulation, experts increasingly favour a straight scope position, as opposed to the original long route. This can be achieved by hooking the tip of the instrument in the second part of the duodenum and then withdrawing it with the lens facing the patient’s left side. As slack is removed from the stomach, the tip initially paradoxically advances. Further withdrawal brings the lens up the medial wall of the duodenum to the longitudinal fold and papilla. Cannulation is usually achieved with only about 60 cm of instrument inside the patient; control of the distal tip is enhanced and less of the shaft is exposed to radiation.

Frequently, it is clinically desirable to opacify both duct systems. In some patients, changing from one duct system to another remains a problem even for the experts. Pancreatography is usually easier to achieve than cholangiography; respective selective success rates of approximately 85% and 70% were widely reported. Increasing experience narrows this gap, but experts cannot produce any magic formula. In general, a pancreatogram is more likely to be successful if the papilla is entered directly en face; cholangiography may then be achieved by placing the catheter tip in the roof of the papilla and angling it upwards in the direction of the liver.

In our last 200 cases, the selective success rates were 87% for cholangiography and 92% for pancreatography. A reason for failure was often apparent. Previous surgery and major pathology were the commonest reasons. Cannulation is usually possible after Billroth II gastrectomy (sometimes easier with a forward viewing instrument) and a peripapillary diverticulum is not a bar unless the papilla lies within it. There is no special paediatric instrument, and ERCP becomes increasingly difficult below the age of 10 years. We have eight patients aged between 6 and 15 years, and success in the neonatal period has been described. Cannulation of the accessory papilla is desirable when Santorini’s duct is dominant as in the case of the separate ventral pancreas.

ERCP is a difficult technique to master. While articles, audiovisual materials, and models may help, proficiency can be achieved only by considerable personal experience. Recent instrument developments have paradoxically made cannulation more difficult, since beginners now start endoscopy with forward viewing systems. Cannulation should not be attempted until the endoscopist is fully familiar with the lateral viewing instrument and the duodenal loop; this reorientation can be achieved during routine endoscopy sessions.
Complications

ERCP carries many potential complications related to medication, endoscopy, cannulation, and contrast injection\textsuperscript{210,214}. In experienced hands complications occur in 2-3\% of examinations, with a mortality of 0-1-0-2\%. Complications are considerably more frequent with an inexperienced team\textsuperscript{224}.

Sepsis and pancreatitis are the two main hazards. A brisk but transient rise in serum levels of amylase and lipase occurs in most patients after pancreatography, particularly when acinar opacification occurs\textsuperscript{228}. This results from excessive injection of contrast, which should be prevented by careful fluoroscopic monitoring. The appearance of a pyelogram may indicate over-injection, and an increased risk of pancreatitis\textsuperscript{224}. The relevance of an asymptomatic rise in serum enzymes remains conjectural, as it may occur even after routine gastroscopy\textsuperscript{218}. Mild abdominal discomfort is not uncommon, often due to over-distension with air. Severe pain and the clinical picture of acute pancreatitis is rare. We have caused seven such episodes in over 1000 examinations; all occurred in patients already suffering from recurrent pancreatitis, and three had pseudocysts. Large surveys in North America have reported acute pancreatitis in 1-3\%\textsuperscript{220} and 1\%\textsuperscript{224}. The Erlangen group initially reported a much higher figure of 7-4\%\textsuperscript{213}; this later fell to 1-3\% after careful attention to contrast volume, avoidance of acinar opacification, and with the routine use of tetracycline\textsuperscript{217}. They found no additional benefit from the use of aprotinin (Trasylol) or glucagon; the latter had previously been reported to provide some suppression of hyperamylasaemia\textsuperscript{222}.

Sepsis is the killer after ERCP\textsuperscript{208,211,215}. It occurs almost exclusively in patients with poor drainage of the pancreatic and biliary systems. In the pancreas (malignant stenosis, pseudocysts) this presumably results from the introduction of infection\textsuperscript{218}. Many patients with biliary stasis are already infected, and cholangitis and septicaemia may occur as a result of dissemination of bacteria already present\textsuperscript{225}. Reviews of North American experience revealed septic cholangitis in 0-8\%\textsuperscript{224} and 0-7\%\textsuperscript{220}, with mortality of 0-1\% and 0-05\%. A recent Erlangen workshop reviewed almost 9000 examinations from 10 European centres. Cholangitis was described in 0-37\%, with a mortality of 0-05\%. A review of over 7000 procedures in Japan revealed 14 deaths from cholangitis\textsuperscript{212}. In this specific group of patients with biliary disease, cholangitis has been reported in as many as 20\% of patients\textsuperscript{71}.

Many centres use prophylactic antibiotics, either parenterally or added to the contrast material\textsuperscript{14,118}. There has been no controlled trial in this context, and some believe it would be unethical\textsuperscript{217}. Our practice is to use prophylactic gentamicin and ampicillin together by parenteral injection prophylactically in any patient with pre-existing cholangitis, and immediately after ERCP when duct stasis is demonstrated. The most effective prevention and treatment of sepsis is prompt surgical decompression. When duct strictures are discovered, contrast volumes should be kept to the minimum sufficient to allow a diagnosis but not necessarily to produce beautiful radiographs and slides.

Introduction of infection into a pseudocyst is a major disaster\textsuperscript{208,211}. When patients are known to have a pseudocyst, pancreatography is rarely indicated. When it is, it should be an immediately preoperative procedure. Patients with relapsing pancreatitis where previously undetected pseudocysts are a pos-
sibility should all be carefully screened by ultrasonography before consideration of ERCP.

Septic complications may present many hours, even days, after ERCP. This fact transforms a simple outpatient procedure into one requiring routine overnight hospital admission—indeed, to a centre capable of handling complex pancreatic and biliary surgery. This ideal provides organisational problems, particularly for endoscopists accepting patients on a day basis from other hospitals. It is not always easy to convince referring physicians and surgeons of the need for urgency in subsequent management. However, using the rules described above, we have seen no septic complications in our last 500 examinations.

As ERCP is often used in the context of jaundice, the possibility of transmitting viral hepatitis has been much discussed but not yet documented, despite the finding of hepatitis-associated antigen on some endoscopes. Our practice is to decline examination of any patient with positive serology, as there is no certain method of disinfecting instruments. Routine use of a bacteriocidal agent such as gluteraldehyde appears sensible; gas sterilisation is time consuming.

Catheter damage to the duodenal mucosa and to the duct systems has been described in rare cases. It should not occur with careful technique. Long-term sequelae of papillary instrumentation and pancreatography are theoretically possible. They have not been described, but would be difficult to detect. The most common complaints after ERCP are caused by inexpert instrumentation. A mundane hazard is over-inflation with air during a prolonged procedure.

**Radiological aspects**

ERCP is primarily a radiological procedure. Its aim is to obtain radiographs of diagnostic quality, and duodenoscopy is merely the vehicle. The aim cannot be achieved without close co-operation between a skilled endoscopist and an interested radiologist, both using optimal equipment. The interpretation of some high quality radiographs is quite difficult; pictures of inferior quality may render the procedure entirely useless. Standard water soluble contrast materials are used. There is no evidence that any particular contrast is better or safer. Lower concentrations (25-30%) should be used when duct systems are dilated. A tipping table is essential, as is the ability to take spot films during fluoroscopy. Some centres use ciné-radiology, or 100-mm spot film. The volume of contrast injection varies according to the patient, the duct size, and whether or not deep cannulation is achieved. Questions about exact volumes are irrelevant; sufficient contrast is injected to provide good radiographs as judged by fluoroscopy.

**CHOLANGIOGRAPHY**

In the presence of bile duct stenosis contrast injection should be kept to a minimum consistent with making a diagnosis, to reduce the risk of cholangitis. In other patients injections should continue until there is adequate filling of the intrahepatic ducts and the gallbladder. Changes in the position of the patient are often more effective than increased volumes. Cystic duct obstruction can be diagnosed if the gallbladder fails to fill after suitable positioning and adequate contrast filling of the intrahepatic tree. In the
absence of sphincter or diversionary surgery, contrast remains in the biliary tree long enough for the cannula and the instrument to be completely removed before radiology. This gives the radiologist freedom to arrange the posture of the patient. Erect films are often appropriate, particularly if an air bubble has been introduced inadvertently. The speed and dynamics of bile duct emptying might be of clinical interest; however, these are no doubt affected by previous instrumentation and medication and a standardised protocol would be necessary for any useful analysis. When there is a question of papillary disease, an increase in duct size since previous examinations is often taken to be of diagnostic importance. However, the duct may appear to be larger on ERCP than on intravenous cholangiography.

Radiographs of the biliary tree are familiar to clinicians and radiologists, and most good quality retrograde cholangiograms are easy to interpret. However, contrast and bile do not mix well and odd appearances may result from layering or streaming; this reinforces the need for radiographs in different positions and projections. Calculi usually float up the duct during contrast installation, and only rarely provide complete obstruction. Sclerosing cholangitis and cholangiocarcinoma may occasionally produce similar radiographic appearances at the hilum of the liver; intraduct brushing cytology and even biopsy may then be appropriate. Intrahepatic cholangiography may give some information about parenchymal disease. The lower bile duct may be narrowed both by chronic pancreatitis and cancer. The distinction can be difficult on cholangiography alone, and simultaneous pancreatography may be necessary. The appearances of the lower 1-2 cm of the bile duct vary from patient to patient, and continuously in an individual as a result of duodenal peristalsis and papillary sphincter activity. A radiographic diagnosis of abnormality in this area should be made with great caution.

**Pancreatography**

Contrast is injected under fluoroscopic control until the column reaches the pancreatic tail or an earlier obstruction. Diagnosis of an obstruction depends upon seeing good filling of the main duct and major branches short of that point; in their absence, lack of further filling may simply reflect inadequate injection of contrast. This is unlikely to occur if the catheter is deeply within the pancreatic duct but many pancreatograms are obtained when the cannula is impacted at the papilla and some contrast refluxes into the duodenum or passes into the bile duct. With average x-ray machines, when the major branches are visible on the fluoroscopic screen, radiographs will demonstrate opacification of most of the minor branches. Parenchymal opacification should be strictly avoided. Pancreatograms are best obtained with the patient lying prone. The supine position is less convenient for the endoscopist (since he should then be facing away from the patient), and less comfortable for the patient. Lateral and oblique pictures may be needed in certain patients. Contrast drains out of the pancreatic duct system very rapidly, and pancreatograms should be exposed with the instrument and catheter in place. Thus numerous radiographs will increase irradiation to the fibroscope bundle. Despite numerous necropsy and surgical studies, pancreatic duct radiograms are still unfamiliar to clinicians and radiologists. To experts in ERCP, their detailed interpretation poses a far greater problem than their achievement. A recent study in our unit provided some alarming figures concerning observer variation. Four experts were asked to look at 51 pancreatograms,
each on three separate occasions, without any clinical information. Considering only the question as to whether the pancreatogram was normal or abnormal, the observers were unanimous with their own three reports in only 47%, 75%, 90%, and 95% of cases.

**The Normal Pancreatogram**

Several authors have described the appearance of the pancreatogram in the groups of patients believed not to have pancreatic disease. As all these patients have been examined because of a symptom, pancreatic health cannot be entirely guaranteed. Equally, there will be a tendency to remove from this normal group any patient with minor pancreatic duct variations, and thus to prejudice the question of normal limits. Pancreatic histology is rarely available. Necropsy pancreatograms are easy to obtain but autolysis takes place rapidly and histological correlations are open to some dispute. Also the subjects necessarily fall into an elderly age group, and pancreatic anatomy may have been modified by the illness causing death.

It is obvious from many studies that the pancreatic shape varies considerably and that duct deviations cannot be accorded any diagnostic significance. Emphasis has been placed upon duct diameter and calibre variation. Necropsy studies have shown increasing ductal sizes with increasing age. This phenomenon was not evident in endoscopic data, but further analysis of the European endoscopy study group collection does show a slight increase of statistical significance over the age of 40 years. There are no objective measurements of calibre variation, and acceptable limits remain a subjective assessment. Slight narrowing of the duct in the head close to the junction with Santorini’s duct is frequently seen. The earliest changes in pancreatitis occur in the small branch ducts; acceptable limits for their variation in shape and size are also at the present time matters of opinion rather than statistic.

Diagnostic pancreatography is complicated by congenital duct anomalies, the commonest resulting from incomplete fusion of the dorsal and ventral remnants. Cannulation of the main papilla may then result in opacification of only a small ventral portion. If the anomaly is not recognised, pathological obstruction of the main duct may be diagnosed in error. Delineation of the remainder of the pancreas then requires opacification of Santorini’s duct via the accessory papilla, a challenge which we have found particularly difficult.

**Pancreatic and Papillary Cancer**

Cancer involving the papillary region is easily diagnosed at endoscopy and confirmed by biopsy or cytology; a cannulation attempt may not be necessary. When the pancreatic duct is blocked close to the papilla, pancreatography will fail. Retrograde cholangiography may then demonstrate a lesion, although the cholangiographic distinction between pancreatitis and cancer is not always simple. Pancreatography, in fact, succeeds in about 80% of patients with pancreatic cancer. The commonest findings are complete duct obstruction or stenosis with upstream dilatation. Rarely, there may be a long tapering stricture or a field defect in acinar opacification. Cancers are rarely demonstrated at an early stage (except of the papilla) mainly because symptoms are then non-specific and patients do not reach specialist investigation. Islet cell tumours are rarely demonstrated, as they may not involve the major
duct or branches\textsuperscript{168}. For the same reason, a normal pancreateogram is occasionally obtained in patients with advanced cancer. We have had this experience once in 55 cases, others have experienced six in 50\textsuperscript{159}, and three in 55\textsuperscript{168}. In some of these cases there have been pathological changes in the cholangiogram\textsuperscript{147}.

\textbf{Pancreatitis\textsuperscript{161–178}}

The pancreateogram appearances of established chronic pancreatitis are obvious, consisting of enlargement and calibre variation of the main duct and its branches, strictures, obstruction, and ductal filling defects. Thus when the diagnostic criteria for chronic pancreatitis are strict, including only those patients with calcification or available abnormal histology, virtually all pancreateograms are abnormal. At the other end of the scale, in patients with recurrent attacks of acute pancreatitis, many pancreateograms are entirely normal\textsuperscript{164,175}. In neither of these extremes is pancreateography needed to provide a diagnosis. Most patients with chronic pancreatitis are seen between these stages, without calcification and with no opportunity for histology. Here the frequency of pancreateographic abnormalities will depend upon the strictness of the criteria by which the diagnosis is judged. The earliest radiographic changes are seen in minor variations of the calibre of fine branches. Here the limits of normality are ill defined, and the scope for observer variation is impressive. Detailed necropsy and surgical studies have demonstrated that the severity of changes in the ductal system and in the parenchyma do not necessarily run in parallel, nor should we expect such a phenomenon.

We have stressed the particular risks involved in performing pancreateography in patients with pseudocysts; when indicated, contrast injection should be kept to a minimum. The cyst connects with the duct system in about 60\% of cases. Frequently, all that is seen is a complete duct obstruction\textsuperscript{168,169,172}.

\textbf{Cancer or Pancreatitis?}

The radiographic distinction between chronic pancreatitis and carcinoma is difficult; indeed both conditions may co-exist. Carcinoma may develop in a patient with chronic pancreatitis. Chronic pancreatitis is frequently found upstream of a stenosing carcinoma. Our own studies on observer variation have confirmed our inability to make a distinction between cancer and pancreatitis on the radiographs alone. In clinical practice, reporting relies also on clinical data, and is quite accurate. Delay in duct emptying has been reported as a sign of carcinoma\textsuperscript{148}, but also occurs in pancreatitis. Other parameters are required, such as cytology.

\textbf{Pancreatic Juice Cytology\textsuperscript{195–205}}

Good results have previously been reported from the cytology of duodenal aspirates during standard secretin/pancreozymin tests. As most pancreatic carcinomas arise from ductal tissue, it was reasonable to hope that access to pure pancreatic juice would provide a good diagnostic method. This hope has not been realised. We have had less than 50\% success, and in no case has cytology been of critical clinical importance. Others have reported positive findings in four out of six\textsuperscript{185}, 22 out of 29\textsuperscript{199}, and 14 out of 26\textsuperscript{205} patients with pancreatic cancer. Results are better for tumours of the head, and cytology

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\url{http://gut.bmj.com/}
may be positive in juice from close to the papilla where the tumour actually prevents pancreatography. Results are poor in the body and tail, where pancreatography is more informative. Further work may yet improve the results. Ductal lavage and brushing cytology have been recommended. As the radiographic distinction between pancreatitis and cancer may be difficult, it is still logical to take juice for cytology in every case of ductal lesion, particularly as particular cytological abnormalities have been reported in pancreatitis as well as cancer. Measurements of carcino-embryonic antigen concentration do not provide a clear cut distinction between pancreatitis and cancer, but other markers may well be described.

**Clinical relevance of diagnostic ERCP**

Diagnostic ERCP has facilitated the management of many patients with biliary and pancreatic disease. However, its precise clinical role alongside other developing techniques is still being clarified.

**JAUNDICE**

ERCP provides an excellent diagnostic method for distinguishing between medical and surgical jaundice, and can be used early in the illness. Initial reports provided a diagnostic rate of approximately 75%. We have made a precise diagnosis in 89 of our last 100 cases; in four of these the diagnosis came from endoscopy alone (papillary or pancreatic cancer with histological confirmation).

The main alternative technique is percutaneous transhepatic cholangiography (PTC). At the time of the introduction of ERCP, the traditional method for PTC was effective only in the presence of dilated ducts, and was usually arranged preoperatively to avoid complications from biliary leakage and bleeding. In this context, ERCP provided major advantages, particularly the ability to demonstrate non-obstructed ducts. These advantages have been considerably eroded by the increasing use of fine-needle PTC. This technique is simple and cheap, and complications are few. Non-obstructed ducts can often be opacified. While the only British figure so far is 25%, figures as high as 67.5% and 85% have been reported. A randomised study of ERCP and PTC led to the conclusion that PTC was the procedure of first choice. In some cases, both techniques may be necessary.

In theory, it is logical to use ERCP in jaundiced patients when the need is to exclude obstruction, and fine-needle PTC when a surgical lesion is strongly suspected. The latter technique also allows preoperative bile drainage, which may itself be of therapeutic importance. The approach to the jaundiced patient will also be influenced by recent continuing developments in ultrasonography and computerised axial tomography.

**PROBLEMS AFTER BILIARY SURGERY**

A substantial group of patients complain of symptoms after cholecystectomy or more complex biliary surgery. Even in the absence of jaundice, intravenous cholangiograms often fail to provide diagnostic radiographs. A high quality retrograde cholangiogram can demonstrate once and for all whether there is a stricture, stone, or no evidence of duct abnormality. In the latter case, the other constituent parts of ERCP provide documentation of peptic and pancreatic health or disease. In many frail patients with retained stones
endoscopic papillotomy allows definitive treatment. In many patients with pain after cholecystectomy, all elements of ERCP prove normal. In some of these, pain can be reproduced by the retrograde cholangiogram, suggesting undue sensitivity or the presence of abnormal sphincter function. Endoscopic manometry provides a new method of investigation in this context.

RECURRENT PANCREATITIS

As surgical management of patients with recurrent pancreatitis is designed to improve duct drainage, a preoperative examination of duct anatomy should be of value. The incidence and severity of duct abnormalities will vary, depending upon the population studied. We found a major duct lesion in almost half of our patients with two or more attacks of acute pancreatitis. ERCP may occasionally demonstrate gallstones which had previously escaped detection by orthodox cholecystography and cholangiography. With more advanced disease, and particularly when there is extensive calcification, pancreatography frequently demonstrates an obstruction in the pancreatic head.

Patients with recurrent pancreatitis or continuing pain and hyperamylasemia may well have a pseudocyst. If this can be demonstrated by a non-invasive technique, pancreatography is rarely indicated. When pancreatography demonstrates a pseudocyst, antibiotics should be used and early surgery performed.

Pancreatography provides a basis for logical duct drainage procedures, and should reduce the inappropriate use of exploratory laparotomy and sphincterotomy surgery. Careful follow-up is essential to discover whether these hopes are realised. It is already clear that the prognosis for patients with a normal or virtually normal ductogram is excellent if the initiating cause for pancreatitis can be eliminated. Endoscopic pancreatography provides a method for postoperative assessment of duct diversion procedures. A good clinical result does not necessarily indicate continuing patency of such an operation.

THE PATIENT WITH OBSCURE EPIGASTRIC PAIN

ERCP is a good method for the diagnosis of pancreatic cancer at the stage at which it usually presents for specialist investigation. Equally a classical pancreatogram provides definite documentation of chronic pancreatitis. However, a normal pancreatogram cannot be used to exclude pancreatitis — in the same way that a normal pyelogram does not exclude nephritis. However, in the context of obscure pain, a normal or virtually normal pancreatogram does indicate that pancreatic surgery need not be further considered.

The diagnostic role of pancreatography has to be considered alongside many other complex and developing techniques including function tests and arteriography. Non-invasive scanning is preferable if equally accurate. Isotope scans are virtually useless, but grey-scale ultrasonography and computerised axial tomography have great potential. Detailed studies of the comparative efficiency of different investigations are important, but are difficult to interpret as the results of most techniques also depend upon the enthusiasm and competence of the user.

ERCP has two advantages over certain other techniques. It can provide diagnosis or exclusion of gastric and duodenal disease and an assessment of
the biliary tract. Direct access to the pancreatic duct allows a functional assessment as well as an anatomical statement.

New developments

**PURE JUICE BIOCHEMISTRY**

Using the same cannulation technique, uncontaminated bile and pure pancreatic juice (PPJ) can be collected for biochemical study. Small collections for cytology are conveniently performed during diagnostic ERCP. However, formal biochemical studies should be performed on a separate occasion, as contrast materials, anticholinergic agents, and the manipulative stimulus of ERCP may affect the results. Equally a prolonged test wastes x-ray screening time. After hormone stimulation, collections can be maintained for more than an hour in most patients. Leaving the endoscope in place allows a frequent check on the precise position of the catheter. Simple longer catheters can be left in the duct systems for prolonged studies. Balloon tipped catheters facilitate this procedure, and work well in the bile duct.

Their safety in the pancreatic duct has not yet been established, and there are certain theoretical hazards when using standard diameter instruments. Even using a balloon catheter, PPJ collection may not be complete, because of some loss via Santorini’s duct and the minor papilla.

Access to PPJ provides a new stimulus for physiological and clinical research. Two striking facts have emerged from our early studies. The

![Fig. 1](http://gut.bmj.com/)  
*Fig. 1* Pure pancreatic juice (PPJ) biochemistry. Volume bicarbonate and amylase concentrations after bolus intravenous injections of secretin in a healthy subject. Note the marked volume and bicarbonate response to a single unit of secretin; also the high amylase concentration in ‘basal’ juice, and a secondary rise in amylase concentration after intravenous injection of 70 CU GIH secretin.
normal pancreas responds to doses of secretin as low as 0.5 CU (GIH secretin given by intravenous bolus) and the maximum bicarbonate concentration is achieved after a bolus injection of only 4 CU (Fig. 1). We have shown that many patients with chronic pancreatitis can produce a normal concentration of bicarbonate (over 120 mm/l) in PPJ. Preliminary reports are available on human volunteers and patients with different disease states. As yet, PPJ studies cannot claim any diagnostic superiority over carefully performed studies of duodenal aspirate function. However, the avenue is now open for extensive investigation of old and new parameters. If it is possible to discover relatively simple disease markers, small quantities of PPJ can be collected at the time of pancreatography to provide a simultaneous anatomical, functional, and diagnostic assessment.

Access to pure bile allows confirmation of biliary composition studies previously performed on duodenal aspirates, and a more precise method for studying hepatic handling of drugs and contrast materials.

ENDOSCOPIC SPHINCTEROTOMY AND REMOVAL OF GALLSTONES

Using standard duodenoscopes or larger experimental instruments, a catheter incorporating a diathermy wire allows unroofing of the papilla and enlargement of the bile duct orifice. After animal experimentation, the procedure has proved to be remarkably simple and safe in man. A cut of 10-15 mm effectively destroys the sphincter mechanism and allows subsequent passage of balloons inflated to 8-10 mm diameter. The term sphincterotomy thus seems more appropriate than mere papillotomy. Most students of this area have predicted frequent perforation if these extensive incisions are made. In fact perforations have been rare, and we have had no such experience in our first 50 cases.

This procedure has mainly been offered to elderly and frail patients with retained stones after cholecystectomy. After adequate sphincterotomy, most stones pass spontaneously within one week. If they are still present when ERCP is repeated, they can usually be removed using balloon catheters or a dormia type basket (Fig. 2). Most groups have achieved complete removal of stones in 80-90% of attempts.

The technique has also been used in a few patients with papillary stenosis, and in some elderly patients with jaundice due to stones who are judged unfit for early cholecystectomy.

Endoscopic sphincterotomy is a major therapeutic advance in the elderly and sick with stones or stenosis. Its more widespread use in younger and fit patients (and relationship to other techniques such as T-tube stone dissolution and extraction) depends on two factors—immediate complications and the possibility of late restenosis. As well as perforation, cholangitis, pancreatitis, and haemorrhage have all been described. Overall complication rates of 7% and 11% are reported, with mortality figures of 1.8% and 4.4%. So far, we have seen none of these serious complications, and it is evident that the short term morbidity and mortality from endoscopic sphincterotomy is less than that for the surgical approach.

The long-term fate of the diathermy sphincterotomy clearly requires careful long-term documentation. At least the endoscopic technique allows careful sequential measurements. In the vast majority of patients examined so far beyond one year, there has been no significant change. Restenosis has occurred...
in rare patients (including one of our own) from earlier experience where short tentative cuts were often made.

SPhincter of Oddi manometry\textsuperscript{227-231}
Measurement of sphincter pressure has potential clinical relevance in patients with symptoms after cholecystectomy and should allow a reassessment of the whole concept of ‘biliary dyskinesia’. Using the cannulation technique, a water perfused side-hole catheter or catheter tip transducer can be passed into and beyond the high pressure zone. Peaks within this zone vary within individual patients\textsuperscript{229}, and simple measurement of biliary-duodenal pressure differences may be sufficient (Fig. 3). Adequate sphincterotomy, whether endoscopic or surgical, usually abolishes this pressure difference\textsuperscript{231}. The detection of abnormally high pressures has proved more difficult. With intense spasm or stenosis, cannulation may fail. Where a high pressure phenomenon exists, it may be intermittent (like the patient’s symptoms) and any isolated reading may be of little relevance. Drug provocation studies may be of clinical interest\textsuperscript{230}, but the pharmacodynamics of the sphincter area are complicated\textsuperscript{28}. Sphincter manometry has not yet found a convincing clinical role.

Perendoscopic needle biopsy\textsuperscript{198}
Using standard endoscopes, it has proved possible to pass a fine needle through the stomach and duodenal wall and obtain positive aspiration
cytology samples from pancreatic tumours. The depth of penetration is obviously limited but this technique deserves further evaluation, at least when tumours of the pancreatic head are suspected on ERCP but are out of range of standard forceps or cytology brushes. A reliable and safe method for obtaining histological confirmation of pancreatitis would be a major diagnostic advance.

PERORAL TRANSPAPILLARY CHOLEDOCHOSCOPY AND PANCREATICOSCOPY

As an extension of ERCP, fine 'baby' instruments can now be passed through 'mother' scopes through the papilla and into the biliary and pancreatic ducts, procedures which were previously possible only at surgery (Fig. 4).

The present small fibrescopes are fragile and provide images of poor quality. Improved instruments will have limited application in a few complex patients.
The future

It is difficult and foolhardy to look ahead in a field which has been developing so quickly. The main hope must be for wider application of those techniques which have already been shown to have clinical value. ERCP should have a dominant place in the investigation of patients with problems after biliary tract surgery, and diathermy sphincterotomy can provide definitive treatment for some. ERCP will continue to be used in many patients with jaundice. In those patients with obvious obstruction fine-needle percutaneous cholangiography is simpler. The widespread availability of retrograde pancreatography should open a new chapter in the surgery of pancreatitis. Preoperative assessment should provide better case selection, and more logical procedures. Subsequent follow-up and repeat pancreatography can demonstrate the results of such operations.

ERCP can usually provide a diagnosis of pancreatic cancer at the late stage at which most patients present. In the future it will have to be judged against increasing developments in imaging (ultrasonography and computerised axial tomography) and, we hope, also in serology. The earlier diagnosis of chronic pancreatitis requires better documentation of minor pancreatographic changes, and their discriminating ability in comparison with other investigations. The availability of pure bile and pure pancreatic juice provides an opportunity for a better understanding of the liver and pancreas, both in health and disease, and may provoke discovery of specific disease markers.

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118Ayoola, B-Jaundice

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C—Cancer
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D—Related techniques and comparisons
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6. Pancreatography

A—Normal and variants

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B—General

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C—Cancer
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D—Pancreatitis
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ERCP


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E—Related techniques and comparisons

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1974


1975


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7. CYTOLOGY

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8. COMPLICATIONS

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9. PAPILLARY MANOMETRY

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10. PAPILLOTOMY AND GALLSTONE EXTRACTION
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11. CHELDOCHOSCOPY AND PANCREATICOSCOPY
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12. PURE SECRETIONS
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