Ultrasonic scanning in pancreatic disease

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SUMMARY We have analysed retrospectively the pancreatic ultrasound scans (using a bistable machine) in 138 consecutive patients, and have related the results to the clinical status and the final diagnosis in each case. The scans were read without knowledge of the patient's clinical state. When technically unsatisfactory scans were excluded from consideration, the overall diagnostic accuracy of ultrasonography proved to be 82%, with a false positive rate of 8%. The scan was abnormal in all 10 patients with cancer of the pancreas: a positive diagnosis of cancer was made in six. All patients with chronic pancreatitis in relapse had abnormal scans, but in 53% the scans were normal in patients in whom the disease was in clinical remission. In seven patients with chronic pancreatitis who suffered relentless pain, the head of the pancreas was swollen and contained cystic areas or emitted abnormal echoes. In acute pancreatitis ultrasonic scanning proved useful in following the progression of the disease to final resolution, or to development of complicating pseudocyst, abscess, or ascites. Random echoes in the early stages of acute pancreatitis are features of haemorrhagic necrosis. In alcoholic relapsing pancreatitis the persistence of abnormal echoes, disposed linearly along the axis of major ducts, suggests the presence of chronic pancreatitis.

Since the earliest reports on the use of ultrasound to assess the pancreas (Engelhart and Blauenstein, 1970; Filly and Freimanis, 1970; Russell 1972) there have been many reviews of its value in established pancreatitis (Lutz *et al.*, 1976; Doust and Pearce, 1976), and in pancreatic tumours (Lanz, 1975; Rettenmaier, 1975). Few reports analyse the place of pancreatic ultrasonography (USS) in investigating the patients who present with features which suggest pancreatic disease. In particular, the significance of a normal ultrasonic scan is unclear.

Methods

PATIENTS

We have analysed retrospectively the results of pancreatic ultrasonography in 138 consecutive adult patients referred for examination from 1971 to March 1977. At the time of referral all patients were suspected on clinical grounds to be suffering from pancreatic disease or its complications. Four patients were excluded because of inadequate follow-up.

The scans, recorded on Polaroid film, were read in the absence of knowledge of the clinical situation, and the interpretation made at that time was related to the clinical status of the patient and the final

diagnosis made with the relevant ancillary investigations including pancreatic function tests.

All the patients were examined without prior preparation on a Kretz Combison B-scanning bistable machine (a frequency of 1.5 or 2.25 MHz. is used). Although a grey scale machine was available during the latter part of the review period, the less sophisticated Kretz machine is preferred in suspected pancreatic disease because of the better manoeuvrability of the transducer and the convenience of its controls, and because of the more positive demonstration of the pancreatic outline with a bistable presentation.

Examinations early in the series were associated with a high failure rate (Fig. 1), usually because of inability to demonstrate the pancreas convincingly. In 1975 we began to use the method of three-dimensional reconstruction (Petri *et al.*, 1975). With the patient supine and the scan plane vertical, sections are taken both sagittally and transversely, the former usually at 2 cm intervals, the latter at 1 cm or even 0.5 cm intervals. In this way the pancreas is visualised in its three dimensions, and, if helpful, the image is drawn. This method led immediately to a reduction in the failure rate (Fig. 1), an increased reliance by clinicians on the method, and, as a result, to a substantial increase in the number of patients referred.

Fig. 1 Number of patients undergoing pancreatic scanning. The proportion of unreadable scans is demonstrated. Note that this proportion has fallen substantially in recent years, and that the number of scans has increased since 1975 (the figures for 1977 include only three months).

The initial sagittal scans identify the level of the pancreas and reveal gross abnormalities in the pancreatic area or elsewhere in the upper abdomen. The pancreas is then carefully delineated in transverse scans. Further refinements—prone scans, oblique supine scans, or sections with a sloping scan plane—are also used, but are needed in only a minority of patients.

NORMAL PANCREAS (Tables 1, 2)

The ultrasonic appearances of the normal pancreas show the recognised wide variation in pancreatic dimensions. In the great majority of cases the diameter of the head does not exceed 30 mm and 20 mm in the body and tail (Weill *et al.*, 1977). Any normal variation in size is gradual, and, conversely, an unexpectedly abrupt variation in contour, even if the size remains within normal limits, becomes significant (Fig. 2).

The pancreas reflects less sound than surrounding tissue, and with available machines the duct system

Table 1 Clinical findings in 134 patients

Clinical diagnosis	No. of patients
Normal pancreas	42
Acute pancreatitis	45
Chronic pancreatitis	32
Fibrocystic disease of pancreas	1
Radiation fibrosis of pancreas	1
Cancer of pancreas	13
Total	134

Table 2 Scan reports in various disease categories

Final diagnosis	No. of patients	Ultrasonic scans		
		Normal pancreas	Unreadable	Abnormal
Peptic ulcer	5	4	1	0
Gastritis	4	4	0	0
Irritable bowel syndrome	9	7	2	0
Biliary disease	4	2	1	1
Hepatitis	3	3	0	0
Cirrhosis of liver	4	3	0	1
Miscellaneous	13	12	0	1
Total	42	35(83%)	4(10%)	3(7%)
Laparotomy or necropsy	15	14(94%)	0	1(6%)

is not seen within the glands in normal patients.

Pancreatic disease was excluded in 42 patients after careful scrutiny of all the relevant information including, where available, the findings at laparotomy or necropsy (Table 1). Scan reports in the various disease categories which comprised this control group are given in Table 2. The scan was normal in 35 (83%) of the whole group, abnormal in three (7%), and unreadable in four (10%), while in the 15 of the control patients in whom the pancreas was assessed at laparotomy or necropsy the scan was normal in 14 (94%) and abnormal in one (6%). An enlarged pancreas on ultrasonography was found in three patients—one patient with gallstones, a second with eosinophilic gastroenteritis who regularly took opiates for his abdominal pain, and the third, a chronic alcoholic with cirrhosis of the liver. Secretin-pancreozymin tests were normal in all three patients. In the patient with hepatic cirrhosis, a repeat examination done six months later showed (Fig. 3) that the size of the pancreas was smaller than previously, suggesting resolution of a pathological process. The patient is symptom free at the present time.

PATHOLOGICAL PANCREAS (Table 1)

Patients with pancreatitis were classified at the time of discharge from hospital according to criteria defined by the Marseille Symposium (Sarles, 1965).

ACUTE PANCREATITIS (45 patients (Table 3))

Patients were first examined at varying intervals

Fig. 2 Transverse section through the normal pancreas at the level of the body. L: Liver. P: Pancreas. M: Mesenteric vessels. V: Inferior vena cava. A: Aorta. S: Spinal bodies. The pattern on the presentation is at 2 cm intervals.

Fig. 3 A border line normal pancreas is shown in a horizontal section through the head region. The diameter of the pancreas measures 3 cm. Key as for Fig. 2.

after the onset of the acute episode. Uniform enlargement of the whole pancreas, which was clearly defined and with fewer echoes from within the pancreas than normal, were the characteristic features at ultrasonography (Fig. 4). These changes could take days or weeks to settle. Although in general the scan appearances corresponded to the clinical assessment of the disease, there were instances when the pancreas remained enlarged despite clinical recovery and return to normal of the serum amylase. In these patients ultrasonic scanning was repeated at intervals until the scan returned to normal, or a complication of acute pancreatitis became obvious. Cysts or pseudocysts commonly were apparent by the fourth week but were occasionally seen earlier (Table 3), and pancreatic abscess was diagnosed in two patients (Fig. 5). In two patients with penetrating duodenal ulceration ultrasonography demonstrated focal enlargement of the head of the pancreas. At laparotomy the pancreas was considered normal in both patients and at follow-up six months after vagotomy and pyloroplasty both remain well.

The abnormal echoes in seven patients in the acute pancreatitis group can be divided into four cases with random echoes and three cases in which the echoes were linearly disposed along the long axis of the main pancreatic duct. We tentatively attribute random echoes to areas of pancreatic necrosis. Of the four patients with these, one who was scanned on the fourth day died on the tenth day with acute haemorrhagic necrosis, the second developed a pancreatic abscess, and the third a large pseudocyst. In the fourth, ultrasonography initially done on the ninth day was normal when repeated at the eighth week. The three patients with linear echoes have been followed for two years. In one patient ultrasonography was repeated at the sixth week; it was normal and he remains well. Of the other two, both with alcoholic relapsing pancreatitis, one was proved at laparotomy two years later to have histological evidence of early chronic pancreatitis, while the other, again two years later, despite clinical quiescence on abstaining from alcohol, has developed some impairment of exocrine pancreatic function.

Fig. 4 Transverse section through the head of the pancreas in a patient with acute pancreatitis. The head is abnormally enlarged and the ultrasonic texture of the gland is anechoic. Key as for Fig. 2.

Fig. 5 Transverse section through the tail of the pancreas. The tail (P) is abnormally enlarged, and laterally contains an area (A) in which echoes are shown. The diagnosis of pancreatic abscess was correctly made.

These two patients more appropriately should now fall into the diagnostic category of alcoholic relapsing chronic pancreatitis.

CHRONIC PANCREATITIS (32 patients (Tables 1, 4, 5))

A diagnosis of chronic pancreatitis was confirmed at laparotomy in 17 patients; diffuse pancreatic calcification was demonstrated radiologically in approximately one-third of the 32 patients. Eleven patients had clinical features of chronic pancreatitis and abnormal secretin pancreozymin tests. Thirty-one of the 32 patients had typical attacks of relapsing chronic pancreatitis; one patient had never experienced any abdominal pain.

Fifteen patients were examined during a phase of clinical remission. This includes one patient with silent chronic pancreatitis (Table 4). Ultrasonographs were usually normal in the absence of calculi, but when these were present abnormal randomly distributed echoes could be detected. The

size of the gland was occasionally increased in some patients who were symptom free, while in advanced disease the size was often reduced. In this sub-group of 15 patients in remission ultrasonography was abnormal in seven (47%) and normal in eight (53%).

Within eight weeks of a relapse (Table 5) ultrasonography showed an enlarged pancreas which often emitted abnormal linear echoes, representing dilatation of the main pancreatic duct (Fig. 6). Of the seven patients who suffered unremitting abdominal pain, in six the head of the pancreas was found to be specially enlarged and contained cystic areas or emitted abnormal echoes (Table 5). These findings were confirmed at major pancreatic surgery, which was required in all seven patients. In this sub-group of 17 symptomatic patients ultrasonographs were abnormal in 14 (82%), and unreadable in three (18%).

In a patient with fibrocystic disease, the tail of the pancreas was found to be slightly enlarged and more distinct than usual, while the size of the pancreas

Table 3 *Acute pancreatitis*

Time after onset of illness	Total no. of patients	Results of scan			Details of scan			
		Normal	Unreadable	Abnormal	Size increased	Abnormal echoes	Pseudo cyst	Abscess
0-14 d	10	2	2	6	6	2	0	0
2-4 w	12	3	5	4	4	1	1	0
4-8 w	9	0	1	8	8	4	5	1
8 w-6 m	12	5	1	6	6	0	2	1
Focal pancreatitis	2	0	0	2	2	0	0	0
Total	45	10	9	26	26	7	8	2

Table 4 *Chronic pancreatitis in remission*

	No. of patients	Ultrasonic scans					
		Normal	Unreadable	Abnormal	Increased size	Reduced size	Random echoes
With duct calculi	4	0	0	4	3	1	4
No duct calculi	11	8	0	3	1	2	0
Total	15	8	0	7	4	3	4

Table 5 *Chronic pancreatitis in relapse*

	No. of patients	Results of scan			Details of scan			
		Normal	Unreadable	Abnormal	Increased size	Random echoes	Dilated duct	Cysts
Constant pain	7	0	1	6	6	4	5	5
Within 8 weeks of relapse	8	0	2	6	6	1	4	0
Obstructive jaundice	2	0	0	2	2	1	1	0
Total	17	0	3	14	14	6	10	5

was generally reduced in a patient who had received previously radiotherapy to the para-aortic glands (Table 1).

CANCER OF PANCREAS (13 patients (Table 6))

Ultrasonographs were abnormal in 10 of 13 patients, three scans were unreadable. When a focal transonic swelling sufficiently large to indent contiguous structures was found, a firm diagnosis of cancer (rather than a cyst) could be made because of the indistinct outline of the neoplastic mass (Fig. 7) and its increased sonic reflectivity (six patients); in one patient the appearances were considered to be more typical of a cyst than cancer, however (Fig. 8). In three patients with uniform enlargement of the gland the appearances on ultrasonography could not be differentiated from those of pancreatitis.

Discussion

With experience the pancreas can be visualised using ultrasound in the great majority of cases. Walls *et al.*, (1975) have previously described the ultrasonic findings of the abnormal pancreas. If the pancreas is acutely involved, either by an acute inflammation or as an exacerbation of chronic

pancreatic disease, then it will be seen to be enlarged, and a reversion to normal size does not occur while clinical activity persists. In acute pancreatitis the gland is more clearly defined and gives rise to even fewer echoes than the normal organ. Serial examinations allow early identification of complicating cysts, pseudocysts, abscess, or ascites, and their progress. A pancreas damaged to such a degree as to have an abnormal secretin pancreozymin test (chronic pancreatitis) frequently will show evidence of duct dilatation seen as linear echoes. Although in this retrospective study pancreatic calculi were usually associated with random rather than linear echoes, in practice it is not possible to distinguish reliably the echoes from those of associated duct dilatations. Focal enlargement of the pancreas can be due to a focus of pancreatitis, cyst, abscess, or cancer. Apart from the size and ultrasonic appearance of the enlargement and of the remainder of the gland, the clinical presentation inevitably colours the diagnosis.

In the past two years, failure to demonstrate the pancreas for technical reasons has occurred but rarely. In assessing the overall diagnostic accuracy of ultrasonography it seems legitimate therefore to

Fig. 6 Transverse sections through the head and body of the pancreas in a patient with chronic pancreatitis in relapse. Notice the generally enlarged gland with the dilated ducts producing echoes more obvious along the centre of the gland. Key as for Fig. 2.

Fig. 7 Transverse section of the pancreatic head. Notice the locally enlarged head of the pancreas, with a normal size of the body—findings of pancreatic carcinoma, confirmed histologically. Key as for Fig. 2.

Fig. 8 Transverse section through the body of the pancreas. The clearly defined relatively anechoic area was misdiagnosed as a cyst, when, in fact, a carcinoma was found at operation. Key as for Fig. 2.

exclude the unreadable scans. These mainly occurred in the earlier part of the review period (Fig. 1). When experience had been gained the overall diagnostic accuracy of 82% (Table 7) then compared with the 84% accuracy in the study of Walls *et al.* (1975). The

increased incidence of false negative scans, 23%, compared to 8.5% in the study of Walls *et al.* (1975), may be related to inclusion in our study of patients with chronic pancreatitis in remission in whom a 53% incidence of normal scans occurred, as has

Table 6 Cancer of pancreas

No. of patients	Results of scan			Details of scan		
	Normal	Unreadable	Abnormal	Cancer	Increased cyst size	
13	0	3	10	6	3	1

Table 7 Diagnostic accuracy of ultrasonography

Final diagnosis	No. of patients examined	No. of patients excluding unreadable scans	Ultrasonography diagnosis	
			Correct	Incorrect
Normal pancreas	42	38	35	3
Acute pancreatitis	45	36	26	10*
Chronic pancreatitis	32	29	29	8
Fibrocystic disease of pancreas	1	1	1	0
Radiation fibrosis of pancreas	1	1	1	0
Cancer of pancreas	13	10	10	0
Total	134	115	94	21

Overall diagnostic accuracy if unsatisfactory scans excluded: 94/115 (82%)

False positive: 3/38 (8%)

False negative: 18/77 (23%)

False negative in chronic pancreatic disease: 8/41 (19.5%)

* The timing of scanning is of critical importance in acute pancreatitis. Thus, in these 10 patients a normal scan does not indicate an incorrect diagnosis, but that the pancreas has already returned to normal.

previously been reported (Doust and Pearce, 1976). If patients with acute pancreatitis are omitted from this assessment (whether the scan is normal or abnormal in these individuals, depends on the degree of restitution of the gland to normal), the overall diagnostic accuracy is 86%. These results and those reported by Walls *et al.* (1975), in both of which studies a bistable machine was used, are similar to the results of an investigation in which grey-scale imaging was employed (Doust and Pearce 1976). It must be stressed that, in our series, unlike these other studies, no clinical information was made available when the scans were read.

The low (8%) incidence of abnormal ultrasonography in patients with non-pancreatic abdominal diseases in this study (Tables 2, 7) suggests that ultrasonography will prove specially useful as a screening test of patients suspected of pancreatic disease. However, although, the scan was usually abnormal in patients with active pancreatitis and cancer, it was often normal in patients with proven chronic pancreatitis when the disease was in clinical

remission (Table 4). Despite a normal scan in these cases, it may therefore be necessary to undertake further pancreatic studies. In investigating pancreatic disease, results must be considered complementary, not mutually exclusive. When possible, the ultrasonograph should be made during a relapse, when, in our experience, no false negatives occurred (Table 5).

Although a degree of overlap is inevitable, the morphological appearances of acute pancreatitis, chronic pancreatitis, and cancer were often sufficiently distinctive to permit a specific diagnosis to be made by ultrasonography. To the role of ultrasonography in prospective screening of patients for pancreatic disease must be added its potential usefulness in differential diagnosis of the various pancreatic pathologies, and its use in following the progression of pancreatic necrosis lesions to final resolution or to development of complications. That ultrasonography is both non-invasive and without hazard is equally of benefit to both patient and doctor.

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