

CURRENT STATUS OF

DUAL-CHANNEL PANCREAS SCANNING

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Although the synthesis of ^{75}Se -selenomethionine was a major step in making possible the display of the pancreas by scanning (1-3), simultaneous localization of selenomethionine in the liver limited definition and delineation of the pancreas. We have reported previously a dual-channel scanning method using ^{198}Au to eliminate or color-differentiate the superimposed liver image (4,5). This technique has been verified by other investigators (6). The present report describes results applying this method to patients with suspected carcinoma of the pancreas, pancreatic insufficiency and cirrhosis as well as to control patients.

MATERIAL AND METHODS

Clinical material. Pancreatic scans were performed on 109 adult male patients, 35-76 years old. Thirty-six patients were free of known pancreatic or hepatic disease, 18 patients had unconfirmed diagnosis by the criteria described below, 10 had carcinoma of the pancreas, 19 had chronic pancreatitis with exocrine insufficiency and 17 had Laennec's cirrhosis. Finally, eight of the nine patients listed in Table 1 as "Other diagnosis" were cases of recurrent pancreatitis, and the ninth patient had a massive intraperitoneal hematoma following splenectomy. Carcinoma of the pancreas was proven by subsequent laparotomy or necropsy. Chronic pancreatitis was evaluated by a positive secretin-pancreozymin test (7), x-ray demonstration of pancreatic calcification, glucose-tolerance determination and steatorrhea determined by the 72-hr stool fat. The diagnosis of cirrhosis was based on clinical findings and confirmatory liver biopsy. Many of the cirrhotic pa-

tients had histories of alcohol ingestion, but none had laboratory or clinical evidence of pancreatic disease.

Patient preparation and technique. On the morning of the examination, the patient received his usual breakfast, followed in 1 hr by 100 μCi of ^{198}Au -colloid and 250 μCi of ^{75}Se -selenomethionine by intravenous injection. One hour after the injection, the patient was scanned in a supine position. As documented in previous studies, the 1-hr period is

TABLE 1. EFFICACY OF DIAGNOSING PANCREATIC DISEASE BY DUAL CHANNEL SCANNING

Confirmed diagnosis	Diagnosis from scan				
	No.	Nor- mal	Ca	Insuffi- ciency	Cir- rhosis
Clinical normal	36	31	0	4	1
Carcinoma of pancreas	10	2	8	0	0
Pancreatic insufficiency	19	6	0	12	1
Cirrhosis	17	4	3	0	10
Other diagnosis					
Acute recurrent pancreatitis	8	4	0	4	0
Postoperative splenectomy with massive intraperitoneal hematoma	1	0	1	0	0
Diagnosis unconfirmed	18				
TOTAL	109				
Percent false negative		14	20	37	41
Percent false positive		18	4	4	2

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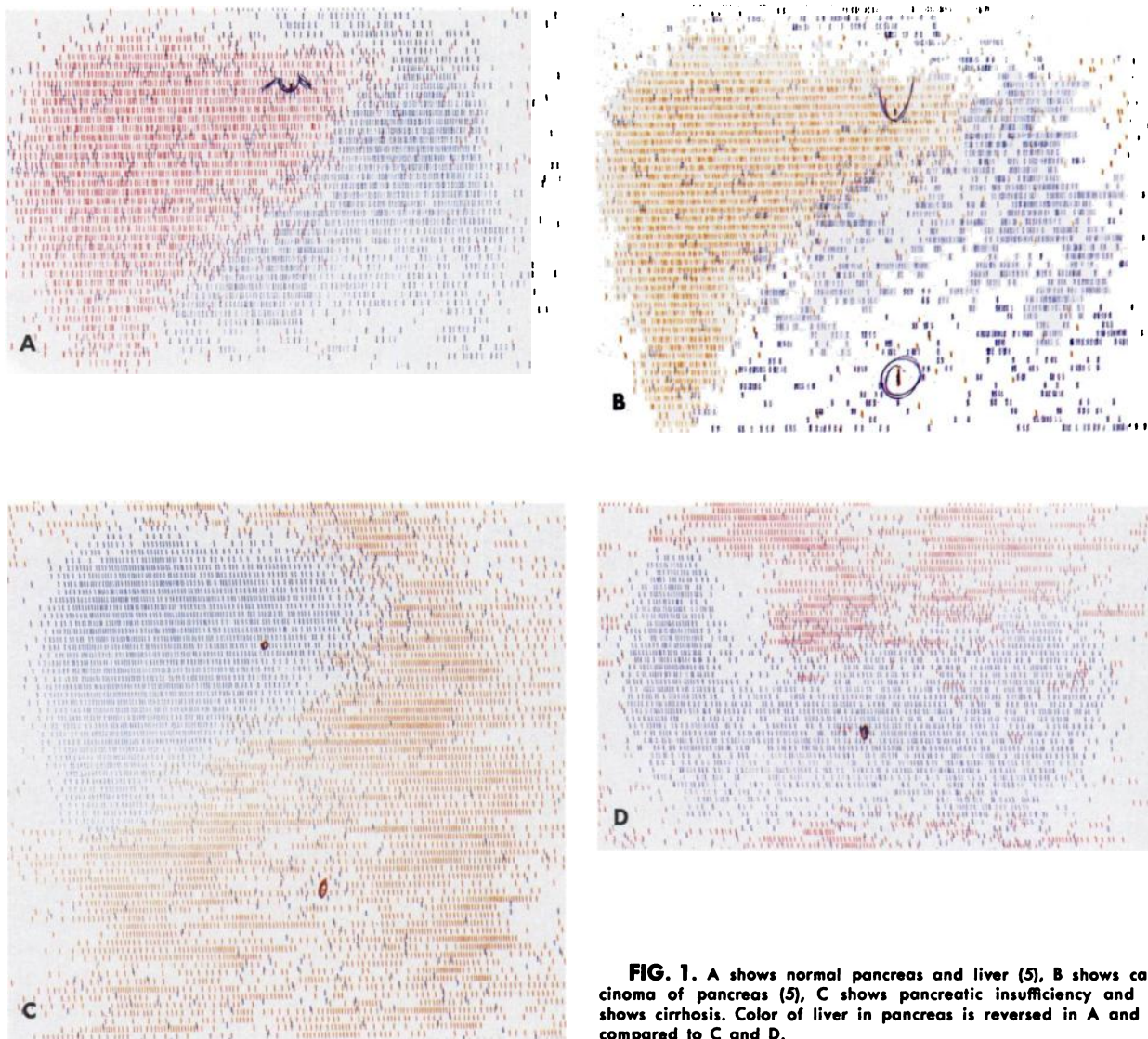


FIG. 1. A shows normal pancreas and liver (5), B shows carcinoma of pancreas (5), C shows pancreatic insufficiency and D shows cirrhosis. Color of liver in pancreas is reversed in A and B compared to C and D.

an adequate time for scanning. If the patient receives no additional food after breakfast, adequate scans can be obtained for a number of hours. In the procedure performed, we found that significant continued accumulation of ^{75}Se activity occurs for a number of hours (4). A modification of a Picker Magnascanner III or V is used, allowing dual-channel isotope subtraction for printout of the liver and pancreas in contrasting colors. The modification to eliminate scalloping (the lateral displacement of alternate scan lines) has been described previously (5). With this method ^{75}Se minus ^{198}Au was printed out with the scan traverse in one direction and ^{198}Au was printed out in the contrasting color as the scan traverse returned in the opposite direction. The scan spacing of 0.2 cm interdigitated the scan

lines while scanning at a speed of 60 cm/min. In both channels 10% of the background was erased. The detector was a 5-in. NaI(Tl) crystal with a 5-in. focal length focusing collimator (Picker Model 2111).

This detector was first placed over the right lobe of the liver remote from the pancreas. Gamma rays of different energies from the two isotopes were discriminated by two pulse-height analyzers and recorded by two individual counting-rate meters. The counting rates were equated, the gold subtracted from selenium and the net value was fed out through a voltage to frequency converter to the input of the scanner operating in the mode described above. In this method the subtract and two-color circuits are used. The subtraction of ^{198}Au from ^{75}Se when the

two counting rates are made equal over the liver eliminates net counting rate from this organ, while the actual display of pancreatic and other extrahepatic selenium is seen in one color. The ^{198}Au information is printed out from the second channel in another color, displaying the distribution of this isotope which is normally confined to the liver. Scans extended from the nipple line to the iliac crest.

The evaluation of the scan images was made by one of the authors for the purpose of this report. Evaluations by other observers were comparable; however, our concern was with the efficacy of the method, not with assessing the diagnostic acumen of various observers. The factors evaluated were the anatomical configurations of the liver and pancreas as well as of the spleen when it was present in the scan. This included the presence or absence of diffuse or focal defects in the liver and pancreas. The relative level of ^{75}Se not cleared by the liver or pancreas and visualized outside of these organs was also estimated. The specific criteria for determining normal pancreas, carcinoma of the pancreas, chronic pancreatitis and cirrhosis are described in the following section. The problem of distinguishing between the various diagnoses are included in the "Discussion."

RESULTS

The correlation of diagnostic results in the 109 patients studied by dual-channel scanning is summarized in Table 1.

Patients without pancreatic disease. The pancreas and liver were consistently visualized in 31 of 36 subjects free of pancreatic and hepatic disease, and no significant defect was seen. Principal anatomic variations in the normal pancreas encountered in this study included the pistol-shaped pancreas, the pancreas with large head and small tail and the pancreas with a large tail and marked attenuation where the body of the pancreas overlies the aorta. These variations in configuration have been discussed previously (4,8). Selenium activity exclusive of hepatic and pancreatic ^{75}Se was minimal and was principally confined to the myocardium. The presence of sufficient concentration of ^{75}Se in the myocardium to permit scanning has been verified in our laboratories. Specific details are the subject of a report in preparation. The spleen was not visualized (Fig. 1A).

Carcinoma of the pancreas. The pancreatic scans of 8 of 10 patients with carcinoma showed "cold" areas in the gland. The spleen was not visualized, and there was very little ^{75}Se outside of the pancreas and liver areas. In one patient with carcinoma of the body and tail of the pancreas, these areas were

devoid of ^{75}Se but the head appeared normal. In many instances the cold areas were diffuse, and later anatomic examination revealed replacement of the pancreas in these areas by masses of tumor tissue. In three instances the diagnosis of carcinoma of the pancreas was made in patients in whom barium-meal examinations were interpreted as normal. The barium-meal studies were adequate and interpreted by a well-qualified radiologist. The comparison of relative merit of barium meal versus scanning was not accomplished. Hypotonic duodenography was not performed. In one instance the two-color printout revealed cold areas in the liver and pancreas without ^{198}Au in the spleen or ^{75}Se in the abdominal field exclusive of the liver and pancreas. This made possible a correct diagnosis of carcinoma of the pancreas with metastases to the liver. In two additional cases, scans were interpreted as normal in patients with suggestive x-ray evidence for carcinoma; laparotomy confirmed that the pancreas was normal. None of the lesions demonstrated in this study were resectable (Fig. 1B).

Chronic pancreatitis. In 12 of 19 patients with chronic pancreatitis the scans also differed greatly from those of normal subjects. These patients did not have evidence of liver disease, and splenic uptake of ^{198}Au was absent in every instance, with normal deposition of ^{198}Au throughout the liver. ^{75}Se activity did not delineate the pancreas because of excessive ^{75}Se activity in the body exclusive of the liver and pancreas. It has subsequently been determined that the pancreas is discernible in these cases if much greater background erasure is used. This pattern has not been observed in normal subjects, patients with cirrhosis without chronic pancreatitis or in patients with carcinoma of the pancreas (Fig. 1C).

Cirrhosis. The scans of 10 of 17 patients with cirrhosis differed in three significant aspects from those of normal subjects. All showed patchy distribution in the pancreas, with small, scattered foci of ^{75}Se activity. This scattering is probably related to decreased counting rate. In every case but one, the scans also showed increased ^{198}Au uptake by the spleen. In two, hepatic "cold" areas previously described in the ^{198}Au scan of the cirrhotic liver (9) were also seen (Fig. 1D).

DISCUSSION

Various investigators have reported on ^{75}Se -selenomethionine as a diagnostic agent in scanning the pancreas. Because of variable evaluation criteria of scans and diagnostic methodology, comparison between series is probably not very meaningful. Burke and Goldstein (10) made a correct diagnosis of

carcinoma of the pancreas in three of four cases proven at surgery and diagnosed two cases of pancreatic insufficiency. Haynie *et al* (11) evaluated 15 normal subjects, interpreting 12 as normal, 1 as abnormal and 2 as equivocal; 11 patients with carcinoma of the pancreas, interpreting 1 as normal, 7 as abnormal and 3 as equivocal; and 11 patients with chronic pancreatitis, evaluating 1 as normal, 8 as abnormal and 2 as equivocal. Sodee (12) made the correct diagnosis in 5 of 6 patients with carcinoma of the pancreas. Burdine and Haynie (13) reported scan interpretation in 29 patients with suspected pancreatic disease. Fourteen had normal scans; 10 patients had "focal areas" in the pancreas, of whom 6 were found to have carcinoma of the pancreas by pathologic examination, and the remaining 4 were not diagnosed. One patient was interpreted as having chronic pancreatitis and in 4 others the liver interfered with the pancreatic scan. Brown *et al* evaluated 80 pancreatic scans, of which 37 were interpreted as normal, 39 as abnormal and 4 as technically unsatisfactory. The normal scans included 7 normals, 16 pancreatitis and 13 tumors. It must be emphasized that in contrast to the above studies this report deals with diagnostic categorization into four classes: normal, carcinoma of the pancreas, pancreatic insufficiency and cirrhosis. The pancreatic lesion must be of sufficient size to permit resolution by the collimation and the counting statistics of the scanning system used. Small lesions of less than 2 cm diameter would not be visualized by most scanning devices. The lesions reported by this technique are presumably examples of relatively massive replacement. Reference to lesion size includes secondary effect due to occlusion of pancreatic ducts.

Diagnosis of pancreatic disease by ^{75}Se -selenomethionine scanning is atraumatic; the procedure can be tolerated by the most cachectic or gravely ill patient. Our data indicate that the dual-isotope scan may be helpful in diagnosing carcinoma of the pancreas and, particularly in cases of cancer in the body and tail, it may demonstrate suspicious areas which are not visualized by conventional barium-meal examinations.

Further investigation is indicated to determine more precisely the relationship of cirrhosis to the apparent decreased pancreatic uptake of ^{75}Se in this disease compared to normals. The subtraction technique is not a significant factor in this observation because the decrease is independent of liver-pancreas overlap.

^{198}Au uptake by the spleen may be a "marker" which will help to prevent erroneous diagnoses of carcinoma of the pancreas in patients with cirrhosis.

However, because the presence of cirrhosis does not exclude the possibility of carcinoma of the pancreas, we feel that exceptional conservatism should be used in interpreting all pancreatic scans in patients with cirrhosis.

When cirrhosis is not present (6), the opportunity to detect hepatic metastases by the simultaneous hepatic scan is a clear advantage, giving important information without the necessity of two separate examinations.

Our data also indicate that this technique can support or suggest a diagnosis of chronic pancreatitis. The diffuse appearance of ^{75}Se on these scans gives an appearance which we did not see in patients with carcinoma. This appearance may, however, interfere with recognition of a tumor or cyst when it is present in a patient with chronic pancreatitis.

The evaluation of a significant number of patients with other diseases may produce scan patterns with confusing similarity to those described, and the usefulness of the described techniques as a dependable clinical diagnostic technique must await further evaluation. Improvement of the method by tape recording the two channels of information, playing the image out on a cathode-ray tube and photographing the image through color filters on Polaroid film, permits great improvement of the quality of the image. This technique permits multiple image production at various channel ratios, and evaluation of pancreatic disease by this improved method is currently underway.

SUMMARY

The dual-channel scanning technique was applied to the diagnosis of pancreatic disease and found helpful. Distinct patterns were discernible in individuals free of pancreatic disease, patients with carcinoma of the pancreas and patients with chronic pancreatitis. With the exception of a visualized spleen, an appearance similar to that of carcinoma of the pancreas was found in patients with cirrhosis. The implications are discussed, and the need for caution in interpreting pancreatic scans in these individuals is stressed. We feel that this atraumatic technique deserves wider clinical trial.

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