SCINTIPHOTOS OF THE PANCREAS: ANALYSIS OF 134 STUDIES

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Early in the decade 1960–1970 visualization and study of the pancreas using radioactive isotopes became feasible. Rectilinear scanners and gamma cameras have permitted successful pancreatic images on an increasing number of patients with ^{75}Se-selenomethionine. Following intravenous injection, this radioactive amino acid accumulates in the pancreas in sufficient concentration to allow satisfactory photographic portrayal of the high-energy gamma emission of the isotope (269 keV). The amino acid is incorporated into pancreatic digestive enzymes secreted into the small intestine and reabsorbed to be used in body protein synthesis.

More recently, camera studies have also been performed successfully and in increasing numbers. This paper surveys 134 pancreatic camera scintiphotos in an attempt to evaluate their usefulness in the diagnosis of pancreatic disease.

METHOD

Protocol. The surveyed population consisted of 134 outpatients and hospitalized patients at the Ochsner Medical Center. The images were obtained from June 1967 to March 1971 using the Pho/Gamma III Scintillation Camera System (Nuclear-Chicago Model 6403). All studies were performed at the request of the referring physician.

TABLE 1. PROTOCOL FOR PANCREAS SCANNING

1. Full meal 1 hr prior to scan.
2. Intravenous injection 2 mCi ^{99m}Tc-sulfur colloid. Oral administration 15 mg ProBanthine.
3. Liver scan begins at 15–20 min (anterior, right lateral, anterior—10-deg oblique cephalad views).
4. Intravenous injection 175 μCi ^{75}Se-selenomethionine. Oral administration 1.02-gm glutamic acid hydrochloride.
5. Pancreas imaging begins immediately—six scintiphotos obtained consecutively at 10-min intervals for 1 hr.
6. Intravenous injection 10 mCi ^{99m}Tc-pertechnetate. Blood-flow study begins at 6 sec, eight scintiphotos obtained at 3-sec intervals for 30 sec.

Until 1969 the procedure for imaging the pancreas at the medical center began with ingestion of a high-protein meal and intramuscular administration of ¼-grain morphine sulfate. However, most patients regurgitated the meal and many reacted to morphine. For such patients, scintiphotos were performed without this preparation and since there seemed to be no appreciable difference in the results, the special meal and morphine were discontinued in 1969.

The present protocol (Table 1) consists of a full meal 1 hr before the patient arrives at the department. Upon arrival ^{99m}Tc-sulfur colloid (2 mCi) is injected intravenously and propantheline bromide (ProBanthine) (15 mg) is given orally with the patient in a sitting position.

Fifteen to 20 min later, liver imaging is begun with the patient in the supine position. Anterior, right lateral, and an anterior view with the collimator angled 10 deg cephalad have proved useful (Fig. 1). These views provide information regarding the size, shape, and, more importantly, the position of the liver. The scintiphoto with the 10-deg cephalad tilt of the collimator demarcates the liver edge and its position so that differentiation between the liver and pancreas is simplified later when the pancreatic images are made.

Selenium-75-selenomethionine (175 μCi) is injected intravenously. At the same time 1.02 gm of glutamic acid are given. This induces continuing secretin and pancreozymin secretion which aids incorporation of selenomethionine into the duodenum by slow passage through the pancreatic ductal system (*1*). Pancreatic imaging commences without delay with the collimator still positioned 10 deg cephalad. At 10 min the first scintiphoto of the pan-

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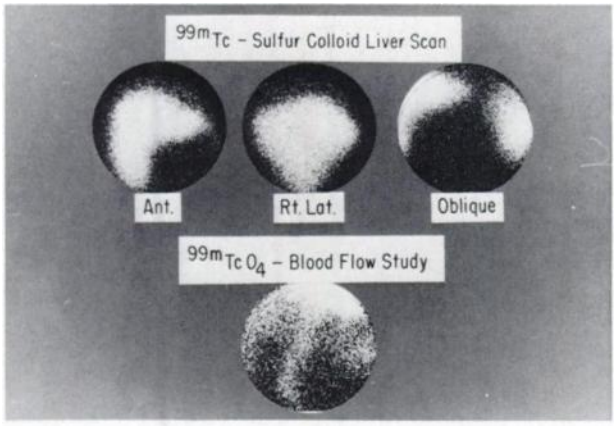


FIG. 1. Top three scintiphotos are camera liver images using ^{99m}Tc-sulfur colloid. These are made before pancreas imaging. Oblique view clearly shows liver edge and space below where pancreas is expected to visualize later after ^{75}Se-selenomethionine injection. Lower scintiphoto is ^{99m}Tc blood-flow study for aorta position.

creas is obtained. Consecutive scintiphotos are then made every 10 min for 1 hr. Any necessary adjustments in position and camera intensity can be made following the first scintiphoto. All photos have three identical views of the pancreas but with different exposure values depending on the settings of the three-lens head of the Polaroid camera. These can reveal subtle changes in contrast and density so that a specific area of interest can be examined in a total of 18 views on six scintiphotos.

As the final procedure, abdominal blood-flow patterns are obtained (Figs. 1 and 2). Technetium-99m pertechnetate (10 mCi) is injected intravenously. Eight scintiphotos are then made beginning at 6 sec for the first and every 3 sec thereafter to 30 sec. With this technique the aorta and its position relative to the pancreas can be studied. The pancreas will often demonstrate a uniform defect in the midbody or at the junction between the head and body. With a pair of spring-adjusted dividers the distance from the reticule illumination to the center of the uptake deficit in the pancreas scintiphoto is compared with the distance from the center of the aorta to the reticule of the blood-flow scintiphoto. It can then be determined whether the deficit corresponds appropriately to the aortic pressure exerted upon the posterior pancreas (Fig. 3).

The camera spectrometer is set on the 269-keV photopeak with window width of 15%, and an average of 50,000 total area counts are obtained on each view of the pancreas. The six consecutive views make the study dynamic by indicating the rapidity of isotope uptake and pancreas secretion. The best view is often at 30–40 min with good visualization remaining at 1 hr (Fig. 4).

Survey methods. The survey was conducted using 134 pancreatic images which were performed as early as 1967 using the camera technique as described. This technique has been essentially the same except that originally only one exposure per scintiphoto was obtained. Later studies included three different exposures per scintiphoto (f stops 8, 9.3, and 11). With the differences in contrast provided, subtle detail could be studied. Much of the time, the brightest of the three provided the best information. However, during angiography a vascular anomaly or islet cell tumor can produce a blush visible on all scintiphotos.

To test the value of the image, all scintiphotos were interpreted without clinical information or other aid. Two reviewers, working separately, recorded their impressions without knowing any other data. Neither the identity of the patient nor any clinical

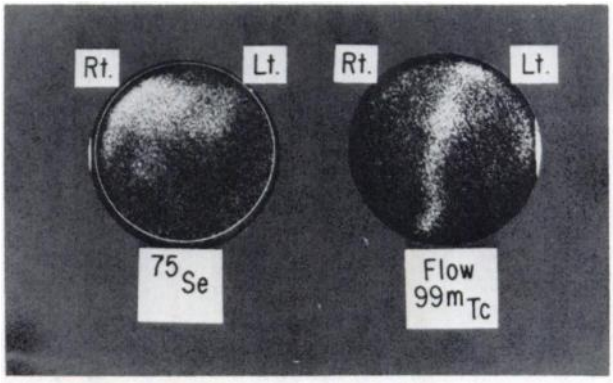


FIG. 2. Normal sigmoid-type pancreas is seen in left scintiphoto. ^{99m}Tc blood flow study reveals tortuous aorta and prominent celiac axis (confirmed by angiography). Splenic artery is also faintly visualized.

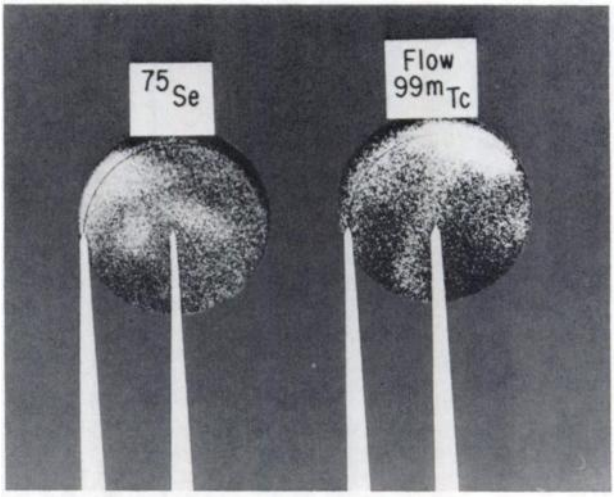


FIG. 3. Comparison of pancreas body thinning and aortic pathway using pair of spring-adjusted dividers. Note one point of divider is on reticule illumination.

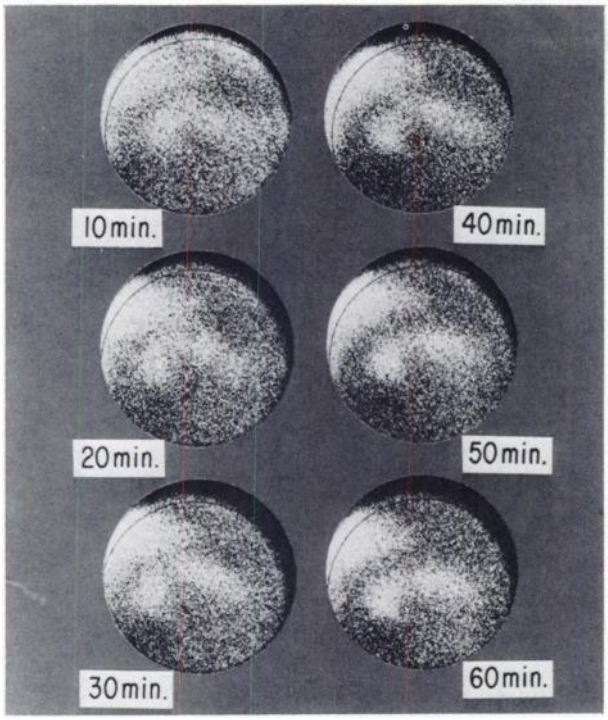


FIG. 4. Normal pancreas image of pistol-shaped pancreas on consecutive 10-min scintiphotos. Quality pancreas image is seen at 40–50 min imaging after injection of 175 μCi ^{75}Se-selenomethionine. Background counts have increased by 60 min.

information was provided. Each reviewer indicated whether the pancreas appeared normal, abnormal, or equivocal. These impressions were then compared with the reading which had been given for each study originally by a third interpreter. The results were collected and tabulated. In those studies in which two opinions disagreed with the third, the majority opinion was used as the "official" choice for the final analysis. Disagreement between the reviewers occurred in ten of the studies with the majority opinion proving correct in eight of the ten.

Studies were then grouped according to normal or abnormal pancreas and those which were correct or incorrect according to the final diagnosis. The diagnosis in some cases was histologically proven and in others only the clinical impressions were available. Image interpretations were also compared with specific diagnoses (i.e., pancreatitis, adenocarcinoma, etc.) and with angiographic studies using only instances where both studies had been performed on the same patient.

RESULTS

Normal and abnormal scintiphotos. Of the total number of scintiphotos (134) (Table 2), 44 were histologically examined. One study was incorrectly interpreted as normal. Retrospectively, this particular scintiphoto showed an equivocally normal head of the pancreas next to the liver edge. At surgery, a 6 × 6-cm lesion was found in the head of the pancreas

TABLE 2. ACCURACY OF 134 PANCREATIC IMAGES AT OCHSNER MEDICAL CENTER JUNE 1967 TO MARCH 1971

	Histologic diagnosis		Clinical diagnosis		Incomplete follow-up
Interpretation	Correct	Incorrect	Correct	Incorrect	
Normal (85)	15	1	63	4	2
Abnormal (49)	24	4	10	4	7
Total (134)	39	5	73	8	9

which proved to be adenocarcinoma (Fig. 5). Four of the studies, interpreted as abnormal, were found to be normal on histologic examination. In review of these four abnormal-appearing organs, it was determined that the left lobe of the liver obscured most of the pancreas in two cases. The ^{99m}Tc-sulfur colloid study for liver position showed an excessive overlap in the viewing field by the left lobe of the liver. This obliterated proper visualization of the pancreas and led to the erroneous conclusion that there was an abnormality present. The remaining two cases were difficult to interpret adequately because of faulty technique.

Of the 81 patients who had a clinical diagnosis only, four normal-appearing scintiphotos were incorrect on a clinical and laboratory basis. Two of these cases were chronic pancreatitis. The other two were thought to have tumors but no histologic evidence was available. Four abnormal-appearing scintiphotos were also incorrect when compared with the final clinical diagnosis. All of these patients were considered to have a normal pancreas. The final impression by the attending clinician in each case: (1) pyloro-

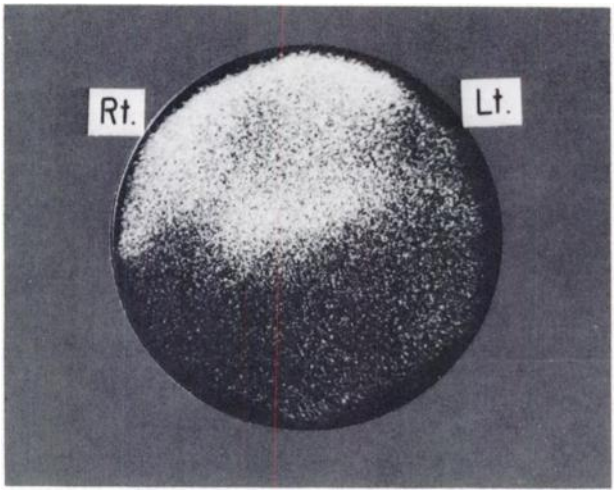


FIG. 5. Scintiphoto showing apparently normal pancreas albeit somewhat short. At surgery 6 × 6-cm adenocarcinoma of pancreas head was discovered.

spasm, (2) hepatic cell necrosis, (3) functional reaction, and (4) irritable bowel. In retrospective examination of the scintiphotos, the left lobe of the liver again obscured the pancreas in one case; two studies were technically poor; and one study failed to reveal any pancreatic uptake of isotope. Followup has yet to reveal a pancreatic abnormality in these patients.

The overall accuracy of 125 complete followup cases was 89.6%. The interpretive results in this study (Table 3) revealed 6% false negative. On strictly proven cases the false negative rate was 6.2%. The false positive percentages were 19% overall and 14.2% on only proven cases.

Specific diagnoses. Image interpretations were also compared with specific diagnoses (Table 4). Of 86 normal pancreata, 78 studies were read as normal. Of 18 patients with tumor involving the pancreas, the scintiphoto was read as abnormal in 17. Thus the accuracy rate for tumor diagnosis was 94%. In 12 cases of pancreatitis, the images revealed the abnormality in ten. Two cases of pseudocyst of

TABLE 3. ACCURACY OF PANCREATIC SCINTIPHOTOS: RESULTS STATED BY OTHER INVESTIGATORS

Investigators	False-negative (%)	False-positive (%)
Hatchett, Shuler, Murison	6 (6.2*)	19 (14.2*)
Rodriguez-Antunez, Alfide, Gill (7)	5	34
Brown, Sircus, Smith, et al (4)	8.1	15.4
Sodee (1)	4	15
Fink, Ben-Porath, Jacobson, et al (3)	14	18

* Proven

TABLE 4. SCINTIPHOTO INTERPRETATION COMPARED WITH FINAL DIAGNOSIS

Final diagnosis	No.	Normal scan	Abnormal scan
Normal pancreas	86	78	8
Tumors of pancreas	18	1	17
Adenocarcinoma	14	1	13
Islet cell	2		2
Reticulum cell	1		1
Metastasis from breast	1		1
Pancreatitis	12	2	10
Pseudocyst	2		2
Miscellaneous (Interstitial fibrosis, atrophic infarction)	4		4
Incomplete	9	2	7

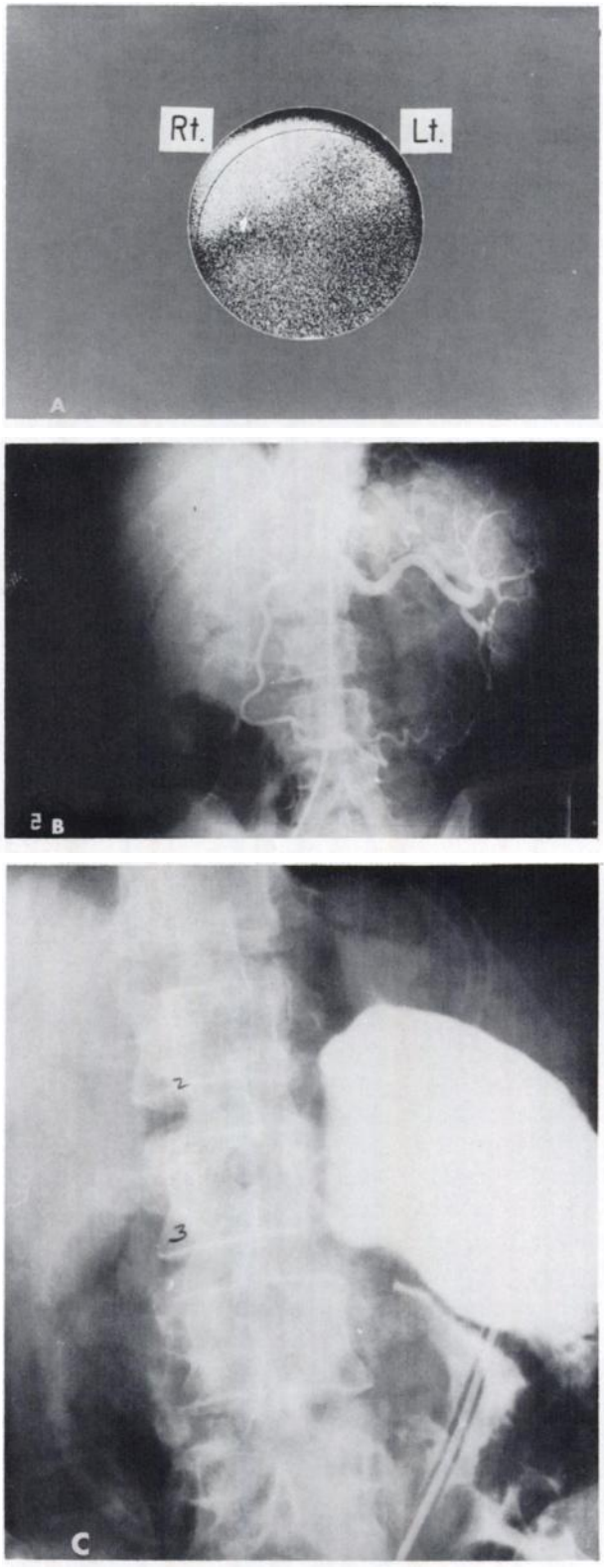


FIG. 6. A is scintiphoto demonstrating markedly diminished uptake of ^{75}Se-selenomethionine in body of pancreas with poor localization of isotope in head. B, selective celiac study, shows splaying of gastro-epiploic arteries with corkscrew terminations indicating large space-occupying lesion in region of pancreas. C shows large pancreatic pseudocyst discovered at exploratory laparotomy. Radiograph shows outline of cyst by contrast material injected at surgery.

TABLE 5. ACCURACY OF SCINTIPHOTO COMPARED WITH ANGIOGRAPHY

	Normal	Abnormal
Both correct	9	11
Both wrong	0	0
Scintiphoto correct / Angiogram wrong	2	3*
Scintiphoto wrong / Angiogram correct	1*	1
Total	12	15

* Pancreatitis.

TABLE 6. NORMAL ANATOMICAL VARIANTS OF PANCREAS

Type	Rate of occurrence (%)
Pistol	25
Horseshoe	17.1
Sigmoid	17.1
Horizontal	14
Dumbbell	9.3
Other	17.5

the pancreas (Fig. 6) were detected by these studies. Two cases of interstitial fibrosis and one each of atrophic pancreas and infarction of the pancreas were all correctly read as abnormal.

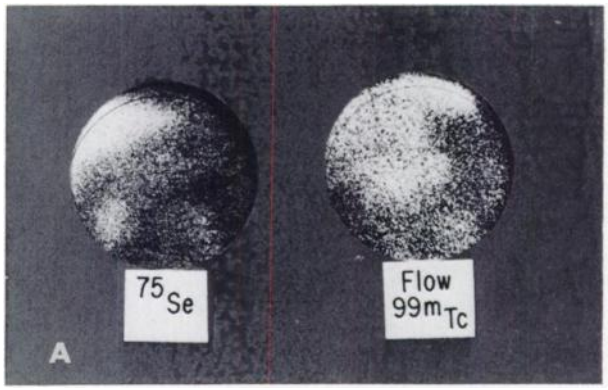
Compared with angiography. In a comparison of radionuclide studies with those of roentgen angiography (Table 5), both studies were correct in the investigation of 20 patients, 11 of whom were diagnosed as abnormal (Figs. 7 and 8). The scintiphoto was correct and the roentgen angiogram incorrect in five cases, whereas the angiogram was correct and the scintiphoto incorrect in two cases. In seven of 27 instances either scintiphoto or angiogram was incorrect. In four of these, the diagnosis was chronic pancreatitis.

Morphological findings. The morphologic characteristics of 64 normal pancreatic scintiphotos were compiled (Table 6 and Figs. 9 and 10). The most common configuration encountered was the pistol shape (25%), followed by the horseshoe and sigmoid shapes (17.1%), the horizontal shapes (14%), and the dumbbell shapes (9.3%). These five shapes comprise 82.5% of all the pancreatic studies. A number of unusual shapes also were revealed: a vertical tail, a short downward hook in the tail, and the usual sigmoid shape folded upon itself. In general the unusual shapes can be considered as variants of the five common forms. King et al (*2*) have described three morphologic patterns: (1) high transverse, (2) horseshoe, and (3) sigmoid. Here again it was noted that definite patterns exist although few have a classic or textbook appearance.

DISCUSSION

In this study, the pancreas was visible totally or in part by camera images in all but three cases (two of chronic pancreatitis; one of interstitial fibrosis of the pancreas). As camera techniques improved since 1967, the studies became better in quality and resolution. In general, the skill of differentiating normal from abnormal was not difficult to develop.

Aside from occasional inaccuracies due to technique, the most frequent error was attributed to confusion between the liver edge and the pancreas. Fink et al (*3*) have had good results with a dual-channel scanning method (modified Picker Magnascanner III or V) to eliminate or differentiate by color the superimposed liver image. When using the gamma camera and confronted with the liver overlap problem, it is appropriate to reposition the patient and reorient the collimator early in the procedure. The pancreas which is straight and at an oblique angle to the liver is the most difficult to study. However, virtually all normal pancreata (greater than 90%) can be demonstrated by scintiphotos.



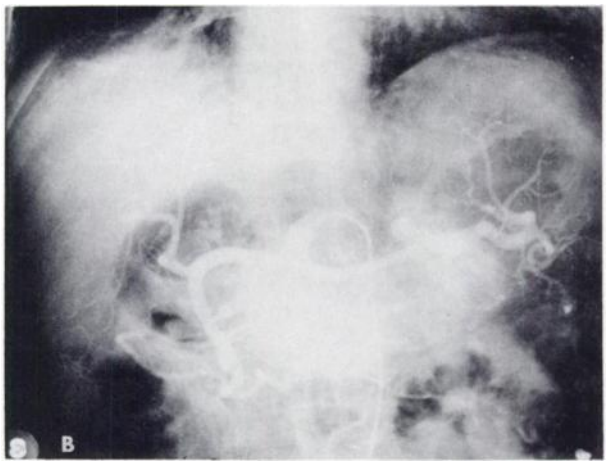


FIG. 7. A shows ^{75}Se-selenomethionine localized only in pancreas head. ^{99m}Tc blood-flow study reveals prominent vascular abnormality in midportion of scintiphoto which corresponds to defect in pancreas. B: Ensuing selective celiac angiogram demonstrates dilated celiac axis and marked tumor stain below. This was highly vascular islet cell tumor involving body and tail of pancreas.

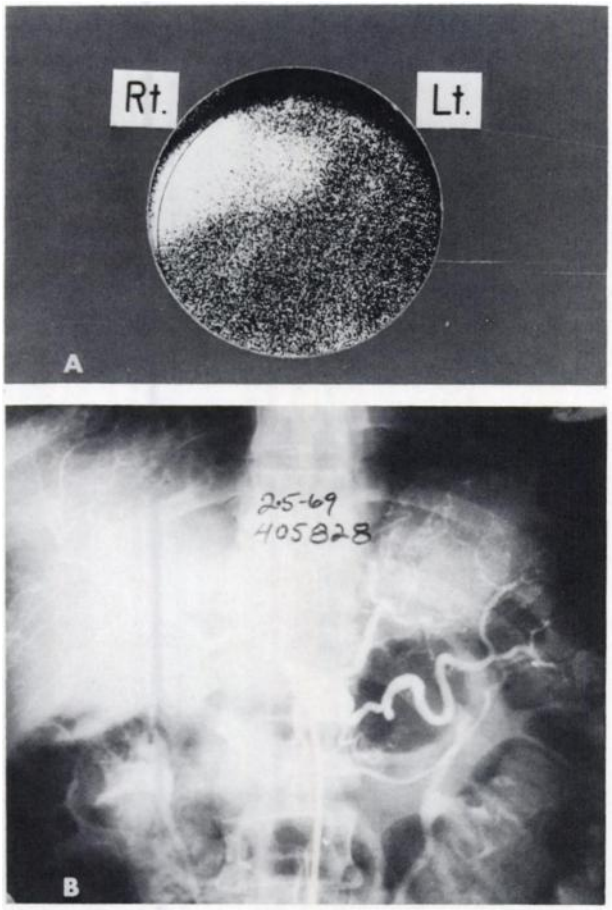


FIG. 8. In A scintiphoto shows decreased uptake of ^{75}Se-selenomethionine in body of pancreas due to space-occupying tumor. In B corresponding selective celiac angiogram demonstrates narrowing of proximal splenic artery due to encasement by adenocarcinoma of body of pancreas.

Chronic pancreatitis is often difficult to evaluate on scintiphotos, particularly if the patient is undergoing remission at the moment of imaging. The scintiphoto will show a patchy mottled distribution of uptake similar to that seen with tumor involvement. With acute pancreatitis, images will show more uniform and diffusely poor uptake or fail to visualize at all. Of the two, chronic pancreatitis is more difficult for the interpreter. However, we believe that further use of imaging in pancreatitis is indicated to help corroborate or substantiate the clinical impression and to determine the results of treatment.

Our results indicate a high degree of accuracy (94%) in diagnosis of pancreatic tumors. Brown (*4*) in a series of 14 pancreatic tumors reported 93% accuracy and Sodee (*1*) in a larger series reported 96% accuracy. Since these results can be proven by surgery or autopsy, the value of imaging can be accurately judged. Tumors of the body and tail of the pancreas are more difficult to diagnose than tumors of the head of the pancreas. Such lesions, previously unsuspected by laboratory data or clinical investigations, may be revealed by imaging alone and, therefore, we recommend its use as a useful diagnostic tool.

False-negative results (Table 3) occur relatively infrequently. Like rectilinear scans, the normal camera scintiphoto correlates well with the normal pancreas. The false-positive results in this survey compare in frequency with other studies, and there is reason to believe this error will decrease with advances in instrumentation as well as the experience gained by the interpreters.

The body of the pancreas may become thinned because of the pressure exerted by the aorta as it passes posteriorly. Also, the organ is slightly mobile

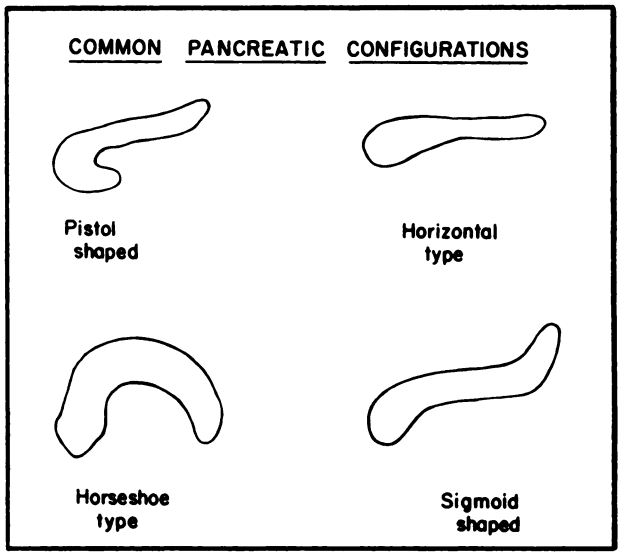


FIG. 9. Common pancreatic configurations based on morphology study of 64 normal pancreas scans.

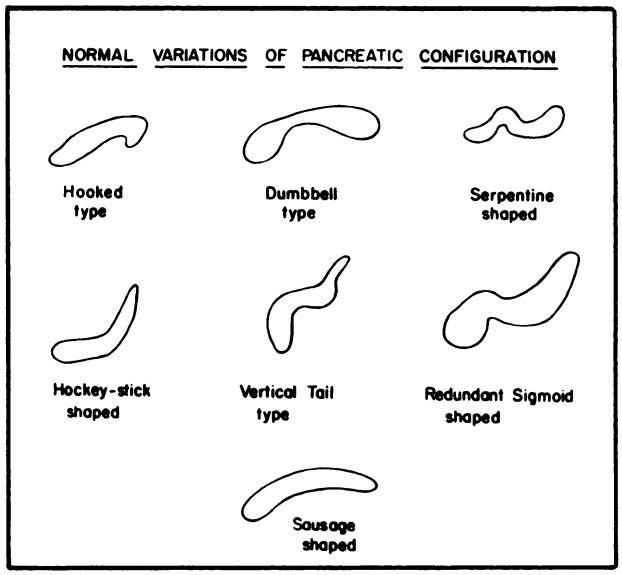


FIG. 10. Normal variations of pancreas seldom encountered. Of these, dumbbell-type is more common. Remainder are unusual forms.

when the patient breathes. Despite these factors, we believe that camera studies demonstrate the pancreatic anatomy well enough to make valuable morphologic judgments. Scintiphotos appear to be especially useful for lesions of the body and tail. Other studies, such as percutaneous cholangiography, hypotonic duodenography, upper gastrointestinal series, and selective angiography (*5,6*) are equally successful in yielding information concerning the head of the pancreas.

The liver and blood-flow studies used in our protocol for pancreatic imaging aid in the diagnosis of disease in other organs. In several cases, metastatic disease to the liver was discovered on the liver position study with ^{99m}Tc-sulfur colloid. Several other cases demonstrated other forms of liver disease. On the blood-flow study, such anomalies as aortic aneurysm, tortuous aorta, prominent celiac axis, and splenic artery (Fig. 2) were identified. Evaluation of the renal arterial flow and renal perfusion is possible with the ^{99m}Tc-pertechnetate blood flow study.

Angiography combined with pancreatic imaging supplies more complete information than either study alone. As stated by Rodriguez-Antunez et al (*7*), the two studies complement each other. A normal pancreatic image cannot absolutely exclude pancreatic disease; however, a normal study with normal angiograms would obviate the need for exploratory laparotomy in most cases. In none of the 27 cases (Table 5) was both static scintiphoto and angiogram incorrect at the same time. However, if the scan is unequivocally negative, angiography is of little added value in finding pancreatic disease in our experience, indicating that the scintiphoto is useful as a screening procedure. Small islet cell tumors (less than 2 cm) are more apt to be discovered by angiography than by more static pancreatic images.

The present radiation dose from the procedure tends to limit the number of studies performed in one individual. Ben-Porath et al (*8*) have calculated the whole-body irradiation dose from ^{75}Se-selenomethionine to be 1.63 rad for the tracer dose of 250 μCi in a 70-kg man. He calculated the dose to the liver as 0.05 rad and to the pancreas 0.06 rad.

SUMMARY

Pancreatic scintiphotos are helpful in distinguishing the normal from the abnormal pancreas and should reduce the number of exploratory laparotomies in patients without pancreatic disease. To a lesser extent the scintiphoto is useful in the specific diagnosis of an abnormality; it is more accurate with tumor diagnosis than with pancreatitis.

In the total survey of 134 patients, 125 have been followed. The overall accuracy of 125 complete followup cases was 89.6%. The interpretive results in this study revealed 6% false negative. On strictly proven cases the false negative rate was 6.2%. The false positive percentages were 19% overall and 14.2% on only proven cases.

Camera images of the pancreas appear to be more useful for lesions of the body and tail. Other studies (angiography, hypotonic duodenography, upper gastrointestinal series, etc.) appear to yield as much useful information concerning the head of the pancreas.

A normal scintiphoto offers a high probability of a normal pancreas and is a useful screening device. The accompanying liver image and blood-flow studies are also an aid in discovering disease in other organs.

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