Role of Scintigraphy in Focally Abnormal Sonograms of Fatty Livers

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Fatty infiltration of the liver may cause a range of focal abnormalities on hepatic sonography which may simulate hepatic nodular lesions. Discrete deposits of fat or islands of normal tissue which are uninvolved by fatty infiltration may stand out as potential space-occupying lesions on the sonograms. Twelve patients with such focally abnormal ultrasound images were referred for liver scintigraphy with ^{133}Xe and ^{99m}Tc colloidal SPECT studies to clarify the issue. These examinations helped identify, in nine of 12 patients, the innocent nature of the sonographic abnormalities which were simply related to the fat deposition process. Further, [^{99m}Tc]RBC scans defined the additional pathologic process in three patients in whom actual space-occupying lesions were indeed present in the liver. Scintigraphy has an important role to play in the understanding of focal hepatic ultrasound abnormalities particularly in unsuspected hepatic steatosis.

J Nucl Med 29:1050–1056, 1988

Fatty infiltration of the liver is a benign condition which is associated with obesity, alcohol abuse, hyperlipidemia, and diabetes mellitus (*1–5*). Computed tomographic (CT) scanning, ultrasound, and nuclear medicine studies can identify the fatty process because it generally involves the liver in diffuse and uniform fashion. When this is not the case, however, the spectrum of abnormal fat deposition in the liver may be problematic to the imaging specialist. Specifically, the reading of hepatic sonograms may become difficult with the erroneous suggestion of metastatic liver disease or the misinterpretation of true metastatic events. Scintigraphic studies are an important and useful adjunct to clarify the incidental focal sonographic abnormalities noted in hepatic steatosis. Retention of radioactive xenon by the liver documents fatty infiltration which is not always suspected sonographically. Imaging with technetium-99m (^{99m}Tc) colloids meanwhile either excludes or confirms the presence of hepatic space-occupying lesions. Technetium-99m red blood cell ([^{99m}Tc] RBC) scans can further help identify the nature of the focal process seen on ultrasound when the radiocolloid study is abnormal.

Received Aug. 3, 1987; revision accepted Dec. 8, 1987.

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PATIENTS AND METHODS

The patients studied consisted of 12 subjects, three males and nine females ranging in age from 49 to 80 yr. This group of patients had recently been referred to the Department of Nuclear Medicine because of focal abnormalities on hepatic ultrasound which were suggestive of space-occupying lesions although such lesions were not particularly suspected clinically. Since fatty infiltration of the liver could have explained the discrepancy between clinical and ultrasound findings, xenon-133 (^{133}Xe) studies of the liver were carried out on all 12 patients for the assessment of fatty changes. The patients also underwent planar imaging of the liver with [^{99m}Tc]sulfur colloid. This was supplemented by single photon emission computed tomography (SPECT) studies in nine of 12 patients. When defects were noted in the liver, the radiocolloid and xenon scans were further complemented with [^{99m}Tc]RBC scintigraphy to further evaluate the blood pool of the lesion. The findings on nuclear and sonographic imaging were then correlated with the final diagnosis as determined by biopsy (two patients), complementary imaging with CT (four patients), or the overall clinical course of the patient (six patients).

The patients were studied according to the following protocols: Hepatic retention of xenon was assessed after the inhalation of a bolus of 10 mCi of ^{133}Xe in a closed circuit rebreathing system with equilibrium and washout images obtained in posterior position over the liver for a period of 12 min following the washin phase. Technetium-99m radiocolloid scans were obtained on a large field-of-view camera with general, all-purpose collimation in the standard projections after the i.v. injection of 8 mCi of [^{99m}Tc]sulfur colloid. SPECT studies were generated from 120 frame acquisitions at 3° intervals on 128 × 128 matrices with reconstruction of raw data by filtered backprojection technique and in the three orthogonal planes. Technetium-99m RBC scintigraphy of the liver was done after the in-vivo-vitro labeling of RBCs with 25 mCi of ^{99m}Tc according to standard procedures.

RESULTS

Our findings are summarized in Table 1. All 12 patients showed retention of ^{133}Xe by the liver establishing a diagnosis of fatty infiltration. Although all of the hepatic sonograms showed focal abnormalities, it was concluded that nine of the 12 patients had no evidence of mass lesions. In five of these, tissue spared by fatty infiltration appeared as focal hypoechogenic areas on ultrasound while in the other four subjects, it was the actual deposition of fat which resulted in discrete hyperechogenic targets on the sonograms. Two of the 12 patients had hemangiomas, while the remaining patient had metastatic lesions which were mistaken for cysts on the ultrasound examination. Subjects 1, 6, 10, and 12 are presented as illustrative cases (Figs. 1–4).

DISCUSSION

Fatty infiltration of the liver is a relatively common entity which is characterized pathologically by the presence of fat droplets in the hepatocytes with sparing of the reticuloendothelial population. In most cases, it appears to be a benign and potentially reversible condition which may accompany alcoholic liver disease, diabetes mellitus, coronary artery disease, obesity, and i.v. hyperalimentation. Hepatic steatosis may be induced by hepatotoxic drugs and may also affect individuals with hepatitis and Wilson's Disease (*1–4*). Patients may be asymptomatic or manifest right upper quadrant discomfort, smooth hepatomegaly, or nonspecific abnormalities of liver related blood tests. More dramatically, fatty infiltration may produce evidence of portal hypertension or various symptoms suggestive of an acute surgical abdomen, obstructive jaundice, or even acute hepatic failure (*1*).

Computed tomographic scanning and ^{133}Xe nuclear imaging are established techniques for the noninvasive diagnosis of fatty infiltration of the liver (*1,6–10*). Fatty liver can be substantiated by CT scan on the basis of a lower mean CT number (Hounsfield unit, HU) for the liver than for the spleen. Hepatomegaly and a hyperdense appearance of the intrahepatic vascular structures relative to the low attenuation hepatic parenchyma are other notable features of the CT image. Radioxenon can also document the pathological process as it shows a high preferential solubility for fat and is retained by the fatty liver in proportion to the fat content of the

TABLE 1
Scintigraphic Findings

Patient (age, sex)	U.S. findings	^{133}Xe retention	Liver/spleen scan	SPECT	RBCs	Nature of ultrasound abnormalities
1 (59, F)	Multiple hypoechoic sites	P*	N†	N	—	Spared tissue simulating lesions in fatty liver
2 (63, F)	Multiple hypoechoic sites	P	N	N	—	Spared tissue simulating lesions in fatty liver
3 (74, F)	Hypoechoic focus	P	N	N	—	Spared tissue simulating lesion in fatty liver
4 (64, F)	Multiple hypoechoic sites	P	N	N	—	Spared tissue simulating lesions in fatty liver
5 (49, M)	Multiple hypoechoic sites	P	N	N	—	Spared tissue simulating lesions in fatty liver
6 (55, F)	Multiple hyperechoic sites	P	N	N	—	Fatty deposits simulating focal lesions
7 (80, F)	Multiple hyperechoic sites	P	N	—	—	Fatty deposits simulating focal lesions
8 (63, F)	Multiple hyperechoic sites	P	N	—	—	Fatty deposits simulating focal lesions
9 (64, M)	Multiple hyperechoic sites	P	N	N	—	Fatty deposits simulating focal lesions
10 (69, F)	Solitary hypoechoic site	P	N	Solitary defect	Hemangioma	Hemangioma in fatty liver
11 (69, M)	Solitary focal hypoechoic site	P	N	Solitary defect	Hemangioma	Hemangioma in fatty liver
12 (62, F)	Hypoechoic sites	P	Defects	—	Vascular lesions	Metastatic lesions in fatty liver

* Present.
† Normal.

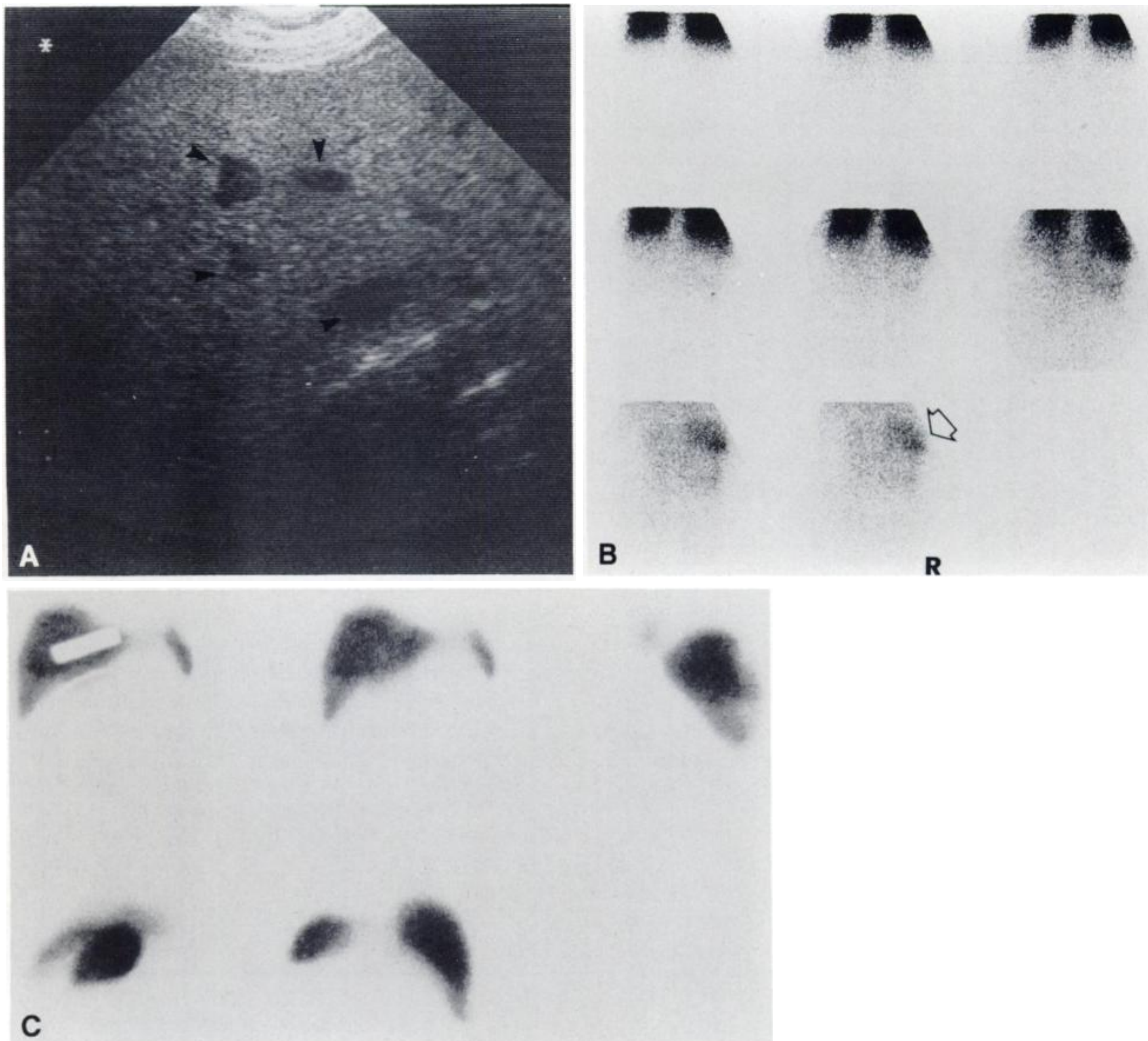

FIGURE 1
Patient 1. The study in this patient revealed multiple hypoechoic sites (arrowheads) suggestive of hepatic nodular lesions (A). Retention of ^{133}Xe in posterior view at the level of the liver (arrows) on the washout frames established a diagnosis of hepatic steatosis (B). Planar (C) and SPECT liver and spleen scans with ^{99m}Tc colloids did not reveal any hepatic space-occupying lesions. The CT scan of the liver also excluded the presence of space-occupying lesions while confirming fatty infiltration. The clinical status of the patient was also in keeping with these findings. The hypoechoic sites on ultrasound can be attributed to islands of spared and uninvolved tissue amid extensive fatty infiltration.

hepatocyte as evaluated by histologic examination. This close parallel between xenon retention and lipid content of the liver has been established in experimental animals and in the clinical setting (*1,5–8*).

Sonography will detect uniform fatty infiltration of the liver which usually manifests as a diffuse hyperechogenicity or "brightness" of the organ with rapid attenuation of sound. The severity of fatty infiltration can also be graded with the technique by comparing the echogenicity of the liver to that of adjacent structures such as the normal renal cortex and by evaluating the definition of portal venule walls (*9*). Focal accumulation of fat, on the other hand, may be recognized because of geometric margins between normal and adipose tissue and also interdigitating borders (*11*). Nevertheless, nonuniform fatty infiltration of the liver may cause a range of localized and challenging changes on hepatic sonography which can erroneously suggest metastatic disease (*5,10–13*). In particular, the irregular and abnormal fatty deposits within the liver may result in discrete sites of hyperechogenicity on the sonogram which may simulate the presence of hepatic nodular lesions. As well, an extensive infiltration of the hepatic parenchyma may cause islands of uninvolved and

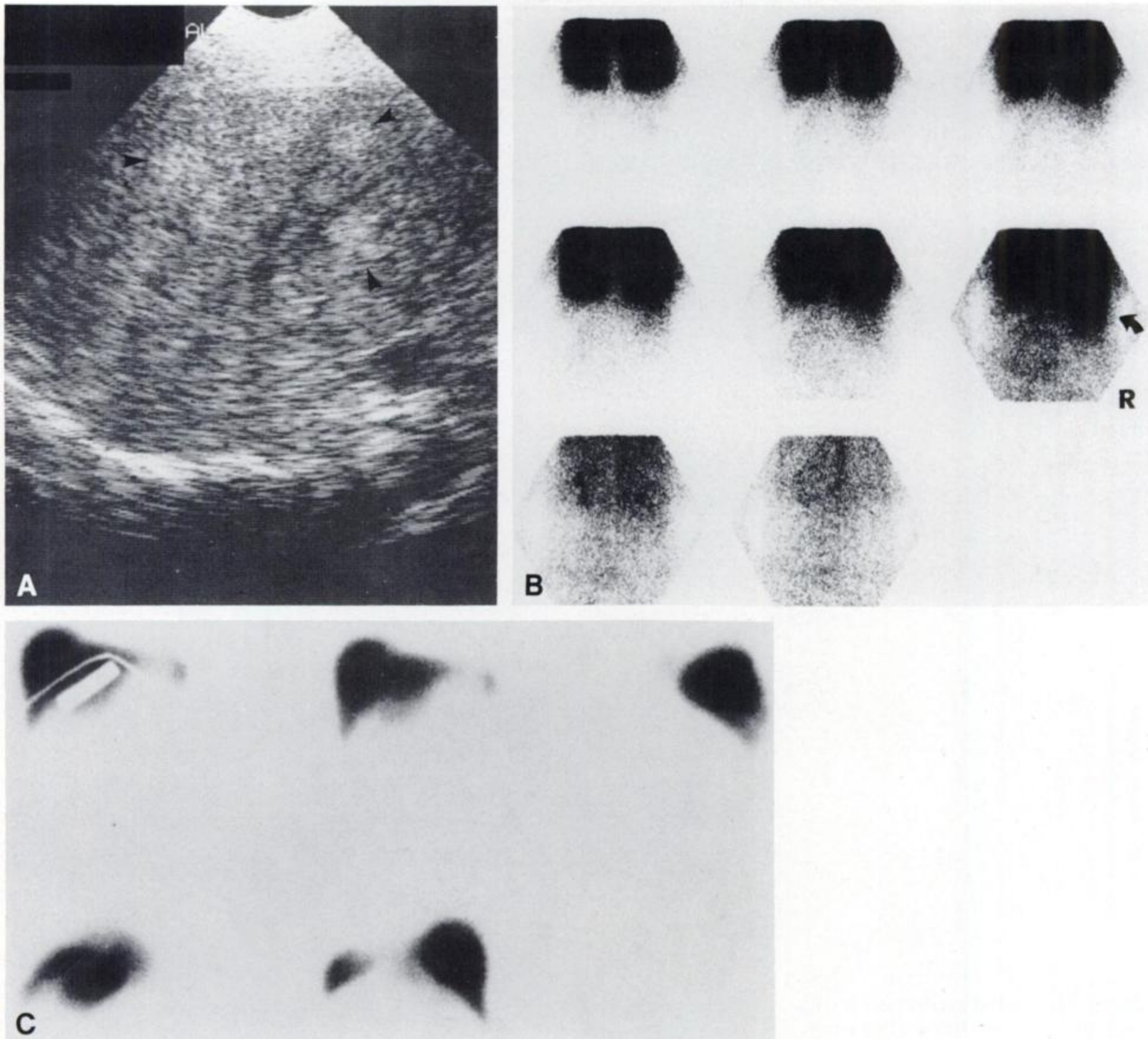

FIGURE 2
Patient 6. In this patient, ultrasound demonstrated multiple hyperechoic sites (arrowheads) which suggested space-occupying lesions (A). Fatty infiltration of the liver was demonstrated by the ^{133}Xe study (B). Planar (C) and SPECT studies of the liver were normal. A CT scan showed multiple hypolucencies at the level of the hyperechogenic foci seen on ultrasound again confirming the presence of fatty infiltration of the liver without evidence of space-occupying lesions. The hyperechogenic sites on the sonograms are caused by the discrete but scattered deposits of fat.

spared tissue to stand out as focal anomalies which again may be mass-like in appearance. The interpretation of the sonogram of a fatty liver in which space occupying lesions are actually present may also be difficult. Under such conditions, hypoechoic lesions may be confused for anechoic structures because of an inappropriate setting of the ultrasound gain so as to compensate for the hyperechogenicity of the fat. Thus, potentially, solid metastatic nodules may be mistaken for cysts, due to the highly reflective nature of the surrounding parenchyma. In other circumstances, hemangiomas may also display atypical acoustic features amid the hyperechogenic fat.

Nuclear medicine can contribute greatly to a fuller understanding of the abnormal sonograms of hepatic steatosis. The physiological nature of nuclear studies allows for a multifaceted approach in the investigation of the liver. Xenon imaging correlates with the presence and severity of the steatosis and is useful in documenting the fatty infiltration which is not always suspected either sonographically or clinically. Furthermore, as the pathological process spares the reticuloendothelial population of the liver, the interpretation of the radiocolloid image is essentially unaffected by the fat droplets even though, on occasion, the liver may have a mottled appearance on the scan (*5*). Consequently, the Kuppfer

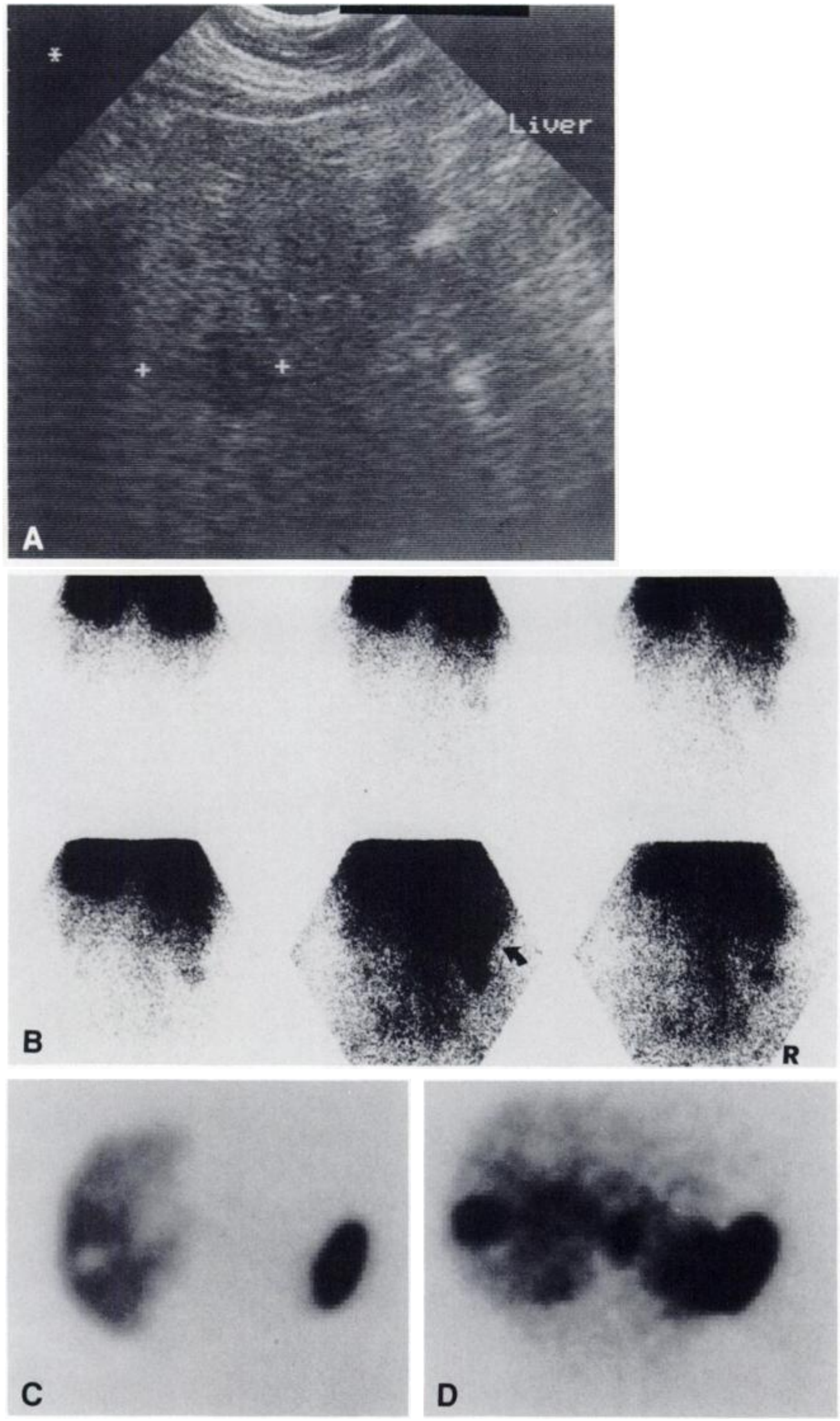

FIGURE 3
Patient 10. Hepatic ultrasound (A) revealed a solitary hypoechoic lesion (crosses) and diffuse fatty infiltration of the liver in this individual. The fatty process was further confirmed on the ^{133}Xe study (B). While planar imaging of the liver and spleen was normal, transverse SPECT sections (C) localized a focal defect at the level of the abnormality on ultrasound indicating a true lesion. Technetium-99m RBC scintigraphy further identified the lesion to be a hemangioma (D).

cell image, especially when optimized by SPECT, appears to be of pivotal diagnostic value in clarifying ultrasound findings (*14*). In our experience, a normal tomographic liver colloid scan effectively rules out the presence of space-occupying lesions when fatty infiltration interferes with the sonographic image and suggests hepatic nodules. On the other hand, a defect on the colloid scan indicates a discrete process other than fat which requires further investigation. In this context, [^{99m}Tc]RBC scintigraphy gives an additional diagnostic dimension to the nuclear algorithm since it is highly specific for hepatic hemangiomas and can also delineate the vascular characteristics of other focal lesions.

Ultrasound and nuclear imaging are important modalities for the noninvasive assessment of hepatic disease. They can play a complementary role for the comprehensive evaluation of focal hepatic abnormalities noted on sonography in the wide cross-section of

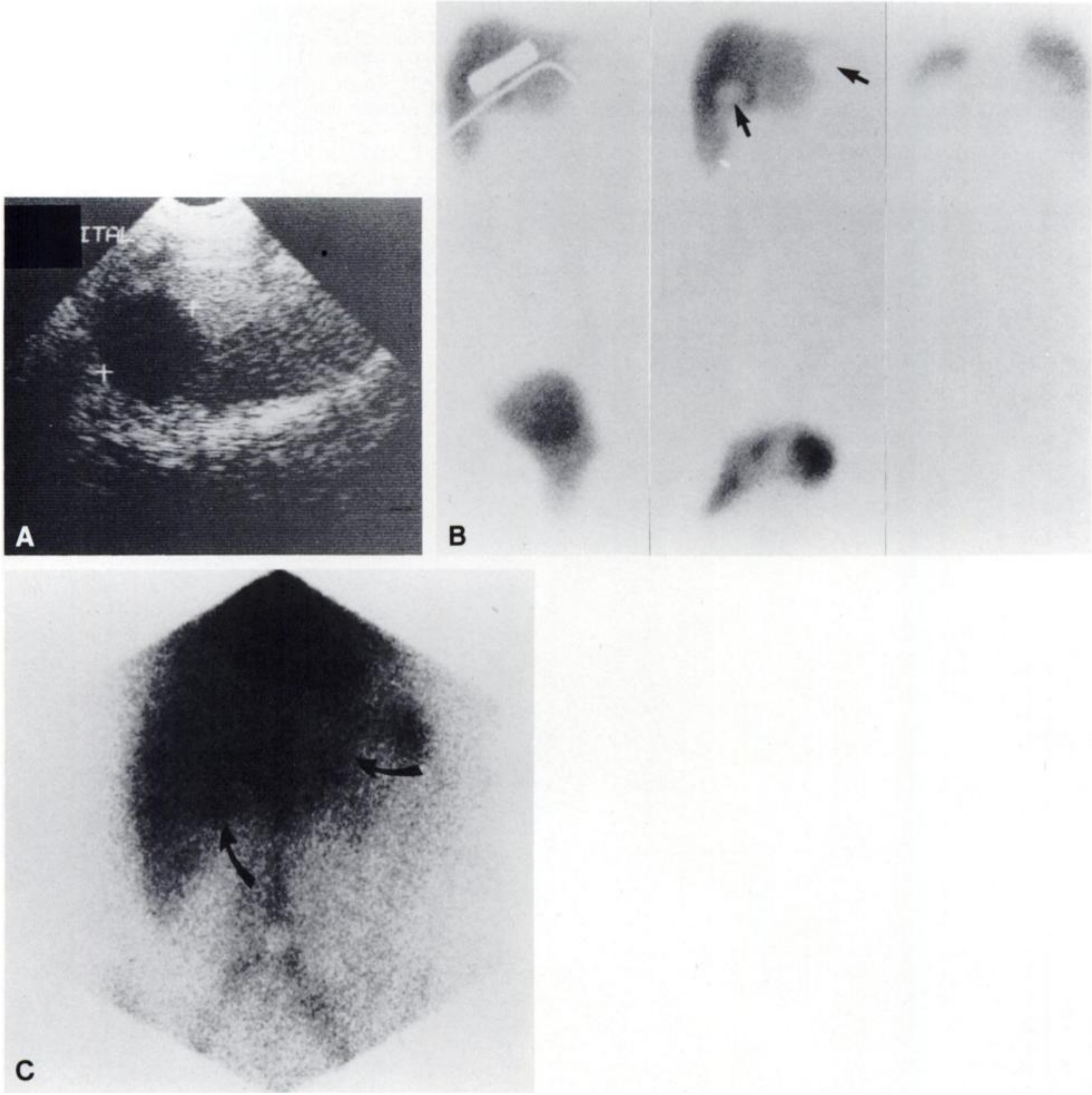

FIGURE 4
Patient 12. This 62-yr-old female with cancer of the breast had echo-poor lesions noted on ultrasound (A). Retention of ^{133}Xe by the liver established a diagnosis of fatty infiltration. The colloidal scan (B) showed large discrete defects (arrows) which, unlike cysts, were vascular (curved arrows) on [^{99m}Tc]RBC scintigraphy (C). As the scintigraphic findings were also not characteristic for hemangiomas, a metastatic process was suspected and eventually confirmed by biopsy. In the presence of fatty infiltration and an incorrect setting of gain, ultrasound may occasionally mistaken solid lesions for cysts.

patients at risk for fatty infiltration of the liver. Indeed, many such potential lesions will be documented by scintigraphy to be innocent manifestations of the fat deposition process.

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