RAPID SEQUENTIAL LIVER IMAGING

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The complex circulatory system of the liver involves a dual blood supply. Approximately 75% of the inflow is derived from the portal vein and 25% from the hepatic artery. An intravenously injected radioactive tracer should therefore theoretically arrive in the liver in two phases. It is further known from anatomic and pathological studies (*1,2*) that the relative distribution of blood supply to the liver is altered by certain diseases such as tumors. It was the purpose of this investigation to determine whether or not the normal dual blood supply and its alteration by disease can be demonstrated by rapid sequential scintiphotography and whether hepatic blood flow patterns may be helpful in characterizing certain disease entities.

MATERIALS AND METHODS

Seventy-seven subjects were studied including 16 hospital patients selected for diseases *not* involving the liver, 22 patients with metastatic carcinoma of the liver, 2 patients with primary liver cell carcinoma, 8 patients with hepatic abscess, and 22 patients with other types of hepatic disease including 14 with cirrhosis and 8 with lymphoma. All subjects had complete histories, physical examinations, and liver function studies including albumin/globulin, alkaline phosphatase, SGOT, SGPT, serum bilirubin, and prothrombin. In all cases of liver disease the diagnosis was confirmed by biopsy, operation, autopsy, or typical clinical course (Table 1).

The subjects were placed supine under an Anger camera detector head with a diverging collimator to view the anterior projection of liver and spleen. Following an intravenous bolus injection of 10 mCi of ^{99m}Tc-sulfur colloid (Squibb) in a volume of 1–4 ml, 4-sec Polaroid exposures were obtained for 32 sec. Immediately thereafter, a 300,000-count scintiphoto was obtained without moving the patient and again repeated at 5 and 15 min after injection. During the initial study, information was continuously recorded on a Nuclear Data 50/50 digital computer magnetic tape system.

TABLE 1. VERIFICATION METHODS OF HEPATIC INVOLVEMENT

	Biopsy	Autopsy	Clinical course
No liver disease			16
Hepatoma	2		
Metastatic cancer	17	3	2
Abscess	6		2
Cirrhosis	9		5
Lymphoma	8		

RESULTS

The following time patterns of radionuclide distribution were noted:

Normal subjects. Filling of the hepatic area with radioactivity is delayed 8–12 sec when compared with the appearance in the abdominal aorta, kidneys, and the remainder of the abdomen (mesentery and bowel) (Fig. 1). Since the circulation time varies from patient to patient, the appearance of radionuclide in the aorta appears to be the best reference

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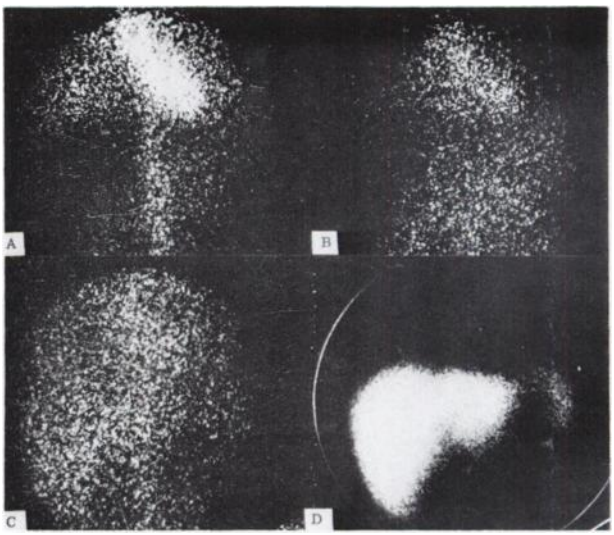

FIG. 1. Hepatic flow study in normal volunteer. A (0–4 sec) and B (4–8 sec) represent first 8 sec of flow in abdominal aorta and surrounding tissue. Note lack of activity in hepatic bed. C represents flow at 28–32 sec. Note uptake in hepatic bed. D represents 300,000-count static view begun 5 min postinjection without moving patient.

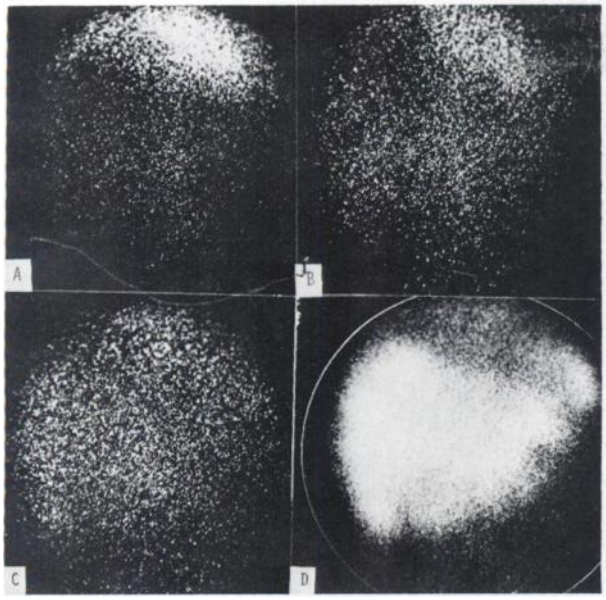

FIG. 2. Metastatic carcinoma (primary: bronchogenic). Format same as Fig. 1. Note early appearance of isotope in hepatic bed.

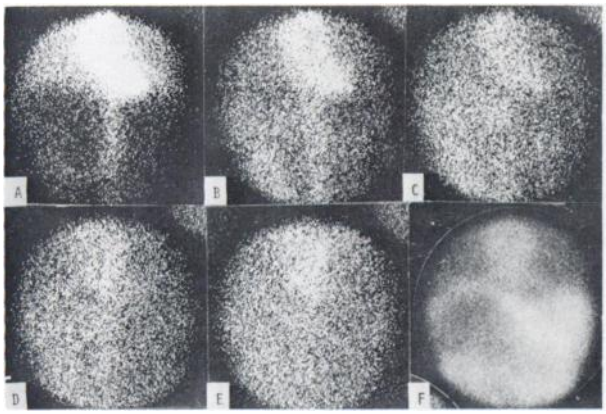

FIG. 3. Hepatoma. Scintiphotos A–E represent first 20 sec of abdominal flow (4 sec/figure). D is 300,000-count static taken 1 min after injection without moving patient. Note increased flow in area which subsequently becomes devoid of activity.

point for evaluating the arterial component of hepatic circulation.

Patients with metastatic carcinoma of the liver. Radioactivity appeared in the liver area earlier than in normals. In most cases the appearance coincided with visualization of the abdominal aorta and kidney (Fig. 2). If a lesion was greater than 6 cm, the uptake was noted to be maximum within the tumor 8–12 sec after the appearance of the abdominal aorta. In general, the delay time was 0–4 sec in patients with carcinoma involving the liver.

Patients with hepatoma. Extremely high concentration of isotope relative to surrounding tissue was noted early in areas which subsequently became cold (Fig. 3). The central area of large tumors filled later than the peripheral areas, a finding common to most large tumors either primary or metastatic.

Patient with liver abscess. Appearance of radioactivity in the liver area as a whole was normal but the area identified on the static image as a defect did not fill throughout the whole study (Fig. 4). In some cases a faint rim of early activity appeared around the lesion. Followup studies showed early filling in cases where significant healing had taken place; the findings were identical to tumor patterns described above.

Cirrhosis. There was a pattern of patchy early concentration of radioactivity distinct from the delayed appearance of the radionuclide in the hepatic bed of the normal subject.

Lymphoma. There was pronounced, diffuse, early appearance of radioactivity throughout the organ. In some cases early focal accumulation was noted in areas which subsequently became "cold" on the static study (Fig. 5).

Graphically these findings could be demonstrated from data acquired by the digital computer. Activity over the lesion is compared with activity over the abdominal aorta and plotted as a function of time (Fig. 6). The marked delay of hepatic filling in the normal is clearly demonstrated in contrast to the early filling in a case of metastatic carcinoma.

DISCUSSION

By using a labeled colloid and a rapid scintillation detector we were able to evaluate hepatic circulation and relate appearance patterns to disease processes.

The early appearance of isotope in the liver bed in patients with carcinoma is probably related to the increased arterial component in the area of the tumor, a finding demonstrated by other investigators

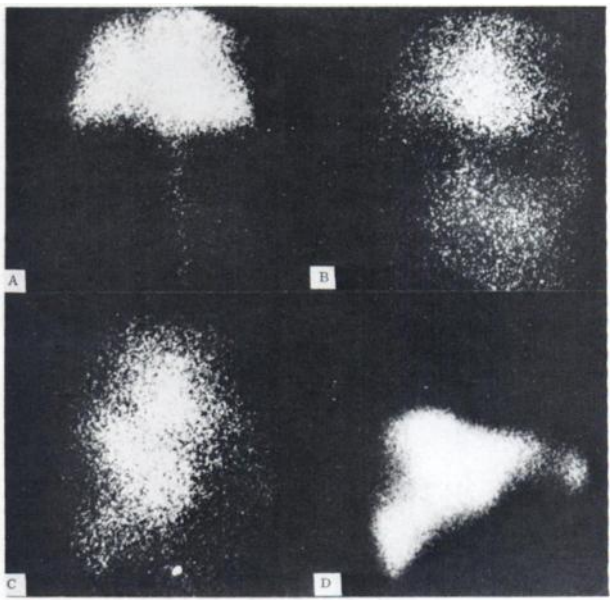

FIG. 4. Hepatic abscess. Format same as Fig. 1. Note cold area laterally in right lobe which remains cold throughout.

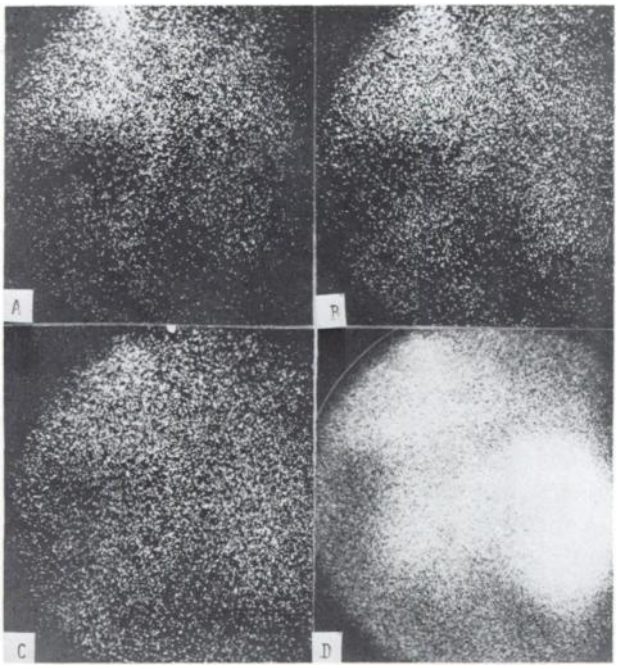

FIG. 5. Lymphoma. Same time sequence as Fig. 1. Study was done with detector positioned posteriorly. Note early hepatic uptake on right.

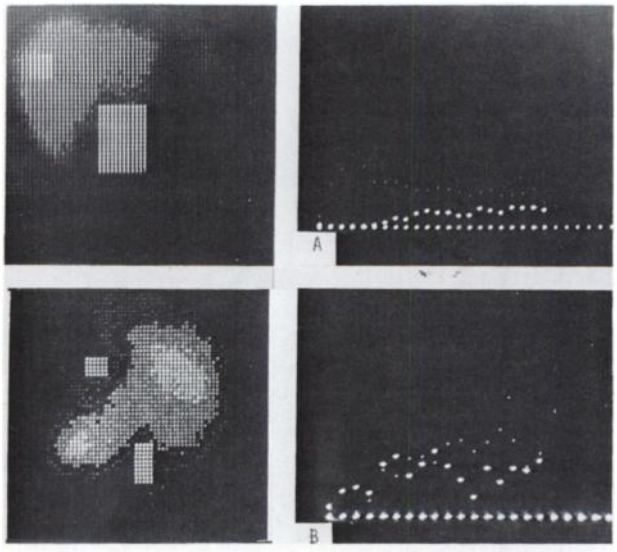

FIG. 6. Computer region-of-interest plot of activity as function of time in 2-sec intervals following intravenous bolus of ^{99m}Tc-sulfur colloid. Selected regions are shown on left. Light dots represent abdominal aorta, heavy dots represent hepatic activity. A is normal study; B shows metastatic carcinoma. Note delayed isotope appearance of hepatic activity relative to aortic appearance in normal and early relative appearance in case of carcinoma.

using nonisotope techniques (*1,2*). Since the larger tumors tend to outgrow their blood supply, it was not surprising to see the peripheral regions of the tumor filled earlier than the central areas.

Abscesses remained cold throughout the study in most cases. Some faint early peripheral activity was seen in two cases and may be related to inflammatory and/or hyperemic changes at the periphery of the lesion. The healing abscess as determined by followup studies showed early filling in all cases.

Early patchy uptake of radiocolloid is noted in cirrhosis. This pattern is very similar to those noted in carcinomatosis and other infiltrative diseases such as lymphoma. The similarity represents a difficulty in distinguishing between cirrhosis and infiltrative disease. We are now in the process of trying to clarify the pattern seen in these diffuse processes and to determine the role of the flow study in their staging.

The early colloid concentration pattern theoretically would be useful in cases with borderline hepatomegaly since the flow study can serve to differentiate between large normal livers and livers with diffuse infiltration, thus supplementing the investigation of "pliability" suggested by Gottschalk (*3*).

The use of 10 mCi of ^{99m}Tc as sulfur colloid is felt to be optimal for this purpose since:

1. The radiation burden to the liver is less than 4 rad (*4*).
2. The counting rates obtained are such that 300,000 counts were obtained in 60–120 sec.
3. The use of a colloid in the 50–150-millimicron range allows the RE system of the liver to be visualized (*5*); thus, spatial comparisons of areas both early and late are possible. Technetium-99m pertechnetate or ^{99m}Tc-HSA is useful in demonstrating an abnormal arterial component; however, the late films do not reveal filling defects, and thus spatial comparison of early and late phases is not possible.

SUMMARY

The use of an intravenous bolus of ^{99m}Tc as sulfur colloid proved effective in detecting alterations of hepatic circulation. The finding may be used as an aid in the differential diagnosis of space-occupying lesions of the liver. Since early hepatic uptake is noted in cirrhosis, lymphoma, or diffuse metastatic disease, the test is not useful in differentiating these entities. However, the test is useful in differentiating cyst or abscess from large tumors and in distinguishing between normal and pathological livers.

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