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= **Abstract** =

Changing Role of Nuclear Medicine for the Evaluation of Focal Hepatic Tumors: From Lesion Detection to Tissue Characterization

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The role of scintigraphic imaging has moved from the detection of lesions to the tissue-specific characterization of lesions over the past 2 decades. Major advances in nuclear medicine imaging include: 1) positron imaging, 2) improved instrumentation, such as the use of multidetector (dual or triple head) gamma cameras for single photon emission computed tomography, and 3) development of numerous new radiopharmaceuticals for positron or single photon imaging (labeled glucose analogue, amino acids, fatty acids, hormones, drugs, receptor ligands, monoclonal antibodies, etc). These advances have resulted in a significantly improved efficacy of radionuclide techniques for the evaluation of various tumors, including those within the liver. The current role of nuclear medicine in the evaluation of focal hepatic tumors is reviewed in this article with an emphasis on the clinical applications of various tracer studies and imaging findings. **(Korean J Nucl Med 1998;32:211-24)**

Key Words: Radionuclide imaging, Liver tumors, Hepatocellular carcinoma, Hemangioma, Liver metastasis

Introduction

In the past, colloid liver scanning was the primary scintigraphic study used for the detection of focal hepatic lesions including metastases, and for the evaluation of other diffuse liver diseases. With the advent of ultrasonography (US), computed tomography (CT) and magnetic resonance imaging (MRI), the primary role of scintigraphic liver imaging has become the tissue characterization of lesions in order to narrow the differential diagnosis. Colloid imaging is now primarily used for subtraction purposes in conjunction with other radionuclide imaging techniques that display liver

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activity, and to characterize focal lesions detected by anatomical imaging. At present, other radiotracers are more frequently used to evaluate focal hepatic lesions.

Recent advances in positron emission tomography(PET) and single photon emission computed tomographic(SPECT) imaging technique, particularly the development of the stable multidetector gamma camera, have dramatically improved the accuracy of radionuclide studies. Tomographic display has provided an additional advantage, i.e. the capability of direct comparison of radionuclide imaging with other cross sectional imaging. With the exception of rapid dynamic study, such as early flow study, SPECT imaging must be performed as a routine part of all static single photon imaging studies for the evaluation of the liver. The development of new radiopharmaceuticals has also significantly improved the efficacy of scintigraphic imaging with expanded clinical applications.

Malignant Neoplasms

1. Metastatic Disease

1) Tc-99m-Colloid Scintigraphy

Following intravenous injection, technetium-99m (Tc-99m) colloid agents, including sulfur colloid, are taken up by cells of the reticuloendothelial system(80% to 85% by Kupffer cells within the liver). The uptake of this radiopharmaceutical is decreased in most focal hepatic lesions. Although no longer a first line study to evaluate metastatic disease, colloid scanning with high-resolution SPECT can be complementary when CT or ultrasonography reveals equivocal lesions[1].

Focal fatty infiltration (FFI) of the liver or focal sparing in diffuse fatty liver can be problematic when interpreting CT or ultrasound studies[2,3]. Kupffer cells are generally present within fatty infiltration[4], and the presence of colloid uptake has been considered to be useful in excluding metastatic deposits[2,5]. It appears that metastatic disease can be confidently excluded when a lesion suspected of being focal sparing in a fatty liver reveals colloid uptake greater than the surrounding tissue. However, the interpretation of colloid scintigraphy in cases of suspected FFI may not be as simple as that of focal sparing. Firstly, metastatic lesions below the resolution of the camera system or lesions located centrally with the liver may not be detected, and therefore, falsely interpreted as "normal" (consistent with FFI). Secondly, though uncommon, a considerable number of FFI cases showing absent colloid uptake have been described[6-11]. Therefore, metastatic disease may be excluded only if the size of lesions suspected of being FFI is considered to be within the resolution limit of the imaging system and colloid uptake is clearly present in the lesions.

Xenon-133 (Xe-133) is fat-soluble, and, after inhalation, typically concentrates in the fatty substance of the liver. While some investigators found Xe-133 scintigraphy to be helpful when sulfur colloid imaging is nondiagnostic[6,12,13], a small series has shown no Xe-133 uptake in 3 of 4 cases of fatty infiltration[14]. Although increased Xe-133 activity which clearly corresponds to suspected areas of fatty infiltration on CT/US would be helpful, the absence of uptake may be nondiagnostic.

2) Positron Emission Tomography

The malignant transformation of cells is associated with a high rate of glycolysis[15]. Fluorine-18 (F-18)-fluorodeoxyglucose (FDG) has become the most commonly used tracer for examining the metabolic characteristics of various tumors with positron emission tomography (PET) following its application in patients with brain tumors[16]. The ratio of FDG uptake between malignant lesions and background (even in the liver) is often striking.

Investigators report that the value of FDG PET for detecting liver metastases in patients with colorectal cancer is superior to that of CT/US/CT portography. Additionally, PET can provide improved staging of apparently resectable local recurrence and metastatic disease[17-19]. Schiepers et al[17] found that the accuracy of PET for liver metastases (98%) compared favorably to that of CT/US (93%). Moreover, PET detected 14 unexpected extrahepatic mestastases in 10 patients. In another series by Vitola et al[18], FDG PET imaging had an even higher diagnostic accuracy (93%) than CT and CT portography (both 76%) in detecting liver metastases and detected unsuspected extrahepatic recurrence in 4 patients. Although the sensitivity of FDG PET was slightly lower than that of CT portography (90% versus 97%), the specificity was much higher (100% versus 9%), including postsurgical sites. FDG PET altered surgical plans in 25% of these patients. In another study, PET affected management decisions in 44% (7 of 16) of patients with metastatic disease[19]. In contrast to metastatic colorectal cancer, low-grade lymphomas or well-differentiated hepatic lesions may not be reliably excluded by PET[20].

In addition to the detection of lesions, FDG PET is useful in monitoring the response to oncologic therapy[20,21].

5-fluorouracil (5-FU) is widely used therapeutic agent for recurrent/metastatic colorectal cancer. F-18 labeled 5-FU was used to predict response to chemotherapy in mice and men[22,23]. Strauss et al[23] found a significant inverse correlation (r=0.86) between [F-18]-5-FU accumulation and tumor growth rate after chemotherapy. Metastatic lesions with no or low [F-18]-5-FU uptake on PET study continued to grow even after chemotherapy, whereas [F-18]-5-FU concentrating tumors showed a good response to therapy.

3) Hepatic Arterial Perfusion Scintigraphy, Hepatic Perfusion Index, and Infusion Pump Study

Unlike normal liver parenchyma, hepatic tumors, including metastases, derives blood supply primarily from the hepatic artery. Hepatic arterial perfusion scintigraphy (HAPS), using Tc-99m-macroaggregated albumin (MAA) infused through an arterial catheter, has been used to detect these lesions and to evaluate the distribution of blood flow before drug delivery[24,25]. On HAPS, most tumors (including hypovascular tumors and metastases) show increased activity. HAPS in combination with a high-resolution triple-headed SPECT camera is reported to have a sensitivity of 97% and specificity of 50% for tumor detection[26], which is superior to those of either MRI or CT. HAPS, when combined with SPECT sulfur colloid scan, may detect lesions smaller than 1 cm. However, HAPS overestimated the unresectability of the lesions; the positive-predictive value for unresectability of CTAP and HAPS was 73% and 60%, respectively[27]. While these two tests are sensitive, their false-positive results for unresectability may deny patients the chance for surgical resection.

The hepatic perfusion index (HPI) is an estimate of the relative proportion of hepatic arterial to total liver blood flow obtained from dynamic hepatic scintigraphy. Based on the fact that hepatic tumors derive their blood supply from the hepatic artery, the HPI has been used to evaluate for occult or subclinical hepatic metastases. The sensitivity of increased HPI for liver metastases appears to exceed 90%[28-30]. It was also suggested that an increased HPI can be associated with occult metastases[28,29,31]. However, the reported specificity varies from study to study and has been reported to be as low as 34% (with a positive-predictive value of 15%) in a series by Huguier et al[30]. This group suggested that HPI could be useful in identifying patients who are at low risk of developing metachronous liver metastases and thus avoid unnecessary adjuvant chemotherapy following resection of the primary tumor[30]. Ballantyne et al suggested that a rising HPI in serial studies is associated with progression of disease[32]. Overall, HAPS and HPI appear to be sensitive, but not a very specific techniques. Therefore, a therapeutic decision should not be made based on abnormal HAPS or HPI alone.

HAPS also can be performed during surgery for placement of an hepatic arterial chemotherapy catheter or after subcutaneous implantation of an infusion pump[25,33]. HAPS provides a simple, reliable, noninvasive method of evaluating pump function (Fig. 5) as well as catheter integrity and placement (Fig. 6)[34]. Confirmation of satisfactory hepatic perfusion is the key to acceptable treatment by this modality as inadvertent perfusion to other organs during hepatic artery infusion chemotherapy can cause serious clinical complications[35]. Kaplan et al[25] reported that injections at a rapid flow rate produce dramatically different flow distribution patterns from those obtained with a slow flow rate. They emphasized that radiotracers introduced at flow rates approximating those attained with infusion pumps will offer the best estimates of both initial catheter placement and subsequent patterns of hepatic distribution of chemotherapeutic agents.

Selective angiography has been performed in 34 patients who had an abnormal scintigram showing unsatisfactory hepatic artery perfusion after surgical placement of an implanted pump and catheter system[36]. The cause of the perfusion defect was hepatic artery thrombosis in 14 cases, extrahepatic flow through collateral vessels in 14 cases, a misplaced catheter in four cases, and a short proper hepatic artery without adequate length for mixing in two cases.

Arterial administration of epinephrine or angiotensin II has been shown to increase tumor-to-liver blood flow ratio during HAPS[37,38]. Similar results were reported in a recent study measuring blood flow with O-15 carbon dioxide and O-15 water PET imaging[39]. During a hypertensive state induced by intravenous angiotensin II, blood flow in both the primary and metastatic liver tumors did not change, while blood flow in the liver parenchyma decreased. This resulted in a increased tumor/liver blood flow ratio. Splenic blood flow decreased also to 55% of the baseline during the hypertensive state. The findings suggest that normal tissue can be protected from chemotherapy by using this approach.

4) Monoclonal Antibody Imaging

In the United States, two labeled antibodies, In-111 satumomab pendetide (In-111 OncoScint) and Tc-99m anti-CEA antibody, are currently, in clinical use for the evaluation of recurrent/metastatic colon and/or ovarian carcinoma. Although imaging with a labeled monoclonal antibody directed against specific tumor is an attractive approach, virtually all labeled antibodies are normally taken up by the liver to various degrees making lesion distinction difficult. Advances in imaging techniques, particularly SPECT and image registration, have improved the accuracy of tumor detection[40,41]. Image subtraction analysis using dual isotope (labeled antibody-colloid) can improve the accuracy of the technique for detecting liver metastases[42]. Labeled antibody imaging is reported to be more sensitive than CT scan in detecting extrahepatic recurrent/metastatic tumor sites. However, the technique does not appear to be sensitive for the detection of liver metastases[43,46], for which CT remains the modality of choice. Overall, the reported detection rate of liver metastases varies from less than 10% to more than

90%[47].

In a study of patients with recurrent/metastatic colorectal or ovarian carcinoma with both In-111 satumomab pendetide (In-111 OncoScint) planar/ SPECT imaging and FDG PET, Oncoscint demonstrated an advantage in the detection of peritoneal carcinomatosis while PET was superior for detecting liver metastases[48].

Excellent preliminary results have been reported for detecting liver metastases using intraoperative gamma probe scintimetry following preoperative scintigraphy with a Tc-99m-labeled anti-cytokeratin human monoclonal antibody in patients with newly diagnosed, recurrent or metastatic colorectal cancer[49]. In this series, overall sensitivity for CT, planar scintigraphic imaging, SPECT, surgery and operative gamma probe scintimetry was 43%, 61%, 78%, 96% and 91%, respectively. Validation studies will be needed.

5) Peptide Receptor Imaging for Carcinoid and other Gastroenteropancreatic Tumors

Somatostatin receptors are found in most endocrine gastroenteropancreatic (GEP) tumors[50]. Octreotide, a synthetic somatostatin analog that is currently used in treating symptomatic patients with carcinoid, has been labeled with radionuclides. Following initial evaluation of [I-123-Tyr3]-octreotide in the late 1980s, [In-111-DTPA-D-Phe1]-octreotide (In-111-octreotide) was introduced in 1990 and has been extensively evaluated for the localization of neuroendocrine primary tumors and metastases. The sensitivity of In-111-octreotide imaging appears significantly higher than that of I-123-octreotide[51]. The former has recently been approved by FDA for clinical use in the United States.

Krenning et al[52] reported a high sensitivity of In-111-octreotide scintigraphy in localizing neuroendocrine tumors (100% for gastrinoma and glucagonoma, 96% for carcinoid and 89% for unclassified APUDoma), except in patients with insulinomas (61%). Other studies have also shown a fairly high sensitivity of octreotide scanning for detecting neuroendocrine tumors[53,54]. False-negative studies do occur due in part to diminished or absent tumor somatostatin receptors, an inherent limitation[55]. However, false positive somatostatin receptor scans are rare[51,52,54,56].

Several studies report that octreotide scanning detects a considerable number of primary and metastatic GEP tumors unrecognized by CT or other anatomical imaging modalities[53-55,57,58]. When the accuracy of octreotide scan is compared to that of CT reported for the detection of liver metastases, those series using In-111 labeling seem to report a similar or higher accuracy with octreotide scanning[54,58], whereas those using I-123 labeling reported poorer results than CT[53,55].

A previous study reported a low detection rate of liver and abdominal metastases, but the poor result was attributed to physiologic liver uptake that often interferes with the interpretation of planar images and the lack of laxative use (to clean bowel activity)[59]. Although planar images often show intrahepatic tumors that exhibit fairly higher octreotide uptake than surrounding liver, SPECT is mandatory as in other radionuclide imaging. In 9 of 13 patients with carcinoid tumors, 9 sites (6 extrahepatic and 3 hepatic) not visualized by other conventional imaging procedures were found by SPECT octreotide scanning[60].

Administration of unlabeled octreotide may result in low accumulation of In-111 octreotide because of occupancy of, competition with, or down-regulation of the receptors. Therefore, concomitant somatostatin treatment has been suggested as a possible factor interfering with the visualization of neuroendocrine tumors[52]. However, in 5 patients with carcinoid tumors and liver metastases, physiologic In-111 octreotide uptake in the liver, spleen and kidney was found to be significantly decreased, thereby, allowing more precise localization of the hepatic lesions during octreotide treatment compared to the studies performed before the treatment[61].

Radiolabeled octreotide can be used in conjunction with intraoperative scintillation detection with guidance from preoperative scintigraphic findings[58].

Overall, octreotide scanning and CT are complimentary. In asymptomatic patients, octreotide scanning may reveal unknown extrahepatic sites of tumor and allow more accurate staging. Apart from its use for tumor localization, octreotide scanning, with its ability to demonstrate somatostatin receptor positive tumors, could be used to select those who are likely to respond favorably to octreotide treatment[51,53].

Many neuroendocrine GI tumors and colonic adenocarcinoma express vasoactive intestinal polypeptide (VIP) receptors. VIP, a neuroendocrine mediator, is a major regulator of water and electrolyte secretion in the GI tract[62]. This peptide causes a watery-diarrhea syndrome[63,64]. I-123 labeled VIP scintigraphy has been performed in 79 patients with various GI neuroendocrine tumors and intestinal adenocarcinoma with excellent results. Especially in carcinoid patients, VIP scintigraphy revealed many lesions previously not shown by CT. The sensitivity of VIP imaging and that of octreotide scanning were almost equivalent for the detection of carcinoid and insulinoma. VIP scan detected approximately 90% of primary and metastatic colorectal, pancreatic, and gastric adenocarcinoma whereas only 17% were detected by octreotide scintigraphy[65].

More recently, the same group compared the in vitro and in vivo binding of I-123-VIP and In-111-labeled monoclonal antibody (CYT-103; OncoScint) in patients with intestinal adenocarcinomas. Despite significant in vitro binding of both agents, the VIP receptor scan was again found to be more sensitive in localizing intestinal adenocarcinomas and metastatic spread[66].

2. Hepatocellular Carcinoma

1) Tc-99m-Colloid Scintigraphy

While hepatocellular carcinoma (HCC) usually displays marked arterial vascularity on dynamic perfusion imaging, its appearance on static imaging is non-specific (focal decreased activity). The colloid scanning can be used to. differentiate regenerating nodules from HCC in a cirrhotic liver. The presence of colloid uptake typically represents regenerating nodules while decreased uptake is nonspecific[67,68].

2) Cholescintigraphy

The appearance of HCC on cholescintigrams can be variable. In a series, delayed Tc-99m-iminodiacetic acid (IDA) images showed tumor uptake equal to or greater than the surrounding liver in 16 (42%) of 38 patients with HCC[69]. In the remaining 22 patients, HCC appeared as a cold area. IDA uptake was seen in 70% of well differentiated tumors, 30% of moderately differentiated tumors, and none of poorly differentiated tumors. Hasegawa et al[70] reported that uptake of Tc-99m-(Sn)-N-pyridoxyl-5-methyltryptophan (PMT), another hepatobiliary imaging tracer, by HCC is generally more intense than that of IDA compound. Another study by the same group showed a close correlation between Tc-99m-PMT uptake by HCC and survival in 162 patients[71]. The median survival of 82 patients in whom tumors showed increased uptake in delayed Tc-99m-PMT imaging was 1013 days, compared to 398.5 days in 80 patients with no tumor upatake. The results from the above reports suggest that roughly one-half of HCC concentrate hepatobiliary tracers. Also, uptake is correlated with the degree of tumor differentiation. Therefore, hepatobiliary imaging may be useful when aspiration cytology is unable to distinguish cirrhotic reactive changes from well-differentiated HCC.

Uptake of hepatobiliary tracers on delayed imaging can be present in other masses originating from hepatocytes such as focal nodular hyperplasia[72,73]. Kotzerke et al[74] reported that the distinction between FNH and HCC is possible with 3-phase imaging (perfusion, 5-10 minutes, and 2-3 hours). In their series, most FNH exhibited hyperperfusion, normal or increased uptake between 5 and 10 minutes, whereas most HCC displayed decreased or no uptake during this phase. Combining hepatobiliary imaging with gallium scanning can increase the accuracy of diagnosis[75].

3) Gallium Scintigraphy

In addition to HCC[76], hepatic abscesses and metastases from a variety of malignancies, including lymphomas, also concentrate radiogallium. However, Serafini et al[77] reported 3 patients in whom recurrent HCC was found first on gallium-67 scan after successful resection of HCC, while CT, MRI, liver function tests, alpha-fetoprotein, and carcinoembryonic antigen were negative. In patients with known HCC, obtaining a baseline and follow-up gallium scan may be valuable for early detection of recurrence.

4) Other Radionuclide Techniques

Thallium-201/Tc-99m-phytate (colloid) subtraction imaging using high-resolution triple head SPECT system has been reported to be useful for evaluation of hepatocellular carcinoma[78]. By using an image subtraction technique to eliminate background liver accumulation, the detection of HCC improved.

FDG PET appears to be a valuable method for histologic grading of HCC[79], as well as for monitoring the effect of therapy and tumor viability[79,80]. Tumor vascularity may be assessed with PET using nitrogen-13 ammonia[81] or HAPS[82].

Benign Neoplasms

1. Hepatic Cavernous Hemangioma

The lesions suspected of being hepatic cavernous hemangiomas (HH) are typically first identified on anatomical imaging studies incidentally or during a metastatic survey. Tc-99m-labeled RBC scintigraphy provides the most specific, noninvasive method for making the diagnosis of HH, although the sensitivity varies depending on the imaging protocol, lesion size and location.

The classic finding of HH on a Tc-99m RBC scan is a perfusion/blood pool mismatch, i.e. decreased perfusion on early dynamic images and a gradual increase in activity on blood pool images over time[4,83,84]. Often, decreased flow is not observed in small lesions, partly due to limited resolution of dynamic imaging. Before acquiring the flow images, information about the location of lesions (the largest one if multiple) should be obtained in order to determine the appropriate projection.

The sensitivity of labeled RBC scan with planar imaging in reports published since 1989 ranges from 30% to 53%[84-90]. The specificity and positive predictive value of labeled RBC scanning approaches 100%. SPECT has improved the sensitivity of RBC imaging, particularly for detection of HHs smaller than 2.5 cm. While an excellent sensitivity (91%-100%) with SPECT using single head gamma camera was initially reported[86,91], most other reports published in the 1990s have shown an approximately 70-80% sensitivity using single head

SPECT[87-89,92].

Following the introduction of triple head high-resolution dedicated SPECT systems, the sensitivity of RBC imaging has further increased. The results of the studies by Ziessman et al[84] and Moon et al[90] which evaluated HHs with a triple head camera are remarkably similar. The reported sensitivity with triple head SPECT was 17-20% for the detection of lesions smaller than 1 cm, 65-80% for lesions between 1 cm and 2 cm, and virtually 100% for those equal to or larger than 1.4 cm. Although the sensitivity for lesions smaller than 1.4 cm was not very high, HHs smaller than 1 cm (as small as 0.5 cm) have been detected[26,84,90]. It is quite notable that the specificity of RBC imaging with SPECT technique remains at 100%[87-89], unlike other radionuclide studies in which an improved sensitivity due to improved resolution and contrast is generally offset by a decreased specificity. Multi-head SPECT systems add another advantage, i.e. the capability of obtaining several sequential dynamic SPECT scans of a short interval following injection of Tc-99m RBC. This allows one to distinguish HH from vascular structures more easily, since HHs exhibit a gradual increase in blood pool activity over time, whereas other structures, including blood vessels, do not.

In a prospective study, Krause et al compared static Tc-99m-RBC SPECT presentation (x-ray type film) with a dynamic three-view display of SPECT slices[88]. The dynamic method improved sensitivity in all size ranges over the static method (95% vs 68%). They suggested the application of the dynamic method to SPECT studies obtained with the triple headed system.

Birnbaum et al showed that the diagnosis of HHs can be improved with fusion of MR, CT, and Tc-99m-labeled RBC SPECT images[93].

1) False Negative and False Positive Results

Increased activity may not be present in cases of HHs with extensive thrombosis and/or fibrosis[4,94].

Several false-positive cases have been reported in the literature which include HCC[94], angiosarcomas[95-97], and metastases[98-100]. On this basis, some authors suggested that even typical scintigraphic features of cavernous HH be interpreted with caution. However, the occurrence of such false-positive results seems extremely rare in view of 100% specificity in virtually all studies other than case reports. One report may be an exception to this. Rabinowitz et al[94] reported 4 cases of HCC which showed increased activity on delayed images. They suggested that distinction between HHs and HCC can be made on early dynamic imaging: HCC show increased flow as well as increased activity on delayed images, whereas HHs will show decreased activity on dynamic images and increased activity on blood pool images. Although this can be a potential problem in countries with a high prevalence of HCC, recent studies, including a large series from Japan (46 HCC), found no HCC that showed increased activity on either planar or SPECT delayed images[85,101].

It is important to distinguish HHs from other vascular structures and from the right kidney to avoid either false-negative or false-positive results[1]. It is essential that RBC scans be read together with anatomical imaging. For example, when a large lesion is reportedly in the posterior portion of the right hepatic lobe, the right kidney, which is usually hot on scans, can be confused with HH. The review of all 3 orthogonal slices is helpful when the known lesion is adjacent to vascular structures[1].

2) Summary

SPECT imaging is essential for Tc-99m RBC imaging for the diagnosis of HH. It appears that SPECT imaging using single-head and triple-head detector can accurately detect HHs larger than 2.5 cm and 1.4 cm, respectively. The sensitivity for smaller lesions, particularly for those adjacent to a blood vessel or the heart, is lower than MRI. However, the specificity and positive-predictive value of the labeled RBC study are close to 100%.

2. Focal Nodular Hyperplasia

Focal nodular hyperplasia (FNH), liver hamartomas, contain variable quantities of normal hepatic cellular elements, including Kupffer cells, hepatocytes and bile ducts arranged in a characteristic pattern. The characteristic triad suggesting FNH has been described as arterial blood flow, normal colloid uptake, and accumulation of Tc-99m-IDA tracer[102].

Thirty % to 70% of focal nodular hyperplasias (FNHs) have either normal or increased Tc-99m-colloid uptake[73,103-106] reflecting the variable quantity of Kupffer cells. Although other focal hepatic lesions, such as regenerating nodules in cirrhotic livers and focal fatty infiltration, will show colloid uptake, in the proper clinical context, the presence of uptake in a hepatic mass suggests the diagnosis of FNH. Decreased Tc-99m-colloid activity may be seen in approximately one third of cases[105,106]. The addition of SPECT to sulfur colloid scintigraphy may increase the sensitivity for detecting FNH[107].

Because of the presence of hepatocytes in FNH, hepatobiliary scanning has also been evaluated for the diagnosis of FNH. Of 25 FNHs in a recent study[73], 19 (76%) showed hyperperfusion during the flow phase, 23 (92%) appeared as hot spots during the clearance phase of hepatobiliary imaging. Hyperperfusion was observed during the flow phase in 76%, and normal sulfur colloid uptake was seen in 16 (64%). The detectability of FNH by IDA scan was greater (92%) than that of CT (84%) or MRI (84%).

3. Hepatocellular Adenoma

Hepatocellular adenomas typically appear as photopenic defects on Tc-99m-colloid scintigraphy. In the past, this was attributed to the absence of Kupffer cells[103,108]. However, a recent pathologic study demonstrated that all hepatic adenomas studied contained Kupffer cells[109]. Yet, most of these lesions (77%) did not demonstrate Tc-99m-colloid uptake for unknown reasons. The authors found no significant histological difference between those lesions that concentrate colloids and those that do not. They also suggested that adenoma should be added to the differential diagnosis of a hepatic mass with colloid uptake because of the presence of uptake in 23% of their cases.

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