

# Imaging the liver — selected topics

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## Introduction

Many imaging modalities are used to evaluate the liver. In the United States, unlike many other parts of the world, computed tomography is the most commonly performed examination for evaluation of hepatic lesions. MRI is used with increasing frequency in select clinical situations especially as MRI techniques are refined, and MRI examinations are easier to perform. There are relative advantages and disadvantages of both hepatic MR and CT. In general, CT is less costly than MR, more readily available, and most radiologists and many referring physicians have a relatively high degree of confidence in looking at CT images. Some studies, however, have found that CT is less sensitive and specific than MR for detection and characterization of focal hepatic disease.

Hepatic MR has several distinct advantages over computed tomography. MR provides outstanding intrinsic soft contrast that can enhance subtle differences between normal and pathologic tissues and tissues of different histologic subtypes. Non-ionizing radiation is used and MRI contrast agents are not nephrotoxic. MRI images may be acquired with multiplanar capabilities which are especially useful in depicting various anatomic relationships. MR studies of the liver take considerably longer than do

CT studies and are more difficult to obtain uniform image quality.

There is still controversy about the precise method of performing both these studies. The issues of the type, dose and delivery of IV contrast media as well as equipment utilized are under intense investigation. In MRI, the pulse sequence used, pulse sequence parameters and use of contrast is also under investigation.

The remainder of this talk will focus on selected issues in hepatic imaging with CT and MRI as they relate to oncology imaging.

## Comparative imaging studies

### Initial studies

Many of the initial CT and MRI comparative imaging studies performed in the 1980s and 1990s used dated technology that would not be considered current now. Therefore, the results of these studies are not applicable with today's imaging equipment. Many of these studies used axial CT instead of spiral or multidetector technology, therefore, thick rather than thin slices were used, which also limits comparison with newer technologies.

MR technology was also relatively slower in the past. This, again, resulted in studies that used thicker slices and frequently used non-breath-hold pulse sequences. In addition, none of the currently used contrast agents were available in these initial comparative imaging trials, limiting both the

sensitivity and specificity for the detection of focal hepatic lesions.

## Liver metastases

Metastases are the most common liver malignancy and occur at least 20 times more frequently than primary hepatocellular cancer. The evaluation of metastatic disease to the liver is one of the most common indications for liver imaging. In general, liver MR is more sensitive for the detection of liver metastases than contrast-enhanced CT.

Liver metastases have a wide variety of appearances on MR images. Most are of low signal intensity on T1-weighted images and bright on T2-weighted images. Imaging features that are suggestive of malignancy include a target-sign or a halo of high signal intensity peripherally, or a heterogeneous signal intensity, with ill-defined borders. It is critical to differentiate between benign hepatic lesions including cysts and hemangiomas and metastases. This distinction is relatively easy with MRI and may be performed with T2-weighted images and contrast enhanced images. Morphologically, on both T2 and post contrast images metastases are generally complex and heterogeneous, and frequently ill-defined, while cysts and hemangiomas are homogeneous and sharply defined.

Contrast-enhanced MRI, especially with gadolinium based agents, increases both detection of liver metastases and aids in liver lesion characterization. Metastases have a variable appearance after gadolinium administration. They may be either hypervascular and enhance on the early arterial phase or hypovascular and enhance later. They often enhance with a complete peripheral ring. The

use of MR contrast agents, other than gadolinium DTPA, has been investigated for a number of years and an additional contrast agent has gained FDA approval. Superparamagnetic iron oxide (SPIO-ferumoxides) is a reticuloendothelial specific, particulate MR contrast agent. SPIO's change hepatic parenchymal contrast by shortening the spin-spin relaxation, resulting in a reduction in signal intensity in tissue containing the contrast agent. Most hepatic tumors do not contain reticuloendothelial cells. Therefore, the contrast between the tumor and normal hepatic parenchyma will be increased. Ferumoxides are principally a T2-contrast agent. If it is necessary to do a T1-weighted sequence, then a precontrast study must also be performed. The current formulation of this agent is administered over 30 minutes by I.V. infusion. As this contrast agent and others enter the market, a cost-benefit analysis will need to be performed to assess the added benefit, considering not only the costs of contrast agent, but also additional time required for imaging, patient preparation and scan interpretation.

## Hepatocellular carcinoma

### CT

Large hepatocellular carcinomas tend to be heterogeneous, and may demonstrate a typical mosaic appearance on CT. Smaller HCCs are often isodense and difficult to detect on conventional CT, which is performed during the portal venous phase of enhancement. Conventional CT has a sensitivity of 48% and a specificity of 70% in the detection of HCC. Non-contrast and delayed images slightly

increase lesion detection by conventional CT. The development of spiral CT, which allows scanning during the arterial phase of enhancement, has been a major advance. Tumors can be imaged during the period when many HCCs are hyperdense relative to the unenhanced parenchyma. Arterial phase imaging detects 30 to 40% more tumor nodules than conventional CT, and will be the only phase to show tumor in 7 to 10% of patients.

### Direct CT arteriography and CT arteriportography

Direct CT arteriography refers to CT done during catheter injection of contrast into the hepatic artery. HCCs are detected as hypervascular lesions, with a sensitivity of approximately 91%. This technique is invasive and requires identification of accessory arteries to the liver. It is also subject to a variety of false positive results. CT arteriportography (CTAP) refers to CT scanning done during catheter injection of contrast into the superior mesenteric artery. Contrast flows to the bowel and returns to the liver via the portal vein, opacifying the normal hepatic parenchyma. Liver tumors, which are supplied by the hepatic artery, appear as hypodense lesions relative to the normal enhanced parenchyma. CTAP is considered the most sensitive preoperative method of detecting liver tumors, but has several limitations in cirrhosis. For example, dysplastic nodules may be hypodense and mistaken for HCC and perfusion defects are common.

### MRI

The morphology of HCC is well demonstrated by MRI. Tumor capsules and central scars are more frequently seen than on CT. HCC

demonstrates variable signal intensity on T1-weighted images. Relative to normal hepatic parenchyma, approximately 1/3 of HCCs are hypointense, 1/3 of HCCs are hyperintense, and 1/3 are isointense. High signal intensity on T1-weighted images is sometimes due to the presence of intracellular lipid, but in other cases the cause is not known. Numerous studies have investigated the characterization of regenerative, dysplastic, and malignant nodules by MRI. Contrast-enhancement is important because T1 and T2 signal intensity alone is insufficient for reliable distinction of these entities. Three different MRI contrast agents have been studied; gadolinium, ferumoxides, and manganese. Gadolinium-DTPA is an extracellular paramagnetic contrast agent that produces enhancement in vascular tissues on T1 weighted images. Dynamic gadolinium-enhanced MRI is the preferred sequence for visualization of HCC, because of the typical hypervascular pattern of enhancement in the arterial phase and because some well differentiated HCCs may only be seen during the delayed phase. HCCs do not contain a significant number of reticuloendothelial cells, and so are more easily visualized against the darkened background on T2-weighted images. While ferumoxides may help lesion detection on T2-weighted images, ferumoxides do not appear to increase lesion detection when compared with gadolinium-enhanced MRI. Manganofodipir trisodium is a manganese based hepatobiliary contrast agent taken up by hepatocytes and secreted in the bile. Manganese causes T1 shortening. As a result, normal parenchyma is bright on T1W images, and lesions are relatively dark.

## Three-dimensional imaging

With the rapid scanning ability of multidetector CT and volumetric MRI, it is feasible to obtain a three-dimensional data set of the entire liver during a single breath hold. With reconstruction of this data, high-quality three-dimensional images may be obtained. They are useful in presurgical planning and mapping of lesions. These images may be combined with other imaging of the liver to produce a comprehensive, non-invasive method for evaluating the hepatic parenchyma, hepatic vasculature and biliary tree.

### Selected reading

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