



Magnetic Resonance Imaging of Liver Metastasis

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Liver magnetic resonance imaging (MRI) is becoming the gold standard in liver metastasis detection and treatment response assessment. The most sensitive magnetic resonance sequences are diffusion-weighted images and hepatobiliary phase images after Gd-EOB-DTPA. Peripheral ring enhancement, diffusion restriction, and hypointensity on hepatobiliary phase images are hallmarks of liver metastases. In patients with normal ultrasonography, computed tomography (CT), and positron emission tomography (PET)-CT findings and high clinical suspicion of metastasis, MRI should be performed for diagnosis of unseen metastasis. In melanoma, colon cancer, and neuroendocrine tumor metastases, MRI allows confident diagnosis of treatment-related changes in liver and enables differential diagnosis from primary liver tumors. Focal nodular hyperplasia-like nodules in patients who received platinum-based chemotherapy, hypersteatosis, and focal fat can mimic metastasis. In cancer patients with fatty liver, MRI should be preferred to CT. Although the first-line imaging for metastases is CT, MRI can be used as a problem-solving method. MRI may be used as the first-line method in patients who would undergo curative surgery or metastatectomy. Current limitation of MRI is low sensitivity for metastasis smaller than 3 mm. MRI fingerprinting, glucoCEST MRI, and PET-MRI may allow simpler and more sensitive diagnosis of liver metastasis.

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Introduction

Liver metastasis, by definition, is a malignant lesion originating in an organ distant from the liver, which would secondarily disseminate and grow in the liver. Liver is a very common site of metastasis. Gastrointestinal tumors such as neuroendocrine tumors, colorectal cancers, esophageal and gastric tumors, and pancreatic cancers are among the most common sources for metastatic disease to the liver. Colorectal cancers (CRCs) are especially very common, with approximately 50% of the patients would have metastatic liver disease either at the time of diagnosis or in the follow-up period after surgical resection.¹ Despite advances in surgery, targeted biologic therapies, and chemotherapy, the survival rates of patients with liver metastasis are still dismal, with a significant

portion of these patients dying owing to their metastatic liver disease.

Disseminations through the portal venous and arterial systems are the most common routes for metastasis. Once the tumor cells detach from their original site, they travel into the vascular system and extravasate into the target organ parenchyma and proliferate. They are frequently found as multiple lesions of different sizes in both liver lobes, and several cancers often incite desmoplastic reaction when they metastasize, which gives them their hard consistency.² Often times, internal necrotic changes give rise to their pseudocystic appearance. Central fibrous scar formation and capsular retraction (when they are located close to the liver capsule) may also be detected.^{3,4}

Clinical Presentation

Most liver metastases are clinically silent and detected with cross-sectional imaging. When they are symptomatic, the disease is most often at an advanced stage and the prognosis is poor. Metastasis from hormonally active tumors may present

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with symptoms related to the hormonally active metabolites secreted by the metastatic cells.

Role of Cross-Sectional Imaging in the Evaluation of Metastatic Liver Disease

Imaging plays a crucial and integral role in the diagnosis and monitoring of metastatic liver disease. Several imaging modalities including ultrasonography (US), computed tomography (CT), positron emission tomography (PET), and PET-CT scans can be used for this purpose. In this article, we are going to focus on the role of MRI, which is becoming the gold standard modality in the diagnosis of hepatic metastases.

MRI for Liver Metastases

MRI offers superior soft tissue resolution, providing several advantages over other cross-sectional imaging modalities for the detection and characterization of the focal liver lesions. This superiority becomes more prominent when it comes to detection of small-sized metastases. The reported sensitivity of contrast-enhanced MRI (CE-MRI) is 91%-97% compared with 71%-73.5% for CT.⁵⁻⁷ The sensitivity of MRI increases, especially, in the characterization of the lesions deemed to be "too small to characterize" on multidetector CT studies⁸ (Fig. 1).

Advanced MRI Techniques

Several new MRI techniques have entered clinical practice in the past few years, and they have now become essential components of standard liver MRI protocols.⁹ Diffusion-weighted imaging (DWI), hepatocyte-specific magnetic resonance (MR) contrast agents (HSMRCA), MR elastography, and MR perfusion may be counted among them. For the sake of brevity, we focus on DWI and HSMRCA. MR elastography and MR perfusion are less commonly used in clinical practice, and both are currently in the research realm awaiting translation into bedside clinical practice. It is highly possible that

they would become part of the routine liver protocols in the coming years.

DWI of the Liver

DWI is a technique that can provide tissue contrast based on the measurement of diffusion properties of the water molecules within tissue.¹⁰ It is mainly based on the intravoxel incoherent motion and provides quantification of the water diffusion and microcapillary blood perfusion within the tissue in a non-invasive manner.¹¹

DWI was mainly a tool for neuroimaging; however, it has become an indispensable part of the liver MRI studies. It is not only used in the detection of liver lesions but also commonly used for focal liver lesion characterization and assessment of treatment response. The technique does not require any IV contrast use, and its use may be even more helpful in patients with renal dysfunction. It is quick to perform, with no significant increase in the overall examination time, and the image quality is getting better with new refinements in the technique. Although it is mainly used as a qualitative method, it also allows quantification, which may provide an objective parameter, especially in assessing tumor response. Ultimately, with the use of DWI, one can obtain highly relevant data regarding the structural tissue changes at cellular level in a noninvasive manner. DWI may be also helpful for the evaluation of the response of malignant liver lesions to new antineoplastic agents, which mainly target the tumor vascularity.⁹ With these agents, the overall hepatic metastasis size may not change despite highly successful devascularization and necrosis of the tumor cells within the metastatic focus. The addition of hepatocyte-specific agent gadoxetate disodium to DWI was reported to be superior to DWI alone for detecting liver metastases from colorectal cancer metastases ≤ 1 cm in diameter.¹²

When it was first introduced, DWI was performed by adding a symmetric pair of diffusion-sensitizing gradients around the 180° refocusing pulse of a T2-weighted sequence.¹³ In densely packed environments, water molecules would not demonstrate any appreciable change in their phases between the 2 gradients and would, therefore, generate little difference in the rephasing. In this situation, there would be

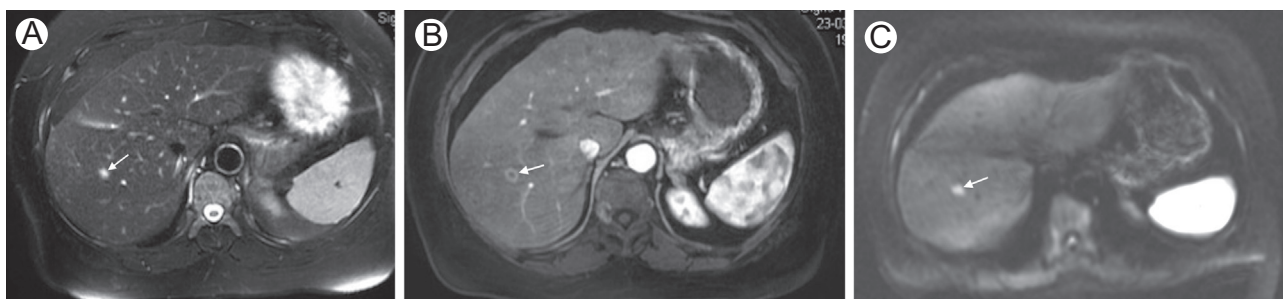


Figure 1 A 45-year-old male patient with newly diagnosed pancreatic cancer with subcentimeter liver metastasis. (A) Axial fat-suppressed T2-weighted image demonstrates 5-mm hyperintense focus in the right liver lobe (arrow). (B) Arterial phase T1-weighted axial contrast-enhanced MR image shows typical ring enhancement (arrow) with (C) subsequent diffusion restriction (arrow) on DWI sequence ($b = 500$).

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