DIAGNOSTIC CAPABILITIES OF MAGNETIC RESONANCE IMAGING AND MODERN APPROACHES

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Abstract. *Magnetic resonance imaging (MRI) is one of the most accurate imaging modalities for the detection and characterization of liver metastases. This article reviews the diagnostic capabilities of MRI and discusses modern imaging approaches used in the evaluation of metastatic liver disease. Advanced MRI techniques, including diffusion-weighted imaging (DWI), apparent diffusion coefficient (ADC) mapping, dynamic contrast-enhanced imaging, and hepatocyte-specific contrast agents, significantly improve the detection of small metastatic lesions and increase diagnostic accuracy. MRI also provides detailed information about lesion morphology, extent, and relationship with surrounding anatomical structures, making it an essential tool for disease staging and treatment planning. Despite certain limitations, MRI remains an indispensable imaging modality in modern oncological practice and contributes to improved patient management and clinical outcomes.*

Keywords: *magnetic resonance imaging, liver metastases, diagnostic imaging, diffusion-weighted imaging, hepatocyte-specific contrast agents.*

Introduction

Magnetic resonance imaging (MRI) has become one of the most advanced and reliable imaging modalities in modern diagnostic radiology. Owing to its excellent soft-tissue contrast and multiparametric imaging capabilities, MRI plays a pivotal role in the evaluation of a wide range of pathological conditions, particularly in oncological diseases.

Unlike computed tomography (CT), MRI does not utilize ionizing radiation, making it a safer imaging technique for repeated examinations and long-term follow-up of cancer patients. In hepatic oncology, MRI has demonstrated superior diagnostic performance in detecting and characterizing focal liver lesions, especially metastatic tumors.

The introduction of diffusion-weighted imaging (DWI), apparent diffusion coefficient (ADC) mapping, dynamic contrast-enhanced imaging, and hepatocyte-specific contrast agents has significantly improved the sensitivity and specificity of MRI in identifying liver metastases.

These advanced imaging techniques enable the visualization of small metastatic lesions that may not be detected by conventional imaging methods, thereby facilitating earlier diagnosis and more accurate disease staging.

Recent technological developments, including high-field 3.0-T MRI systems, accelerated acquisition techniques, artificial intelligence (AI)-assisted image reconstruction, radiomics, and quantitative image analysis, have further enhanced the diagnostic capabilities of MRI.

These innovations improve image quality, reduce examination time, and increase diagnostic confidence while supporting personalized treatment planning in patients with metastatic liver disease.

Relevance of the Study

Magnetic resonance imaging (MRI) is one of the most effective imaging techniques for detecting liver metastases. Its high soft-tissue contrast and advanced imaging sequences enable accurate identification of metastatic lesions, particularly small tumors.

Main part

Magnetic resonance imaging (MRI) is one of the most advanced imaging techniques used in modern diagnostic radiology. It produces high-resolution images of soft tissues using a strong magnetic field and radiofrequency pulses without exposing patients to ionizing radiation. MRI provides excellent tissue contrast, making it highly effective for detecting and characterizing focal liver lesions. In hepatic oncology, MRI plays a crucial role in identifying metastatic tumors, evaluating lesion morphology, and assessing tumor extent. The introduction of high-field MRI systems and advanced imaging protocols has significantly improved image quality and diagnostic confidence. MRI enables accurate visualization of lesion size, number, location, and relationship with adjacent vascular structures.

Recent advances in MRI technology have greatly enhanced the diagnosis of liver metastases. Functional imaging techniques, including diffusion-weighted imaging (DWI), apparent diffusion coefficient (ADC) mapping, dynamic contrast-enhanced MRI, and hepatocyte-specific contrast agents, have significantly increased the sensitivity of MRI, particularly for lesions smaller than 10 mm.

These techniques improve tissue characterization and facilitate the differentiation of malignant and benign hepatic lesions. In addition, three-dimensional image reconstruction and multiparametric MRI provide comprehensive anatomical and functional information. The integration of artificial intelligence and radiomics into MRI interpretation has further improved lesion detection, quantitative analysis, and diagnostic accuracy.

MRI offers several advantages over other imaging modalities in the evaluation of liver metastases. Its superior soft-tissue contrast, absence of ionizing radiation, and advanced functional imaging capabilities contribute to high diagnostic accuracy.

MRI is particularly valuable for detecting small metastatic lesions, assessing treatment response, and monitoring disease progression. It is also widely used for preoperative evaluation and treatment planning. However, MRI has certain limitations, including longer examination time, higher cost, and contraindications in patients with some implanted medical devices or severe claustrophobia.

Despite these limitations, MRI remains one of the most reliable imaging modalities for liver metastasis assessment. The combined use of MRI with other imaging techniques, particularly computed tomography, provides comprehensive diagnostic information and supports optimal clinical decision-making in patients with metastatic liver disease.

Conclusion

Magnetic resonance imaging (MRI) is one of the most accurate and reliable imaging modalities for the detection and evaluation of liver metastases. Its excellent soft-tissue contrast and advanced imaging techniques enable precise identification and characterization of metastatic lesions, particularly small hepatic tumors.

Modern MRI approaches, including diffusion-weighted imaging and hepatocyte-specific contrast-enhanced imaging, have significantly improved diagnostic performance and clinical decision-making. Although MRI has certain limitations, such as longer examination time and higher cost, its diagnostic advantages outweigh these disadvantages in many clinical situations.

Therefore, MRI plays a crucial role in the early diagnosis, staging, treatment planning, and follow-up of patients with liver metastases, contributing to improved therapeutic outcomes and patient prognosis.

References

1. Maino C., Granata V., Fusco R., et al. Liver Metastases: The Role of Magnetic Resonance Imaging. Diagnostics. 2023;13(20):3196.
2. Görgec B., de Jong M.C., et al. MRI in Addition to CT in Patients Scheduled for Local Treatment of Colorectal Liver Metastases (CAMINO): A Multicentre, Randomised Controlled Trial. The Lancet Oncology. 2024;25(2):197–208.
3. Granata V., Fusco R., De Muzio F., et al. Radiomics and Machine Learning Analysis by Computed Tomography and Magnetic Resonance Imaging in Colorectal Liver Metastases. La Radiologia Medica. 2023;128(10):1310–1322.
4. Zhang L., Bai L., Wang H., et al. Diagnostic Performance of Contrast-Enhanced CT Combined with MRI for Colorectal Liver Metastases. BMC Gastroenterology. 2025;25:188.
5. Chen Y., Li X., Zhao H., et al. Advances in Magnetic Resonance Imaging for the Diagnosis of Liver Metastases. Journal of Clinical and Translational Hepatology. 2025.
6. Ozaki K., Matsui O., Kobayashi S., et al. Liver Metastases: Correlation Between Imaging Features and Pathological Findings. Radiographics. 2022;42(5):1385–1407.