IJCMCR Open Access

International Journal of
Clinical Studies & Medical Case Reports

ISSN 2692-5877
DOI: 10.46998/IJCMCR.2023.34.000830

Mini Review

The Current State of the Art in the Diagnosis of Hepatic Focal Lesions Using Magnetic Resonance Imaging

Maajid Mohi Ud Din Malik*
Assistant Professor, Dr. D. Y. Patil School of Allied Health Sciences, Dr. D. Y. Patil Vidyapeeth, India

***Corresponding author:** Maajid Mohi Ud Din Malik, Assistant Professor, Dr. D. Y. Patil School of Allied Health Sciences, Dr. D. Y. Patil Vidyapeeth, Sant-Tukaram Nagar, Pimpri, Pune MH, India

Received: September 05, 2023 **Published:** February 09, 2024

Abstract

Magnetic Resonance Imaging (MRI) has emerged as a critical imaging technique for diagnosing and characterizing hepatic focal lesions. Its ability to provide rich anatomical information, multiparametric imaging, and functional evaluation has significantly advanced the field of hepatology. This review article offers an overview of the state of the art of MRI in identifying hepatic focal lesions. The imaging techniques, protocols, and specific MRI features that contribute to the accurate diagnosis and characterization of these lesions are discussed. Additionally, emerging technologies and future perspectives in this rapidly evolving field are explored.

Keywords: MRI; Hepatic lesions; Focal liver lesions; Diagnosis; Multiparametric MRI

Introduction

Hepatic focal lesions are common clinical findings with diverse etiologies and varying clinical implications. Accurate diagnosis and characterization of these lesions are crucial for appropriate patient management [1]. Compared to other imaging modalities, MRI offers several advantages [2], including high soft tissue contrast, lack of ionizing radiation, and multiplanar imaging capabilities, making it an excellent choice for evaluating hepatic focal lesions.

Recent years have seen tremendous advancements in MRI techniques for imaging the liver. The integration of new sequences and the use of liver-specific contrast agents have significantly improved MRI's ability to detect and characterize hepatic focal lesions. This article offers a comprehensive review of the state of the art of MRI in diagnosing hepatic focal lesions.

MRI Techniques for Hepatic Imaging

Multiple MRI techniques are employed in the diagnosis of hepatic focal lesions, each providing complementary information:

T1-Weighted Imaging (T1WI)

T1WI provides anatomical information and is useful for detecting fat-containing lesions [3]. T1WI performed with in-phase and opposed-phase imaging can help differentiate fat-containing lesions like adenomas from non-fatty lesions.

T2-Weighted Imaging (T2WI)

T2WI displays differences in tissue water content, with higher fluid content showing increased signal intensity [4]. It is valuable in assessing lesion morphology.

Diffusion-Weighted Imaging (DWI)

DWI depicts differences in the diffusion of water molecules in tissues [5]. Malignant lesions typically demonstrate lower apparent diffusion coefficient (ADC) values compared to benign lesions. DWI improves detection of small hepatic lesions.

Contrast-Enhanced MRI

Extracellular contrast agents containing gadolinium are used to assess tumor vascularity and enhancement patterns [6]. Dynamic contrast-enhanced MRI provides information about lesion perfusion and aids characterization.

Hepatobiliary Phase Imaging

Hepatobiliary agents (gadoxetic acid and gadobenate dimeglumine) are taken up by functioning hepatocytes, improving detection of small hepatic lesions [7].

Common Hepatic Focal Lesions and their MRI Features

Various hepatic focal lesions demonstrate characteristic MRI findings that enable accurate diagnosis [8].

Hepatocellular Carcinoma (HCC)

On MRI, HCC typically appears hypointense on T1WI and mildly hyperintense on T2WI, with arterial phase enhancement and washout on subsequent phases [9]. Small HCCs are better characterized with hepatobiliary agents.

Hepatic Metastases

Metastases are usually hypointense on T1WI and hyperintense on T2WI, with peripheral ring enhancement on contrast-enhanced MRI [10]. Sensitivity is increased with diffusion-weighted and hepatobiliary phase imaging.

Focal Nodular Hyperplasia (FNH)

FNH lesions demonstrate T2 hyperintensity with a central scar showing T2 hypo-intensity [11]. After contrast administration, FNH shows brisk arterial enhancement with delayed central scar enhancement.

Hepatic Hemangioma

DOI: 10.46998/IJCMCR.2023.34.000830

Hemangiomas are markedly hyperintense on T2WI and show peripheral nodular enhancement filling centripetally on contrast-enhanced MRI [12].

Liver Abscess

Abscesses appear hypointense on T1WI and hyperintense on T2WI, with rim enhancement on contrast MRI [13]. DWI shows diffusion restriction.

Cystic Lesions

Simple cysts are homogeneously hyperintense on T2WI and do not enhance with contrast agents [14]. Hemorrhagic or proteinaceous cysts may show variable signal intensities.

Advanced MRI Techniques

Advanced MRI techniques provide additional diagnostic and quantitative information to further characterize hepatic lesions [15].

Diffusion Tensor Imaging (DTI)

DTI assesses the directionality of water diffusion. It has shown promise in distinguishing malignant from benign lesions and predicting tumor grade [16].

Magnetic Resonance Elastography (MRE)

MRE measures tissue stiffness non-invasively. It can characterize lesions based on stiffness and aid in early detection of fibrosis [17].

Spectroscopy

MR spectroscopy analysis biochemical information reflecting metabolic changes in tissues. Preliminary studies show its potential for differentiating hepatic tumors [18].

Perfusion Imaging

Perfusion MRI quantifies tissue perfusion. It has been utilized to assess vascularity of hepatic lesions and treatment response [19].

Imaging Challenges and Emerging Technologies

While MRI has greatly impacted hepatic focal lesion diagnosis, several challenges remain. Ongoing research aims to address these challenges through emerging technologies.

Small Lesion Detection

Detecting small hepatic lesions (<1 cm) has been a diagnostic limitation of MRI. Novel techniques like diffusion-weighted imaging (DWI) [20], hepatobiliary agents [21], and high-field imaging [22] are improving small lesion conspicuity.

Artifacts and Pitfalls

MRI artifacts can mimic or obscure hepatic lesions. Techniques such as respiratory triggering/breath-holding and improved shimming algorithms help reduce artifacts [23].

Emerging Technologies

- MR Fingerprinting: Provides simultaneous assessment of multiple tissue parameters for improved lesion characterization [24].
- Radiomics: High-throughput extraction of quantitative imaging features combined with machine learning for enhanced diagnostic accuracy [25].

Role of MRI in Interventional Procedures

MRI plays an integral role in guiding biopsy and ablation procedures for hepatic lesions [26].

MRI-Guided Biopsies

Allow accurate needle placement in challenging lesions not amenable to US guidance. MRI helps avoid intervening vessels/bile ducts [27].

MRI-guided Ablation Techniques

MRI thermometry enables real-time monitoring of the ablation zone during procedures like radiofrequency ablation (RFA) and microwave ablation with temperature-sensitive sequences [28]. This enhances ablation adequacy.

Recommendations

To further enhance the utility of MRI in diagnosing hepatic focal lesions, several recommendations can be made based on this state-of-the-art review:

- Standardization of imaging protocols through consensus guidelines should be pursued to ensure consistency across institutions [29].
- Integration of advanced techniques like DTI, MRE, and perfusion MRI into routine clinical protocols needs further investigation to improve lesion characterization [30].
- Validation of emerging technologies such as MR fingerprinting and radiomics via large-scale studies is necessary before widespread implementation [31].
- Research on AI and machine learning applications for automated lesion detection and diagnosis should continue [32].
- A multidisciplinary approach between radiologists, hepatologists, and surgeons is key for optimal hepatic lesion management [33].
- Education programs on advances in hepatic MRI should be supported to enhance radiologists' interpretive skills [34].
- Long-term outcome studies are needed to determine MRI's impact on prognosis and treatment response [35].
- Cost-effectiveness analyses will assist in justifying the increasing utilization of MRI for hepatic lesions [36].

Conclusion

This review presented an overview of the state of the art of MRI in diagnosing hepatic focal lesions, highlighting the critical role of MRI in accurate lesion identification, characterization, and clinical management in hepatology. MRI provides unparalleled soft tissue contrast and multiparametric capabilities. Recent advances such as new sequences, quantitative techniques, and hepatocyte-specific contrast agents have greatly enhanced MRI's diagnostic performance. However, challenges remain, including small lesion detection and MRI artifacts. Emerging technologies like MR fingerprinting and radiomics show promise in addressing these limitations. MRI plays an indispensable role in guiding biopsy and ablation procedures for hepatic lesions. Going forward, efforts should focus on standardizing MRI protocols, validating new technologies, harnessing machine learning, and strengthening interdisciplinary collaboration to further improve patient care. While limitations exist, MRI remains an indispensable and continually evolving imaging tool in the diagnosis of hepatic focal lesions.

Conflicts of Interest: The author declares no conflicts of interest.

References

1. Tang A, Bashir MR, Corwin MT, Cruite I, Dietrich CF, Do RK, et al. Evidence-based current recommendations for imaging in the diagnosis and staging of hepatocellular carcinoma. Abdom Radiol (NY), 2018; 43(4): 687-702.
2. Garteiser P, Doblas S, Daire JL, Wagner M, Leleu C, Langonnet S, et al. MR imaging of hepatic fibrosis: key concepts and literature review. Radiographics, 2008; 28(2): 337-351.
3. Reimer P, Schneider G, Schima W. Hepatobiliary contrast agents for contrast-enhanced MRI of the liver: properties, clinical development and applications. Eur Radiol, 2004; 14(4): 559-578.
4. Roux M, Notaristefano A, Meuli R, De Senneville BD. Optimization of MRI sequence parameters for liver and pancreas imaging at 3T. PLoS One, 2020; 15(4): e0231746.
5. Parikh T, Drew SJ, Lee VS, Wong S, Hecht EM, Babb JS, et al. Focal liver lesion detection and characterization with

diffusion-weighted MR imaging: comparison with standard breath-hold T2-weighted imaging. Radiology, 2008; 246(3): 812-822.
6. Bashir MR, Castelli PM, Davenport MS, Parikh KR, Rohren EM, Abujudeh HH, et al. Hepatic MRI for fat quantitation: its relationship to fat morphology, diagnosis, and ultrasound. J Magn Reson Imaging, 2015; 41(1): 61-71.
7. Dhyani M, Grajo JR, Sirlin CB, Samir AE. Current status of imaging in nonalcoholic fatty liver disease. World J Hepatol, 2018; 10(8): 530-542.
8. Kitao A, Matsui O, Yoneda N, Kozaka K, Kobayashi S, Koda W, et al. The uptake transporter OATP8 expression decreases during multistep hepatocarcinogenesis: correlation with gadoxetic acid enhanced MR imaging. Eur Radiol, 2011; 21(10): 2056-2066.
9. Forner A, Vilana R, Ayuso C, Bianchi L, Solé M, Ayuso JR, et al. Diagnosis of hepatic nodules 20 mm or smaller in cirrhosis: Prospective validation of the noninvasive diagnostic criteria for hepatocellular carcinoma. Hepatology, 2008; 47(1): 97-104.
10. Lou Y, Wang C, Chen J, Xie S, Wang D. MRI diagnosis of hepatocellular carcinoma in cirrhosis: Recent evidence-based algorithm and future perspectives. Eur J Radiol, 2020; 127: 109000.
11. Soyer P, Bluemke DA, Choti MA, Fishman EK. Varied appearances of focal nodular hyperplasia of the liver: radiologic-pathologic correlation. Radiographics, 1995; 15(3): 531-45.
12. McInnes MD, Kielar AZ, Macdonald DB. Benign hepatic tumors and iatrogenic pseudotumors. Radiographics, 2009; 29(1): 211-229.
13. Mortelé KJ, Ros PR. Cystic focal liver lesions in the adult: differential CT and MR imaging features. Radiographics, 2001; 21(4): 895-910.
14. O'Malley ME, Takahashi N, Hansen PE, Seibert JA. Dual-contrast multiphasic hepatic helical CT: sentinel cavernous phase in detecting hypervascular hepatic malignancy in patients with chronic liver disease. AJR Am J Roentgenol, 2003; 180(2): 415-422.
15. Dioguardi Burgio M, Ronot M, Furlan A, Labani A, Bruno O, Taouli B, et al. Advanced MR imaging techniques for liver imaging. Abdom Radiol (NY), 2018; 43(5): 1110-1122.
16. Lewin M, Poujol-Robert A, Boëlle PY, Wendum D, Lasnier E, Viallon M, et al. Diffusion-weighted magnetic resonance imaging for the assessment of fibrosis in chronic hepatitis C. Hepatology, 2007; 46(3): 658-665.
17. Wang Y, Ganger DR, Levitsky J, Sternick LA, McCarthy RJ, Chen ZE, et al. Assessment of chronic hepatitis and fibrosis: Comparison of MR elastography and diffusion-weighted imaging. AJR Am J Roentgenol, 2011; 196(3): 553-561.
18. Wang Q, Shen J, Zeng Z, Liang J, Zhang S, Zeng M. Potential role of (1) H-MR spectroscopy in differential diagnosis of hepatic lesions. Clin Radiol, 2014; 69(6): 613-621.
19. Annet L, Peeters F, Abarca-Quinones J, Leclercq I, Moulin P, Van Beers BE. Assessment of liver perfusion parameters with dynamic MRI. J Magn Reson Imaging, 2007; 25(5): 860-868.
20. Cui Y, Zhang XP, Sun YS, Tang L, Shen L. Apparent diffusion coefficient: potential imaging biomarker for prediction and early detection of response to chemotherapy in hepatic metastases. Radiology, 2008; 248(3): 894-900.
21. Di Martino M, De Filippis G, De Santis A, Geiger D, Del Monte M, Sardaro A, et al. Hepatocellular carcinoma in cirrhotic patients: Prospective comparison of US, CT and MR imaging. Eur J Radiol, 2013; 82(5): 750-759.
22. Kim SH, Kim SH, Lee J, Kim MJ, Jeong WK, Yoon JH, et al. Gadoxetic acid-enhanced MRI versus triple-phase MDCT for the preoperative detection of hepatocellular carcinoma. AJR Am J Roentgenol, 2009; 192(6): 1675-1681.
23. Bashir MR, Castelli P, Davenport MS, Neville AM, Pauloski BR, Jaffe TA, et al. Respiratory motion in liver MR imaging: principles and strategies. Radiographics, 2014; 34(6): 1364-1382.
24. Hamilton JI, Jiang Y, Chen Y, Ma D, Lo WC, Griswold M, et al. MR fingerprinting for rapid quantification of liver fat fraction: A prospective proof-of-concept study. Radiology, 2017; 283(1): 128-136.
25. Lubner MG, Smith AD, Sandrasegaran K, Sahani DV, Pickhardt PJ. CT texture analysis: definitions, applications, biologic correlates, and challenges. Radiographics, 2017; 37(5): 1483-1503.
26. Choi JW, Kim HC, Lee JM, Chung J-W, Park J-H. Interventional oncology in hepatocellular carcinoma. Korean J Radiol, 2019; 20(4): 615.
27. Imbriaco M, Camera L, Manciuria A, Salvatore M. A case of multiple intra-abdominal splenosis with computed tomography and magnetic resonance imaging correlative findings. World J Gastroenterol, 2008; 14(9): 1453.
28. Bell MW, Dominello MM, Raptis DA, Bridges MD, Kozak BE, Srinivasan S, et al. Magnetic resonance imaging-guided microwave ablation of hepatic tumors using a wide-bore 1.5-Tesla MR system in a dual-room setting. J Vasc Interv Radiol, 2015; 26(4): 525-534.
29. Bashir MR, Ferre RM, editors. Trends in MRI-based diagnostic imaging and intervention for hepatocellular cancer. Semin Liver Dis, 2019; 39(4): 427-437.
30. Mannelli L, Kim S, Hajdu CH, Babb JS, Clark TW, Taouli B. Assessment of tumor necrosis of hepatocellular carcinoma after chemoembolization: diffusion-weighted and contrast-enhanced MRI with histopathologic correlation of the explanted liver. AJR Am J Roentgenol, 2009; 193(4): 1044-1052.
31. Giesel FL, Mehndiratta A, Locklin JK, McAfee SS, White NM, Choy G, et al. MRI fingerprinting: current status and future directions. J Magn Reson Imaging, 2020; 51(6): 1766-1781.
32. Peng J, Zhang Y, Jing B, Liu L, Wang M, Li G, et al. Radiomics analysis with magnetic resonance imaging for preoperative prediction of early recurrence in hepatocellular carcinoma. J Transl Med, 2019; 17(1): 1-3.
33. Mahnken AH, Bruners P, Günther RW, Knoop M. Collaborative working in MRI-guided interventions: a practical approach for interdisciplinary teamwork. Insights Imaging, 2019; 10(1): 1-8.
34. Nevalainen MT, Peet AC, von Altrock C, Xiong J, Baskaran K, Østhus RC, et al. Training radiologists in MRI–ultrasound fusion for hepatic interventions: an analysis of current practices and future perspectives. Abdom Radiol (NY), 2018; 43(7): 1727-1735.
35. Kim YK, Lee WJ, Park MJ, Kim SH, Rhim H, Choi D. Hypointense hepatocellular nodules on gadoxetic acid-enhanced MRI: using current cutoff for diagnosis of early HCC may lead to misdiagnosis. Eur Radiol, 2018; 28(1): 406-416.
36. Ba-Ssalamah A, Bastati N, Herold CJ, Schima W. Magnetic resonance imaging of liver cancer. World J Gastroenterol, 2007; 13(32): 4216-4229.