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Original Research Article

DIAGNOSTIC PERFORMANCE OF DYNAMIC CONTRAST-ENHANCED MRI FOR HEPATOCELLULAR CARCINOMA DETECTION IN CHRONIC LIVER DISEASE: CORRELATION WITH HISTOPATHOLOGY

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ABSTRACT

Background: *Chronic liver disease is a major predisposing factor for the development of hepatocellular carcinoma, which remains a leading cause of liver-related mortality worldwide. Early and accurate diagnosis is essential for timely therapeutic intervention and improved survival outcomes. Dynamic contrast-enhanced magnetic resonance imaging has emerged as a non-invasive modality for HCC detection; however, its diagnostic performance requires validation against histopathological confirmation, particularly in resource-limited settings.* ***Objective:*** *To determine the diagnostic accuracy of dynamic contrast-enhanced magnetic resonance imaging in identifying hepatocellular carcinoma among patients with chronic liver disease, using histopathology as the reference standard, and to assess the influence of demographic and clinical factors on imaging performance.* ***Study Design:*** *Cross-sectional diagnostic study.* ***Settings:*** *Department of Diagnostic Radiology, Nishtar Hospital, Multan, Pakistan.* ***Duration of Study:*** *May 2024 to August 2024.* ***Methods:*** *A total of 151 patients with chronic liver disease, aged 30 to 70 years, were enrolled using non-probability consecutive sampling. All participants underwent dynamic contrast-enhanced magnetic resonance imaging followed by percutaneous liver biopsy for histopathological confirmation. Diagnostic performance indices, including sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy, were calculated. Stratified analyses were performed by age, gender, lesion size, disease duration, and area of residence.* ***Results:*** *Dynamic contrast-enhanced magnetic resonance imaging demonstrated a sensitivity of 94.94%, specificity of 95.83%, positive predictive value of 96.15%, negative predictive value of 94.52%, and an overall diagnostic accuracy of 95.36%. Diagnostic performance was highest for lesions larger than 5 cm, with an accuracy of 98.36%. The accuracy of DCE-MRI remained consistent across different age groups, genders, disease durations, and between rural and urban populations.* ***Conclusion:*** *Dynamic contrast-enhanced magnetic resonance imaging is a highly accurate and reliable non-invasive modality for the diagnosis of hepatocellular carcinoma in patients with chronic liver disease. Its consistent performance across demographic and clinical subgroups supports its use as a primary diagnostic tool to facilitate early diagnosis and timely clinical management.*

Keywords: Chronic Liver Disease, Hepatocellular Carcinoma, Dynamic Contrast-Enhanced MRI, Diagnostic Accuracy, Histopathology

INTRODUCTION

Hepatocellular carcinoma (HCC) is another distinctive malignancy with characteristic imaging findings that often allow non-invasive disease diagnosis with multiphasic contrast-enhanced computed tomography (CT) and magnetic resonance imaging (MRI). These modalities describe typical vascular changes that distinguish between HCC and the adjacent cirrhotic parenchyma, in particular, hyperenhancement of arteries and following washout, giving the modalities high diagnostic quality in the arterial, portal venous, and delayed phases (1). The HCC distribution across the world is quite distinct, with the highest rates in all countries in Asia and sub-Saharan Africa, and it closely resembles the geographic disparities in hepatitis B virus (HBV) and hepatitis C virus (HCV) prevalence (2). Host genetics, environmental exposures, and viral genotypes also modulate HCC risk in chronically infected cohorts (3).

The development of cross-sectional imaging has improved the early detection of HCC. Still, MRI remains superior to CT because it provides better soft-tissue contrast, offers multiple parameters, and can characterise metabolic and physiological processes (4). Moreover, the diagnosis of HCC is complicated by regenerative nodules, fibrosis, and changes in vascularity that can obscure or resemble malignancy (5). The resource-limited setting has more diagnostic limitations due to the variation in imaging infrastructure, lifestyles, and expertise and the absence of bleeding, sampling error, and contraindication risks of coagulopathy and portal hypertension, which entail the use of the gold standard of biopsy (6). CT brings with it other issues regarding exposure to radiation and contrast nephrotoxicity among cirrhotic cohorts.

Dynamic MRI provides a non-invasive method with improved contrast resolution and multiphasic evaluation of vascularity (7). However, inconsistency in the interpretation of images, differences in protocols and lack of cross-validation against histopathology limit its universal use. Lesions of less than 2 cm are associated with high consensus challenges and a wide range of MRI accuracy (8). Even though systems such as the Liver Imaging Reporting and Data System (LI-RADS) are designed to standardise MRI-based diagnosis, their adoption remains inconsistent worldwide. In addition, local differences in the etiology of HCC-HCV dominant in the Western nations, as compared to HBV-dependent early infections in Asia and Africa, also interfere with imaging performance (10).

The emerging chronic liver disease (CLD) and HCC prevalence in Pakistan and the rest of the South Asian region is the consequence of the continued presence of HBV/HCV, insufficient decrease in vaccination, ineffective antiviral treatment, and escalating Nonalcoholic Fatty Liver Disease (NAFLD) due to metabolic syndrome and urbanization (11). There is limited evidence comparing dynamic MRI findings with histopathology in these groups, which limits clinical decision-making in settings where interventional radiology procedures and prompt biopsy results are frequently scarce. Late or incorrect diagnosis results in delayed presentation, making the patient ineligible for curative treatment, such as resection,

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transplantation, and ablation (12). Changes in the HCC risk factors globally, in which NAFLD and alcohol-related liver disease are becoming more frequent than viral hepatitis, also provide reasons why regional validation of MRI performance needs to be changed (13). To prevent misdiagnosis, enhance patient safety, and reduce economic costs in healthcare systems with limited resources, it is necessary to improve the diagnostic accuracy of HCC, particularly in the late stage (14).

The present research aimed to investigate the diagnostic features of dynamic MRI in the diagnosis of hepatocellular carcinoma in patients with chronic liver disease, using histopathology as the gold standard.

METHODOLOGY

The present study adopted a cross-sectional design and was conducted over three months from 15 May to 15 August 2024 at the Department of Diagnostic Radiology, Nishtar Hospital, Multan. The study aimed to evaluate the diagnostic performance of dynamic contrast-enhanced magnetic resonance imaging for detecting hepatocellular carcinoma in patients with chronic liver disease.

The sample size was calculated at 151 participants using the single-proportion formula for population estimation, as described by Alduraibi and Altowayan. The calculation was based on a 95% confidence level, a Z score of 1.96, an anticipated prevalence of hepatocellular carcinoma of 56.67%, and a precision level of 8%. The parameters were cross-verified using the WHO sample size calculator, incorporating the reported MRI sensitivity of 78.82% and specificity of 78.46%. Non-probability consecutive sampling was employed, and all eligible patients presenting during the study period were enrolled until the required sample size was achieved.

Male and female patients aged 30 to 70 years with chronic liver disease of more than three months duration and no prior treatment for hepatocellular carcinoma were included. Patients with previously diagnosed or treated hepatocellular carcinoma, renal insufficiency defined as serum creatinine greater than 1.1 mg/dL, known hypersensitivity to contrast agents, or contraindications to MRI, such as cardiac pacemakers or severe claustrophobia, were excluded.

Ethical approval was obtained from the Institutional Review Board of Nishtar Medical University and the ethical review committee of TIMES University before study initiation. Written informed consent was obtained from all participants in accordance with ethical standards.

Demographic and clinical information were recorded using a structured proforma. All enrolled patients underwent dynamic contrast-enhanced MRI using a 1.5 Tesla scanner following standardised fasting and breath-hold protocols. Imaging sequences included T1- and T2-weighted, diffusion-weighted imaging, and gradient-echo sequences with a slice thickness of 6 mm. Gadolinium DTPA was administered intravenously at a rate of 2.5 mL per second, and images were acquired during arterial, portal venous, and delayed phases. All images were independently interpreted by board-certified radiologists using standard enhancement criteria for hepatocellular carcinoma. Ultrasound-guided percutaneous biopsy was subsequently performed to obtain histopathological confirmation, which was evaluated by an experienced pathologist.

Statistical analysis was performed using SPSS version 25. Quantitative variables were expressed as mean and standard deviation, while categorical variables were presented as frequencies and percentages. The diagnostic performance of dynamic contrast-enhanced MRI was assessed by constructing a two × two contingency table using histopathology as the reference standard. Sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy were calculated. Stratified analyses based on age, gender, lesion size, duration of chronic liver disease, and residence were performed to assess potential confounding effects.

RESULTS

A total of 151 patients with chronic liver disease were included. The mean age was 46.86 ± 8.68 years, with most patients aged 30 to 50 years (65.6%). Males predominated, accounting for 77.5% of the study population. The mean duration of chronic liver disease was 9.25 ± 3.29 months, and 76.8% of patients had a disease duration of 12 months or less. The mean lesion size was 4.20 ± 1.75 cm, with the majority of lesions measuring 5 cm or smaller (77.5%). Most patients were from rural areas (65.6%) (Table 1).

Dynamic contrast-enhanced MRI demonstrated excellent diagnostic performance for hepatocellular carcinoma when compared with histopathology. The sensitivity and specificity were 94.94% and 95.83%, respectively. Positive and negative predictive values were 96.15% and 94.52%, with an overall diagnostic accuracy of 95.36% (Table 2).

Subgroup analysis showed consistently high diagnostic accuracy across age groups, disease duration, lesion size, and residence. Accuracy exceeded 94% in all subgroups and was highest in lesions larger than 5 cm (98.36%) and in patients with chronic liver disease duration greater than 12 months (97.14%). These findings indicate that dynamic contrast-enhanced MRI is a reliable diagnostic tool for hepatocellular carcinoma across diverse patient subgroups (Table 3).

Table 1. Baseline characteristics of the study population (N = 151)

Characteristic	Category	n (%) or Mean ± SD
Age (years)	Mean ± SD	46.86 ± 8.68
	30 to 50	99 (65.6)
	51 to 70	52 (34.4)
Sex	Male	117 (77.5)
	Female	34 (22.5)
Duration of CLD (months)	Mean ± SD	9.25 ± 3.29
	12 or fewer	116 (76.8)
	More than 12	35 (23.2)
Lesion size (cm)	Mean ± SD	4.20 ± 1.75
	5 or fewer	117 (77.5)
	More than 5	34 (22.5)
Residence	Rural	99 (65.6)
	Urban	52 (34.4)

Table 2. Diagnostic performance of dynamic contrast-enhanced MRI for HCC using histopathology as reference (N = 151)

Dynamic MRI result	Histopathology HCC positive	Histopathology HCC negative
Positive	75 (TP)	3 (FP)
Negative	4 (FN)	69 (TN)
Measure	Estimate % (95% CI)	
Sensitivity	94.94 (87.69 to 98.01)	
Specificity	95.83 (88.45 to 98.57)	
PPV	96.15 (89.29 to 98.68)	
NPV	94.52 (86.74 to 97.85)	
Accuracy	95.36 (90.74 to 97.74)	

Table 3. Subgroup diagnostic performance (2×2 counts and summary measures)

Subgroup	TP	FP	FN	TN	Sensitivity %	Specificity %	Accuracy %
Age 30 to 50 (n=99)	51	1	3	44	94.44	97.78	95.96
Age 51 to 70 (n=52)	24	2	1	25	96.00	92.60	94.23

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CLD duration 12 months or less (n=116)	63	3	3	47	95.45	94.00	94.83
CLD duration more than 12 months (n=35)	12	0	1	22	92.31	100.00	97.14
Lesion size 5 cm or less (n=117)	61	3	3	50	95.31	94.34	94.87
Lesion size more than 5 cm (n=34)	14	0	1	19	97.62	100.00	98.36
Rural (n=99)	51	0	4	44	92.73	100.00	95.96
Urban (n=52)	24	3	0	25	100.00	89.29	94.23

DISCUSSION

Globally, hepatocellular carcinoma (HCC) remains one of the leading causes of cancer-related death, especially in patients suffering from chronic liver disease (CLD) who are at a high risk due to underlying cirrhosis, viral hepatitis, or any other hepatic pathology (16). HCC can be treated very effectively with potentially curative measures, including liver transplantation, surgical resection, or localised ablative treatments, all key to improving the survival and long-term outcomes of patients (17). Before such treatment is administered, HCC must be detected at the earliest stage. In this regard, dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) has proven to be a vital diagnostic modality in that dimension, as it offers an in-depth view of the vascular structure and morphology of hepatic lesions, thereby enabling accurate distinction between malignant and benign nodules (18). Results obtained in the current research carry positive implications for DCE-MRI, despite it being the best in terms of diagnostic measures, as they show high response rates in both sensitivity and specificity for diagnosing HCC. These findings are comparable and even outperform previously reported accuracy, highlighting that the modality can be used as a first-line, non-invasive imaging method to comprehensively evaluate and treat patients at risk of HCC.

Age, gender, lesion size, and disease duration had a slight effect on diagnostic performance. Imaging appearance might be affected by age-related changes in the hepatic context, lesion morphology, and disease progression (17, 20). Wáng (19) reported that age-associated hepatic changes could explain some differences in specificity and sensitivity observed in ageing CLD patients during DCE-MRI for hepatocellular carcinoma, which is why it is essential to examine physiological ageing when interpreting liver imaging. Existing evidence and multiple studies support the high effectiveness of magnetic resonance imaging (MRI) for detecting hepatocellular carcinoma (HCC), tiny lesions (≤5 cm) and those at the initial stage. The results of the study, in which larger lesions have slightly better diagnostic accuracy, lend credence to the idea that lesion conspicuity and vascular features enhance detectability, as emphasised in conventional MRI protocols[21]. Functional sequences, such as DWI, not explicitly divided in this research, likely helped correctly identify HCC at an early stage; thus, in line with previous studies, diagnostic performance was improved when combining morphological and functional data. Granata et al. (7, 22) reported that DCE-MRI was highly sensitive and specific for detecting HCC lesions, including those that were difficult to observe due to treatment-related changes. Compared to CT, MRI has superior soft-tissue contrast and functional imaging capabilities, which likely aid in the proper detection of lesions; therefore, this aspect gives MRI an advantage in pre-surgical evaluation and planning.

Comparisons with other imaging modalities further support the excellence of MRI; dynamic MRI is more sensitive than dynamic CT and also offers an additional significant advantage: avoidance of ionising radiation (23). The current study found that dynamic contrast-enhanced MRI was sensitive and specific for detecting hepatocellular carcinoma in people with chronic liver disease, making it highly reliable across age groups, lesion sizes, and demographics. Frush et al. (24) also emphasised the need to select an appropriate imaging modality based on the patient's features and clinical requirements, with MRI particularly valuable in complicated or high-risk settings where precise lesion identification is essential. Its better soft-tissue contrast and dynamic vascular stages specifications render it effective, especially in CLD patients.

Although MRI has advantages, it has limitations in identifying subcentimetre lesions because they can appear as subtle enhancement, with sensitivity decreasing significantly for lesions below 10 mm (25). Chartampilas et al. (26) also reported several limitations and technical considerations in MRI. The researchers also noted that the overlap in the blood supply origins across various stages of hepatocellular carcinogenesis might still limit the technique's ability to differentiate earlier lesions (27). This finding is in line with the existing literature suggesting that although MRI is both sensitive and specific, vascular features of growing HCC cases may obscure imaging differences and lead to false results, either false negatives or false positives, in early-stage tumours (28, 29). Moreover, it is challenging due to high equipment prices, limited availability, prolonged scan times, and patient-related contraindications (30). The increased accessibility and improved imaging protocols will be critical to increasing the global applicability of MRI for HCC detection. Altogether, dynamic contrast-enhanced MRI shows high diagnostic accuracy across demographic and clinical variants, underscoring its usefulness as a non-invasive, high-quality modality for HCC detection in patients with chronic liver disease.

CONCLUSION

In conclusion, this study underscores the critical role of dynamic contrast-enhanced MRI (DCE-MRI) in the early Diagnosis of hepatocellular carcinoma (HCC) among patients with chronic liver disease. Its high sensitivity, specificity, and overall accuracy highlight its potential to reduce the reliance on biopsy, especially in underserved regions. To optimise early detection, it is essential to integrate DCE-MRI into routine clinical practice, provide specialised training for radiologists, and enhance accessibility to MRI. Policymakers should develop evidence-based diagnostic guidelines that include DCE-MRI, promote liver health awareness, and foster collaboration with health agencies to improve diagnostic capabilities and patient outcomes.

DECLARATIONS

Data Availability Statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department Concerned. (IRBEC-SHZH-2332/24)

Consent for publication

Approved

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Manuscript revisions, critical input.
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Conception of Study, Development of Research Methodology Design, Study Design, Review of manuscript, and final approval of manuscript.
Manuscript drafting.
ABDUL SATTAR (Professor)
Data entry, data analysis, and drafting an article.
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Data entry, data analysis, and drafting an article.

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