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RESEARCH ARTICLE

BRIDGING THE GAP IN HEPATOCELLULAR CARCINOMA DETECTION: EVALUATING LI-RADS WITH MRI

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ABSTRACT

Objectives: *This study aimed to determine diagnostic accuracy of the LI-RADS (Liver Imaging Reporting and Data System) using magnetic resonance imaging (MRI) for detecting Hepatocellular carcinoma (HCC) in cases of liver cirrhosis diagnosed to have hepatic nodules ⩽ 20 mm, using histopathology as the reference.*

Study Design: *Descriptive cross-sectional study*

Place and Duration of Study: *Department of Radiology, Holy Family Hospital, Rawalpindi. Study duration was from 25-03-2024 till 24-01-2025*

Patients and Methods: *After ethical approval, 170 consecutive eligible patients underwent multiphasic gadolinium-enhanced abdominal MRI on a 1.5 Tesla system (33 mT/m gradient), with LI-RADS interpretation by a consultant radiologist. All patients also underwent ultrasound-guided percutaneous fine needle biopsy, and histopathology served as the gold standard. Data were analyzed using SPSS 20, with diagnostic performance assessed via a 2×2 contingency table, and stratification applied to evaluate the impact of effect modifiers on diagnostic accuracy.*

Results: *A total of 170 patients (53% males, 47% females) were included, with mean age 45.28±11.67 years, BMI 30.38±2.33 kg/m², cirrhosis duration 7.93±2.46 months, and nodule size 11.25±5.25 mm; HCC was identified in 60% by LI-RADS. Diagnostic performance showed sensitivity 60.78%, specificity 95.58%, PPV 95.38%, NPPV 61.90%, and accuracy 74.70%.*

Stratified accuracy was similar by age (<40: 75.38%, >40: 73.53%) and sex (males 74.44%, females 75%), but higher with BMI >27 kg/m² (76.69% vs. 71.64%) and cirrhosis duration >10 months (83% vs. 70.94%); accuracy was 77.02% for nodules <10 mm and 72.91% for >10 mm. Overall, LI-RADS shows high specificity but moderate sensitivity, with better performance in higher BMI and longer cirrhosis duration.

Conclusion: *This study demonstrates Li-RADS with MRI to have high diagnostic accuracy for detection of hepatocellular carcinoma. Standardization of reports of CT and MRI with LI-RADS improves consistency, reduces errors, and enhances patient management. It also supports nationwide data collection, enabling future research and AI-driven analysis in HCC diagnostics.*

Keywords: *Diagnostic Accuracy, Hepatocellular Carcinoma, Liver Imaging Reporting and Data System, Magnetic Resonance Imaging*

INTRODUCTION

Hepatocellular carcinoma (HCC) is a primary liver malignancy that typically arises in background of preexisting chronic liver disease. The individuals with chronic hepatitis B hepatitis C infections are considered high-risk. Diagnosing HCC may be challenging and frequently necessitates the usage of multiple imaging-techniques. Ideally, the tumors measuring approximately 2 cm should be identified early to allow access to the full range of therapeutic options.

However, as the specific symptoms are often subtle or absent, HCC is often identified at an advanced stage.[1] Hence, median survival once HCC is diagnosed is limited to approx. 6-20 months.[2] HCC is a primarily tumor that originates from liver, that typically arises in

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chronic liver disease cases. Treating physicians often face diagnostic difficulties, and several imaging modalities have to be obtained for each case.[3]

The most commonly used imaging modalities for diagnosing HCC include ultrasound, CT, MRI, and angiography. A characteristic imaging appearance on one of these tests, along with an elevated serum alpha-fetoprotein (AFP) level, is typically adequate for confirming the diagnosis. Helical CT is generally preferred by radiologists due to the high cost and longer acquisition time associated with standard MRI scans.[4] However, MRI is useful in patients with renal insufficiency and patients allergic to the dye or contrast material used in CT scan. MRI is especially useful when CT findings are inconclusive, particularly in a liver with significant nodularity, as it can more accurately distinguish dysplastic nodules from HCC. Additionally, MRI outperforms CT in differentiating vascular pathologies, including the hemangiomas, and areas of focal fat from hepatocellular carcinoma.[5]

The LI-RADS system designed and formulated by American College of Radiology (ACR), provides a standardized framework for interpreting CT and MRI in case having liver cirrhosis or those that carry certain other risk factors that may contribute to HCC (Figure I). This study aimed to evaluate diagnostic accuracy of LI-RADS while being applied to MRI in order to diagnose the hepatocellular carcinoma. LI-RADS may be utilized as a standardized diagnostic and prognostic tool, helping to minimize under- or over-reporting while also aiding in the monitoring of follow-up cases.

The LI-RADS aims to achieve several long-term goals, including the creation of a standardized imaging terminology, the definition of criteria for interpretating the image, the unification of radiological report structure and content, the establishment of minimum technical standards, and the development of a formal system for data collection.[6] The successful implementation of these goals is anticipated to strengthen communication between radiologists and clinicians. This will also decrease the inconsistencies and errors in image interpretation, ensure the comprehensive reporting, reduce the incidence of suboptimal imaging studies, and promote effective monitoring of outcomes, performance evaluation, quality assurance, research, and meta-analysis.[7]

LI-RADS encompasses a complete range of hepatic lesions extending from benign lesions, to potentially cancerous and definitive malignancy amongst the cirrhotic or cases at risk of HCC.[8] This system incorporates the imaging diagnostics beyond vascularity to assess the probability of HCC and includes specific criteria for identifying vascular invasion.[9] In addition, LI-RADS being intended to be useful for radiology consultants, regardless of them being expert in liver related imaging, and can be applied both in tertiary liver centers and other settings, as well as in daily clinical evaluation of their patients and also for research purposes. It offers generalized guidance on CT or MRI interpretation, along with the rationale of this being recommended. The LI-RADS criterion are structured for facilitation of organized and standardized imaging interpretation and reporting of at-risk cases for HCC.[10]

The purpose of this study is to evaluate the role of LI-RADS in standardizing liver imaging interpretation and reporting to improve diagnostic accuracy,

CT/MRI Diagnostic Table

Arterial phase hyperenhancement (APHE)		No APHE		APHE (not rim)		
Observation size (mm)		< 20	⩾20	<10	10-19	⩾ 20
Count major features: • "Washout" (not peripheral) • Enhancing "capsule" • Threshold growth	None	LR-3	LR-3	LR-3	LR-3	LR-4
	One	LR-3	LR-4	LR-4	LR-4 / LR-5	LR-5
	⩾ Two	LR-4	LR-4	LR-4	LR-5	LR-5

LR-4 / LR-5 Observations in this cell are categorized LR-4, except:
·LR-5g, if ⩾ 50% diameter increase in < 6 months (equivalent to OPTN 5A-g)
LR-5us, if "washout" and visibility at screening ultrasound (per AASLD HCC criteria)

Figure I: Overview of all the LI-RADS categories based on MRI.

communication, and overall clinical outcomes.

PATIENTS AND METHODS

This was a descriptive cross-sectional study. The study set-up was Radiology Department, Holy Family Hospital (HFH) Rawalpindi. Study duration was 25th March 2024 till 24th Jan 2025, and was conducted after ethical approval (ERB# 4826/RTH/RWP). Data were collected using non-probability, consecutive sampling. Sample size was calculated as per 95% confidence level, with a desired precision of 10% for sensitivity and 4% for specificity, and an HCC prevalence of 64.15%. LI-RADS MRI as 65.40% and 96.40% in diagnosing HCC,[11] estimated sample size was 170. Cirrhotic patients aged 25-65 years, of both genders with hepatic nodules $\leqslant$ 20 mm on ultrasonography (well circumscribed, hypo echoic lesions) and duration of cirrhosis >3 months were included, while the patients in whom contrast agent (Gadolinium) is contraindicated (e.g. acute or chronic renal failure), already taking chemotherapy for hepatic neoplasm, contraindicated for MRI studies (having MRI incompatible prosthesis or implant) and noncooperative patients were excluded from the study.

Total 170 consecutive patients referred to dept. of radiology HFH, Rawalpindi, who fulfilled inclusion criteria were inducted for study. Written informed consent was obtained for each study participant. Multiphasic gadolinium enhanced Abdominal MRI was performed on all patients. The 1.5 Tesla MRI system was used having 33 mT/m gradient strength. MRI examinations were performed with a phased-array body coil. Patient was in supine position during imaging which increased the ratio of signal-to-noise. Intravenous Gadolinium 0.5 mmol/L was used in all patients. The LI-RADS results with magnetic resonance imaging (MRI) were reported by a radiology consultant having experience of $\geqslant$ 5 years after the fellowship. The presence or absence of hepatocellular carcinoma was documented as outlined in the operational definition (Fig 1).[12] All patients subsequently underwent percutaneous ultrasound guided fine needle biopsy in the designated ward, and the histopathology report of the specimen was obtained from the hospital's central laboratory. The findings from the LI-RADS using MRI were compared with histopathology results. Data on age, gender, duration of cirrhosis, BMI, and hepatic nodule size were collected using a specified study proforma.

The analysis of study data was conducted via SPSS version 20.0. The mean values along with standard deviations were calculated for age, BMI, total duration of liver cirrhosis and size of hepatic nodule size. Regarding gender and the presence or absence of hepatocellular carcinoma, frequencies and percentages were computed. A 2×2 contingency table was used to calculate the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of LI-RADS with MRI in diagnosing hepatocellular carcinoma in hepatic nodules $\leqslant$ 20 mm in cirrhotic patients, using histopathological diagnosis as gold standard. The effect modifier variables (i.e., age, gender, body mass index, total duration since liver cirrhosis, nodule size of HCC) were addressed via stratification and diagnostic accuracy was then calculated post-stratification.

RESULTS

Amongst 170 cases, it was observed that the mean age was 45.28 ± 11.67 (range: 25-65) years. The BMI (kg/m2) was calculated as 30.38 ± 2.33 (27-34) kg/m2. It was observed that the duration of cirrhosis was 7.93 ± 2.46 (4-12) months. The size of hepatic nodule (mm) was 11.25 ± 5.25 (5-20) mm. Of the total patients, 90(52.9%) were male and 80(47.10%) were female cases.

Hepatocellular carcinoma on LI-RADS was present in 102 (60%) and absent in 68 (40%) patients (Figure-II). The sensitivity of hepatocellular carcinoma was calculated at 60.78%, with a specificity of 95.58%. The PPV was 95.38%, the NPV was 61.90%, while overall diagnostic accuracy was 74.70% (Table-II). By stratification of age, the diagnostic accuracy of hepatocellular carcinoma was 75.38% in below forty years age group while in forty years and above age group the diagnostic accuracy was 73.53%. The diagnostic accuracy of hepatocellular carcinoma was 74.44% in males while in females the diagnostic accuracy was 75%. In patients with BMI <27 kg/m2 the diagnostic accuracy of HCC was determined to be 71.64% while in patients with BMI > 27 kg/m2 the diagnostic accuracy was 76.69%. In patients with duration of cirrhosis <10 months the diagnostic accuracy of HCC was 70.94% while in patients with cirrhosis >10 months the diagnostic accuracy was 83.01%. In patients with size of hepatic nodule <10 mm the diagnostic accuracy of hepatocellular carcinoma was 77.02% while in patients with size of hepatic nodule >10 mm the diagnostic accuracy was 72.91%.

DISCUSSION

This study reports mean age of HCC cases to be 45 years,

indicating that hepatocellular carcinoma (HCC) affects a relatively younger population in our setting. In contrast, data from the United States shows a significantly higher median age of HCC diagnosis,

which is 64 years. This disparity may be due to differences in risk factors, including prevalent hepatitis B and hepatitis C infected cases in our population, leading to earlier onset of liver disease and subsequent HCC development. These findings highlight the need for early screening and surveillance programs tailored to the local demographics.[13]

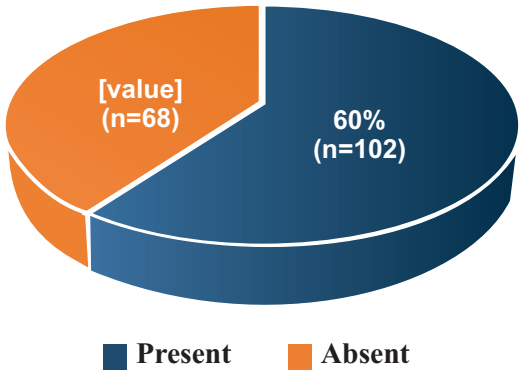

Figure II: The distribution of Hepatocellular carcinoma on LI-RADS (n = 170).

Table I: Hepatocellular carcinoma on LI-RADS and on histopathology (n = 170)

Hepatocellular carcinoma on LI-RADS	Hepatocellular carcinoma on histopathology		Total
	Yes	No	
Yes	TP= 62 [a]	FP= 3 [b]	65
No	FN= 40 [c]	TN= 65 [d]	105
Total	102	68	170
Sensitivity 60.78%; Specificity 95.58%; PPV (Positive predictive value) 95.38%; NPPV (Negative predictive value) 61.90% Diagnostic accuracy 74.7%			

This study has included approx. equal number of male (53%) and female (47%) patients. Research has highlighted significant gender-based disparities in incidence, severity, prognostic outcome of HCC. The varying epidemiological distribution of factors contributing to damaging the liver and role of sex hormones could be underlying reasons to these disparities. Men are observed to have HCC at earlier age as compared to women. Though the exact mechanism is not clear, however protective mechanism of estrogens is suggested for this gender disparity.[14] Our study included equal number of males and female cases and LIRADS demonstrated the diagnostic accuracy that was consistent when comparing the genders i.e., 74.44% in males Vs. 75% in females with HCC. This concludes that LI-RADS is applicable equally in both the genders.

The mean duration of cirrhosis observed in this study was 7 months, with cases ranging from as early as 4 months to up to a year. The transition from cirrhosis to hepatocellular carcinoma varies significantly depending on the underlying cause of liver disease. Factors such as viral hepatitis, disease associated with alcohol use and metabolic disorder influence the rate of progression, highlighting the necessity for diligent monitoring and early identification strategies in high-risk patients. A Hyderabad based study conducted by Attari SA et al found HCC in 7.2 % of HCV positive case undergoing the liver biopsy.[15] A study by Philip et al demonstrated that in their HCC patients, cirrhosis was observed approx. 10 years before HCC was diagnosed.[16] In contrast, our patients reported a much shorter duration of diagnosed cirrhosis. This may be due to delayed diagnosis resulting from a lack of routine screening, limited access to healthcare facilities, or inadequate imaging, particularly among underprivileged populations. The diagnostic accuracy of LI-RADS was notably higher (83%) in patients with cirrhosis of longer duration, as opposed to those with cirrhosis lasting less than 10 months (70.9%). This suggests that prolonged disease progression may lead to more distinct imaging characteristics, improving LI-RADS performance in HCC detection.

The mean size of hepatic nodule (mm) was 11.25 mm in our cases at presentation. The minimum size of nodule was 5 mm and maximum 20 mm. With respect to the size of hepatic nodule, the diagnostic accuracy of hepatocellular carcinoma was 77% for nodules less than 10 mm size, while for nodule >10 mm the diagnostic accuracy was 73%. This supports the need for an active diagnostic work-up, even for nodules smaller than 10 mm, if the ultimate aim is to diagnose HCC at earliest possible stage.[17]

In the present study, the diagnostic accuracy of the Liver Imaging Reporting and Data System (LI-RADS) was

found to be 74.7%, suggesting a reasonably good performance in differentiating hepatocellular carcinoma (HCC) from other hepatic lesions. This finding aligns with previously published literature, though there is some variability in reported diagnostic accuracy rates. For example, Ling et al. reported a higher diagnostic accuracy of 86% in their cohort, along with good inter-observer agreement.[18] This suggests that LI-RADS can be a reliable tool in clinical practice when applied consistently. However, inter-observer variability remains a concern in some studies. Kiri et al. found only moderate inter-observer agreement, and they attributed this variability to potential confounding factors such as elevated body mass index (BMI) and the presence of steatohepatitis. These factors may obscure lesion characteristics and complicate image interpretation, thereby reducing the diagnostic precision of LI-RADS.

Additional studies support this notion of variability in LI-RADS performance. Davenport et al.[19] reported that LI-RADS improves standardization in liver lesion reporting, however the accuracy and consistency of interpretations can vary depending on the radiologist's experience and patient-specific factors such as liver parenchymal changes.

Similarly, Barth BK et al.[20] found that although LI-RADS categories generally correlate well with histopathologic findings, discrepancies can still occur, particularly in atypical cases or in patients with concurrent liver pathologies.

Taken together, these studies underscore both the strengths and limitations of LI-RADS. While it offers a structured and standardized approach for the evaluation of hepatic lesions in at-risk populations, its diagnostic performance can be influenced by patient-related factors, radiologist expertise, and image quality. Continued efforts toward radiologist training, protocol optimization, and potential refinements in LI-RADS criteria are essential to improve accuracy and reduce inter-observer variability.

Most LI-RADS research is based on Western populations, with minimal studies validating its accuracy in Pakistani patients with diverse genetic, environmental, and viral hepatitis-related risk factors. Additionally, many radiology centres don't routinely use LI-RADS, leading to inconsistent reporting and diagnosis of HCC across different hospitals and regions. Many radiologists and clinicians lack formal training in LI-RADS, affecting its adoption and proper utilization. LI-RADS, a standardized tool, is non-invasive and minimizes misdiagnosis by categorizing hepatic nodules systematically, preventing unnecessary biopsies or delayed treatments. Hence, implementing LI-RADS widely can significantly improve liver cancer management and outcomes for our patients.

CONCLUSION

This study demonstrates Li-RADS with MRI to have high diagnostic accuracy for detection of hepatocellular carcinoma. Standardization of reports of CT and MRI with LI-RADS improves consistency, reduces errors, and enhances patient management. It also supports nationwide data collection, enabling future research and AI-driven analysis in HCC diagnostics.

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Authors' Contribution

Zahida Khanum: Conception of study/Designing/ Planning, Experimentation/Study Conduction, Analysis/Interpretation/ Discussion, Manuscript Writing

Madiha Maryam Azam: Conception of study/Designing/ Planning, Experimentation/Study Conduction, Manuscript Writing

Lubna Meraj: Experimentation/Study Conduction, Manuscript Writing, Critical Review

Hina Hanif Mughal: Experimentation/Study Conduction, Manuscript Writing, Critical Review

Nadia Shams: Experimentation/Study Conduction, Analysis/Interpretation/Discussion, Manuscript Writing, Critical Review

Saba Bari: Experimentation/Study Conduction, Manuscript Writing, Critical Review

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