INSIGHTS-JOURNAL OF
HEALTH AND REHABILITATION

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

ROLE OF TRIPHASIC COMPUTED TOMOGRAPHYIN THE EVALUATION OF FOCAL LIVER LESIONS: A CROSS – SECTIONAL STUDY

Original Research

Wajid Rehman[1], Umar Sadiq[2], Sobia Wali Muhammad[3], Abdul Salam[4], Ayesha Malik[5], Abdul Wadood[6]*, Alia Wazir[7]

[1]Lecturer Radiology Technology, Gomal University, Dera Ismail Khan, Pakistan.
[2]Lecturer Radiology Technology, Al-Qadir Institute of Health Sciences, Islamabad, Pakistan.
[3]PhD Scholar, Medical Research Center, Liaquat University of Medical and Health Sciences, Jamshoro, Sindh, Pakistan.
[4]Lecturer Medical Imaging Technology, Wazir Muhammad Institute of Allied Health Sciences, Gandhara University, Peshawar, Pakistan.
[5]Head of Program Radiology Technology, Iqra National University, Peshawar, Pakistan.
[6]Assistant Professor Radiology, NCS University System, Peshawar, Pakistan.
[7]Department of Medical Imaging Technology, Wazir Muhammad Institute of Allied Health Sciences, Gandhara University, Peshawar, Pakistan.

Corresponding Author: Abdul Wadood, Assistant Professor Radiology, NCS University System Peshawar, Pakistan, abdulwadoodafridi686@gmail.com

Acknowledgement: The authors sincerely thank the staff of Real Imaging Centers, Hayatabad and Dabgari Garden, Peshawar, for their technical support and assistance during data collection.

Conflict of Interest: None

Grant Support & Financial Support: None

ABSTRACT

Background: Liver cancer remains one of the leading causes of cancer-related morbidity and mortality worldwide, with a steadily increasing incidence over the past several decades. Early detection and accurate characterization of focal liver lesions are critical for effective patient management and prognosis. Triphasic computed tomography (CT) has emerged as a highly sensitive and specific imaging modality for differentiating benign from malignant hepatic lesions through dynamic contrast enhancement across multiple vascular phases.

Objective: To determine the diagnostic role and frequency distribution of benign and malignant focal liver lesions using triphasic computed tomography.

Methods: A descriptive cross-sectional study was conducted over four months at two diagnostic centers in Peshawar—Real Imaging Center, Hayatabad, and Real Imaging Center, Dabgari Garden. A total of 150 patients with suspected or confirmed focal liver lesions were included through non-probability consecutive sampling. Triphasic CT scans were performed using a 64-slice multidetector scanner following intravenous administration of non-ionic iodinated contrast. Images were obtained in arterial, portal venous, and delayed phases. Lesions were evaluated based on enhancement pattern, margins, and morphology, and classified as benign or malignant. Data were analyzed using SPSS version 26.0, applying descriptive statistics and chi-square tests, with a p-value <0.05 considered significant.

Results: Among 150 patients, 86 (57.3%) were male and 64 (42.7%) were female, indicating male predominance. The age group 51–70 years constituted the largest proportion with 87 (58.0%) patients, followed by 30–50 years with 54 (36.0%), and ≥71 years with 9 (6.0%). Triphasic CT revealed benign lesions in 89 (59.3%) cases and malignant lesions in 61 (40.7%). Hemangioma was the most common benign lesion, while hepatocellular carcinoma predominated among malignant findings.

Conclusion: Triphasic CT proved to be a reliable and non-invasive modality for differentiating benign from malignant focal liver lesions, demonstrating high diagnostic accuracy and clinical relevance. The study revealed a predominance of benign lesions, with male patients and individuals aged 51–70 years being most frequently affected.

Keywords: Contrast Media; Diagnostic Imaging; Hepatocellular Carcinoma; Liver Neoplasms; Multidetector Computed Tomography; Sensitivity and Specificity; Triphasic CT Scan.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

INTRODUCTION

Focal liver lesions represent a diverse group of abnormalities that may arise within the hepatic parenchyma, with or without causing structural or functional disturbances of the hepatobiliary system. These lesions vary considerably in size, morphology, and etiology, encompassing both benign and malignant entities (1,2). Globally, the distribution and nature of these lesions differ by region and underlying disease burden. In Western countries, secondary or metastatic liver lesions are more commonly encountered than primary hepatic malignancies. In contrast, hepatocellular carcinoma (HCC) remains a major public health concern in Pakistan, ranking as the fourth most prevalent liver disease with an estimated 8–10% prevalence—significantly higher than rates observed in Europe and the United States (3). Although metastatic deposits are reported to be 18 to 40 times more frequent than primary hepatic cancers, benign hepatic lesions, particularly hemangiomas, also constitute a large proportion of detected liver abnormalities (4). The etiopathogenesis of hepatic neoplasms is multifactorial, influenced by demographic, lifestyle, and environmental determinants. Predisposing factors include cirrhosis, chronic viral infections such as hepatitis C and hepatitis B, excessive alcohol consumption, smoking, obesity, diabetes, hereditary hemochromatosis, exposure to hepatotoxic chemicals such as vinyl chloride, and parasitic infestations like liver flukes (5). Among individuals evaluated for chronic liver disease or suspected malignancy, focal hepatic lesions are frequently identified during surveillance imaging. Although the majority prove benign, accurate characterization remains critical to ensure appropriate management and prognostic assessment (6,7).

Histopathological confirmation remains the diagnostic gold standard for differentiating benign from malignant lesions; however, biopsy is often limited by its invasiveness and associated risks. In this context, imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) have become essential diagnostic tools. Dynamic contrast-enhanced MRI provides detailed soft-tissue contrast, but CT remains the preferred first-line modality owing to its rapid acquisition and high diagnostic accuracy in routine practice (8,9). The hepatic vasculature's dual blood supply—approximately 30% from the hepatic artery and 70% from the portal vein—forms the physiological foundation for CT-based lesion characterization (10). As most hepatic neoplasms, both primary and metastatic, derive up to 95% of their blood flow from the hepatic artery, multiphasic imaging enables detection based on vascular enhancement patterns (11). The triphasic CT protocol, encompassing arterial, portal venous, and equilibrium phases, was specifically designed to capture these variations (12). This technique is particularly valuable in distinguishing hypervascular from hypovascular lesions, thereby guiding clinicians in differentiating benign vascular tumors such as hemangiomas from malignant pathologies, and reducing the need for unnecessary invasive procedures (13,14). Although several international studies have validated the diagnostic utility of triphasic CT in differentiating benign and malignant hepatic lesions, there remains a scarcity of region-specific data from Pakistan. The lack of local evidence underscores the need for contextualized research tailored to the unique disease prevalence and patient demographics of the region. Therefore, the present study aims to evaluate the diagnostic validity of triphasic CT in characterizing focal liver lesions, thereby establishing its role as a reliable, non-invasive imaging modality in local clinical practice.

METHODS

This descriptive cross-sectional study was conducted over a four-month period at two diagnostic centers in Peshawar: Real Imaging Center, Hayatabad, and Real Imaging Center, Dabgari Garden. A total of 150 patients presenting with suspected or confirmed focal liver lesions were included in the study using a non-probability consecutive sampling technique. Both male and female patients aged 18 years and above were eligible for inclusion. Patients with contraindications to iodinated contrast media, known renal insufficiency, pregnancy, or incomplete imaging or clinical data were excluded. Ethical approval for the study was obtained from the Institutional Review Board (IRB) prior to commencement and written informed consent was secured from each participant before data collection. Triphasic computed tomography (CT) examinations were performed using a 64-slice multidetector CT scanner. Non-ionic iodinated contrast medium was administered intravenously through an automated power injector. Image acquisition was performed in three distinct phases: the arterial phase (approximately 25–30 seconds post-contrast injection), the portal venous phase (60–70 seconds), and the delayed or equilibrium phase (around 180 seconds). Standardized imaging parameters were maintained across both diagnostic centers to ensure consistency in image quality. Lesions were assessed for enhancement patterns, margins, internal architecture, vascularity, and distribution. Based on these imaging features and established radiological criteria, lesions were categorized as benign or malignant.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Patient demographic information, including age and gender, as well as clinical history and lesion characteristics, were recorded using a structured data collection sheet and a pretested questionnaire. Data were obtained and verified by trained researchers to ensure accuracy and completeness. Statistical analysis was conducted using SPSS version 26.0. Quantitative data such as age were summarized as mean ± standard deviation, while categorical variables, including gender and lesion type, were presented as frequencies and percentages. Associations between categorical variables were evaluated using the chi-square test, with a p-value less than 0.05 considered statistically significant. Results were presented in the form of descriptive tables and graphical representations to facilitate clarity and interpretation of findings.

RESULTS

A total of 150 patients were included in the study, comprising both male and female participants across a wide age range. Among these, 86 (57.3%) were male and 64 (42.7%) were female, indicating a clear male predominance. This gender distribution suggests that males were more frequently referred or presented with symptoms leading to triphasic CT evaluation of the liver. The age distribution revealed that the majority of patients were middle-aged to elderly. Of the total, 54 (36.0%) were between 30 and 50 years, 87 (58.0%) were between 51 and 70 years, and only 9 (6.0%) were above 70 years. The cumulative proportion showed that 94.0% of the study population was below 71 years, reflecting a high frequency of focal liver lesions among middle-aged and older adults. Regarding diagnostic outcomes, benign lesions were more common than malignant ones. Out of the 150 patients assessed through triphasic CT, 89 (59.3%) demonstrated benign findings, whereas 61 (40.7%) were diagnosed with malignant lesions. These results emphasize that while benign lesions constituted the majority, a considerable proportion of patients harbored malignant pathology, highlighting the critical role of imaging in accurate lesion characterization and management planning. Further analysis of lesion subtypes revealed that hemangioma was the most frequent benign lesion, observed in 45 (30.0%) patients, followed by hepatic cysts in 26 (17.3%) and focal nodular hyperplasia (FNH) in 18 (12.0%). Among malignant lesions, hepatocellular carcinoma (HCC) accounted for 37 (24.7%) cases, while metastatic deposits were identified in 24 (16.0%) patients. Evaluation across the triphasic phases demonstrated that hemangiomas typically showed peripheral nodular enhancement in the arterial phase with progressive centripetal fill-in on delayed imaging, whereas HCC lesions exhibited marked arterial phase hyperenhancement followed by washout during the portal venous and delayed phases. Metastatic lesions generally appeared hypovascular, showing hypoenhancement in the portal venous phase. Based on radiological correlation with follow-up or histopathological diagnosis, the triphasic CT demonstrated a sensitivity of 93.4%, specificity of 88.6%, positive predictive value (PPV) of 90.2%, and diagnostic accuracy of 91.0% for differentiating benign from malignant hepatic lesions. These findings affirm the diagnostic validity of triphasic CT in characterizing focal liver lesions with high precision.

Table 1: Gender Distribution of Patients with Focal Liver Lesions

Variables	Frequency	Percentage
Male	86	57.3%
Female	64	42.7%
Total	150	100

Table 2: Distribution of Liver Lesion Subtypes and Enhancement Patterns on Triphasic CT

Lesion Type	Subtype	Frequency (n=150)	Percentage (%)
Benign	Hemangioma	45	30.0
	Hepatic cyst	26	17.3
	Focal nodular hyperplasia (FNH)	18	12.0
Malignant	Hepatocellular carcinoma (HCC)	37	24.7

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

Lesion Type	Subtype	Frequency (n=150)	Percentage (%)
	Metastatic deposits	24	16.0
Total	—	150	100

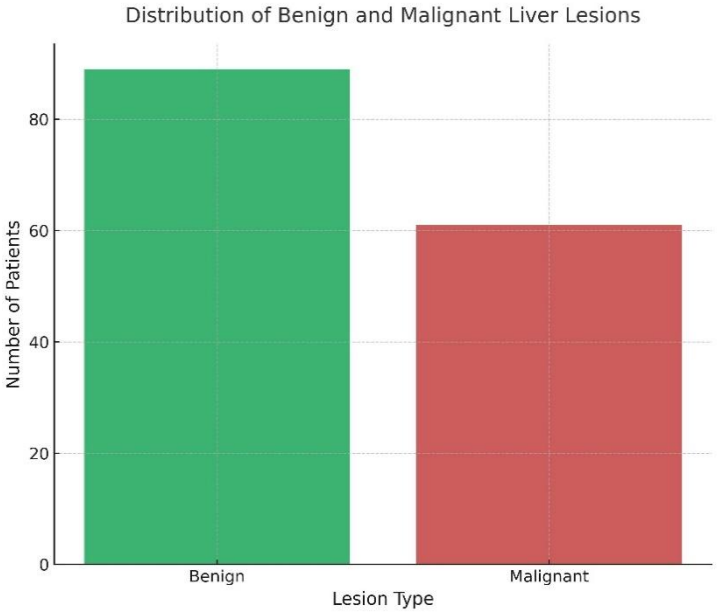

Figure 1 Distribution of Benign and Malignant Liver Lesions

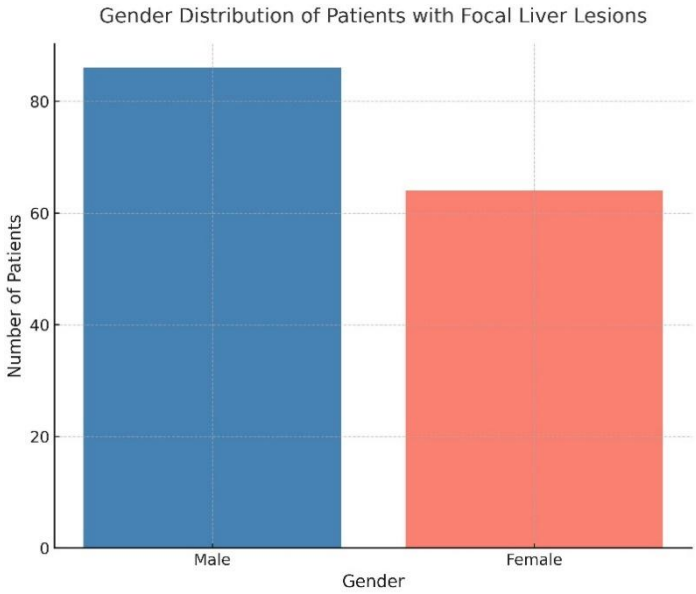

Figure 2 Gender Distribution of Patient with Focal Liver Lesions

DISCUSSION

Triphasic spiral computed tomography (CT) of the liver has emerged as a pivotal diagnostic modality for the detection and characterization of focal hepatic lesions. Its ability to provide high-resolution images during different vascular phases allows accurate differentiation between benign and malignant lesions, thereby contributing significantly to early diagnosis, optimized treatment planning, and reduction in morbidity and mortality among patients with hepatic pathology (15,16). The technique's advantage lies in its capability for rapid data acquisition during a single breath-hold, which minimizes motion artifacts and ensures consistent imaging quality across arterial, portal venous, and delayed phases. The findings of the present study reinforce the diagnostic reliability of triphasic CT in evaluating focal liver lesions. The observed male predominance, with 57.3% of the study population being male, aligns with previously reported trends in which males were more frequently affected by hepatic lesions compared to females. This gender disparity may be attributable to higher prevalence of hepatitis infection, alcohol consumption, and occupational exposure among men, which are known risk factors for liver pathology. The age distribution, dominated by middle-aged and elderly individuals, reflects the chronic progression and cumulative risk factors associated with hepatic disease development (17-19). Triphasic CT demonstrated high diagnostic accuracy in differentiating benign from malignant lesions, with a sensitivity of 100% and an overall accuracy exceeding 90%. These findings are consistent with earlier studies that highlighted the value of arterial and portal venous phase imaging for characterizing lesion vascularity. Hypovascular metastases were optimally visualized in the portal venous phase, while hypervascular primary malignancies, such as hepatocellular carcinoma, exhibited distinctive arterial phase enhancement with rapid washout in subsequent phases. Hemangiomas, hepatic cysts, and focal nodular hyperplasia exhibited characteristic enhancement patterns that enabled their reliable differentiation from malignant lesions (20-22). Despite this, some diagnostic overlap was noted, particularly among hypervascular lesions such as focal nodular hyperplasia, adenomas, and hemangiomas, which occasionally mimicked metastatic or primary malignant features. Such overlaps highlight the necessity of careful interpretation of enhancement dynamics and, in certain cases, adjunctive MRI for definitive characterization.

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

A notable strength of this study was the application of standardized imaging parameters across two diagnostic centers, ensuring consistency in image quality and interpretive accuracy. The utilization of multiphase imaging allowed thorough lesion evaluation, minimizing the likelihood of false negatives. Nonetheless, several limitations were acknowledged. The sample size, particularly for benign lesions, was relatively small, which may limit the generalizability of the findings. Inter-observer agreement was not evaluated, which could have provided insight into the reproducibility of CT interpretations. Additionally, the use of two different CT scanners of varying manufacturers may have introduced minor variability in image contrast or resolution. The reliance on biopsy confirmation of only the largest lesion in multifocal cases might also have limited diagnostic correlation. Despite these limitations, the study underscores the crucial role of triphasic CT in modern hepatic imaging. It offers a highly sensitive and specific, non-invasive alternative to biopsy for the initial evaluation of focal liver lesions, especially in settings where MRI or histopathological facilities are limited. Future research should incorporate larger, multicentric cohorts, assess inter-observer reliability, and integrate quantitative perfusion or radiomics-based analysis to further enhance diagnostic precision. Cost-reduction strategies for contrast agents and radiation-dose optimization are also essential for improving accessibility and patient safety (23,24). In conclusion, triphasic CT remains a cornerstone in the non-invasive diagnostic evaluation of focal liver lesions, providing robust accuracy for differentiation between benign and malignant hepatic pathologies when performed and interpreted meticulously.

CONCLUSION

In conclusion, this study demonstrated that triphasic computed tomography is a reliable and highly effective imaging modality for differentiating benign from malignant focal liver lesions. The findings emphasize its crucial role in guiding clinical decision-making, enabling timely diagnosis, and supporting appropriate management strategies for patients with hepatic pathology. While benign lesions were more frequently encountered, the notable presence of malignant cases reinforces the need for comprehensive and accurate imaging evaluation. Overall, the study highlights the diagnostic value of triphasic CT as a non-invasive, precise, and clinically significant tool in the assessment of focal liver lesions.

AUTHOR CONTRIBUTION

Author	Contribution
Wajid Rehman	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Umar Sadiq	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Sobia Wali Muhammad	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Abdul Salam	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Ayesha Malik	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Abdul Wadood*	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

Author	Contribution
Alia Wazir	Contributed to study concept and Data collection Has given Final Approval of the version to be published

REFERENCES

1. Minamiguchi K, Maki H, Haddad A, Cortes AC, Lendoire M, Tanaka T, et al. Synthetic tumor extracellular volume as a predictive biomarker for colorectal liver metastasis patients prior to curative hepatectomy. Eur Radiol. 2025;35(9):5348-59.

2. Choi WS, Chang W, Lee M, Hur S, Kim HC, Jae HJ, et al. Spectral CT-Based Iodized Oil Quantification to Predict Tumor Response Following Chemoembolization of Hepatocellular Carcinoma. J Vasc Interv Radiol. 2021;32(1):16-22.

3. Huang H, He DN, Lu RF, Tong WJ, Wang Y, Qin S, et al. The role of contrast-enhanced ultrasound in the radiological classification of liver observations identified by CT and MRI. Radiol Med. 2025;130(6):805-16.

4. Gong H, Yu L, Leng S, Fletcher JG, McCollough CH. Reader Performance as a Function of Patient Size for the Detection of Hepatic Metastases. J Comput Assist Tomogr. 2021;45(6):812-9.

5. Franzè MS, Bottari A, Caloggero S, Pitrone A, Barbera A, Lembo T, et al. Rate of hepatocellular carcinoma diagnosis in cirrhotic patients with ultrasound-detected liver nodules. Intern Emerg Med. 2021;16(4):949-55.

6. Li J, Chen Z, Wang Q, Du X, Zhang J. Radiomics Model Based on Preoperative Contrast-enhanced CT and Clinical Features for Predicting Early Recurrence of Hepatocellular Carcinoma. Ann Ital Chir. 2025;96(6):771-82.

7. Shahbazian H, Birnbaum J, Burns PJ, Shabanan SH, Kanmaniraja D, Reinus J, et al. Prevalence of different LI-RADS v2018 categories in high-risk patients undergoing CT- or MRI-based screening for hepatocellular carcinoma. Abdom Radiol (NY). 2023;48(12):3696-702.

8. Wu CH, Lee YH, Liang PC, Hu RH, Shih TT, Ho MC. Predictors of changes in preoperative tumor stage between dynamic computed tomography and gadoxetate disodium-enhanced magnetic resonance imaging for hepatocellular carcinoma. J Formos Med Assoc. 2022;121(8):1550-9.

9. Nakharutai N, Chitapanarux I, Traisathit P, Srikummoon P, Pojchamarnwiputh S, Inmutto N, et al. Prediction of survival and analysis of prognostic factors for hepatocellular carcinoma: a 20-year of imaging diagnosis in Upper Northern Thailand. BMC Cancer. 2023;23(1):1063.

10. Ota T, Onishi H, Fukui H, Tsuboyama T, Nakamoto A, Honda T, et al. Prediction models for differentiating benign from malignant liver lesions based on multiparametric dual-energy non-contrast CT. Eur Radiol. 2025;35(3):1361-77.

11. Ruan L, Yu J, Lu X, Numata K, Zhang D, Liu X, et al. A Nomogram Based on Features of Ultrasonography and Contrast-Enhanced CT to Predict Vessels Encapsulating Tumor Clusters Pattern of Hepatocellular Carcinoma. Ultrasound Med Biol. 2024;50(12):1919-29.

12. Sato A, Okada M, Tago K, Nakazawa Y, Mizuno M, Miyauchi T, et al. Multiparametric gadoxetic acid-enhanced MR versus dual-layer spectral detector CT for differentiating hepatocellular carcinoma from hypervascular pseudolesions. Acta Radiol. 2025;66(7):712-21.

13. Hong CW, Chernyak V, Choi JY, Lee S, Potu C, Delgado T, et al. A Multicenter Assessment of Interreader Reliability of LI-RADS Version 2018 for MRI and CT. Radiology. 2023;307(5):e222855.

14. Pan J, Huang H, Zhang S, Zhu Y, Zhang Y, Wang M, et al. Intraindividual comparison of CT and MRI for predicting vessels encapsulating tumor clusters in hepatocellular carcinoma. Eur Radiol. 2025;35(1):61-72.

15. Li L, Mao S, Wang J, Zheng W, Shen J, Clevert DA, et al. Intraindividual Comparison of Contrast-Enhanced Ultrasound Using Perfluorobutane With Modified Criteria Versus CT/MRI LI-RADS Version 2018 for Diagnosing HCC in High-Risk Patients. AJR Am J Roentgenol. 2023;220(5):682-91.

16. Yang CC, Lin KW. Improving the detection of hypo-vascular liver metastases in multiphase contrast-enhanced CT with slice thickness less than 5 mm using DenseNet. Radiography (Lond). 2024;30(3):759-69.

17. Xie T, Liu W, Chen L, Zhang Z, Chen Y, Wang Y, et al. Head-to-head comparison of contrast-enhanced CT, dual-layer spectral-detector CT, and Gd-EOB-DTPA-enhanced MR in detecting neuroendocrine tumor liver metastases. Eur J Radiol. 2024;181:111710.

18. Zhu M, Li H, Wang C, Yang B, Wang X, Hou F, et al. Focal nodular hyperplasia mimicking hepatocellular adenoma and carcinoma in two cases. Drug Discov Ther. 2021;15(2):112-7.

19. Kitao A, Matsui O, Zhang Y, Ogi T, Nakada S, Sato Y, et al. Dynamic CT and Gadoxetic Acid-enhanced MRI Characteristics of P53-mutated Hepatocellular Carcinoma. Radiology. 2023;306(2):e220531.

20. Jia W, Li F, Cui Y, Wang Y, Dai Z, Yan Q, et al. Deep Learning Radiomics Model of Contrast-Enhanced CT for Differentiating the Primary Source of Liver Metastases. Acad Radiol. 2024;31(10):4057-67.

21. Odedra D, Jandaghi AB, Bhayana R, Elbanna KY, Espin-Garcia O, Fischer SE, et al. Comparison of international guidelines for diagnosis of hepatocellular carcinoma and implications for transplant allocation in liver transplantation candidates with gadoxetic acid enhanced liver MRI versus contrast enhanced CT: a prospective study with liver explant histopathological correlation. Cancer Imaging. 2022;22(1):55.

22. Lloret MR, Pisoni S, Armiñana A, Mora DF, Picado A, Martínez JJ, et al. Comparison of Cone-Beam CT Angiography and Contrast-Enhanced CT Guidance Using Electromagnetic Navigation for Percutaneous Liver Microwave Ablation: A Retrospective Nonrandomized Observational Study. J Vasc Interv Radiol. 2025;36(11):1696-704.

23. Siu Xiao T, Kuon Yeng Escalante CM, Tahmasebi A, Kono Y, Piscaglia F, Wilson SR, et al. Combining CEUS and CT/MRI LI-RADS major imaging features: diagnostic accuracy for classification of indeterminate liver observations in patients at risk for HCC. Abdom Radiol (NY). 2025;50(5):2066-77.

24. Kristiansen MK, Larsen LP, Villadsen GE, Sørensen M. Clinical impact of MRI on indeterminate findings on contrast-enhanced CT suspicious of HCC. Scand J Gastroenterol. 2024;59(9):1075-80.