Section: Radio Diagnosis

Original Research Article

DIAGNOSTIC PERFORMANCE OF TRIPLE-PHASE COMPUTED TOMOGRAPHY IN THE EVALUATION OF HEPATIC MASSES: CORRELATION WITH HISTOPATHOLOGY

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ABSTRACT

Background: Hepatic masses encompass a wide spectrum of benign and malignant lesions that may demonstrate overlapping imaging characteristics. Triple-phase computed tomography (CT) provides information regarding lesion vascularity and enhancement kinetics and may facilitate non-invasive lesion characterization. The objective is to assess the correlation of triple-phase CT findings with histopathological evaluation and determine the diagnostic performance of CT in the assessment of hepatic masses. **Materials and Methods:** This prospective observational study included 75 patients aged >20 years with clinically suspected or previously detected hepatic lesions. All participants underwent triple-phase contrast-enhanced CT followed by image-guided core needle biopsy. CT findings were compared with histopathological diagnoses, which served as the reference standard. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated. **Result:** Histopathology identified 34 malignant and 41 benign lesions. Triple-phase CT correctly identified 26 malignant lesions and 28 benign lesions, with 13 false-positive and 8 false-negative classifications. The sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy of CT were 76.47%, 68.29%, 66.67%, 77.78%, and 72.00%, respectively. **Conclusion:** Triple-phase CT demonstrated clinically useful diagnostic performance in differentiating benign and malignant hepatic masses. However, because of its imperfect sensitivity and specificity, CT findings should be integrated with clinical and laboratory information, with histopathological confirmation for indeterminate or discordant lesions.

INTRODUCTION

Hepatic masses represent an important diagnostic challenge in clinical practice because they encompass a broad spectrum of benign and malignant lesions with variable clinical presentation, imaging characteristics, and therapeutic implications.[1] Hepatocellular carcinoma, intrahepatic cholangiocarcinoma, metastatic lesions, hemangioma, focal nodular hyperplasia, hepatic adenoma, and other focal liver lesions may demonstrate overlapping clinical and radiological features.[2,3] Accurate characterization of these lesions is therefore essential for appropriate management, treatment planning, and prognostic assessment. The increasing availability of advanced cross-sectional imaging has substantially improved the detection and characterization of focal hepatic lesions.[1,4]

Computed tomography (CT) is an important imaging modality in the evaluation of hepatic masses because of its wide availability, rapid acquisition, high spatial resolution, and ability to assess both the liver parenchyma and extrahepatic disease.[3,5] Triple-phase CT, comprising unenhanced, arterial, portal venous, and/or delayed phase imaging depending on the institutional protocol, provides information regarding the vascularity and enhancement kinetics of hepatic lesions. The characteristic enhancement pattern of a lesion across different phases can help differentiate benign from malignant masses and may also suggest a specific histological diagnosis.[5,6] Arterial-phase hyperenhancement followed by washout in the portal venous or delayed phase, for

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example, is an important imaging pattern in the diagnosis of hepatocellular carcinoma in appropriate clinical settings. Similarly, peripheral nodular enhancement with progressive centripetal filling is characteristic of many hepatic hemangiomas, while metastatic lesions may demonstrate variable enhancement depending on the primary malignancy.[7-9]

Despite considerable advances in CT technology, imaging-based characterization of hepatic masses may remain challenging, particularly in lesions with atypical enhancement patterns, small lesions, coexisting liver disease, or overlapping radiological appearances.[10] Errors in characterization may result in unnecessary invasive procedures or, conversely, delayed diagnosis and treatment of malignant disease.[11,12] Therefore, assessment of the diagnostic performance of triple-phase CT against a definitive diagnostic reference remains clinically relevant.

Histopathological examination provides definitive evaluation of tissue architecture and cellular characteristics and is considered the reference standard for establishing the diagnosis of many indeterminate hepatic masses when tissue sampling is clinically indicated.[13] Correlating CT findings with histopathological diagnoses can help determine the accuracy of characteristic enhancement patterns and identify imaging features associated with specific hepatic lesions. Such correlation is particularly valuable in routine clinical practice, where radiological diagnosis directly influences further investigation and treatment decisions.[14]

Although triple-phase CT is extensively used for the evaluation of hepatic masses, its diagnostic performance may vary according to lesion type, enhancement characteristics, and patient population. Systematic correlation between radiological findings and histopathological diagnoses can therefore provide important evidence regarding the reliability of CT in differentiating various hepatic masses.[11,14]

The present study was undertaken to assess the correlation between triple-phase CT findings and histopathological evaluation in patients with hepatic masses. In addition, the study aims to determine the diagnostic performance of triple-phase CT by calculating its sensitivity, specificity, positive predictive value, and negative predictive value, thereby evaluating its utility as a non-invasive diagnostic tool in the assessment and characterization of hepatic masses.

MATERIALS AND METHODS

Study Design and Setting: This was a prospective observational study conducted over 18 months in the Department of Radio-diagnosis, National Institute of Medical Sciences and Research (NIMSR) Hospital, Jaipur, Rajasthan. The study included patients with clinically suspected hepatic lesions or lesions previously detected on ultrasonography or conventional CT.

Study Population and Sample Size: Patients aged >20 years, of either sex, with a hepatic mass detected clinically or on ultrasonography and willing to participate were included. Purposive sampling was used, and the calculated sample size was 75 patients.

Inclusion and Exclusion Criteria

Patients aged >20 years with a hepatic mass and providing informed consent were included. Patients with renal failure, previous significant contrast reactions, pregnancy, or blunt hepatic trauma causing architectural distortion were excluded.

Imaging and Histopathological Evaluation: All patients underwent triple-phase contrast-enhanced CT, including arterial, portal venous, and delayed phases, using non-ionic iodinated contrast (300 mg I/mL; approximately 1.5 mL/kg). Lesion size, number, location, margins, attenuation, enhancement pattern, washout, necrosis, lymphadenopathy, ascites, and vascular involvement were assessed. LI-RADS categorization was applied in appropriate cases of suspected hepatocellular carcinoma.

Image-guided core needle biopsy was performed under USG or CT guidance. Histopathological examination included routine H&E staining, with special stains and immunohistochemistry (including AFP, CK7, and CK19) when required. The final histopathological diagnosis was considered the reference standard.

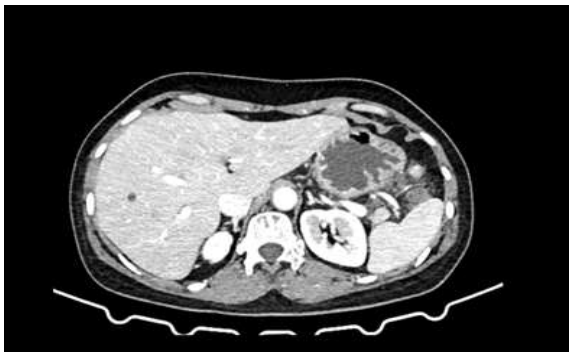

Image 1: Axial section of Portal phase of CECT Whole Abdomen showing a single well defined non enhancing lesion in the right lobe of liver with no

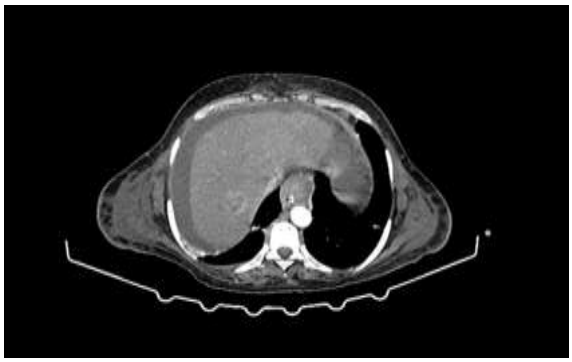

Image 2: Axial section of Arterial phase of CECT Whole Abdomen showing an ill-defined mass lesion showing enhancement in the arterial phase along with significant ascites which was proven to be malignant on HPE

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Representative CT findings are shown in images 1–3. [Image 1] demonstrates a well-defined non-enhancing hepatic lesion on the portal venous phase. [Image 2] shows an ill-defined arterially enhancing hepatic mass associated with ascites that was subsequently confirmed as malignant on histopathology. [Image 3] demonstrates multiple ill-defined heterogeneous enhancing hepatic masses with ascites and lymphadenopathy, also confirmed as malignant on histopathological examination.

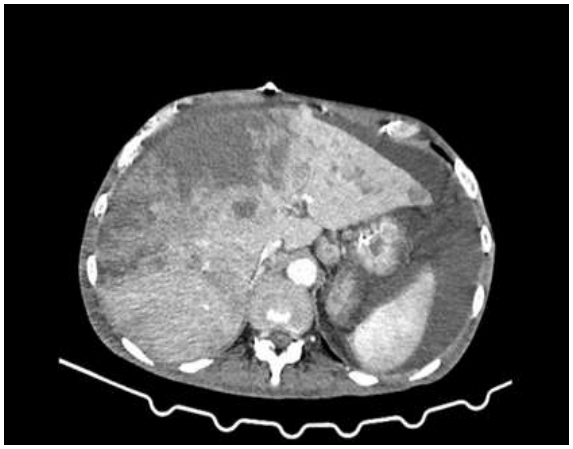

Image 3: Axial section of Arterial phase of CECT Whole Abdomen showing multiple ill-defined heterogeneously enhancing soft tissue density mass lesions with ascites and lymphadenopathy which was proven to be malignant on HPE

Data Collection and Statistical Analysis: Clinical, demographic, CT, and histopathological findings were recorded using a structured proforma. Data were analyzed using IBM SPSS Statistics and Microsoft Excel. Categorical variables were expressed as frequencies and percentages, while continuous variables were summarized using appropriate descriptive statistics. Chi-square/Fisher's exact test was used for categorical comparisons, and appropriate parametric or non-parametric tests were used for continuous variables.

The diagnostic performance of triple-phase CT was evaluated against histopathology using a 2×2 contingency table, with calculation of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy. A two-sided p-value <0.05 was considered statistically significant.

RESULTS

A total of 75 patients with hepatic masses were included in the present study. The demographic, clinical, laboratory, ultrasonographic, and CT findings were evaluated, and the radiological diagnosis obtained from triple-phase CT was subsequently correlated with the final histopathological diagnosis. The diagnostic performance of triple-phase CT was assessed using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy.

[Table 1] summarizes the demographic and anthropometric characteristics of the study participants. The mean age was 52.75 ± 13.59 years, with males comprising 52.0% and females 48.0% of the study population. The mean BMI of the participants was 25.59 ± 6.29 kg/m². [Table 2] presents the laboratory profile of the participants. The mean serum bilirubin, AST, ALT, and ALP levels were 1.96 ± 0.88 mg/dL, 70.81 ± 31.51 U/L, 61.11 ± 21.05 U/L, and 217.16 ± 77.51 U/L, respectively, while the mean AFP level was 219.62 ± 134.06 ng/mL.

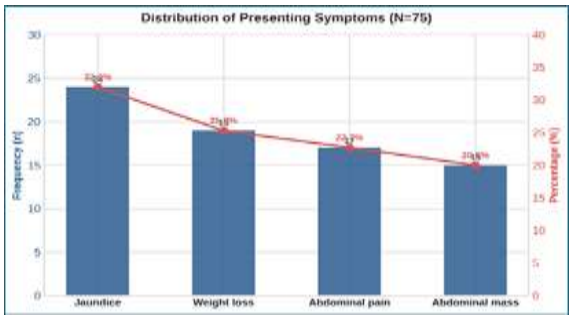

Figure 1: Distribution of Presenting Symptoms

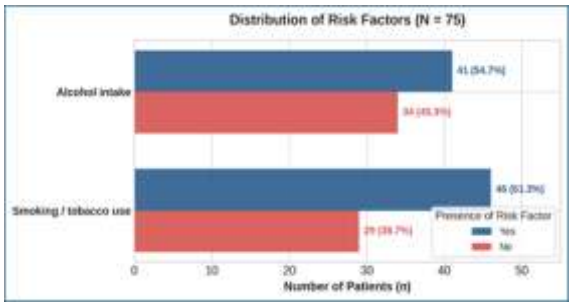

Figure 2: Distribution of Risk Factors

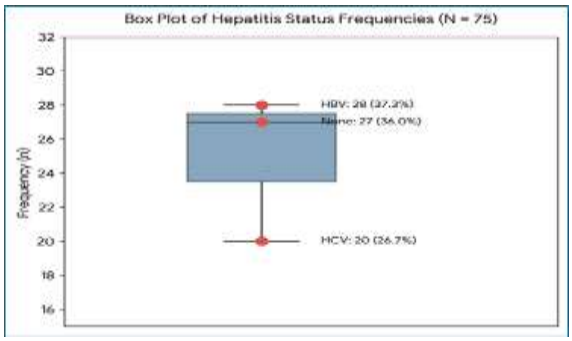

Figure 3. Hepatitis Status of Study Participants

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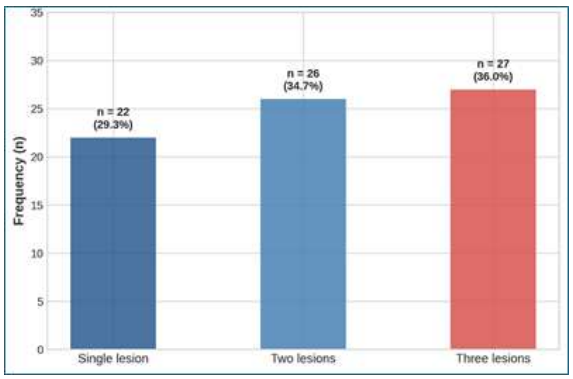

Figure 4. Number of Hepatic Lesions on Ultrasonography

[Figure 1] illustrates the distribution of presenting symptoms. Jaundice was the most common presenting symptom (32.0%), followed by weight loss (25.3%), abdominal pain (22.7%), and abdominal mass (20.0%). [Figure 2] shows the distribution of major risk factors. Smoking/tobacco use was reported in 61.3% of participants, while alcohol intake was reported in 54.7%.

[Figure 3] demonstrates the distribution of viral hepatitis status. HBV infection was present in 37.3% of participants, HCV infection in 26.7%, while 36.0% had no documented viral hepatitis. Figure 4 depicts the number of hepatic lesions identified on ultrasonography. Three lesions were observed in 36.0% of participants, followed by two lesions in 34.7% and a single lesion in 29.3%.

[Table 3] summarizes the major CT characteristics of the hepatic lesions. Ascites was present in 45.3% of participants, whereas lymphadenopathy was identified in 52.0% of cases. The correlation between triple-phase CT and histopathological diagnosis is presented in [Table 4]. Triple-phase CT correctly classified 26 malignant and 28 benign lesions, while 13 lesions were false-positive and 8 were false-negative. The sensitivity, specificity, PPV, NPV, and overall diagnostic accuracy were 76.47%, 68.29%, 66.67%, 77.78%, and 72.00%, respectively. Finally, [Table 5] summarizes the procedure-related and hospitalization parameters. The mean interval between CT and biopsy was 16.57 ± 7.09 days, and the mean duration of hospital stay was 6.17 ± 2.53 days.

Table 1: Demographic and Anthropometric Characteristics of Study Participants

Variable	Value
Age (years), mean ± SD	52.75 ± 13.59
Sex, n (%)	
Male	39 (52.0)
Female	36 (48.0)
Height (cm), mean ± SD	167.28 ± 9.31
Weight (kg), mean ± SD	72.28 ± 12.27
BMI (kg/m²), mean ± SD	25.59 ± 6.29

Table 2: Laboratory Profile of Study Participants

Laboratory parameter	Mean ± SD
Serum bilirubin (mg/dL)	1.96 ± 0.88
AST (U/L)	70.81 ± 31.51
ALT (U/L)	61.11 ± 21.05
ALP (U/L)	217.16 ± 77.51
Albumin (g/dL)	3.76 ± 0.58
PT/INR	1.38 ± 0.25
Serum creatinine (mg/dL)	1.05 ± 0.23
Serum urea (mg/dL)	29.72 ± 9.44
AFP (ng/mL)	219.62 ± 134.06

Table 3: Triple-Phase CT Characteristics of Hepatic Lesions

CT characteristic	n (%)
Ascites	
Present	34 (45.3)
Absent	41 (54.7)
Lymphadenopathy	
Present	39 (52.0)
Absent	36 (48.0)

Table 4: Correlation of Triple-Phase CT Diagnosis With Histopathological Diagnosis

CT diagnosis	Histopathology: Malignant	Histopathology: Benign	Total
Malignant	26 (TP)	13 (FP)	39
Benign	8 (FN)	28 (TN)	36
Total	34	41	75

Diagnostic performance

Parameter	Value
Sensitivity	76.47%
Specificity	68.29%

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Positive predictive value	66.67%
Negative predictive value	77.78%
Overall diagnostic accuracy	72.00%

Table 5: Procedure-Related and Hospitalization Parameters

Parameter	Value
Contrast reaction, n (%)	
Present	27 (36.0)
Absent	48 (64.0)
Biopsy-related complication, n (%)	
Present	41 (54.7)
Absent	34 (45.3)
CT-to-biopsy interval (days), mean ± SD	16.57 ± 7.09
Hospital stay (days), mean ± SD	6.17 ± 2.53

DISCUSSION

Principal Findings: The present prospective observational study evaluated the diagnostic utility of triple-phase contrast-enhanced computed tomography (CT) in the characterization of hepatic masses using histopathology as the reference standard. Among 75 patients, triple-phase CT demonstrated a sensitivity of 76.47%, specificity of 68.29%, positive predictive value (PPV) of 66.67%, negative predictive value (NPV) of 77.78%, and overall diagnostic accuracy of 72.00%. Histopathology identified 34 malignant and 41 benign lesions, whereas CT classified 39 lesions as malignant and 36 as benign. Thus, although CT demonstrated good ability to identify malignant lesions, a proportion of benign lesions were overcalled as malignant and some malignant lesions were radiologically underdiagnosed.

These findings are clinically relevant because the characterization of focal hepatic lesions depends substantially on enhancement behavior across vascular phases. Borgheresi et al. emphasized that a systematic assessment of lesion morphology, attenuation, vascularity, enhancement pattern, and associated findings across multiphasic imaging is central to the characterization of focal liver lesions.[5] The diagnostic performance observed in the present study therefore reflects the practical value of multiphasic CT while also demonstrating the limitations associated with overlapping imaging appearances.

Comparison With Previous Studies: The findings of the present study are broadly comparable with the prospective observational work of Mittal et al., who specifically evaluated focal hepatic lesions using triple-phase contrast-enhanced CT.[1] Their study provides particularly relevant comparative evidence because of the similarity in study design and imaging approach. The diagnostic performance observed in our cohort supports the role of triple-phase CT as an effective first-line cross-sectional technique for characterization of focal hepatic lesions, although differences in lesion spectrum, sample characteristics, CT acquisition protocols, and criteria used for radiological classification may account for differences in diagnostic estimates between studies.

Similarly, Mittal et al. evaluated triple-phase CT in an Indian patient population and demonstrated its usefulness in the characterization of focal liver lesions.[2] The consistency between these Indian studies and the present findings strengthens the applicability of multiphasic CT in routine clinical practice, particularly in settings where CT is more readily available than advanced liver MRI. However, the moderate specificity and PPV observed in our study indicate that CT findings should be interpreted in conjunction with clinical background, laboratory parameters, and, when necessary, tissue diagnosis.

The importance of multiphasic imaging has also been demonstrated using advanced computational approaches. Wei et al. reported that deep learning combined with multistage CT imaging can improve focal liver lesion diagnosis.[3] Their findings highlight the potential of extracting complementary information from different CT phases rather than relying on a single post-contrast acquisition. In comparison, the present study relied on conventional radiological interpretation, making its findings particularly relevant to real-world clinical workflows. The relatively moderate diagnostic accuracy observed here also suggests an opportunity for future integration of quantitative imaging and artificial intelligence-based analysis to improve lesion classification.

The ACG Clinical Guideline on focal liver lesions by Frenette et al. emphasizes that evaluation should integrate clinical risk factors, laboratory findings, and appropriate contrast-enhanced imaging, with further characterization or tissue diagnosis reserved for lesions that remain indeterminate.[4] The present findings support this approach because triple-phase CT demonstrated substantial diagnostic capability but did not achieve perfect discrimination between benign and malignant lesions. Histopathological confirmation therefore remains important when imaging findings are atypical or discordant with the clinical context.

Role of LI-RADS and Diagnosis of Hepatocellular Carcinoma: In patients with suspected hepatocellular carcinoma (HCC), the application of standardized LI-RADS criteria can improve consistency in image interpretation. Liang et al. demonstrated through a diagnostic meta-analysis that LI-RADS provides useful diagnostic performance for

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HCC on CT and MRI.[6] Similarly, Lee et al. reported that LI-RADS version 2018 provides structured categorization for the diagnosis of HCC and demonstrated clinically useful diagnostic performance.[7]

More recent evidence further supports the value of the highest-probability LI-RADS categories. Lee et al. found that LI-RADS category 5 provides strong diagnostic discrimination for HCC compared with combined LR-4/LR-5 categories.[8] Goins et al. also demonstrated the diagnostic value of LR-5 using individual participant data, supporting its role in identifying probable HCC.[9] In addition, Dawit et al. demonstrated that ancillary imaging features can provide additional information regarding HCC and overall malignancy risk.[10]

The present study used LI-RADS in appropriate cases of suspected HCC, thereby providing a standardized framework for radiological assessment. Nevertheless, because the present study included all hepatic masses rather than only patients with suspected HCC, its overall diagnostic accuracy cannot be directly compared with studies specifically evaluating LR-5 or LI-RADS-based HCC diagnosis. This distinction is important because the diagnostic performance of LI-RADS is influenced by the underlying risk population and is not directly applicable to every patient with a focal liver lesion.

Kim et al. compared CT and MRI performance for LI-RADS category 5 and demonstrated the important role of MRI in HCC characterization.[11] This may partly explain why triple-phase CT in the present study achieved moderate rather than very high diagnostic accuracy. MRI offers superior soft-tissue contrast and additional sequences, including diffusion-weighted imaging and hepatobiliary-phase imaging, which can assist in the characterization of indeterminate lesions. Therefore, CT should be viewed as an important diagnostic modality within a broader imaging pathway rather than as an absolute substitute for MRI in all cases.

Imaging Features and Malignancy Assessment: In the present cohort, ascites was identified in 45.3% of patients and lymphadenopathy in 52.0%. These findings are clinically important because extrahepatic manifestations may increase suspicion for advanced malignant disease, although neither finding is independently diagnostic of malignancy. The presence of lymphadenopathy, ascites, vascular abnormalities, and multifocal disease can provide valuable contextual information when interpreted alongside lesion enhancement characteristics.

The multiphasic nature of CT is particularly valuable in this setting because different hepatic lesions demonstrate characteristic vascular behavior. Borgheresi et al. described the importance of enhancement patterns and systematic cross-sectional assessment in differentiating common benign and malignant focal liver lesions.[5] The present findings support this concept but also demonstrate that imaging appearances may overlap sufficiently to result in false-positive and false-negative classifications.

CT Versus Histopathology: Histopathology identified 34 malignant lesions, while CT classified 39 lesions as malignant. Of these, 26 were true-positive diagnoses and 13 were false-positive diagnoses. Conversely, CT correctly identified 28 of 41 benign lesions, while 8 malignant lesions were classified as benign. The resulting sensitivity of 76.47% indicates that approximately three-quarters of malignant lesions were detected by CT, whereas the specificity of 68.29% indicates that approximately two-thirds of benign lesions were correctly characterized.

The NPV of 77.78% was higher than the PPV of 66.67%, suggesting that a CT interpretation of benign disease provided somewhat greater reassurance than a CT interpretation of malignancy provided definitive confirmation in this cohort. This is clinically meaningful because false-positive malignant interpretations may lead to invasive procedures, additional investigations, and patient anxiety, whereas false-negative interpretations may delay definitive diagnosis. Consequently, indeterminate or discordant CT findings should prompt appropriate additional imaging or tissue sampling rather than relying exclusively on CT categorization.

Role of Biopsy and Histopathological Confirmation: Image-guided core needle biopsy served as the reference diagnostic method in the present study. Hoffmann et al.reported extensive experience with CT-guided percutaneous biopsy of focal liver lesions and demonstrated the established role of image-guided tissue sampling in obtaining definitive diagnoses.[13] Schmidt et al. further demonstrated the potential clinical benefits of MRI-guided biopsy for small focal liver lesions compared with CT-guided biopsy, highlighting the continuing evolution of image-guided tissue diagnosis.[14]

The present study therefore reinforces a complementary rather than competitive relationship between imaging and histopathology. Triple-phase CT provides non-invasive lesion characterization and assists in determining the likelihood of malignancy, while biopsy provides tissue-level confirmation when imaging is inconclusive or when histological information is required for definitive management.

Emerging Role of Advanced CT Techniques: The diagnostic performance achieved in the present study also provides a baseline against which newer CT technologies may be evaluated. Jensen et al. demonstrated that dual-energy CT combined with deep-learning reconstruction can improve the detection and characterization of liver metastases compared with conventional single-energy CT approaches.[12] Together with the findings of Wei et al,[3] this suggests that future improvements in CT-based hepatic lesion assessment may arise not only from conventional multiphasic acquisition but also from technological advances in reconstruction, spectral imaging, quantitative biomarkers, and artificial intelligence.

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Such developments could potentially reduce false-positive and false-negative diagnoses and improve characterization of lesions that demonstrate atypical enhancement patterns. However, these technologies require prospective validation across diverse patient populations before they can replace established diagnostic pathways.

Clinical Implications: The findings of the present study support the use of triple-phase CT as an important imaging modality for the initial characterization of hepatic masses, particularly where rapid and widely available cross-sectional imaging is required. A diagnostic accuracy of 72.00% demonstrates meaningful clinical utility but also indicates that CT findings should not be interpreted in isolation. Clinical history, liver disease status, viral hepatitis, tumor markers such as AFP, and associated imaging findings should be incorporated into the final assessment.

The contemporary diagnostic approach recommended by Frenette et al. supports this integrated strategy, with imaging serving as a central component of focal liver lesion evaluation while additional imaging or tissue diagnosis is used for indeterminate lesions.[4] The results of the present study are therefore consistent with a multimodality diagnostic pathway in which triple-phase CT provides the initial characterization, standardized reporting systems such as LI-RADS are applied when appropriate, and histopathology is reserved for lesions requiring definitive tissue confirmation.

Strengths: The major strengths of this study include its prospective design, standardized triple-phase CT assessment, systematic comparison with histopathology, and direct calculation of clinically relevant diagnostic performance measures. The inclusion of patients with both benign and malignant hepatic masses also reflects the spectrum encountered in routine clinical practice. Furthermore, the use of image-guided core biopsy and histopathological examination as the reference standard strengthens the validity of the CT–pathology correlation.

Limitations: This study has several limitations. First, the sample size was relatively small (n=75) and the study was conducted at a single tertiary-care institution, which may limit generalizability. Second, purposive sampling may have introduced selection bias. Third, the study included a heterogeneous group of hepatic lesions, and lesion-specific diagnostic performance could not be adequately evaluated for individual tumor types. Fourth, histopathological assessment was based on image-guided biopsy rather than surgical specimens in all patients, which may introduce sampling error, particularly in heterogeneous lesions. Finally, differences in CT acquisition protocols and radiologist interpretation may influence diagnostic performance. Larger multicenter prospective studies incorporating lesion-specific analysis, standardized LI-RADS application, MRI correlation, and advanced quantitative or artificial intelligence-based CT techniques are warranted.

Overall Interpretation: Overall, the present study demonstrates that triple-phase CT provides clinically useful diagnostic discrimination between benign and malignant hepatic masses, with 76.47% sensitivity, 68.29% specificity, and 72.00% overall accuracy. These findings are consistent with the established role of multiphasic CT in focal liver lesion evaluation reported by Mittal et al,[1,2] and with contemporary recommendations emphasizing structured imaging assessment.[4,5] At the same time, the imperfect specificity and sensitivity observed in our cohort highlight the importance of integrating CT findings with clinical and laboratory information and using histopathological confirmation for indeterminate or discordant lesions. Emerging approaches incorporating LI-RADS, dual-energy CT, deep-learning reconstruction, and artificial intelligence may further improve diagnostic performance in the future.[3,6–12]

CONCLUSION

Triple-phase contrast-enhanced CT demonstrated clinically useful diagnostic performance in the evaluation of hepatic masses, with a sensitivity of 76.47%, specificity of 68.29%, positive predictive value of 66.67%, negative predictive value of 77.78%, and overall diagnostic accuracy of 72.00% when compared with histopathology. These findings support triple-phase CT as an important non-invasive imaging modality for initial characterization and differentiation of benign and malignant hepatic lesions. However, its moderate specificity and sensitivity indicate that CT findings should be interpreted in conjunction with clinical and laboratory parameters, while histopathological confirmation remains important for indeterminate or discordant lesions. Standardized approaches such as LI-RADS and emerging advanced imaging techniques may further improve diagnostic accuracy.

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