MAK HILL Publications Research Journal of Medical Sciences

Research Article
doi: 10.36478/makrjms.2025.3.20.26

OPEN ACCESS

Key Words
Computed tomography, focal liver lesions, diagnosis, enhancement patterns, hepatocellular carcinoma, hemangioma

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Received: 25th February 2025
Accepted: 29th March 2025
Published: 03rd April 2025

Citation: C. Sylviya, Sathish Babu and S. Vinod, 2025. Evaluation of the Role of Computed Tomography in the Diagnosis and Characterization of Focal Liver Lesions. Res. J. Med. Sci., 19: 20-26, doi: 10.36478/ makrjms.2025.3.20.26

Evaluation of the Role of Computed Tomography in the Diagnosis and Characterization of Focal Liver Lesions

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Abstract
Focal liver lesions represent a diverse group of abnormalities that can be either benign or malignant. Accurate diagnosis and characterization are crucial for determining appropriate management strategies. Computed tomography (CT) plays a pivotal role in the evaluation of these lesions, offering detailed imaging that aids in distinguishing between different lesion types. This study aims to assess the effectiveness of CT in diagnosing and characterizing focal liver lesions, considering various demographic, clinical and radiological parameters. This prospective observational study was conducted at a tertiary care hospital's Department of Radiology over a six months period. Fifty patients with suspected focal liver lesions, identified through clinical examination or preliminary imaging, were included. CT scans were performed using a multi-detector CT scanner with a standardized protocol that included non-contrast and contrast-enhanced phases (arterial, portal venous and delayed). Data on demographics, clinical presentation and CT findings, including lesion number, type, location and enhancement patterns, were collected and analyzed. Descriptive statistics were used to present the findings. The study cohort consisted of 28 males and 22 females, with the majority of cases occurring in the 41-50 age group. Abdominal pain was the most common presenting symptom, observed in 92% of patients. Lesions were most frequently located in both liver lobes (42%) and multiple lesions were more common (54%) than solitary ones. The most prevalent lesions were hemangiomas and metastases (20% each), followed by hepatocellular carcinoma (16%). CT enhancement patterns varied by lesion type, with hemangiomas showing peripheral nodular enhancement and hepatocellular carcinomas demonstrating arterial hyper enhancement with washout. CT is highly effective in diagnosing and characterizing focal liver lesions, providing detailed information on lesion type, distribution and enhancement patterns. This facilitates accurate diagnosis and aids in guiding clinical management, highlighting the importance of CT in the comprehensive evaluation of liver pathology.

INTRODUCTION

Focal liver lesions encompass a broad spectrum of abnormalities, ranging from benign conditions such as hemangiomas and simple cysts to malignant pathologies like hepatocellular carcinoma (HCC) and metastases. Accurate diagnosis and characterization are paramount in determining the appropriate clinical management, as treatment strategies vary significantly between benign and malignant lesions. The liver's complex vascular supply and involvement in diverse systemic diseases make it a common site for focal abnormalities[1,2]. Computed tomography (CT) has emerged as a cornerstone in the evaluation of liver lesions due to its ability to provide detailed anatomical and vascular information. By utilizing non-contrast and multi phasic contrast-enhanced imaging protocols, CT allows for the precise assessment of lesion morphology, distribution and enhancement patterns, aiding in differentiation between benign and malignant entities[3]. Liver lesions are frequently encountered in clinical practice, with their prevalence varying based on the population studied and underlying risk factors[4]. Hemangiomas are the most common benign liver tumors, occurring in 1-5% of the general population, whereas hepatocellular carcinoma (HCC) is the predominant primary malignant liver tumor, particularly in regions with high rates of hepatitis B and C infections. Metastatic liver lesions are more common than primary tumors and represent a significant proportion of secondary malignancies, especially in cancers like colorectal and breast carcinomas[5,6]. Numerous studies have highlighted the utility of CT in diagnosing liver lesions. A study by Andrew[7] demonstrated the superior diagnostic accuracy of multi phasic CT in differentiating benign from malignant lesions based on enhancement patterns. Similarly, Tin[8] emphasized the role of CT in staging liver malignancies and guiding biopsy procedures. Advances in imaging technology, including multi-detector CT and refined contrast protocols, have further enhanced the diagnostic yield of CT, particularly in characterizing complex or atypical lesions. Despite the availability of various imaging modalities such as ultrasound and MRI, CT remains the most widely used tool for evaluating focal liver lesions due to its accessibility, rapid acquisition times and high spatial resolution. This study aims to reinforce the pivotal role of CT by evaluating its effectiveness in diagnosing and characterizing focal liver lesions. Understanding the demographic, clinical and imaging features of these lesions can aid in better resource allocation and patient management, particularly in resource-limited settings.

Aim and Objectives:

Aims: To evaluate the effectiveness of computed tomography (CT) in the diagnosis and characterization of focal liver lesions, considering various demographic, clinical and radiological parameters.

Objectives:

- To analyze the demographic distribution of patients with focal liver lesions.
- To evaluate the clinical presentation and symptomatology of patients with focal liver lesions.
- To characterize the types and distribution of focal liver lesions and their enhancement patterns on CT.

MATERIALS AND METHODS

Study Design: This study is a prospective observational study conducted at the Department of Radiology in a tertiary care hospital. The informed consent was obtained from all patients or their guardians.

Study Population: The study included patients who were referred to the radiology department with suspected focal liver lesions based on clinical examination or preliminary imaging studies. A total of 50 patients were enrolled in the study over a period of six months from April 2024 To September 2024.

Inclusion Criteria:

- Patients of all ages and both sexes with suspected focal liver lesions.
- Patients who underwent computed tomography (CT) scan for the evaluation of focal liver lesions.
- Patients who provided informed consent.

Exclusion Criteria:

- Patients with diffuse liver disease without focal lesions.
- Patients who did not undergo CT scanning.
- Patients who did not provide informed consent.

Imaging Technique: All CT scans were performed using a multi-detector CT scanner. The following protocol was used for imaging:

- Non-contrast images were obtained through the liver.
- Contrast-enhanced images were acquired in the arterial, portal venous and delayed phases following the administration of intravenous contrast media.
- The contrast media used was non-ionic iodinated contrast at a dose of 1.5 mL/kg body weight.
- Images were reconstructed in axial, coronal and sagittal planes for comprehensive evaluation.

Data Collection: Data were collected using a structured proforma, which included:

- **Demographic Details:** Age, sex and other relevant demographic information.
- **Clinical Presentation:** Symptoms and duration of symptoms at presentation.
- **CT Findings:** Number, size, location and enhancement patterns of the focal liver lesions.

Lesion Characterization: Lesions were characterized based on their CT appearance, including:

- **Number of Lesions:** Solitary or multiple.
- **Type of Lesions:** Based on their radiological characteristics and enhancement patterns.
- **Enhancement Patterns:** Specific patterns observed during the arterial, portal venous and delayed phases.

Statistical Analysis: Data were analyzed using descriptive statistics. Continuous variables were expressed as mean±standard deviation (SD) and categorical variables were expressed as frequencies and percentages. The demographic distribution, clinical presentation and lesion characteristics were presented in tables and figures.

Quality Control: All CT scans were reviewed by two experienced radiologists independently to ensure consistency and accuracy in the interpretation of findings. Any discrepancies were resolved by consensus.

Ethical Considerations: The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Patient confidentiality was maintained throughout the study and all data were anonymized before analysis.

RESULTS AND DISCUSSIONS

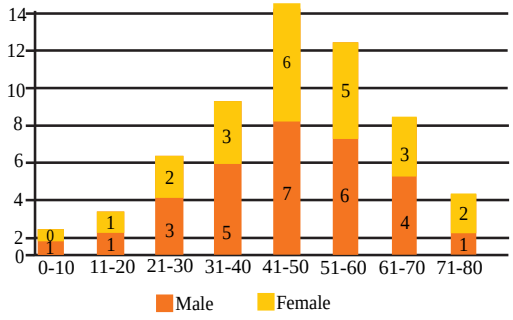

Fig. 1: Age and Sex Distribution

This bar chart presents the distribution of 50 patients based on age and sex. The age groups range from 0-10 years to 71-80 years. The highest number of cases (13) occurred in the 41-50 age group, followed by 11 cases in the 51-60 age group. Males constituted a slight majority with 28 cases, while females accounted for 22 cases. The data indicate a higher prevalence of focal liver lesions in middle-aged adults, with a relatively balanced distribution between sexes.

A Case of Hemangioma:

- Hypodense area in plain CT showing peripheral enhancement on arterial phase with minimal centripetal filling of contrast in portal venous phase (Fig. A).
- Homogenization of contrast in delayed Phases (Fig. B).

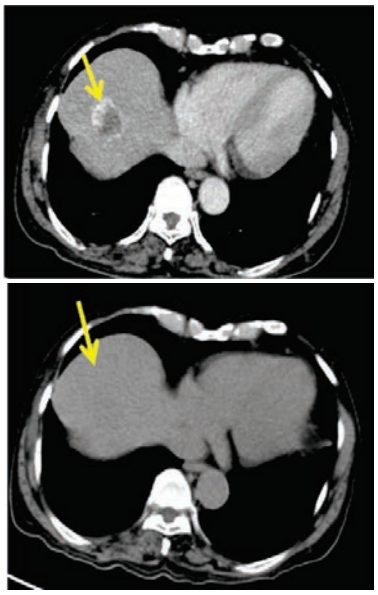

Fig. 2: (a, b) A Case of Haemangioma

Table 1: Presentation of Symptoms

Symptom	Number of Patients	Percentage (%)
Abdominal Pain	46	92
Anorexia	17	34
Jaundice	8	16
Weight Loss	6	12
Fever	5	10

This table summarizes the clinical symptoms observed in the 50 patients with focal liver lesions. Abdominal pain was the most common symptom, reported by 92% of patients. Other symptoms included anorexia (34%), jaundice (16%), weight loss (12%) and fever (10%). These findings highlight abdominal pain as the predominant clinical feature, while other symptoms were less frequently reported.

A Case of Multi Centric Hepatocellular Carcinoma in Cirrhotic Morphology of Liver:

Arterial Phase: Liver is grossly enlarged with surface irregularity changes (arrow) multiple hypodense lesion with heterogeneous enhancement in post contrast study noted involving the entire left bone of liver, segment VIII, VII and part of caudate lobe (star). (Fig. 3A).

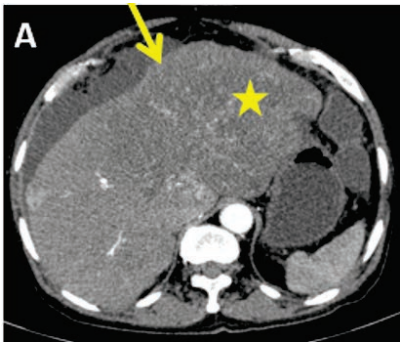

Fig. 3A: Arterial Phase

Portal Phase: Lesions shows washout in venous phase. (Fig.3B).

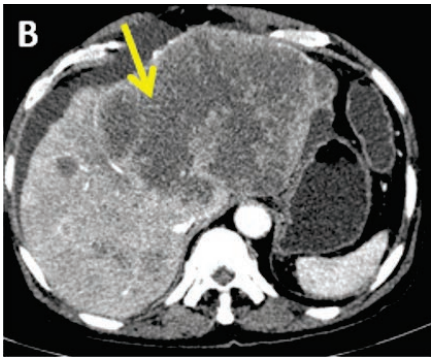

Fig. 3B: Portal Phase

Delayed Phase: There is retention of enhancement in the periphery of the lesion-suggesting Pseudo Capsule. (Fig. 3C).

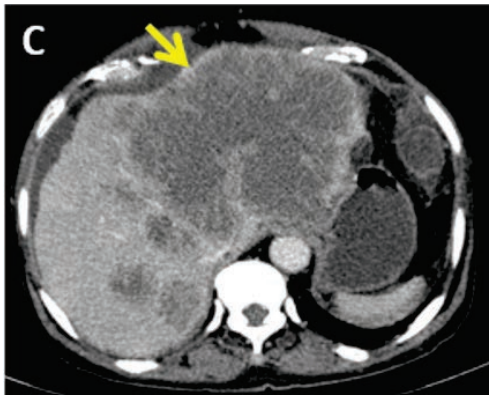

Fig. 3C: Delayed Phase

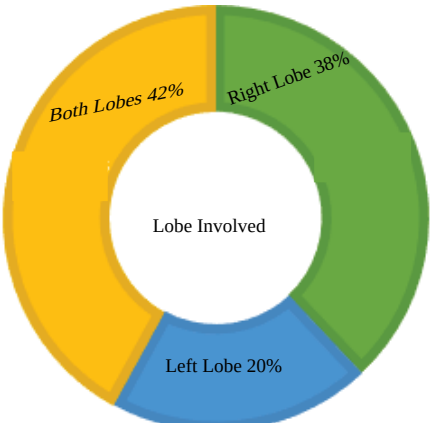

Fig. 4: Lobe Involvement

This table details the distribution of focal liver lesions based on the lobe involvement. Among the 50 patients, 38% had lesions confined to the right lobe, 20% to the left lobe and 42% had lesions affecting both lobes. The data suggest that while the right lobe is the most commonly affected, a significant proportion of patients exhibit lesions in both lobes, indicating widespread liver involvement in many cases.

A Case of Pyogenic Liver Abscess: Hepatomegaly with coalescent multiple peripherally enhancing and inter communicating hypodense area (cluster sign) in both the lobes with minimal intra hepatic biliary radical dilatation in the segment III of liver. (Fig. 5).

Fig. 5: A Case of Pyogenic Liver Abscess

Table 2: Lesion Characteristics

Lesion Type	Number of Patients	Percentage (%)
Solitary	23	46
Multiple	27	54

This table categorizes the lesions into solitary and multiple types. Out of the 50 patients, 54% had multiple lesions, while 46% had solitary lesions. This suggests that multiple lesions are slightly more prevalent in patients with focal liver lesions, potentially indicating a higher likelihood of metastatic or multi focal disease processes.

A Known Case of Carcinoma Ascending Colon with Liver Metastasis:

Arterial Phase: Multiple peripherally enhancing lesions with central hypoenhancing necrosis. (Fig.6A).

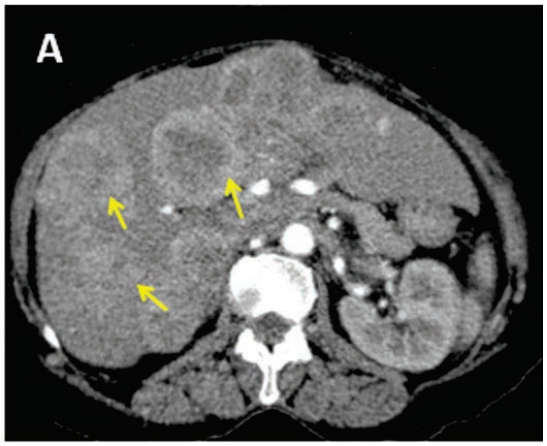

Fig. 6A: Arterial Phase

Delayed Phase: Washout in delayed phase (helpful in distinguishing a metastasis from a hemangioma. (Fig. 6B).

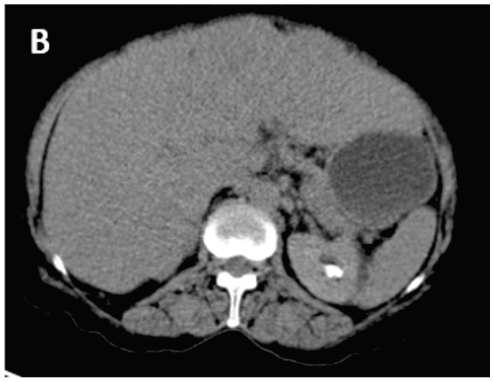

Fig. 6B: Delayed Phase

Table 3: Distribution of Lesions

Lesion Type	Number of Cases	Percentage (%)
Hemangioma	10	20
Metastases	10	20
Hepatocellular Carcinoma (HCC)	8	16
Abscess	6	12
Simple Cyst	5	10
Hepatic Trauma	4	8
Hydatid Cyst	2	4
Focal Fatty Infiltration	2	4
Cholangiocarcinoma	2	4
Focal Nodular Hyperplasia (FNH)	1	2
Hepatoblastoma	1	2
Arteriovenous Malformation (AVM)	1	2

This table provides the distribution of various types of liver lesions among the patients. Hemangiomas and metastases were the most common, each accounting for 20% of the cases. Hepatocellular carcinoma (HCC) was observed in 16% of the patients, while abscesses were found in 12%. Other less common lesions included simple cysts, hepatic trauma, hydatid cysts, focal fatty infiltration, cholangiocarcinoma, focal nodular hyperplasia (FNH), hepatoblastoma and arteriovenous malformations (AVM). The diverse range of lesions emphasizes the importance of CT in diagnosing and characterizing different types of focal liver lesions.

Arterial Phase: III defined heterogeneously enhancing lesions. (Fig. 7A).

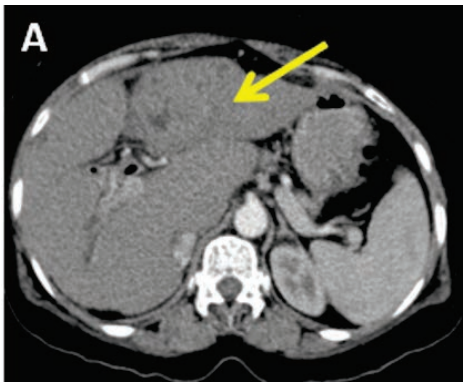

Fig. 7A: Arterial Phase

Portal Phase: The lesions shows heterogeneous enhancement on porto Venous phase with homogenization in delayed phase. (Fig. 7B).

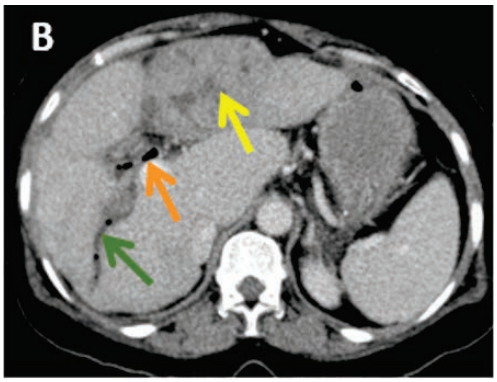

Fig. 7B: Portal Phase

Delayed Phase: Central and peripheral IHBRD (green arrow) with pneumobilia (orange arrow). (Fig. 7C).

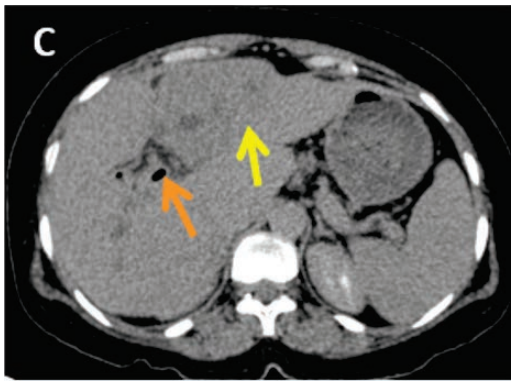

Fig. 7C: Delayed Phase

Table 4: Enhancement Patterns of Common Lesions

Lesion Type	Enhancement Pattern	No. of Cases	Percentage (%)
Hemangioma	Peripheral nodular	10	100
Metastases	Hypoenhancing	9	90
HCC	Arterial hyper enhancement with washout	8	100
Abscess	Peripheral enhancement	5	83.33
Simple Cyst	Non-enhancing	5	100

This table outlines the enhancement patterns observed on CT imaging for common liver lesions. Hemangiomas showed peripheral nodular enhancement in all 10 cases. Metastases were hypoenhancing in 90% of the cases, while all hepatocellular carcinoma (HCC) lesions demonstrated arterial hyper enhancement with washout. Abscesses exhibited peripheral enhancement in 83.33% of cases and simple cysts were non-enhancing in all instances. These enhancement patterns provide crucial diagnostic information, aiding in the differentiation and characterization of various liver lesions.

The findings of this study align with previous research emphasizing the critical role of computed tomography (CT) in the evaluation of focal liver lesions. In this

study, CT demonstrated excellent capability in identifying and characterizing a wide variety of liver lesions, with hemangiomas and metastases being the most frequently diagnosed (20% each), followed by hepatocellular carcinoma (16%). These results are consistent with similar studies. For example, Mamone[9] reported hemangiomas as the most common benign lesion detected on CT, with characteristic peripheral nodular enhancement patterns, mirroring the findings in this study where all hemangiomas showed peripheral nodular enhancement. Similarly, hepatocellular carcinoma (HCC) in our study exhibited arterial hyper enhancement with washout in 100% of cases, comparable to the diagnostic accuracy reported in the study by Violi[10], which emphasized the importance of arterial phase imaging for HCC characterization. The predominance of multiple lesions (54%) in our cohort suggests a significant representation of metastatic disease, correlating with findings from Vito[11], who also highlighted the utility of CT in detecting hypo vascular metastases with hypoenhancing characteristics, observed in 90% of metastatic cases in our study. In terms of symptomatology, abdominal pain was the most common presenting complaint (92%), in agreement with Gupta[12], who also identified abdominal pain as the primary symptom in patients with liver lesions. However, the lower prevalence of systemic symptoms such as fever (10%) and jaundice (16%) in our study might reflect the predominance of benign and primary malignant lesions over diffuse liver diseases. CT enhancement patterns observed in this study provide a reliable basis for lesion characterization. The peripheral enhancement in liver abscesses (83.33%) noted here aligns with Wei[13], who found similar enhancement features to be pathognomonic. Moreover, the non-enhancing characteristic of simple cysts in all cases in this study is consistent with earlier findings by Venkata[14]. Compared to older imaging modalities, CT offers superior spatial resolution and multi phase imaging capabilities, enabling comprehensive evaluation. However, limitations such as radiation exposure and potential contrast-induced nephropathy remain areas of concern, as also highlighted in studies by Jain[15]. The study's limitations include a small sample size, a single-center setting and technical variability due to the use of a specific multi-detector CT scanner, which may not be applicable to other healthcare settings or populations.

CONCLUSION

The study demonstrated that computed tomography (CT) is an effective imaging modality for diagnosing and characterizing focal liver lesions. CT provides detailed information on lesion morphology, enhancement patterns and lobe involvement, enabling accurate differentiation between different types of liver lesions. It aids in clinical management and treatment planning for patients with liver pathology. CT plays a critical role in evaluating liver lesions, particularly in detecting malignant lesions like hepatocellular carcinoma and metastases. The correlation between clinical symptoms and CT findings emphasizes the importance of imaging in complementing clinical evaluation, providing a more comprehensive understanding of the patient's condition. CT remains a cornerstone in non-invasive diagnosis of focal liver lesions, improving diagnostic accuracy and patient outcomes.

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