Role of triple phase computed tomography in hepatic lesion evaluation

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Abstract- **This study aimed to evaluate the utility of triple-phase computed tomography (CT) scans in characterizing hepatic lesions and to determine the predictive accuracy of this imaging technique for differentiating various types of liver lesions. A retrospective analysis was conducted on 45 patients with suspected or confirmed hepatic lesions who underwent triple-phase CT scans. The CT scans were reviewed by radiologist,Dr Sarthak Sharma and the findings were correlated with the final diagnoses, established through ultrasound histopathology and follow-up imaging. The diagnostic performance of triple-phase CT, including sensitivity, specificity, positive predictive value, and negative predictive value, was calculated for the characterization of different hepatic lesions, such as hepatocellular carcinoma, hemangioma, metastases. The results demonstrated that triple-phase CT is a valuable tool for the characterization of hepatic lesions, providing high accuracy in differentiating between various lesion types. The study concludes that triple-phase CT is a reliable imaging modality for the assessment of hepatic lesions, aiding in accurate diagnosis and management.**

Index Terms- **Triple phase CT scan , Hepatic lesions, contrast enhancement, portal venous phase ,arterial phase, delayed phase.**

I. INTRODUCTION

The liver is divided into four lobes: right, left, caudate, and quadrate, the quadrate lobe is situated on the inferior surface of the right lobe, the caudate lobe is situated between the left and right lobes, anterior and superior. Couinaud classification is the most extensively used anatomic categorization of hepatic segments. It identifies eight functionally independent liver segments based on vascularization, bile duct distribution, and lymphatic drainage. The liver is responsible for a wide variety of essential functions, including waste elimination, protein synthesis in plasma, bile generation to facilitate digestion, and nutrition storage. Liver lesions have a wide range of diseases, from benign hemangiomas to malignant primary hepatocellular carcinoma and metastases.

Hepatic diseases are common causes of morbidity and mortality in India, and are encountered frequently in day-to-day practice. Due to wide spread use of diagnostic imaging modalities, Hepatic lesions are incidentally discovered even in asymptomatic patients. The differential diagnosis of hepatic disease is broad due to wide group of pathologies affecting the liver. The diagnostic features of most of these lesions have considerable overlap with each other and require further specific characterization and differentiation. It is critical to reliably detect and diagnose hepatic lesions and outline appropriate line of management. The objectives of hepatic imaging are to diagnose hepatic pathology, its characterization, staging, evaluation of biliary ductal system, response to treatment, and the assessment of vascular anatomy for surgical approach.

Ultrasonography is the first line of investigation for suspected hepatic diseases and frequently identifies asymptomatic focal hepatic disease incidentally. It is useful to detect the site and number of lesions and also involvement and infiltration of the lesion into vasculature. However, it is limited by operator dependency, inability to diagnose lesions <1cm and low specificity1.The presence of diffuse hepatic disease also lowers the sensitivity of Ultrasonography for the detection of focal lesions. Similarly, pseudo-lesions, such as focal fatty infiltrations or focal fatty sparing are sometimes difficult to differentiate from other pathological liver lesions. Triple phase Computed Tomography (CT) allows more precise detection and characterization of focal hepatic lesions. Owing to the unique dual blood supply of liver from Hepatic Artery (20%) and Portal Vein (80%), the patterns of differential contrast uptake help in differentiating lesions based on their vascular supply .The hepatic circulation is divided into three distinct phases namely - arterial phase, portal venousphase, and equilibrium (venous) phase. Using the Triple-phase technique, CT is used to study the liver during these three distinct hepatic circulatory phases.The

first phase evaluates the arterial phase ,which corresponds to the hepatic arterial system. The second phase corresponds to uptake of contrast by the portal venous system and is termed as the portal venous phase. During the third phase, the hepatic veins which remained unenhanced during the early arterial and portal venous phases, are now enhanced. This phase is termed as the Delayed Phase/ Equilibrium Phase. With ideal acquisition timing and thin collimation, the lesions are differentiated according to their enhancement pattern in the different perfusion phases, thus permitting improved lesion detection and characterization. CT also provides the opportunity to screen the entire abdomen and pelvis for associated pathology, metastasis, ascites , vasculature and bony lesions. Despite the increased use of MRI over the last few years, the importance of CT prevails, chiefly due to excellent visualizations of liver anatomy, morphology of liver lesions and satisfactory delineation of relationship with adjacent structures.

II. AIM

To systematically evaluate and characterize hepatic lesions using triple-phase computed tomography (CT) scanning, and to assess the diagnostic accuracy and predictive value of triple-phase CT in differentiating between various types of hepatic lesions, including benign and malignant pathologies. The study seeks to determine how effectively triple-phase CT imaging can be used as a non-invasive diagnostic tool in the clinical assessment and management of liver lesions.

III. MATERIAL AND METHODS

3.1 Study design and patient selection:

This retrospective study included 45 patients who underwent triple-phase CT from march 2025 to June 2025 at jammu healthcare and diagnostic centre jammu. Patients met the inclusion criteria if they had undergone triple-phase CT and had confirmed biopsy results. Both benign and malignant hepatic lesions were included, provided biopsy confirmation was available. No restrictions were applied regarding the stage or severity of the disease, ensuring a broad representation of hepatic conditions. Patients were excluded if they had not undergone a triple-phase protocol or if their images were distorted or affected by technical errors. Additionally, patients were excluded if they had not completed the full diagnostic cycle for hepatic lesions due to the absence of a biopsy result.

3.2 Triple--phase's protocol:

CT scans were performed using a Siemens somatom Go now with 96 slices. Patients were positioned supine with arms above their heads during the inspiration phase.

3.3 Contrast agent

iohexol, a nonionic, water-soluble, low-osmolar iodinated contrast medium (LOCM), was used in this study due to its safety profile, with a significantly lower risk of adverse reactions compared to high-osmolar contrast media (HOCM). The dose was individualized based on patient weight (1–1.5 mL/kg), ranging from 80 to 120 mL, and followed by 30–50 mL of normal saline. This weight-based protocol optimizes contrast use while maintaining image quality for liver imaging. The contrast was administered intravenously at a flow rate of 4 mL/s using an 18-gauge needle.

3.4 Scanning parametres

A craniocaudal scan, spanning from the diaphragm's superior edge to the iliac crest, was performed with 1 mm slices. This thin-slice approach was chosen to boost spatial resolution, aiding in the identification of small or indistinct liver lesions and reducing partial volume effects. The use of 1 mm slices is standard in abdominal CT imaging, known to improve diagnostic accuracy by enhancing the visibility of fine anatomical details and allowing for dependable lesion characterization, especially in complex cases like hepatic fibrosis and subtle malignancies. The timing intervals for the arterial (35–45 s), portal venous (65–75 s), and delayed (3–10 min) phases in the triple-phase CT protocol were based on established guidelines and protocols to optimize diagnostic accuracy. The arterial phase captures hypervascular lesions like hepatocellular carcinoma, the portal venous phase highlights hypovascular lesions and hepatic venous structures, and the delayed phase detects contrast retention patterns in lesions such as cholangiocarcinoma.

IV. RESULTS

Notably, hepatic lesions were more commonly observed in males (approximately 70–75% of total cases), despite the majority being non-alcoholic. A significant proportion of these male patients had a history of diabetes, whereas this was less frequently observed in females. In contrast, thyroid-related history was noted in some female patients but was rarely seen in males.Hepatic lesions such as HCC and abscesses were more prevalent in male patients. Specifically, HCC was identified in 69.3% of male cases, and liver abscesses were observed in 75% of the male group. On the other hand, conditions like fatty liver (77.8%) and hemangioma (60%) were more commonly detected in female patients. Hepatomegaly and liver cirrhosis also showed a higher frequency in females. Rare lesions such as hamartoma and focal nodular hyperplasia (FNH) were exclusively observed in female patients (100%). The

distribution of hepatic cysts was nearly equal between the two genders.

The majority of hepatic lesions were located in the right lobe (72.8%), followed by the left lobe (24.3%) and the quadrate lobe (2.9%), with no lesions detected in the caudate lobe. Benign lesions, including hemangiomas and cysts, were predominantly observed in the right lobe, likely due to its larger size and richer vascular supply. Similarly, hepatocellular carcinoma (HCC) and metastatic lesions were more frequently found in the right lobe, reflecting its role as the main recipient of portal venous blood, which supports the development of both primary and secondary hepatic lesions. Lesions in the left and quadrate lobes were comparatively infrequent, possibly due to their smaller size and reduced vascularization.

Findings from the "Clear Phase" analysis revealed that hypervascular lesions, such as HCC, were most optimally visualized during the arterial phase (22.6%). In contrast, hypovascular lesions—including cysts and metastases—were predominantly identified in the portal venous phase (61.1%), especially within the right lobe. The delayed phase (13.2%) was more effective for detecting lesions such as cholangiocarcinoma and fibrotic changes. A small proportion of lesions (3.1%) exhibited comparable visibility across all imaging phases. Additionally, the results demonstrated that 72.1% of patients had focal hepatic lesions, whereas 27.9% presented with diffuse hepatic involvement.

Triple-phase CT scan has shown high accuracy in diagnosing various liver conditions. It was most accurate in detecting cysts and fatty liver, with accuracy rates of 95.3% and 95.0%, respectively, indicating a very close match with the final confirmed diagnosis (gold standard). It also performed well in identifying metastatic liver disease and liver abscesses, with accuracies of 92.0% and 91.1%. For detecting hepatocellular carcinoma (HCC), the scan had an accuracy of 90.1%. Although slightly lower, the accuracy remained high for liver cirrhosis and hemangioma, recorded at 88.9% and 87.6%, respectively. These findings support the effectiveness of triple-phase CT in diagnosing a wide range of hepatic lesions with reliable precision.

V. DISCUSSION

Triple-phase CT has demonstrated high diagnostic accuracy in evaluating hepatic abnormalities, particularly in identifying cysts and fatty liver. Its strong performance in diagnosing hepatocellular carcinoma (HCC), liver abscesses, and metastatic lesions highlights its reliability and consistency in clinical practice. The high degree of agreement with the gold standard further reinforces triple-phase CT as a dependable imaging modality for the detection and characterization of a wide spectrum of liver lesions.The age distribution in this study reveals a notable trend: the prevalence of hepatic lesions increases with age, with the highest number of cases observed in patients over 60 years. This trend is especially evident in malignant lesions, suggesting that advancing age may be a critical factor contributing to the development and progression of liver pathology. This finding underscores the importance of routine liver screening and timely imaging evaluations in older populations.

The anatomical distribution of hepatic lesions also offers important diagnostic insights. The right lobe of the liver was the most commonly affected site, accounting for 72.8% of all lesions. This predominance can be attributed to the right lobe's larger size and its richer vascular supply, primarily from the portal vein, which may facilitate the development of both benign and malignant lesions. The higher frequency of lesions in this region has practical implications for radiological assessments. Radiologists should ensure detailed evaluation of the right lobe, particularly during the arterial and portal venous phases, as these phases offer optimal visualization of hypervascular and hypovascular lesions, respectively. Overall, the findings from this study support the role of triple-phase CT as a powerful diagnostic tool, especially when assessing older patients and when focusing on the commonly affected regions of the liver. Early and accurate identification of hepatic lesions can lead to better clinical outcomes through timely intervention and management.

The findings from our study highlight hemangioma as the most prevalent hepatic lesion, with a higher incidence in females, showing a higher incidence in females, which supports the findings of Aytekin et al Hepatic hemangioma is the most common solid tumor found in the liver, occurring in up to 20% of cases. Hemangioma is typically found by accident, but has a noticeable preference for females, with a female-to-male ratio that can range from 2:1 to 5:1. This tendency could be explained by the influence of hormones specific to females.

Our findings indicate a higher prevalence of HCC among males, with its incidence rising with age, aligning with previous research (Ahirwar et al., 2016). The diagnostic accuracy of triple-phase CT for HCC was high in our study, reaching 90.1%, consistent with other reports showing accuracies of 91.6% and 96.4% (Cao et al., 2020; Hafeez & Khan, 2017). Triple-phase CT's rapid acquisition and superior spatial resolution underscore its essential role in HCC diagnostics (Shi et al., 2020). HCC

typically demonstrates characteristic enhancement during the arterial phase, followed by contrast washout in the portal venous phase and appearing hypodense in the delayed phase (Hameed et al., 2018).

While magnetic resonance imaging (MRI) is widely regarded as the gold standard in hepatic imaging due to its superior sensitivity—particularly for lesions ≥2 cm, with reported sensitivities of 0.82 for MRI versus 0.66 for CT—the specificity of MRI and computed tomography (CT) remains comparable (0.91 for MRI versus 0.92 for CT), emphasizing the reliability of CT in confirming hepatocellular carcinoma (HCC) (Roberts et al., 2018). However, as highlighted by Lewis et al., all imaging modalities, including MRI and CT, show reduced diagnostic performance for lesions smaller than 1 cm, underscoring the persistent challenges in the early detection of hepatic malignancies. Despite the diagnostic advantages of MRI, triple-phase CT remains a practical and highly effective modality, particularly in resource-limited settings or in cases where MRI is contraindicated. In our study, triple-phase CT provided detailed anatomical and vascular information, which proved essential in accurately characterizing lesions and guiding clinical decisions. Moreover, its capability to differentiate resectable from unresectable tumors and to assess suitability for locoregional therapies highlights its continued relevance in hepatic imaging protocols.

CT imaging continues to be a preferred method for diagnosing liver cirrhosis, a finding supported by previous studies (Fuhrman et al., 2022; van Timmeren et al., 2020). In our analysis, triple-phase CT identified cirrhosis with an accuracy of approximately 89%. Importantly, it offers a non-invasive alternative when liver biopsies are either contraindicated or yield inconclusive results (Lambin et al., 2017). The exceptionally high specificity of 99.9% observed in our study further reinforces triple-phase CT's value in clinical settings, as it effectively minimizes false positives. This high specificity ensures that only patients with true pathological changes are subjected to further interventions, thereby reducing unnecessary testing and improving the overall efficiency of care.

Emerging technologies in artificial intelligence (AI), particularly deep learning (DL), are increasingly influencing the future of hepatic imaging. DL algorithms, which learn directly from imaging data without the need for manual feature selection, have shown great promise in enhancing the diagnostic accuracy of liver cancer detection (Shi et al., 2020). These tools have been successfully integrated into CT and MRI analysis for automated detection and characterization of HCC. By assisting radiologists in identifying suspicious lesions, measuring tumor burden, and predicting treatment response, AI-powered systems can significantly improve diagnostic precision, streamline workflows, and ultimately enhance patient outcomes

VI. CONCLUSION

This study demonstrates that triple-phase CT imaging is a highly effective and accurate diagnostic tool for evaluating a broad range of hepatic lesions. Its ability to provide detailed anatomical and vascular information makes it a valuable modality in clinical decision-making, particularly in differentiating between benign and malignant lesions and assessing treatment eligibility. The findings contribute to the growing body of evidence supporting the use of triple-phase CT in hepatic imaging. However, the limited sample size highlights the need for further large-scale studies to validate these results and to explore its diagnostic performance across a wider variety of hepatic pathologies. Continued research in this area is essential for advancing diagnostic strategies and improving patient outcomes in hepatic disease management.

REFRENCES

[1]. Role of **triple phase computed tomography** findings for **evaluation** of **hepatic lesions CP Ahirwar, A Patil, N Soni - Int J Res Med Sci, 2016 - core.ac.uk**

[2]. Triphasic **computed tomography** (**CT**) **scan in** focal tumoral **liver lesions S Hafeez, MS Alam, Z Sajjad, ZA Khan… - Journal of the …, 2011 - ecommons.aku.edu**

[3]. Role of **Triple Phase Computed Tomography in** the **Evaluation** of **Liver Lesions VK Tatikonda, VDP Gorrela, A Racherl - 2021 - ijars.net**

[4]. Hepatocellular carcinoma: detection with **triple-phase** multi–detector row helical **CT in** patients with chronic hepatitis **A Laghi, R Iannaccone, P Rossi, I Carbone, R Ferrari… - Radiology, 2003 - pubs.rsna.org**

[5]. Correlation of **computed tomography and** positron emission tomography **in** patients with metastatic gastrointestinal stromal **tumor** treated at a single institution with … **H Choi, C Charnsangavej, SC Faria… - Journal of clinical …, 2007 - ascopubs.org**

[6]. J Comput Assist Tomogr. 1997 Mar-Apr;21(2):229-35. doi: 10.1097/00004728-199703000-00012.PMID: 9071291

[7]. Radiology. 1998 Jan;206(1):143-50. doi: 10.1148/radiology.206.1.9423664.PMID: 9423664

[8]. AJR Am J Roentgenol. 1996 Sep;167(3):753-7. doi: 10.2214/ajr.167.3.8751695.PMID: 8751695
[9]. Abdom Imaging. 2001 Sep-Oct;26(5):510-4. doi: 10.1007/s00261-001-0007-x.PMID: 11503090
[10]. LH Schwartz, EJ Gandras, SM Colangelo, MC Ercolani… - Radiology, 1999 - pubs.rsna.org
[11]. Diagnostic imaging of **hepatic lesions** in adults **R Lamba, G Fananazapir, MT Corwin… - Surgical Oncology …, 2014 - surgonc.theclinics.com**