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ROLE OF CONTRAST-ENHANCED COMPUTED TOMOGRAPHY IN THE EVALUATION OF HEPATOCELLULAR CARCINOMA IN CHRONIC LIVER DISEASE

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Abstract

Background: *Hepatocellular carcinoma (HCC) represents a significant global health burden, particularly among individuals with chronic liver disease. Contrast-enhanced computed tomography (CECT) is the primary imaging modality for evaluating HCC.*

Objective: *This study aimed to assess the demographic characteristics and imaging features of HCC in patients with chronic liver disease using CECT, with emphasis on lesion location, margins, and associated findings.*

Methods: *This analytical cross-sectional study was conducted at the Department of Radiology, Shalamar Hospital, Lahore, over a four-month period. A total of 140 patients diagnosed with HCC and chronic liver disease were enrolled using consecutive sampling. All participants underwent multiphasic CECT using a 64-slice Siemens CT scanner with a standardized protocol (120 kVp, 120-170 mAs, 100-120 mL non-ionic contrast at 3-5 mL/s). Data on demographic characteristics, clinical presentations, and imaging features, including lesion location, margins, and associated findings, were collected using a structured pro forma. Statistical analysis was performed using SPSS version 25, with descriptive statistics presented as frequencies and percentages.*

Results: *The study population comprised 111 males (79.3%) and 29 females (20.7%), demonstrating a strong male predominance. Fatigue was the most common symptom (65.0%), followed by fever (57.9%) and nausea (54.3%). Abdominal distention was present in 79.3% of patients. Regarding lesion characteristics, segment III was the most frequent location (25.0%), followed by segment IV (22.9%) and segment II (15.7%). Irregular margins were observed in 58.6% of lesions. Fatty liver appearance was predominant (90.0%), while fibrotic changes were noted in 8.6% of cases. Ascites was present in 39.3% of patients, and free fluid collection was observed in 85.8% of cases. Pain in the right and left hypochondriac regions was reported in 27.8% and 30% of patients, respectively.*

Conclusion: *CECT demonstrates high sensitivity in detecting and characterizing HCC in patients with chronic liver disease. The modality provides detailed information on lesion location, margins, and associated*

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findings, which are essential for treatment planning. The study confirms a male predominance in HCC incidence, with segment III the most common location. These findings support the continued use of CECT as the primary imaging modality for evaluating HCC.

INTRODUCTION

The liver is the largest internal organ and the largest gland in the human body, serving vital roles in nutrient metabolism, waste excretion, detoxification, and bile secretion [1]. Anatomically, it is divided into four lobes—the right, left, caudate, and quadrate lobes—and is protected by the diaphragm and thoracic cage [2]. The liver receives a dual blood supply from the portal vein (80%) and the hepatic artery (20%), which is critical for its metabolic functions and also influences the enhancement patterns of hepatic lesions during contrast-enhanced imaging [3].

Hepatocellular carcinoma (HCC) is a malignant tumor that primarily develops in individuals with underlying chronic liver disease (CLD) or cirrhosis. Major risk factors include chronic infection with the Hepatitis B virus (HBV) and Hepatitis C virus (HCV), alcohol consumption, and metabolic conditions such as obesity and diabetes [4, 5]. Globally, HCC is a leading cause of cancer-related mortality. The management of HCC depends heavily on early and accurate diagnosis, where imaging plays a central role.

Contrast-enhanced Computed Tomography (CECT) is a cornerstone in the diagnostic algorithm for HCC. It utilizes multiphasic imaging—including arterial, portal venous, and delayed phases—to exploit the unique vascularity of HCC lesions, which typically show arterial phase hyper-enhancement followed by "washout" in the portal venous or delayed phases [6, 7]. Modern multidetector CT (MDCT) technology, such as 64-slice systems, allows for high temporal and spatial resolution, enabling the detection of even small nodules and the characterization of their vascular patterns [8, 9].

Previous studies have highlighted the diagnostic accuracy of MDCT. For instance, Ronzoni et al. [8] reported that MDCT effectively depicted 102 of 139 HCC cases in cirrhotic patients, emphasizing its sensitivity in preoperative evaluation. Other researchers have noted that enhancement patterns may vary with tumor size and cellular differentiation, with smaller lesions sometimes exhibiting atypical patterns [10, 11]. In the Pakistani population, where HCV is highly prevalent, limited data exist on the detailed CECT characteristics of HCC. This study aimed to fill this gap by evaluating the role of contrast-enhanced computed tomography in assessing demographic characteristics, clinical presentations, and detailed imaging features (lesion location, margins, background liver changes, and associated findings) of hepatocellular carcinoma among patients with chronic liver disease.

MATERIALS AND METHODS

This analytical cross-sectional study was conducted at the Department of Radiology, Shalamar Hospital, Lahore, Pakistan, over a period of four months. The sample size of 140 patients was calculated using the formula for a single proportion, with a 90% confidence level, an expected proportion of portal involvement of HCC of 16% based on Lafitte et al. [12], and a 5% margin of error. A consecutive sampling technique was used to enroll participants who met the inclusion criteria. Adult patients diagnosed with hepatocellular carcinoma in the setting of chronic liver disease were included in the study. Exclusion criteria comprised patients under 18 years of age, pregnant women, patients with deranged renal function tests, individuals with known allergic reactions to iodinated contrast media, and those who had undergone nuclear medicine procedures within the preceding 48 hours. Ethical approval was obtained from the Institutional Review Board of Superior University Lahore, and written informed consent was obtained from all participants following a detailed explanation of the study procedures in their native language (Urdu). All information and data collection were maintained confidentially, with participants remaining anonymous throughout the study. Subjects were informed of their right to withdraw at any time without penalty.

All patients underwent abdominal CECT using a standardized multiphasic protocol on a Siemens 64-slice CT scanner. Patients were

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positioned supine, and images were acquired craniocaudally during breath-hold. Non-ionic iodinated contrast medium (100-120 mL) was administered intravenously at a rate of 3-5 mL/second using a motorized power injector through an 18-20 gauge intravenous cannula placed in an antecubital vein. Imaging parameters included tube voltage of 120 kVp, tube current of 120-170 mAs, axial resolution of 0.625 mm, beam collimation of 40 mm, gantry rotation time of 0.6 seconds, and beam spacing of 0.6 mm. Multiphasic acquisition included non-contrast, late arterial (approximately 25-35 seconds post-contrast), portal venous (60-70 seconds), and delayed phases (3-5 minutes). Bolus-tracking software was used to optimize arterial-phase timing.

Data was collected using a structured Questionnaire that captured demographic information (age, gender), clinical history, presenting complaints, risk factors including viral hepatitis status, and detailed CT imaging findings. Imaging variables assessed included lesion location according to Couinaud's liver segments, lesion margins (regular vs. irregular), presence of ascites, free fluid collection, liver parenchymal appearance (normal, fatty, fibrotic), and associated features such as vascular invasion. Ascites was defined as free fluid in the peritoneal cavity, while free fluid collection referred to perihepatic or pelvic fluid not necessarily confined to the peritoneal space. Laboratory data, including HCV serology and serum alpha-fetoprotein levels, were recorded when available.

Statistical analysis was performed using SPSS version 25. Descriptive statistics were computed for all variables. Quantitative variables such as age were presented as mean and standard deviation. Qualitative variables, including gender, clinical symptoms, and imaging characteristics, were reported as frequencies and percentages.

RESULTS

A total of 140 patients with hepatocellular carcinoma and chronic liver disease were included in this study. The mean age of the study population was 52.4 ± 11.3 years (range: 28-78 years). The demographic and clinical characteristics of the study population are summarized in **Table 1**.

Table 1: Demographic and Clinical Characteristics of Study Population

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	111	79.3
	Female	29	20.7
Abdominal Distention	Present	111	79.3
	Absent	29	20.7
Fatigue	Present	91	65.0
	Absent	49	35.0
Nausea	Present	76	54.3
	Absent	64	45.7
Fever	Present	81	57.9
	Absent	59	42.1
Ascites	Present	55	39.3
	Absent	85	60.7
Free Fluid Collection	Present	120	85.8
	Absent	20	14.2
Pain in the right hypochondrium	Present	39	27.8
	Absent	101	72.2
Pain in the left hypochondrium	Present	42	30.0
	Absent	98	70.0

The study demonstrated a marked male predominance, with males comprising 79.3% (111/140) of the study population compared to 20.7% (29/140) females, yielding a male-to-

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female ratio of approximately 3.8:1. Among clinical presentations, abdominal distention was the most frequent complaint, reported in 79.3% of patients. Fatigue was present in 65.0% of cases, while fever and nausea were observed in 57.9% and 54.3% of patients, respectively. Pain localized to the right and left hypochondriac regions was reported in 27.8% and 30.0% of participants, respectively.

Table 2: Distribution of Hepatocellular Carcinoma According to Liver Segments

Liver Segment	Frequency (n)	Percentage (%)
Segment II	22	15.7
Segment III	35	25.0
Segment IV	32	22.9
Segment V	23	16.4
Segment VI	9	6.4
Segment VII	12	8.6
Segment VIII	7	5.0

Analysis of lesion location according to Couinaud's liver segmentation revealed segment III as the most frequent site of HCC involvement, accounting for 25.0% (35/140) of cases. Segment IV was the second most common location with 22.9% (32/140), followed by segment V (16.4%, 23/140) and segment II (15.7%, 22/140). The right posterior segments (VI and VII) and segment VIII demonstrated lower frequencies at 6.4%, 8.6%, and 5.0%, respectively.

Table 3: Imaging Characteristics of Hepatocellular Carcinoma on CECT

Imaging Feature	Category	Frequency (n)	Percentage (%)
Lesion Margins	Irregular	82	58.6
	Regular/Well-defined	58	41.4
Liver Parenchymal Appearance	Normal	2	1.4
	Fatty Liver	126	90.0
	Fibrotic	12	8.6
Fibrotic Liver (Specific)	Present	10	7.1
	Absent	130	92.9

Regarding morphological characteristics, irregular lesion margins were observed in the majority of cases (58.6%, 82/140), while 41.4% (58/140) demonstrated regular, well-defined margins. Evaluation of background liver parenchyma revealed fatty liver changes in 90.0% (126/140) of patients, while fibrotic appearance was noted in 8.6% (12/140). An isolated fibrotic liver without significant fatty change was present in 7.1% of cases (10/140). Normal liver parenchymal appearance was observed in only 1.4% of patients (2/140).

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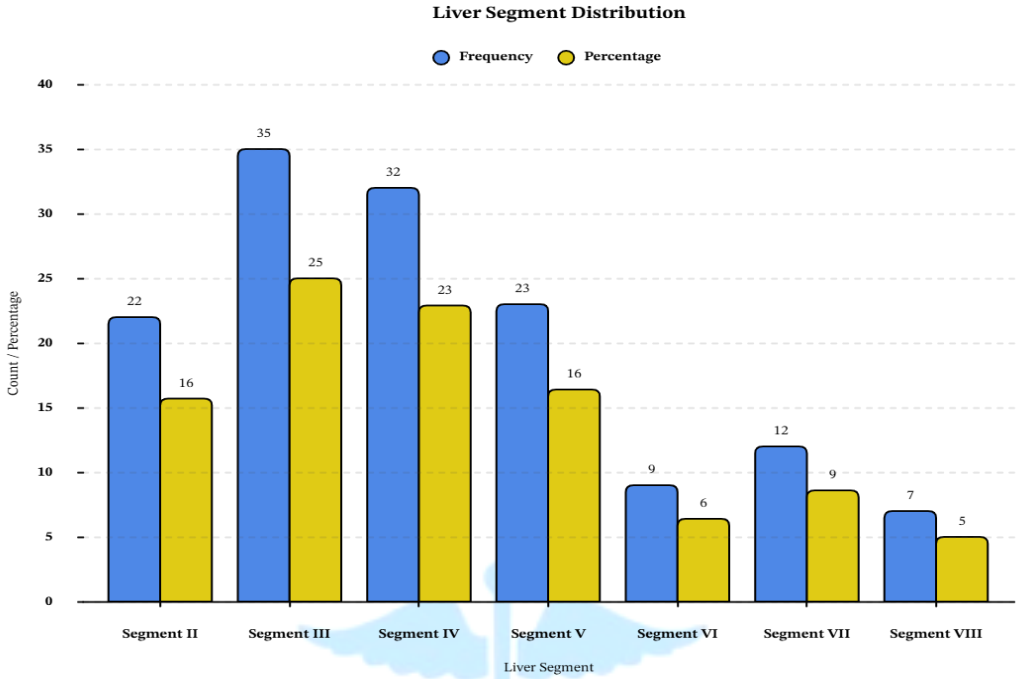
Figure 1: Distribution of HCC lesions across Couinaud's liver segments (n=140). Segment III was the most frequent location (25.0%), followed by segment IV (22.9%).



DISCUSSION

This study evaluated the role of contrast-enhanced computed tomography in assessing hepatocellular carcinoma in 140 patients with chronic liver disease. Our findings demonstrate that CECT provides detailed characterization of lesion location, margins, and background liver parenchyma, with a notable male predominance and segment III as the most common tumor location. These results align with established literature while offering region-specific insights relevant to Pakistan, where HCV infection is endemic.

The demographic profile of our cohort, characterized by a mean age of 52.4 years and a significant male predominance (3.8:1), aligns closely with established global epidemiological trends. Previous literature consistently reports a higher incidence of HCC in males, often attributed to both biological factors and higher exposure to risk factors such as chronic viral hepatitis and alcohol consumption [13, 14]. Clinical presentations in our study were dominated by abdominal distention (79.3%) and fatigue (65.0%), which are common indicators of advanced chronic liver disease or large tumor burdens, similar to symptomatic proportions reported in existing literature [15, 16].

The segmental distribution of HCC in our study showed a high frequency of involvement in Segment III (25.0%) and Segment IV (22.9%), followed by Segment V (16.4%). This finding presents an interesting contrast to some existing literature; for instance, Renzulli et al. identified Segment VIII as the most frequent site of HCC involvement (27.4%) in a large series of 322 nodules [17].

The predilection for the left lobe segments (III and IV) in our population might suggest variations in local hemodynamic factors or differences in the underlying distribution of liver parenchymal changes. Identifying the specific Couinaud segment is not merely a descriptive exercise but carries profound clinical significance, as lesion location directly dictates the feasibility of surgical resection, the choice of percutaneous ablation techniques, and the technical approach for transarterial chemoembolization (TACE) [17, 18].

Regarding morphological features, a majority of our patients (58.6%) demonstrated irregular lesion margins on CECT. In the context of the literature, regular, well-defined margins are typically associated with nodular HCC, whereas

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irregular margins often signify infiltrative growth patterns or the absence of a pseudo-capsule [16, 19]. Infiltrative HCC is known to be more aggressive, often associated with higher rates of vascular invasion and poorer prognosis [19]. The high prevalence of irregular margins in our cohort may reflect a late-stage presentation where tumors have already begun to permeate the surrounding parenchyma. CECT remains the cornerstone of HCC evaluation due to its ability to demonstrate these margins alongside hallmark vascular patterns, such as arterial phase hyperenhancement and portal-venous washout, which are essential for non-invasive diagnosis [16, 20].

A notable finding in this study was the high prevalence of fatty liver changes (90.0%) as the background parenchymal condition. While cirrhosis has traditionally been the primary precursor to HCC, there is an increasing recognition of HCC arising in the setting of non-alcoholic fatty liver disease (NAFLD), often even in the absence of advanced fibrosis [14, 21]. Our findings underscore this epidemiological shift, highlighting that fatty liver changes are a frequent background finding in contemporary HCC populations. The clinical significance of CECT in this context is paramount, as it allows for the simultaneous assessment of the tumor and the background liver, which is critical for comprehensive staging and treatment planning [20, 22, 23].

CONCLUSION

Contrast-enhanced computed tomography plays a vital role in the comprehensive evaluation of hepatocellular carcinoma in patients with chronic liver disease. This study demonstrates that CECT provides high sensitivity for HCC detection and offers detailed characterization of lesion location according to Couinaud's segmentation, margin assessment, and associated findings, including ascites and background parenchymal changes. The study confirms male predominance in HCC occurrence, with segment III being the most common tumor location. The high prevalence of fatty liver changes in the background parenchyma highlights the increasing importance of metabolic risk factors in HCC pathogenesis. These findings support the continued use of multiphasic CECT as a primary imaging modality for HCC diagnosis, characterization, and treatment planning in clinical practice.

LIMITATIONS

The limitations of this study include its single-center design, which may limit the generalizability of the findings to populations with different demographic characteristics and risk factor distributions. Histopathological confirmation of hepatocellular carcinoma was not available for all lesions. It is recommended that further longitudinal studies be conducted.

FUNDING

None declared.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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