Ultrasound versus Triphasic Computed Tomography Liver Imaging Reporting and Data System in Suspected Hepatocellular Carcinoma

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Abstract

Background: Computed Tomography (CT) liver imaging reporting and data system (LIRADS) offers substantial inter reader reliability for 3 essential criteria and category assignment. The ultrasound (US) LI RADS standardizes the approach, interpretations, and documenting of screening and surveillance US intended to determine hepatocellular carcinoma (HCC) in high - risk individuals.

Objectives: To assess correlation between US and CT in LIRADS for hepatocellular carcinoma patients.

Patients and methods: it's a prospective study that was performed on 20 adult cases with cirrhosis due to hepatitis B and C. All cases underwent CT, US examination, triphasic CT with contrast and biopsy taking.

Results: As regards the diameter of the lesions, there were significant differences between both groups (p value =0.002). All cases were correlated by histopathological confirmation. Regarding to the final outcome depending on histopathological finding, comparison with other imaging modalities as U/S or, specific triphasic CT criteria /or follow up of cases, which were accepted as a standard reference 16 patients (80%) correlated by histopathological confirmation ; 4 patients (2 hemangioma &2 atypical hemangioma) (20%) not correlated by histopathological correlation and confirmed by triphasic CT because risk of intra-abdominal bleeding.

Conclusion: US serves as an effective initial imaging modality, particularly for identifying hypoechoic lesions. In contrast, triphasic CT provides essential insights through its detailed assessment of arterial enhancement, washout characteristics, and capsule appearance, all of which are vital to distinguish HCC from non-HCC lesions.

Keywords: Ultrasound; Triphasic Computed Tomography; Hepatocellular Carcinoma; Hepatitis B.

DOI: 10.21608/SVUIJM.2025.390286.2184

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Received: 1 July,2025.

Revised: 26 July, 2025.

Accepted: 5 August, 2025.

Published: 7 August, 2025

Cite this article as Heba Allah Moataz Mostafa Gomaa, Sherif Abdelfattah Saber, Mahmoud Abdelaziz Dawoud, Naglaa Samy Fahmy Abou Taira. (2025). Ultrasound versus Triphasic Computed Tomography Liver Imaging Reporting and Data System in Suspected Hepatocellular Carcinoma. SVU-International Journal of Medical Sciences. Vol.8, Issue 2, pp: 371-383.

Introduction

Hepatocellular carcinoma (HCC) ranks as the third leading cause of cancer-related mortality globally and is the sixth most frequently diagnosed cancer. In Egypt, HCC represents a significant public health concern **(Forner et al., 2012)**.

Major risk factors for HCC include Hepatitis B & C infections, as well as cirrhosis resulting from alcohol use or non-alcoholic causes. Curative treatments such as surgical resection, liver transplantation, and ablative therapies like radiofrequency ablation and transarterial chemoembolization are most effective when the disease is detected at an early stage. Therefore, early diagnosis and prompt intervention are vital for successful management of HCC patients **(Yang et al., 2019)**.

Screening strategies typically involve imaging techniques—such as ultrasound (US), Computed Tomography (CT) scans, and magnetic resonance imaging (MRI)—as well as blood tests for tumor markers like alpha-fetoprotein, usually conducted every six months **(Yang et al., 2019)**.

The Liver Imaging Reporting and Data System (LI-RADS) provides a standardized terminology and classification framework for interpreting imaging findings in liver lesions. It assigns a score to liver lesions, indicating their likelihood of being HCC **(Chernyak et al., 2018)**.

LI-RADS is specifically designed for use in patients with risk factors for HCC, including individuals with chronic hepatitis B (even without cirrhosis), as well as those with cirrhosis due to hepatitis B or C, alcoholic liver disease, or non-alcoholic causes.

However, it is not intended for cases of cirrhosis resulting from congenital hepatic fibrosis, vascular disorders such as Budd–Chiari syndrome, or for patients under 18 years of age. The system aims to reduce inconsistencies in how liver lesions are interpreted in at-risk individuals.

The LI-RADS scoring system ranges from LR-1, indicating a benign lesion, to LR-5, which suggests a high probability of malignancy **(Goins et al., 2023)**. The US LI-RADS (US LI-RADS) standardizes how screening and surveillance USs are performed, interpreted, and reported in patients at high risk for hepatocellular carcinoma. This group includes individuals with cirrhosis from any cause and certain patients with chronic hepatitis B infection **(Son et al., 2019)**.

The US LIRADS scheme is composed of an US category and a visualization score: US categories define the exam as negative, subthreshold, or positive and direct next steps in management **(Son et al., 2019)**.

The US LI-RADS framework consists of two main components: an US category and a visualization score. The US category classifies the exam as negative, subthreshold, or positive, and helps guide subsequent clinical management.

This work aimed at assessing correlation between US and CT in LI-RADS for HCC cases.

Patients and methods

This prospective study was performed on twenty adult cases of both sexes, with cirrhosis secondary to chronic HBV&HCV infection.

The study was done from October 2022 to October 2023. Following obtaining the approval from the Ethical Committee Tanta University, Tanta, Egypt. We asked the participants or their relatives for informed written consent.

Exclusion criteria included cirrhosis secondary to vascular disorders, congenital causes, hypersensitivity to contrast media, patients with renal impairment and pregnant females.

All cases underwent complete history taking, recent Cr levels, history of any allergy to contrast material, vital signs, US examination, triphasic CT with contrast and biopsy taking.

Ultrasound examination

Using Siemens USA machine with convex probes produces a frequency of 3.5MHZ that was connected with printing facility via digital graphic printer (Mitsubishi Corporation, Japan).

Triphasic CT with contrast

Using 320 multidetector CT Scanner (Aquilion One; Toshiba medical systems, Ohtawara, Japan) and Optima GE 660.128 slices CT.

Biopsy

The lesions were categorized into 2 groups: HCC group and non-HCC group.

Diagnosing LR-3, LR-4 and LR-5 lesions were established:

Histological findings after biopsy or surgery. Cases without biopsy or operation, diagnosing HCCs depend upon (the history of chronic viral hepatitis and/or cirrhosis and consistent findings (concerning HCC) at CT images). Thereafter, the lessons were applied to the HCC group.

LR-1 & -2 lesions were diagnosed using cross-sectional imaging technique (such as US, CT) follow-up, histopathology if available, cases with pathologically proved benign lesions, in addition to those without pathological confirmation, were allocated in the non-HCC group. The findings will be correlated by histopathological findings.

Statistical analysis

All the data were coded, computed for analysis via Statistical Package for Social Sciences (SPSS) version 26 for Windows (IBM Corp., Armonk, N.Y., USA). Qualitative data were represented as frequencies and relative percentage. The Shapiro-Wilk test for normality was performed and showed normal distribution. Expression of Quantitative data was in the form of mean ± SD, and comparisons between two groups were carried out using student T-test. As regards P-value: P-value <0.05 was considered significant, whereas that greater than 0.05 was considered not significant, and that less than 0.01 was considered highly significant.

Results

Age, sex, number of focal lesions distribution, diameter of lesions in US, CT, US findings and US LIRAD score of the studied patients were enumerated at (**Table.1**).

Table1. Age, sex, number of focal lesions distribution, diameter of lesions in US, CT, US findings and US LIRAD score of the studied patients

Variables		N = 20
Age (years)		59.350±8.487
Sex	Male	12(60.0%)
	Female	8(40.0%)
No of focal lesion	One	13 (65.00%)
	Two	4 (20.00%)
	Three	1 (5.00%)
	Four	2 (10.00%)
	32	20 (100.00%)
US Size of lesion (mm)		30.25±17.519
CT Size of lesion (mm)		39.35±22.203
US Finding	Hypo echoic focal lesion	16 (80.00%)
	Hyper echoic focal lesion	2 (10.00%)
	Isoechoic focal lesion	2 (10.00%)
	Total	20 (100.00%)
US LIRAD	Negative	2 (10.00%)

score	**Sub threshold**	1 (5.00%)
	Positive	17 (85.00%)
	Total	20 (100.00%)

Data are presented as mean ± SD or frequency (%). CT: Computed Tomography. LIRAD: Liver Imaging Reporting and Data System, US: ultrasound.

CT findings, CT LIRAD score, HCC and Non-HCC among studied patients were enumerated at (**Table. 2).**

Regarding age, sex, no significant differences were documented between both groups. Concerning the diameter of the lesion, a statistically significant difference between 2 groups was proved (p value =0.002). (**Table. 3).**

Table 2. CT findings, CT LIRAD score, HCC and Non-HCC among studied patients

Variables		**N=20**
CT findings		
Arterial enhancement		16(80.0%)
Venous washout		10(50.0%)
delayed enhancement		2(10.0%)
CT LIRAD score		
LIRAD 1		2(10.0%)
LIRAD 2		2(10.0%)
LIRAD 3		5(25.0%)
LIRAD 4		1(5.0%)
LIRAD 5		10(50.0%)
Total		20(100.0%)
HCC group	**HCC**	10(50.0%)
	Non-HCC	10(50.0%)
Non-HCC group	**Metastasis**	6(60.0%)
	Hemangioma	2(20.0%)
	Atypical hemangioma	2(20.0%)

Data is presented as frequency (%). CT: Computed Tomography. LIRAD: Liver Imaging Reporting and Data System. HCC: hepatocellular carcinoma.

Table 3. Age, sex, the major features in US LI-RADS distribution and major CT LI-RADS imaging among studied patients

Variables		**HCC group**			
		HCC	**Non-HCC**	**t**	**P-value**
Age		60.200±9.578	58.500±7.663	0.438	0.666
Chi-Square				**X^2**	**P-value**
Sex	**Male**	8(80.0%)	4(40.0%)	3.333	0.068
	Female	2(20.0%)	6(60.0%)		
Major features in US LI-RADS distribution					
Size of lesion (mm)		41.50±13.954	19.00±13.115	2.740	0.002*
Finding	**Hypo echoic focal lesion**	10(100.0%)	6(60.0%)	5.000	0.082
	Hyper echoic focal lesion	0(0.0%)	2(20.0%)		
	Iso echoic focal lesion	0(0.0%)	2(20.0%)		
LIRAD score	**Negative**	0(0.0%)	2(20.0%)	3.529	0.171
	Sub threshold	0(0.0%)	1(10.0%)		
	Positive	10(100.0%)	7(70.0%)		

Major CT LI-RADS imaging					
Size of lesion (mm		54.500±15.89	24.200±16.954	2.896	0.005*
LIRAD score	**LIRAD 1**	0(0.0%)	2(20.0%)	20.000	<0.001*
	LIRAD 2	0(0.0%)	2(20.0%)		
	LIRAD 3	0(0.0%)	5(50.0%)		
	LIRAD 4	0(0.0%)	1(10.0%)		
	LIRAD 5	10(100.0%)	0(0.0%)		
Arterial enhancement		10(100.0%)	6(60.0%)	5.000	0.025*
Venous washout		10(100.0%)	4(40.0%)	20.000	<0.001*
Capsule		4(40.0%)	0(0.0%)	5.000	0.025*

Data are presented as mean ± SD or frequency (%). *: significant p value (< 0.05). X^2: chi-square test. T: student t-test. SD: standard deviation. CT: Computed Tomography. LIRAD: Liver Imaging Reporting and Data System, US: ultrasound.

All cases are correlated by histopathological confirmation. Regarding to the final outcome of the studied 20 patients depending on histopathological finding, comparison with other imaging modalities as U/S or, specific triphasic CT criteria /or follow up of the cases, which were accepted as a standard reference 16 patients (80%) correlated by histopathological confirmation ; 4 patients (2 hemangioma &2 atypical hemangioma) (20%) not correlated by histopathological correlation and confirmed by triphasic CT because risk of intra-abdominal bleeding. (**Table.4)**

Table 4. US LIRAD, CT LIRAD scores, histopathological confirmation of HCC &NON-HCC group

US		
LIRAD score	**Negative**	2(10.0%)
	Sub threshold	1(5.0%)
	Positive	17(85.0%)
CT LIRAD score		
LIRAD score	**LIRAD 1**	2(10.0%)
	LIRAD 2	2(10.0%)
	LIRAD 3	5(25.0%)
	LIRAD 4	1(5.0%)
	LIRAD 5	10(50.0%)
Histopathological confirmation		
Conformation	**No**	4(20.0%)
	Yes	16(80.0%)
		10 HCC patients and 6 metastasis patients

Data is presented as frequency (%). CT: Computed Tomography. LIRAD: Liver Imaging Reporting and Data System, US: ultrasound.

CT LIRAD score can predict HCC compared to histopathological confirmation with sensitivity (50.0%), specificity (58.3%), PPV (44.4%), NPV (63.6%), and accuracy (55.0%). However, at US LIRAD score can't predict HCC compared to histopathological confirmation sensitivity (87.5%), specificity (16.67%), PPV (41.2%), NPV (66.7%), and accuracy (45.0%). (**Table. 5).**

Table 5. Diagnostic value of CT LIRAD scores and US LIRAD score compared to histopathological confirmation.

Variables	CT LIRAD score	US LIRAD score
True positive	4	7
True negative	7	2

False positive	5	10
False negative	4	1
McNemar test	**1**	**0.012***
Kappa	0.082	0.035
Sensitivity	50.0%	87.5%
Specificity	58.3%	16.7%
PPV	44.4%	41.2%
NPV	63.6%	66.7%
Accuracy	55.0%	45.0%

Data are presented as frequency (%). PPV: Positive predictive value, NPV: Negative predictive value, US: ultrasound.

Case 1: A- 57-y-old male cases with cirrhotic liver present with abdominal discomfort. On US: Cirrhotic liver. Hypoechoic mass at right lobe of the liver at segment V measure 30 mm x20mm. No intra hepatic biliary radical dilatation. (**Fig.1).** Using US LIRAD table the lesion is categorized as US 3 positive Triphasic CT. (**Fig.2).**

Using LIRAD system: The lesion is categorized as LR-5: Definitely HCC. (**Table.5).**

Final diagnosis: A biopsy was obtained from this lesion for histopathological examination that concluded confirmed HCC group.

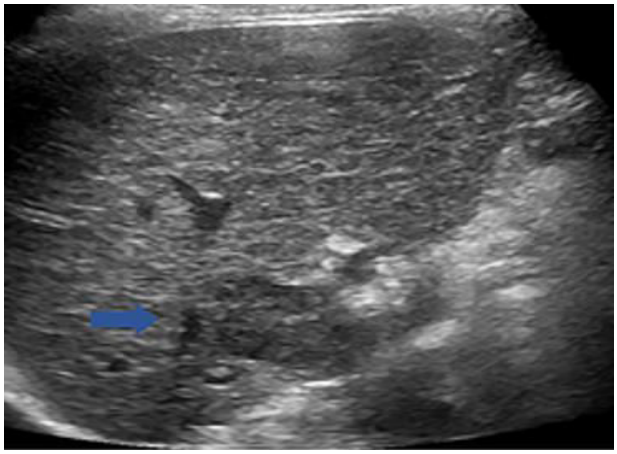
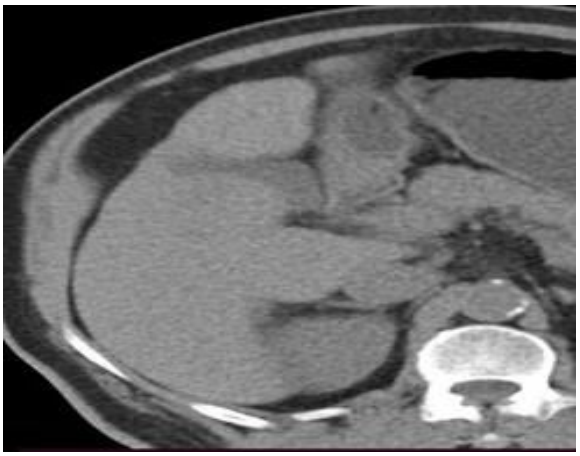
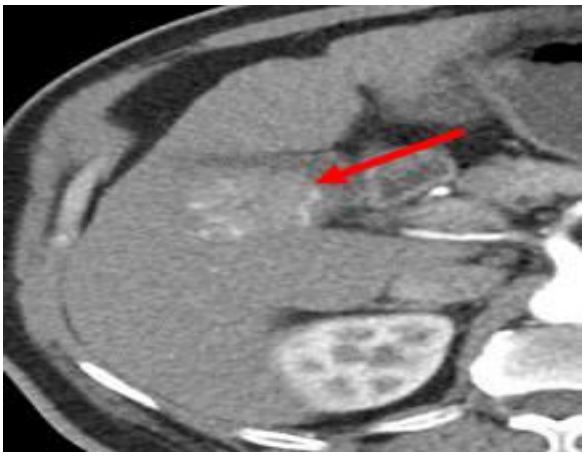


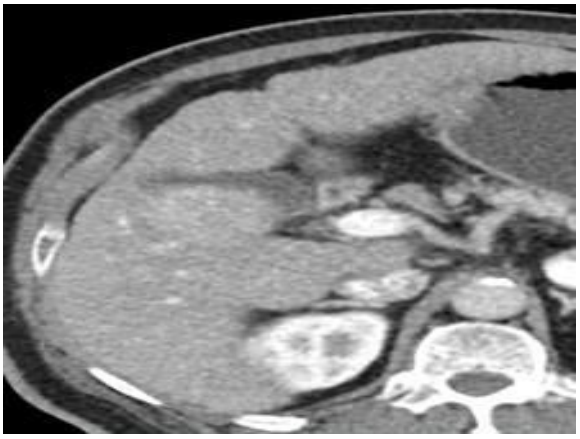
Fig.1. On US: Cirrhotic liver. Hypoechoic mass at right lobe of the liver at segment V measure 30 mm x20mm. No intra hepatic biliary radical dilatation



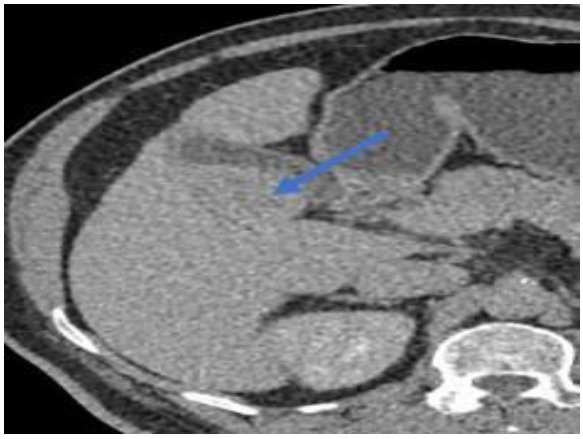
(A)



(B)



(C)



(D)

Fig.2. (A) Axial CT images prior to contrast administration, (B) after contrast administration at arterial phase, (C) Porto Venous phase and (D) delayed phase reveal hepatic cirrhosis , focal lesion in the Rt lobe at segment V measure 45 mm show enhancement at arterial phase (detected by the red arrow)with enhancing capsule and wash out at delayed phase (blue arrow)

Table 5. CT LIRADS for case (1)

APHE			**No APHE**		**Nonrim APHE**
Observation Size (mm)		Less than 20	Equal to or more than 20	Less than 10	10–19
Count Additional Major Features	None	[LR-3]	[LR-3]	[LR-3]	[LR-4]
	One	[LR-3]	[LR-4]	[LR-4]	[LR-5]
	≥ Two	[LR-4]	[LR-4]	[LR-4]	[**LR-5**] (**circled**)

APHE = Arterial Phase Hyperenhancement. Major Features include Enhancing "capsule", Nonperipheral "washout" and Threshold growth. LI-RADS Categories: LR-3: Intermediate probability( ) , LR-4: Probably HCC( ) and LR-5: Definitely HCC ( ).

Case 2: A -48-y-old female cases with hepatic focal lesion detected incidentally by US. Well defined hyperechoic lesion in right lobe mainly segments 7. US features are classic for benign lesion. **(Figs 3, 4).**

Using LIRAD system: The CT findings are consistent with hemangioma. According to LIRADS, it is categorized as LR-1 (Definitely benign). So, no need for LIRADS table.

Final diagnosis: Triphasic CT finding and correlations with US confirmed that the lesion is benign hepatic hemangioma (non-HCC group).

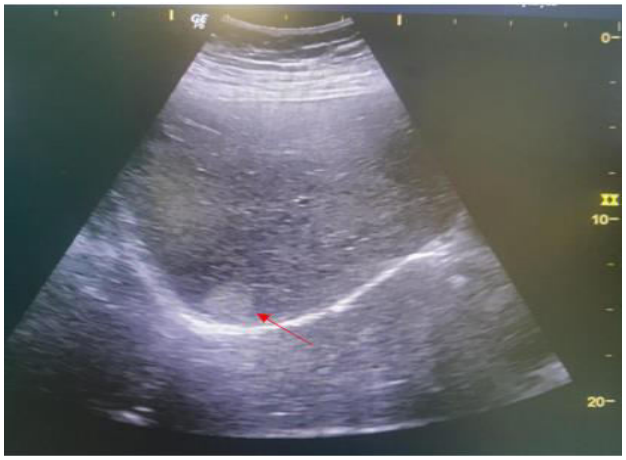
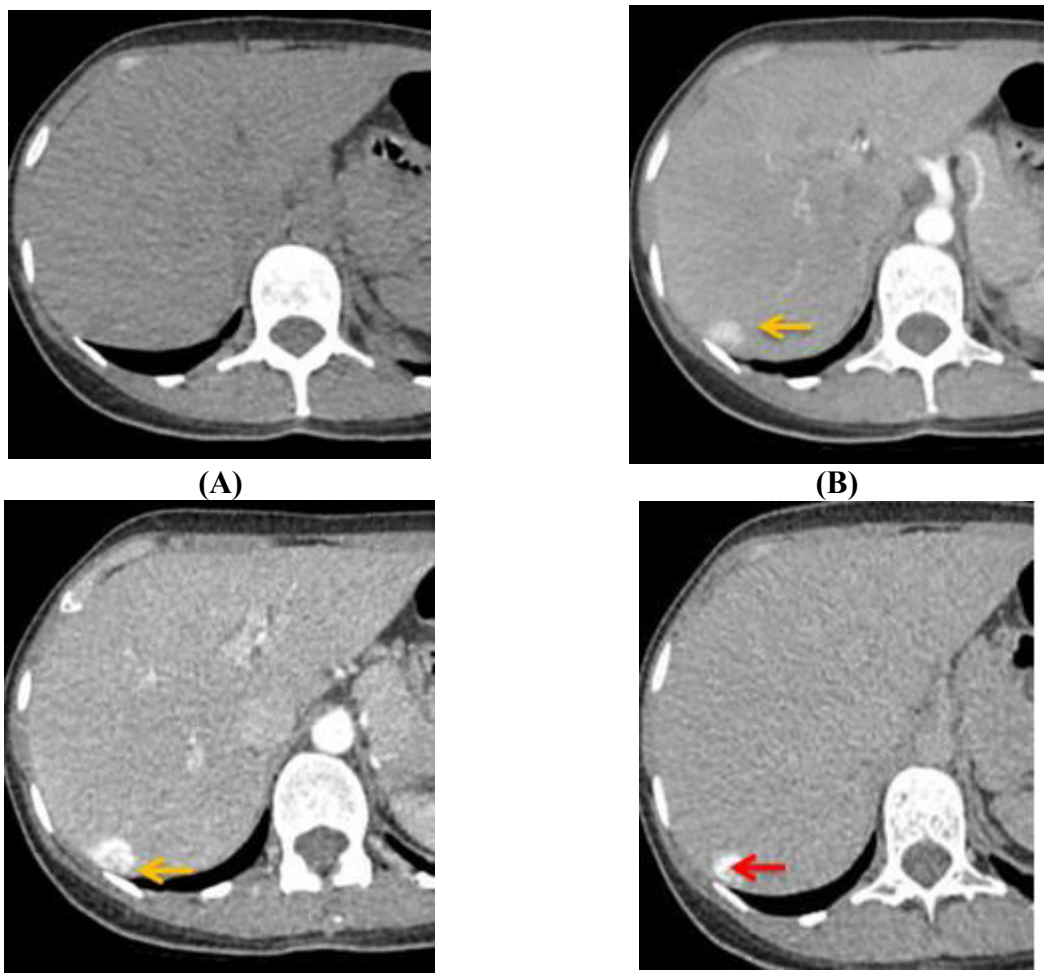


Fig.3. On US. Well defined hyperechoic lesion in right lobe mainly segment vII. US features are classic for benign lesion. On US LIRAD US-1 Negative .



(A) **(B)**

(C) **(D)**

Fig.4. Axial CT images obtained prior to contrast administration (A), after contrast administration at arterial phase (B), porto-venous phase (C) and delayed phase (D) revealed a 19-mm right hepatic lobe focal lesion at segment VII revealing hyper-enhancement at arterial and porto-venous phases (yellow arrows) and no washout at delayed phases (red arrow)

Case 3: A -50-y-old female cases with hepatic focal lesion detected incidentally by US. Enlarged liver: Well, defined isoechoic lesion at segment IV a. measure 15 mmx15mm No intra hepatic biliary radical dilatation. **(Figs 5, 6).** Using US LIRAD the lesion is categorized US 3 positive Triphasic CT (**Fig.6).**

Using LIRAD system: The CT findings are consistent with atypical hemangioma. According to LIRADS, it is categorized as LR-2 (probably benign). So, no need for LIRADS table.

Final diagnosis: Triphasic CT findings confirmed that the lesion is hepatic atypical hemangioma (non-HCC group).

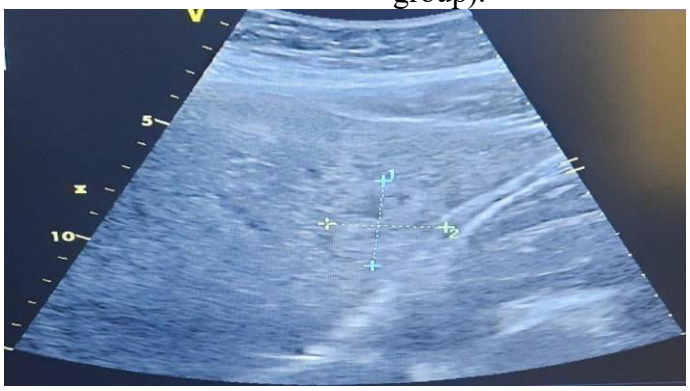
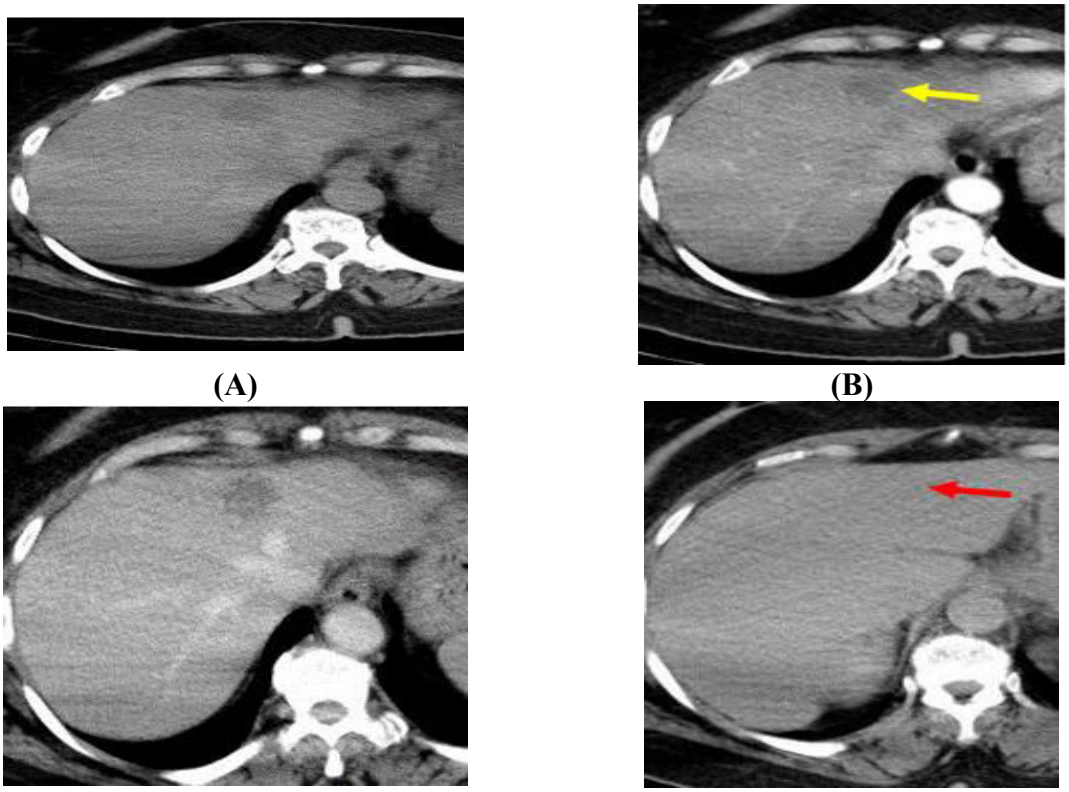


Fig. 5: On US . Enlarged liver: Well, defined isoechoic lesion at segment IV a. measure 15 mmx15mm No intra hepatic biliary radical dilatation



(A) **(B)**

(C) **(D)**

Fig. 6. Axial CT images before contrast administration (A) and after contrast administration at arterial phase (B) Porto Venous phase (C) and delayed phase (D) show left hepatic lobe focal segment IV A measure 20 mm show peripheral arterial nodular enhancement(B) (yellow arrow) with iso dense at delayed phase (D) (red arrow)

Discussion

Indeed, HCC ranks as the 3rd leading cause of cancer-related deaths globally and is the 6th most commonly diagnosed malignancy. In Egypt, it poses a significant public health concern, accounting for 33.63% of cancers in men and 13.54% in women.

Risk factors for HCC include HBV& HCV infections, alcoholic liver disease, and non-alcoholic cirrhosis. Unfortunately, HCC is often diagnosed at an advanced stage, leading to a poor prognosis **(Ganesan and Kulik, 2023)**.

In our study, the LI-RADS US-3 category demonstrated elevated specificity (one hundred percent) yet low sensitivity (43.3%) for detecting hepatocellular carcinoma (HCC). Overall, the sensitivity of US LI-RADS in identifying HCC tends to be below average. Previous studies have reported US sensitivity for HCC detection ranging from 20.5% to 94%**(Shapiro et al., 1996 ;Tzartzeva et al., 2018)**. These results are consistent with a meta-analysis that estimated a sensitivity of 47% for identifying early-stage HCC **(Tzartzeva et al., 2018)**.

Among studies using the US LI-RADS system, Tillman et al. **(Tzartzeva et al., 2018)** also reported a sensitivity of approximately 47%. However, this contrasts with findings from Millet et al.**(Millet et al., 2019)** where US LI-RADS demonstrated a much higher sensitivity of 82.4% for HCC detection.

Each of the 20 patients were assessed according to the major criteria of US LI-RADS. As regards the diameter of the lesions, a significant difference between both groups was determined (p value =0.002).

There has been ongoing discussion about combining US with AFP testing or MRI for more effective monitoring of patients at risk for HCC. Recent research indicates that abbreviated MRI protocols—utilizing fewer imaging sequences and excluding dynamic contrast imaging—may have pros over conventional MRI. These shorter MRI exams not only demonstrate higher sensitivity (ranging from 82.6% to 85.2%) but also significantly reduce scan time, sometimes to as little as 5 min.**(Tillman et al., 2018)**.

One of the key advantages of CT LI-RADS is that it enhances communication between radiologists and clinicians. The CT LI-RADS diagnostic algorithm assigns each liver observation in high-risk patients a category ranging from LR-1 to LR-5, indicating the probability of hepatocellular carcinoma. Studies have shown that interobserver agreement in LI-RADS categorization is strong, and the use of structured LI-RADS reporting contributes to greater consistency in radiology reports.

In our results, Comparison between the two group concerning the major features in CT LIRADS: Each of the 20 patients were assessed according to the major features of CTLI-RADS. There was a significant difference between both groups.

Such finding result didn't agree with Park, et al. **(Park et al., 2021)** who found in their study that the median size of HCC and non-HCC malignancy was 29.3 mm and 36.2 mm, respectively without statistically significant differences between 2 groups.

Schellhaas, et al. **(Schellhaas et al., 2016)** observed no significance in tumor size between the 2 groups as regard features of LI-RADS

However, Alhasan, et al. **(Alhasan et al., 2019)** agree with these results as he stated that larger observation diameter can predict HCC diagnosis as he found in 59 patients, as there were significant differences in diameter of lesion between HCC lesion compared to all lesions regarding features of LI-RADS **(Ludwig et al., 2019)**.

The enhancement pattern plays a crucial role in accurately evaluating HCC. Typically, HCC lesions show strong enhancement during the late arterial phase

(around 35 seconds after contrast administration), followed by rapid washout in the portal venous phase. During this phase, the lesion becomes less distinct or appears hypoattenuating relative to the surrounding hepatic tissue.

Arterial phase hyper-enhancement was the commonest observed major criterion as detected in our study in16/20 and was seen more frequently in HCC lesions than non-HCC lesions (100 % vs 80%) with significant differences between both groups (p value=0.025), Washout appearance was the 2nd frequent observed major criterion, documented in our study in 10/20 (50%of lesions), and was seen only in HCC lesions with statistically significant difference between two groups.

These results match with the results of Ludwig, et al. **(Ludwig et al., 2019)** who found that APHE were seen more frequently in HCC lesions (87%) than non-HCC lesions (26%). Also, washouts were seen more in HCC lesions (72%) than non-HCC lesions (16%) so both APHE and washout show a statistically significant difference between 2 groups.

In the study of Park, et al. **(Park et al., 2021)**, both APHE and washout show statistically significant difference between two groups.

Based on the tumor capsule, rim enhancement on delayed post-contrast images leading to a capsule-appearance can be considered relatively specific for HCC **(Ludwig et al., 2019)**.

Capsule appearance was seen only on 4/20 (20 % of lesions) and was observed only in HCC lesions with statistically significant difference between two groups.

These findings are similar to findings of Ludwig DR, et al. **(Ludwig et al., 2019)** who found that capsule was seen in 56% of HCC lesions and 21% of non-HCC lesions so significant differences were determined between both groups (p value <0.001). Also, Kim YY, et al. **(Son et al., 2019)** stated that the capsule was seen in (62%) of HCC lesions while was seen in (11%) of non-HCC lesions so there was significant difference between two groups.

Unfortunately, the incidence of HCC is rising due to multiple contributing factors, including the implementation of more advanced surveillance programs, an aging population of hepatitis C virus (HCV) patients benefiting from improved treatments, and the increasing prevalence of Western lifestyle habits. These factors have led to a higher occurrence of non-alcoholic steatohepatitis (NASH), which is strongly linked to HCC development—Venook et al. **(Venook et al., 2010)**. Importantly, a notable proportion of patients with NASH may progress to HCC even in the absence of cirrhosis, as noted by Kolly et al. **(Kolly and Dufour, 2016)** Furthermore, a large retrospective study revealed that individuals with non-alcoholic fatty liver disease are monitored less frequently than those with liver disease due to alcohol use or HCV infection. As a result, patients with NASH are less likely to be included in routine surveillance programs unless they have already developed cirrhosis **(Mittal et al., 2015)**.

The limitations of the study are the small sized sample in addition to few research papers concerning examining US-LI-RADS since it's a relatively novel algorithm.

Conclusion

US serves as an effective initial imaging modality, particularly for identifying hypoechoic lesions. In contrast, triphasic CT provides essential insights through its detailed assessment of arterial enhancement, washout characteristics, and capsule appearance, all of which are vital for distinguishing HCC from non-HCC lesions.

Acknowledgments: Nil

Financial support and sponsorship: Nil

Conflict of Interest: Nil

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