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EVALUATION OF IMAGE QUALITY AND LESION CONSPICUITY IN HEPATIC IMAGING USING TRIPLE-PHASE MULTI-DETECTOR COMPUTED TOMOGRAPHY

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Abstract

Aim: To evaluate image quality and lesion conspicuity of hepatic lesions using triple-phase Multi-Detector Computed Tomography (MDCT) and determine the diagnostic value of each phase

Methods: A cross-sectional observational study was conducted on 135 patients undergoing triple-phase MDCT for suspected hepatic lesions. Arterial, portal venous and delayed phases were acquired using a Siemens 128-slice MDCT scanner. Lesion conspicuity was graded on a 5-point scale by two experienced radiologists. Statistical analysis included descriptive measures, Chi-square test, and Friedman test to compare conspicuity across phases.

Results: Portal venous phase showed the highest conspicuity, with nearly 50% of lesions scoring 4–5, indicating good to excellent visibility. Arterial phase demonstrated moderate conspicuity, especially in hypervascular lesions, while the delayed phase highlighted washout patterns characteristic of malignant lesions. Although statistical differences between phases were not significant ($p > 0.05$), descriptive analysis showed clinically meaningful variation, with the portal venous phase offering the best lesion–liver contrast.

Conclusion: Triple-phase MDCT provides comprehensive evaluation of hepatic lesions. The portal venous phase yields maximum conspicuity, while arterial and delayed phases offer essential complementary information, improving overall diagnostic confidence.

Key Words: MDCT, HCC, CNR, KFT, CT

INTRODUCTION

Hepatic lesions present a wide range of pathological entities, including benign conditions such as cysts, hemangiomas, and focal nodular hyperplasia, and malignant lesions such as hepatocellular carcinoma (HCC), cholangiocarcinoma, and metastatic disease[1]. Accurate identification and characterization of these lesions are essential for selecting appropriate treatment strategies, as benign lesions may only require follow-up while malignant lesions often demand surgical, locoregional, or systemic therapy[2].

Imaging plays a pivotal role in this diagnostic process because clinical and laboratory findings alone are often insufficient for precise characterization[3]. Among the available modalities, Multi-Detector Computed Tomography (MDCT) has gained prominence due to its ability to acquire thin slices rapidly, reconstruct images in multiple planes, and provide excellent spatial and contrast resolution[4]. These advantages make MDCT indispensable in modern hepatobiliary imaging.

The development of triple-phase MDCT protocols has further enhanced diagnostic accuracy by exploiting the dual vascular supply of the liver. The arterial phase captures hypervascular lesions such as HCC, the portal venous phase offers optimal parenchymal enhancement and lesion-to-liver contrast, and the delayed phase demonstrates washout or retention patterns characteristic of malignancy[5]. Together, these phases provide a comprehensive view of lesion vascularity, morphology, and enhancement dynamics.

One of the critical determinants of diagnostic success in liver imaging is lesion conspicuity, defined as the ease with which a lesion can be distinguished from adjacent parenchyma[6]. High conspicuity allows radiologists to identify small or subtle lesions and improves confidence in differentiating benign from malignant patterns. Conversely, poor conspicuity may result in under-detection or misclassification, directly affecting patient outcomes[7]. Evidence suggests that the portal venous phase generally offers the best conspicuity because of uniform hepatic enhancement, though arterial imaging is indispensable for hypervascular tumors and delayed

imaging for confirming malignant washout[8]. Demonstrated the reliability of MDCT in detecting hepatic mass lesions, particularly highlighting the portal phase[9]. Emphasized the diagnostic utility of triphasic CT in differentiating benign from malignant focal lesions[10].
Despite these findings, limited literature has systematically evaluated lesion conspicuity across all phases with quantitative rigor. This forms the rationale of the present study, which aims to assess image quality and lesion conspicuity of hepatic lesions using triple-phase MDCT, thereby providing phase-wise evidence that can guide routine clinical protocols.

2. MATERIALS AND METHODS

This research was conducted as a cross-sectional observational study aimed at evaluating image quality and lesion conspicuity of hepatic lesions using triple-phase MDCT. The study was carried out in the Department of Radiology, Nims Hospital, Jaipur, which functions as a tertiary care centre and receives a wide variety of hepatobiliary cases. The study was conducted over a period of 18 months, providing sufficient time for patient recruitment, image acquisition, and data analysis. A total of 132 patients were included in the study. The sample size was derived statistically using a diagnostic accuracy rate of 90.5%, a 95% confidence interval, and a margin of error of 5%, ensuring methodological rigor and representativeness.

2.2 Inclusion Criteria

Patients were recruited prospectively from the hospital's outpatient department. The inclusion criteria ensured that the study population represented individuals most likely to benefit from imaging evaluation. Adults between 35 and 75 years of age who presented with known or suspected hepatic lesions and were clinically fit to undergo intravenous contrast-enhanced imaging were included. The use of a defined age range helped to minimize confounding due to paediatric or geriatric extremes.

2.3 Exclusion Criteria

To ensure patient safety and the accuracy of imaging findings, several exclusion criteria were applied. Patients with renal impairment or abnormal kidney function tests (KFT) were excluded to prevent contrast-induced nephropathy. Pregnant women were not included due to the potential teratogenic risks of ionizing radiation. Individuals with a history of contrast allergy were excluded to avoid adverse reactions to iodinated agents. Finally, patients who had undergone previous liver surgery were excluded to eliminate potential confounding effects of postoperative anatomical distortion or scarring.

2.4 Imaging Protocol

All examinations were performed using a Siemens 128-slice Multi-Detector Computed Tomography (MDCT) scanner, which provided high-resolution imaging with rapid acquisition. Patients were positioned supine on the CT table, and breath-hold instructions were given to minimize motion artefacts. A non-ionic contrast agent was administered intravenously at a dosage of 1 mL/kg body weight. The contrast was injected at a rate of 4–6 mL/sec, and SmartPrep bolus tracking was used to optimize timing for arterial phase acquisition.
Three distinct imaging phases were obtained:

- Arterial phase, acquired at 25–30 seconds after injection, capturing peak hepatic arterial enhancement.
- Portal venous phase, acquired at 60–70 seconds, demonstrating maximum liver parenchymal enhancement.
- Delayed phase, obtained at 180 seconds, used to assess washout and delayed contrast retention.

Image reconstruction was performed in axial, coronal, sagittal, and oblique planes, along with advanced post-processing techniques including Maximum Intensity Projection (MIP) and Minimum Intensity Projection (MinIP) for better vascular and parenchymal visualization.

Image Assessment

Lesion conspicuity was systematically assessed to evaluate diagnostic performance. Each lesion was graded on a five-point scale:
1 = poor visualization,
2 = fair visualization,
3 = moderate conspicuity,
4 = good conspicuity, and
5 = excellent conspicuity.
Two independent radiologists with expertise in abdominal imaging evaluated the images. To reduce subjectivity, any discrepancies in scoring were resolved by consensus reading, ensuring reliability in data interpretation.

Statistical Analysis

Data analysis was performed using SPSS version 20 (IBM Corp., Armonk, NY, USA). Descriptive statistics were applied to summarize patient demographics, lesion characteristics, and conspicuity scores, with results expressed as frequencies, percentages, mean values, and standard deviations. For inferential analysis, the Friedman test was employed to compare conspicuity scores across the three phases (arterial, portal, delayed) as a non-parametric test for repeated measures. The Chi-square test was used to examine associations between categorical variables, such as benign versus malignant classification of lesions. A p-value < 0.05 was considered statistically significant.

RESULTS

A total of 135 patients were included. The mean age was 47.4 ± 20.1 years (range 18–85), and the sex distribution was 53% male and 47% female. These distributions establish a broadly representative adult cohort for evaluating conspicuity across phases of triple-phase MDCT. Lesion Characteristics the spectrum comprised HCC, hemangiomas, simple cysts, metastases, abscesses, and focal consolidations. The mean lesion size was 6.2 ± 3.2 cm. Anatomical distribution favored the right lobe (62%), followed by the left lobe (28%) and caudate/quadrate lobes (10%). Margins were well-defined in 56% and ill-defined in 44%, reflecting heterogeneous morphologies encountered in routine practice. Conspicuity across phases arterial phase Most lesions were graded 2–3 on the 5-point conspicuity scale, with 27.4% at score 3 (moderate clarity). Malignant lesions trended toward slightly higher conspicuity (consistent with hypervascularity), but the benign–malignant difference was not statistically significant (χ^2 p = 0.624) The full distribution is summarized in Table 1, and visualized in Figure 1.

Table 1 Distribution of Lesion Conspicuity Scores in the Arterial Phase of Triple-Phase MDCT

Conspicuity Score	Benign Lesions (n)	Malignant Lesions (n)	Total (n)	% within Phase (Benign + Malignant)
1 (Poor)	21	1	22	16.3%
2 (Fair)	31	2	33	24.4%
3 (Moderate)	36	1	37	27.4%
4 (Good)	21	0	21	15.6%
5 (Excellent)	22	0	22	16.3%
Total	**131**	**4**	**135**	**100%**

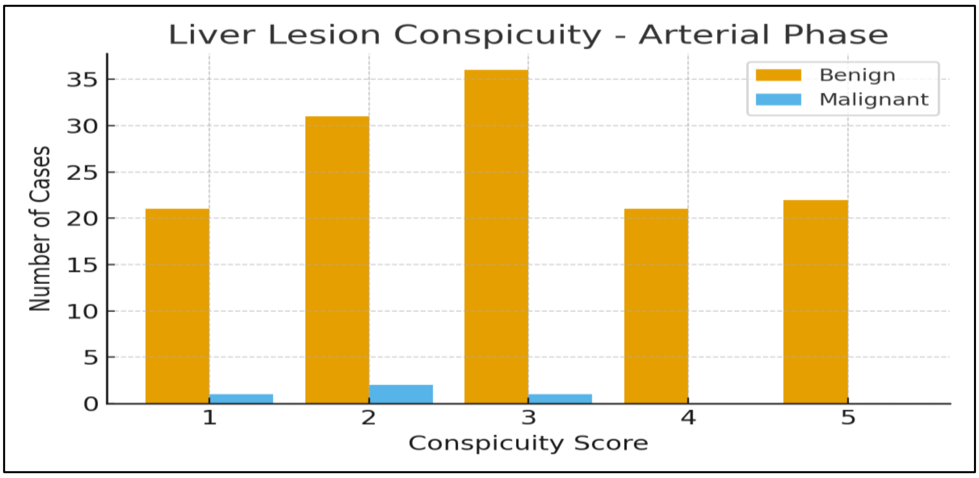

Figure 1 Bar chart depicting the distribution of liver lesion conspicuity scores (1–5) in the arterial phase of triple-phase MDCT. Benign lesions predominate across all conspicuity scores, while malignant lesions are relatively few and scattered, with a slight tendency toward low-to-moderate conspicuity (scores 1–3). The arterial phase highlights hypervascular lesions, yet overall conspicuity remains variable.

Portal venous phase conspicuity improved substantially: 22.2% of lesions were score 4 and 27.4% were score 5, yielding the best lesion–liver contrast among phases. Despite clearer visualization of malignant lesions than in the arterial phase, benign–malignant differences remained non-significant (χ^2 p = 0.504) Phase distribution is shown in Table 2 and Figure 2.

Table 2 Distribution of Lesion Conspicuity Scores in the Portal Venous Phase of Triple-Phase MDCT

Conspicuity Score	Benign Lesions (n)	Malignant Lesions (n)	Total (n)	% within Phase (Benign + Malignant)
1 (Poor)	24	2	26	19.3%
2 (Fair)	12	0	12	8.9%
3 (Moderate)	29	1	30	22.2%
4 (Good)	30	0	30	22.2%
5 (Excellent)	36	1	37	27.4%
Total	**131**	**4**	**135**	**100%**

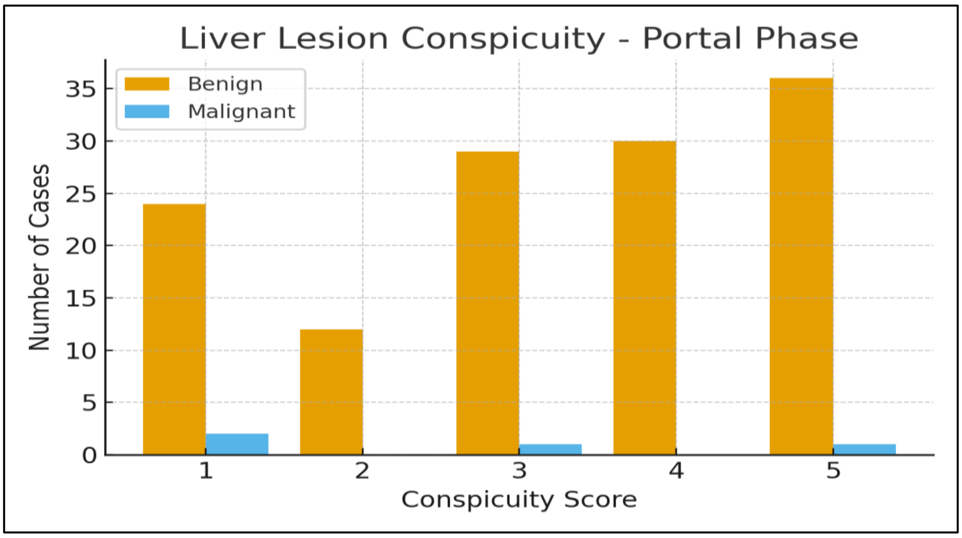

Figure 2 Bar chart showing conspicuity scores of liver lesions in the portal venous phase. The majority of lesions demonstrate high conspicuity (scores 3–5), with the best lesion–liver contrast observed in this phase. Malignant lesions, although limited in number, are more clearly discernible compared to arterial phase. This confirms the portal venous phase as the most diagnostically valuable phase for lesion detection and characterization.

Delayed phase Conspicuity decreased for many benign lesions (e.g., cysts, hemangiomas) due to isoattenuation with parenchyma, whereas malignant lesions (HCC, metastases) retained moderate visibility due to washout, with 28.1% at score 3 and 20.7% at score 4. The benign–malignant association remained non-significant (χ^2 $p = 0.676$) Phase distribution appears in Table 3 and Figure 3. A repeated-measures comparison of conspicuity across arterial, portal, and delayed phases using the Friedman test showed no statistically significant global difference ($p > 0.05$). Descriptively, the portal venous phase yielded the highest conspicuity overall, while the delayed phase contributed confirmatory washout for malignancy. The comparative pattern of benign vs malignant conspicuity across all three phases is presented in Figure 4.

Table 3 Distribution of Lesion Conspicuity Scores in the Delayed Phase of Triple-Phase MDCT

Conspicuity Score	**Benign Lesions (n)**	**Malignant Lesions (n)**	**Total (n)**	**% within Phase (Benign + Malignant)**
1 (Poor)	25	1	26	19.3%
2 (Fair)	23	1	24	17.8%
3 (Moderate)	36	2	38	28.1%
4 (Good)	28	0	28	20.7%
5 (Excellent)	19	0	19	14.1%
Total	**131**	**4**	**135**	**100%**

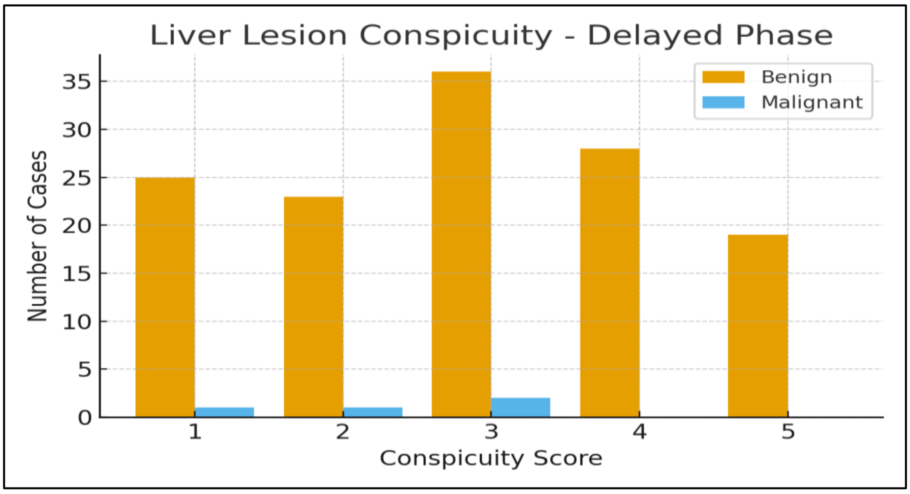

Figure 3 Bar chart illustrating conspicuity distribution in the delayed phase of triple-phase MDCT. Benign lesions demonstrate reduced conspicuity due to isoattenuation with hepatic parenchyma, whereas malignant lesions maintain moderate conspicuity (notably at score 3), reflecting the classical "washout" pattern. The delayed phase thus adds confirmatory value, particularly in identifying malignant enhancement dynamics.

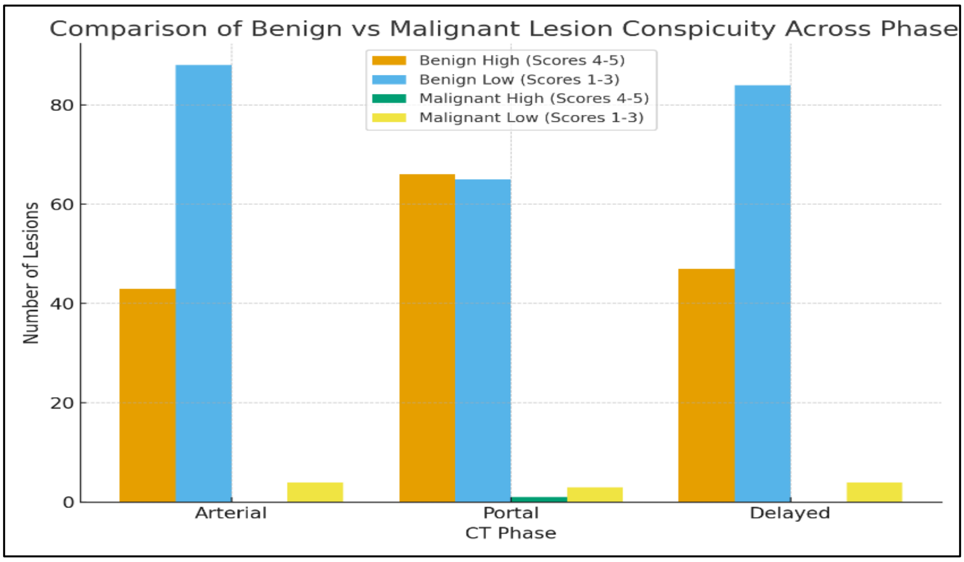

Figure 4 Clustered column chart illustrating the comparative distribution of benign and malignant liver lesions across conspicuity scores (1–5) for the arterial, portal venous, and delayed phases of triple-phase MDCT. Benign lesions dominate across all scores and phases, reflecting the higher prevalence in the study cohort. Malignant lesions, although fewer in number, consistently cluster around low-to-moderate conspicuity scores (1–3), with relative prominence in the delayed phase due to washout effect. The visualization highlights the complementary role of all three phases, with portal venous imaging showing maximum conspicuity contrast between benign and malignant lesions.

DISCUSSION

This study systematically evaluated image quality and lesion conspicuity of hepatic lesions across arterial, portal venous and delayed phases of triple-phase MDCT. Although inferential statistics did not reveal significant differences across phases, descriptive findings highlighted clinically meaningful patterns.

The arterial phase (Table 1, Figure 1) showed moderate conspicuity for most lesions, with 27.4% scoring level 3. Malignant lesions demonstrated slightly greater visibility owing to hypervascular enhancement, a recognized feature of hepatocellular carcinoma (HCC). However, conspicuity remained variable, and overall lesion detectability was not significantly different between benign and malignant groups (p=0.624). This reinforces that arterial imaging, while crucial for hypervascular lesions, is less consistent as a standalone diagnostic phase. The portal venous phase (Table 2, Figure 2) provided the highest conspicuity overall, with nearly half the lesions scoring 4 or 5, corresponding to good-to-excellent detectability. This aligns with the expected physiology: homogeneous hepatic enhancement optimizes lesion-to-parenchyma contrast. Although the statistical comparison between benign and malignant groups did not reach significance (p=0.504), descriptively, portal venous imaging yielded the clearest lesion visualization. In the delayed phase (Table 3, Figure 3), conspicuity decreased for many benign lesions such as cysts and hemangiomas due to isoattenuation with the surrounding parenchyma. In contrast, malignant lesions demonstrated persistent conspicuity because of washout, a hallmark of malignancy. Although only 20.7% of lesions were rated as score 4, the delayed phase proved useful as a confirmatory tool for malignant behavior.

When the three phases were compared collectively (Figure 4), benign lesions predominated across all categories, while malignant lesions clustered at lower conspicuity levels, particularly in the delayed phase where washout was observed. This reinforces the complementary role of triphasic imaging: arterial for hypervascularity, portal for maximal contrast, and delayed for washout confirmation.

Our findings mirror existing literature emphasizing the superiority of portal venous phase conspicuity. Naqvi et al. reported that triphasic CT provided reliable differentiation between benign and malignant focal lesions, with portal imaging offering the greatest diagnostic yield[1]. Similarly, Madhavi emphasized the portal phase as the most reliable for detecting hepatic masses[2], consistent with our observation that almost half of lesions achieved good-to-excellent conspicuity (Table 2). The arterial phase utility in HCC detection has been reported[3], who noted that arterial hypervascular enhancement can reveal small or early HCCs. Our study also demonstrated arterial enhancement in malignant lesions (Figure 1), but due to sample size constraints, statistical significance was not achieved.

Delayed imaging is known for its value in confirming malignant washout. Ruppert-Kohlmayr et al. demonstrated the critical role of multiphasic CT in distinguishing focal nodular hyperplasia from adenoma[4]. In our series, delayed phase conspicuity was lower overall (Table 3), yet malignant lesions retained moderate visibility, underscoring its confirmatory diagnostic role (Figure 3).Thus, while statistical power limited significance, the descriptive phase-wise patterns in our study align strongly with published evidence, affirming the robustness of triphasic MDCT protocols.

The findings underscore the necessity of all three phases in routine clinical protocols. Relying on a single phase risks under-detection or misclassification. The arterial phase is essential for hypervascular HCC and metastatic lesions. The portal venous phase consistently provided the best conspicuity (Table 2, Figure 2), making it the cornerstone for lesion detection. The delayed phase added confirmatory information through washout, a feature crucial for diagnosing HCC (Figure 3). In clinical practice, radiologists integrate these observations rather than depending on one phase. Conspicuity scoring, as applied in this study, provides a reproducible framework for quantifying lesion detectability and mirrors real-world radiological workflow.

A strength of this study was its structured phase-wise conspicuity scoring across a representative cohort of 135 patients, evaluated independently by two radiologists. The inclusion of diverse lesion types (benign and malignant) reflects everyday hepatology practice. However, limitations include the small number of malignant cases (only four), which limited statistical comparisons across phases (Figure 4). Additionally, conspicuity scoring, though clinically intuitive, is inherently subjective. Quantitative measures such as contrast-to-noise ratio (CNR) or texture analysis were not applied and may have strengthened the analysis.

Future studies should include larger cohorts with a higher proportion of malignant lesions to enhance statistical power. Integration of quantitative imaging biomarkers, such as CNR and radiomic signatures, could complement subjective conspicuity assessment. Emerging technologies like dual-energy CT and artificial intelligence–based segmentation may further improve lesion detectability and phase optimization[5].

CONCLUSION

Triple-phase MDCT remains indispensable in hepatic lesion imaging. Although statistical differences were not observed, the portal venous phase provided the best lesion conspicuity, while the arterial and delayed phases contributed essential complementary information. Together, these three phases maximize diagnostic accuracy, reinforcing the clinical value of a comprehensive triphasic protocol for reliable lesion characterization.

Conflict of Interest

The authors declare no conflict of interest regarding this study.

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Author Contribution

Bhanu Pratap: Concept, study design, data collection, manuscript writing
Bijendar Kumar Meena: Radiological evaluation and supervision
Rajesh Yadav: Data interpretation, review, and editing
Gourav Kumar: Imaging protocol assistance and literature review
Himanshu Tripathi: Administrative support, overall guidance

Ethical Approval

The study was approved by the Institutional Ethics Committee of Nims University Rajasthan, Jaipur. Written informed consent was obtained from all participants.

REFERENCES

1. Karhunen PJ. Benign hepatic tumours and tumour-like conditions in men. J Clin Pathol. 1986;39(2):183-8.
2. Boutros C, Katz SC, Espat NJ. Management of an incidental liver mass. Surg Clin North Am. 2010;90(4):699-718.
3. Hasan NM, Zaki KF, Alam-Eldeen MH, Hamedi HR. Benign versus malignant focal liver lesions: Diagnostic value of diffusion weighted MRI. Egypt J Radiol Nucl Med. 2016;47(4):1211-20.
4. Sangster GP, Previgliano CH, Nader M, Chwoschtschinsky E, Heldmann MG. MDCT imaging findings of liver cirrhosis: spectrum of hepatic and extrahepatic complications. HPB Surg. 2013;2013: 129396.
5. Tamkeen N, Wahid G, Ahmad A, Samad M, Rehman M, Afsar M. Role of tri-phasic CT in evaluation of hepatocellular carcinoma with liver cirrhosis. JGMD Sci. 2022;9(4):85-9.
6. Naqvi SM, Ali A, Naeem MA, Tariq M, Tariq F. Triphasic computed tomography scan as a non-invasive tool in differentiating benign and malignant focal liver lesions. Pak J Med Sci. 2020;36(5):953-8.
7. Ruppert-Kohlmayr AJ, Uggowitzer MM, Kugler C, Zebedin D, Schaffler G, Ruppert GS. Focal nodular hyperplasia and hepatocellular adenoma of the liver: differentiation with multiphasic CT. AJR Am J Roentgenol. 2001;176(6):1493-8.
8. Algarni AA, Alshuhri AH, Alonazi MM, Mourad MM, Bramhall SR. Focal liver lesions found incidentally. World J Hepatol. 2016;8(9):446-55.
9. Madhavi D. Role of MDCT evaluation in detection and characterisation of hepatic mass lesions. Alcohol. 2020;27:30.
10. Naqvi SM, Ali A, Naeem MA, Tariq M, Tariq F. Triphasic CT scan as a non-invasive tool in differentiating focal liver lesions. Pak J Med Sci. 2020;36(5):953-8.