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Role of sonoelastography and triphasic CT scan in focal liver lesions: A cross-sectional study.

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Abstract

Background

Focal liver lesions (FLL) range from benign entities to malignant tumours, and accurate characterisation is essential for management decisions. This study assessed the diagnostic utility of sonoelastography (SE) and triphasic computed tomography (CT) in evaluating FLL, comparing their diagnostic efficacy and correlation with histopathological findings.

Methods

This cross-sectional study was conducted in the Department of Radiodiagnosis, Katihar Medical College, Katihar, from July 2022 to December 2024, involving 60 patients with clinically suspected FLL. All patients underwent SE using shear wave elastography and triphasic CT. Diagnostic parameters (sensitivity, specificity, positive and negative predictive values, and accuracy) were calculated and compared against histopathological examination (HPE), the reference standard.

Results

The mean age was 48.0 ± 17.2 years, with a male predominance (83.3%). Amoebic abscess and metastasis were the most common diagnoses (25.0% each), followed by hemangioma and hepatocellular carcinoma (16.7% each). Overall, 30 lesions (50.0%) were benign and 30 (50.0%) were malignant. Arterial-phase peripheral rim hyperenhancement (30.0%) and delayed-phase hypoenhancement (50.0%) were the commonest CT patterns. SE stiffness values greater than 2.44 m/s were strongly suggestive of malignancy. Triphasic CT showed 100% sensitivity, specificity, and accuracy against HPE.

Conclusion

SE and triphasic CT are complementary, reliable, non-invasive modalities for characterising FLL. Triphasic CT demonstrated excellent diagnostic accuracy, while SE provided additional stiffness-based information; together, they improve diagnostic confidence and may reduce reliance on invasive biopsy.

Recommendation

Triphasic CT combined with SE should be considered as a first-line, non-invasive strategy for the diagnostic work-up of FLL, with further validation in larger, prospective, multicentric studies before wider adoption into routine clinical protocols.

Keywords: *Diagnostic efficacy, Focal liver lesion, Imaging modalities, Sonoelastography, Triphasic computed tomography (CT) scan*
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Introduction

Focal liver lesions (FLL) are regarded as a serious diagnostic challenge during abdominal assessment; liver cancer is the sixth leading cause of cancer mortality in women and the second leading cause among men [1]. FLLs may be benign or malignant. Benign lesions can be cystic or solid and include hepatic adenoma, hemangioma (the most frequent), bile duct cysts, focal fatty change, nodular

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hyperplasia, and hydatid cysts [2–4].

Primary or secondary (metastatic) malignant hepatic lesions can occur. Hepatocellular carcinoma (HCC) is the most frequent primary malignant hepatic tumour, followed by cholangiocarcinoma; hepatoblastoma and angiosarcoma are less common [5].

Ultrasound, computed tomography (CT), colour Doppler, positron emission tomography (PET), and magnetic resonance imaging (MRI) are the principal non-invasive modalities used to identify and characterise FLLs, while angiography and percutaneous biopsy remain more invasive options [6, 7].

Ultrasound is inexpensive, widely available, and non-radiating, making it the first-line investigation for the liver. Contrast-enhanced CT improves lesion detection but carries the risks of radiation exposure and iodinated-contrast reactions, particularly in patients with renal impairment or allergy. MRI avoids ionising radiation and can be used safely in patients allergic to iodinated contrast, but is limited by cost and scan duration [8].

Liver biopsy remains the traditional gold standard for tissue diagnosis; however, sampling variability limits its diagnostic utility, and it is an invasive procedure with risks of pain, morbidity, and, rarely, death [9–12].

Sonoelastography combined with conventional ultrasonography is a modern technique that provides a non-invasive assessment of tissue elasticity [13]. Shear Wave Sonoelastography (SWE), in particular, offers a quantitative, operator-independent, reproducible measure of focal tissue stiffness in kilopascals and has been used to characterise focal liver lesions in addition to assessing diffuse liver fibrosis [14–16].

Triphasic CT remains the most widely used cross-sectional technique for evaluating FLLs, given the liver's dual (hepatic arterial and portal venous) blood supply, with most primary and secondary hepatic tumours deriving 80–95% of their blood supply from the hepatic artery [17–20]. Because benign lesions such as haemangiomas, cysts, and focal nodular hyperplasia are common, an optimal CT protocol must combine high lesion-detection sensitivity with the ability to characterise lesions accurately [21–23]. The triphasic technique, acquiring arterial, portal venous, and delayed/equilibrium phase images, was developed to meet this need [24–26], and arterial-phase imaging in particular improves identification of hypervascular tumours such as HCC [29, 30]. Although MRI offers comparable diagnostic speed, CT remains more widely used owing to its availability and shorter scan times [27, 28]. This study assessed the diagnostic utility of sonoelastography (SE) and triphasic computed tomography (CT) in evaluating FLL, comparing their diagnostic efficacy and correlation with histopathological findings.

Materials and methods

Study design

This was a cross-sectional, single-centre study designed to assess and compare the diagnostic efficacy of sonoelastography (SE) and triphasic computed tomography (CT) in characterising focal liver lesions (FLL), using histopathological examination (HPE) as the reference standard. Imaging and reference-standard data were collected and analysed for each participant at a single time point during the study period, consistent with a cross-sectional design.

Study setting

The study was conducted in the Department of Radiodiagnosis, Katihar Medical College, Katihar, Bihar — a tertiary care teaching hospital that provides comprehensive diagnostic imaging services, including conventional radiography, ultrasonography with colour Doppler and elastography, and multidetector contrast-enhanced computed tomography, to patients referred from medicine, surgery, oncology, and gastroenterology departments. The department is equipped with a GE Healthcare LOGIQ S8 XDclear ultrasound system and a GE Revolution ACTs 16-slice CT scanner, both of which were used for image acquisition in this study.

Bias

Several measures were taken to limit bias. Consecutive enrolment of all eligible patients during the study period was used to reduce selection bias. Histopathological examination, an objective reference standard independent of the imaging findings, was used for final diagnosis in all cases. Imaging protocols (ultrasonography, SE, and triphasic CT) were standardised and performed on fixed equipment throughout the study to reduce measurement bias. Formal blinding of radiologists to clinical information and formal assessment of interobserver agreement were not performed and are acknowledged as limitations of the study (see Limitations).

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Table 1: Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Clinically suspected focal liver lesions	Focal lesions smaller than the minimum collection box size (1×1 cm)
Previously USG-diagnosed patients for focal liver lesions	Previous hepatic focal lesions
Hepatic focal lesions, single or multiple (diameter > 1 cm)	Unable to hold their breath
—	Pregnant women
—	Patients with chronic kidney disease
—	Patients allergic to contrast
—	Severe uncontrolled comorbid condition

Sample size determination

A total of 60 patients with clinically suspected FLL, meeting the eligibility criteria in Table 1, were enrolled over the 30-month study period. The original manuscript did not report a formal a priori sample size calculation (e.g., based on expected sensitivity/specificity of triphasic CT and an acceptable margin of error); the authors should state the formula and assumed parameters used, if a calculation was performed, or explicitly describe the sample as a convenience sample of all eligible patients presenting during the study period.

Sampling procedure

Participants were recruited by consecutive (non-probability) sampling: all patients presenting to the Department of Radiodiagnosis with clinically suspected or ultrasonographically diagnosed FLL during the study period were screened sequentially against the inclusion and exclusion criteria, and those satisfying the criteria were enrolled until the target sample was reached.

Data collection procedure

Patients presenting with clinically suspected FLL, or those with a prior ultrasonographic diagnosis of FLL, were screened against the eligibility criteria in Table 1 and enrolled after informed consent. Each participant underwent a detailed clinical evaluation, including history taking, physical examination, and relevant laboratory investigations, followed by conventional ultrasonography and sonoelastography, and subsequently triphasic CT.

Conventional ultrasonography (USG) and sonoelastography (SE) were performed using the GE Healthcare LOGIQ S8 XDclear system, with patients examined in the supine and left lateral decubitus positions after an overnight fast. Serial grayscale and Doppler images were obtained to assess lesion number, size, echotexture, vascularity, and location. Shear Wave Elastography (SWE) was then performed for all lesions: a region of interest of at least 1 × 1 cm was placed within each lesion, avoiding necrosis, calcification, and major vessels, and three consecutive stiffness measurements (in m/s and kPa) were averaged. Stiffness values greater than 2.44 m/s were considered suggestive of malignancy.

Triphasic CT was performed using the GE Revolution ACTs 16-slice scanner. Non-contrast, arterial phase (25–30 seconds post-injection), portal venous phase (60–70 seconds), and delayed venous phase (3–5 minutes) images were acquired after intravenous administration of iodinated contrast at 1.5 mL/kg body weight. Lesions were evaluated for size, enhancement pattern, arterial hyperenhancement, portal venous washout, calcification, necrosis, and vascular invasion.

Histopathological examination, obtained by ultrasound-guided fine needle aspiration cytology or biopsy, served as the reference standard, and imaging findings from both SE and CT were compared against it.

Statistical analysis

Data were analysed using IBM SPSS Statistics; continuous variables were expressed as mean ± standard deviation and categorical variables as frequency (n) and percentage (%). The chi-square test was used to compare categorical variables, with the chi-square statistic (χ^2), degrees of freedom, p-value, and Cramer's V reported where significant. Correlation between SE stiffness values and histopathological diagnosis was assessed using Pearson's correlation coefficient, with $p < 0.05$ considered statistically significant.

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Ethical considerations

The study was approved by the Institutional Ethics Committee (IEC/IRB) of Al-Karim University, Katihar, under approval number KMC/IEC/2021-2024/009/MD (Radio). Informed consent for participation, treatment, and open-access publication was obtained from or waived for all participants in accordance with the approved protocol.

Results

Participants' flow

During the study period (July 2022–December 2024), all patients presenting to the Department of Radiodiagnosis with clinically suspected or ultrasonographically diagnosed FLL were screened against the eligibility criteria in Table 1. Sixty patients satisfied the inclusion criteria, provided informed consent, and were enrolled; all 60 completed ultrasonography with sonoelastography, triphasic CT, and histopathological reference-standard testing, and were included in the final analysis. The study does not report the number of patients screened but excluded, or lost before enrolment;

The study included 60 patients who fulfilled the inclusion criteria. The mean age of the study population was 48.01 ± 17.22 years; most patients belonged to the 31–60-year age group (n = 25, 41.7%), followed by those aged over 60 years (n = 22, 36.7%). There was a marked male predominance, with 50 male patients (83.3%) and 10 female patients (16.7%). A history of alcohol consumption was present in 24 patients (40.0%).

Table 2: Distribution of histopathological diagnosis, Cirrhosis, and final HPE report

Parameter	n	%
HPE diagnosis: Amoebic abscess	15	25.0
HPE diagnosis: Cholangiocarcinoma	5	8.3
HPE diagnosis: Hemangioma	10	16.7
HPE diagnosis: Hepatic echinococcal disease	5	8.3
HPE diagnosis: Hepatocellular carcinoma	10	16.7
HPE diagnosis: Metastasis	15	25.0
Cirrhosis: No	53	88.3
Cirrhosis: Yes	7	11.7
HPE report: Benign	30	50.0
HPE report: Malignant	30	50.0

Note. HPE = histopathological examination.

Histopathological examination revealed amoebic abscess and metastatic lesions as the most common diagnoses, each occurring in 15 patients (25.0%). Hemangioma and hepatocellular carcinoma were each identified in 10 patients (16.7%), while cholangiocarcinoma and hepatic echinococcal disease were found in five patients each (8.3%). Cirrhosis was present in seven patients (11.7%). Overall, benign and malignant lesions each accounted for 30 patients (50.0%).

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Table 3: Ultrasonographic characteristics of the focal liver lesions

Variable	n	%
Portal vein involvement present	6	10.0
Portal vein involvement absent	54	90.0
Single lesion	34	56.7
Multiple lesions	26	43.3
Heteroechoic lesion	47	78.3
Hypoechoic lesion	8	13.3
Hyperechoic lesion	5	8.3
Increased vascularity present	14	23.3
Increased vascularity absent	46	76.7

Portal vein involvement was observed in six patients (10.0%). Solitary lesions were more common, present in 34 patients (56.7%), while multiple lesions were observed in 26 patients (43.3%). Most lesions were heteroechoic (n = 47, 78.3%), and increased vascularity was seen in 14 patients (23.3%).

Table 4:Enhancement pattern on Triphasic Computed Tomography

Enhancement Pattern	n	%
Arterial phase: Puddle enhancement	10	16.7
Arterial phase: Variegated enhancement	8	13.3
Arterial phase: Homogeneous hyperenhancement	4	6.7
Arterial phase: Peripheral rim hyperenhancement	18	30.0
Arterial phase: Incomplete hyperenhancement	5	8.3
Arterial phase: Hypoenhancement	12	20.0
Arterial phase: Mixed enhancement	3	5.0
Portal venous phase: Persistent enhancement	27	45.0
Portal venous phase: Hypoenhancement	10	16.7
Portal venous phase: Cystic hypoenhancement	20	33.3
Portal venous phase: Mixed enhancement	3	5.0
Delayed venous phase: Persistent enhancement	19	31.7
Delayed venous phase: Capsular enhancement	8	13.3
Delayed venous phase: Hypoenhancement	30	50.0
Delayed venous phase: Mixed enhancement	3	5.0

In the arterial phase, peripheral rim hyperenhancement was the most common finding (n = 18, 30.0%). Persistent enhancement predominated in the portal venous phase (n = 27, 45.0%), and hypoenhancement was the most frequent finding in the delayed venous phase (n = 30, 50.0%).

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Table 5: Comparison of Triphasic CT diagnosis with histopathological examination

Triphasic CT Diagnosis	HPE Diagnosis	Concordance
Amoebic abscess (n = 15, 25.0%)	Amoebic abscess (n = 15, 25.0%)	15/15
Cholangiocarcinoma (n = 5, 8.3%)	Cholangiocarcinoma (n = 5, 8.3%)	5/5
Hemangioma (n = 10, 16.7%)	Hemangioma (n = 10, 16.7%)	10/10
Hepatic echinococcal disease (n = 5, 8.3%)	Hepatic echinococcal disease (n = 5, 8.3%)	5/5
Hepatocellular carcinoma (n = 10, 16.7%)	Hepatocellular carcinoma (n = 10, 16.7%)	10/10
Metastasis (n = 15, 25.0%)	Metastasis (n = 15, 25.0%)	15/15

Note. CT = computed tomography; HPE = histopathological examination.

Triphasic CT correctly diagnosed amoebic abscess and metastatic lesions in 15 patients each (25.0%), hepatocellular carcinoma and hemangioma in 10 patients each (16.7%), and cholangiocarcinoma and hepatic echinococcal disease in five patients each (8.3%), showing complete concordance with the histopathological diagnosis.

Table 6: Comparison of Computed Tomography Report with Histopathological Examination Report

CTHistopathological Examination Report Report	Benign HPE, n (%)	Malignant HPE, n (%)
Benign	30 (100.0)*	0 (0.0)
Malignant	0 (0.0)	30 (100.0)*

Note. *Statistically significant association between CT report and HPE report: $\chi^2 = 60.00$, df = 1, p = 0.001, Cramer's V = 1.00.

A statistically significant association was observed between the CT report and the HPE report in differentiating benign from malignant lesions ($\chi^2 = 60.00$, df = 1, p = 0.001, Cramer's V = 1.00).

Table 7: Diagnostic characteristics of Triphasic Computed Tomography

Diagnostic Parameter	Value (%)	95% CI
Sensitivity	100.0	88.4–100.0
Specificity	100.0	88.4–100.0
Positive predictive value	100.0	88.4–100.0
Negative predictive value	100.0	88.4–100.0
Accuracy	100.0	94.0–100.0

Note. CI = confidence interval.

Triphasic CT demonstrated excellent diagnostic performance, with sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy of 100.0% against the histopathological reference standard.

Discussion

The detection of FLL has increased in recent years because of improvements in imaging technology and the rising burden of chronic liver disease, yet reliably distinguishing benign from malignant lesions remains the central clinical challenge, since management and prognosis differ substantially between the two groups. Conventional USG

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and CT provide valuable structural and morphological information, but morphology alone is often insufficient for definitive characterisation; SE and triphasic CT add functional information — tissue stiffness and dynamic vascular enhancement, respectively — that helps close this diagnostic gap.

The demographic profile of this cohort — a mean age of 48.01 ± 17.22 years, male predominance (83.3%), and a substantial proportion with a history of alcohol use (40.0%) — suggests that, in this population, FLL most often develops against a background of alcohol-related liver injury in middle-aged men, consistent with the pattern reported by earlier studies of FLL risk factors [18].

Amoebic abscess and metastasis were the leading diagnoses (25.0% each), followed closely by HCC and hemangioma (16.7% each). This distribution indicates that, in this endemic setting, infective and secondary malignant aetiologies were at least as common as primary hepatic malignancy — an interpretation consistent with, though somewhat broader than, prior literature that emphasises metastasis and HCC as the predominant malignant FLLs [19, 20].

On conventional ultrasonography, the higher frequency of increased vascularity and portal vein involvement among lesions later confirmed malignant on HPE (rather than being incidental findings) suggests that these grayscale/Doppler features reflect the more aggressive angiogenic and invasive biology of malignant FLL, and therefore have practical value as red-flag sonographic features prompting further triphasic CT evaluation.

On triphasic CT, peripheral rim arterial hyperenhancement (30.0%) and delayed-phase washout/hypoenhancement (50.0%) were the dominant patterns. Because washout on delayed imaging reflects more rapid contrast egress from tumour neovasculature than from surrounding parenchyma, this pattern is a physiologically expected signature of hypervascular malignant lesions such as HCC and metastasis, in line with previous reports [21, 22].

The complete concordance between triphasic CT diagnosis and HPE ($\chi^2 = 60.00$, df = 1, p = 0.001, Cramer's V = 1.00), and the resulting 100% sensitivity, specificity, and accuracy, indicate that — within this cohort and case-mix — the combination of arterial, portal venous, and delayed-phase enhancement characteristics was sufficient to correctly classify every lesion as benign or malignant. This should be interpreted as reflecting a favourable case-mix of radiologically distinct lesion types within a single-centre sample, rather than as evidence that triphasic CT alone can be expected to achieve perfect accuracy across the broader, more diagnostically ambiguous case-mix (e.g., small or atypical lesions) encountered in general practice.

Similarly, the significantly greater SE stiffness values in malignant than benign lesions, with a threshold of 2.44 m/s suggestive of malignancy, are consistent with the biological expectation that increased cellularity, fibrosis, and desmoplastic reaction raise tissue stiffness in malignant tumours, an effect previously described in liver and other solid-organ lesions [23, 24].

Taken together, these findings support a complementary role for the two modalities: triphasic CT contributes detailed vascular and morphological characterisation, while SE contributes an orthogonal, radiation-free measure of tissue stiffness; using them together may increase diagnostic confidence and reduce reliance on invasive biopsy in selected patients, consistent with prior comparative work [17].

Generalizability

The findings of this study should be extrapolated to other populations with caution. The cohort was drawn from a single tertiary-care centre in a region with a comparatively high prevalence of amoebic liver abscess and alcohol-related liver disease, and included a case-mix with a markedly male predominance; the diagnostic performance of SE and triphasic CT observed here may not directly generalise to settings with a different burden of infective liver disease, a more balanced sex distribution, or a case-mix weighted toward small, indeterminate, or atypical lesions, which are more diagnostically challenging than the relatively distinct lesion types encountered in this sample. The underlying physiological principles — vascular enhancement kinetics on triphasic CT and stiffness-based differentiation on SE — are expected to apply broadly across populations; however, the very high (100%) diagnostic accuracy reported here is likely specific to this cohort and should be validated in larger, multicentric, and more heterogeneous populations before being generalised to routine clinical practice.

Conclusions

Sonoelastography and triphasic computed tomography are valuable and complementary imaging modalities in the evaluation of focal liver lesions. Sonoelastography provides a non-invasive assessment of tissue stiffness, while triphasic computed tomography enables accurate lesion characterisation based on dynamic vascular enhancement patterns. Their combined use enhances diagnostic confidence and improves differentiation between benign and malignant focal liver lesions, supporting appropriate clinical decision-making and potentially reducing the need

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for invasive diagnostic procedures.

Limitations

- Single-centre study with a relatively small sample size of 60 patients, which may limit the generalizability of the findings.
- Possible selection bias, as only clinically suspected or previously USG-diagnosed cases of FLL were included.
- Interobserver variability in the interpretation of imaging findings was not formally assessed.
- A formal a priori sample size calculation was not reported.
- The excellent (100%) diagnostic performance observed should be interpreted cautiously, as it may reflect the specific case-mix of this cohort and requires validation in larger multicentric studies.

Recommendations

- Further prospective, multicentric studies with larger and more heterogeneous sample sizes are needed to confirm the diagnostic role of SE and triphasic CT in FLL.
- Future studies should report a priori sample size calculations and formally assess interobserver agreement for both SE and CT interpretation.
- Triphasic CT and SE should be used as complementary modalities, with correlation to histopathology maintained in cases of diagnostic uncertainty, particularly for small or atypical lesions.
- A structured participant flow diagram (screened, excluded, enrolled, analysed) should be incorporated into future reporting to improve methodological transparency.

Acknowledgement

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List of abbreviations

FLL – Focal Liver Lesion(s)
SE – Sonoelastography
SWE – Shear Wave Elastography
USG – Ultrasonography
CT – Computed Tomography
HCC – Hepatocellular Carcinoma
HPE – Histopathological Examination
PPV – Positive Predictive Value
NPV – Negative Predictive Value
PET – Positron Emission Tomography
MRI – Magnetic Resonance Imaging
IEC/IRB – Institutional Ethics Committee / Institutional Review Board
m/s – Metres per Second
kPa – Kilopascal

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No financial support was received from any organisation for the submitted work.

Conflict of interest

In compliance with the ICMJE uniform disclosure form, all authors declare no financial relationships, at present or within the previous three years, with any organisation that might have an interest in the submitted work, and no other relationships or activities that could appear to have influenced the submitted work.

Data availability

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request. [Authors to confirm final data-sharing statement before submission.]

Author contributions

All authors reviewed the final version of the manuscript and agreed to be accountable for all aspects of the work.
Concept and design: Dr Syed Haleem Haider Abidi, Dr Ahmad Rizwan Karim, Dr Khushboo Mustafi.
Acquisition, analysis, or interpretation of data: Dr Syed Haleem Haider Abidi, Dr Ahmad Rizwan Karim, Dr Khushboo Mustafi.
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Human subjects

Informed consent for treatment and open-access publication was obtained or waived by all participants in this study. Al-Karim University, Katihar, issued approval IEC/IRB No: KMC/IEC/2021-2024/009/MD (Radio).

Animal subjects

All authors have confirmed that this study did not involve animal subjects or tissue.

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