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Diagnostic Accuracy of Ultrasonography for Diagnosing Liver Mass Taking CT Triphasic Liver as Gold Standard

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ABSTRACT

Background: Accurate distinction of benign and malignant lesions of the liver is critical for a proper clinical management. Ultrasonography is first line imaging modality that is used for hepatic lesions; however, diagnostic accuracy of ultrasound is much improved when shear wave elastography (SWE) technique is employed for the characterization of liver lesion on the basis of tissue stiffness. This study was done to ascertain the diagnostic accuracy of ultrasonography with shear wave elastography in the diagnosis of liver masses using triphasic computed tomography (CT) as the reference standard. **Methods:** This cross-sectional validation study carried out at Radiology Department of Islamabad Diagnostic Centre, Islamabad during 22 June 2024 to 30th December 2024. A total of 208 patients between 25 and 75 years of age with suspected focal lesions in the liver were included. All patients were scanned with ultrasonography with SWE followed by triphasic CT of the liver. Demographic data, clinical features, and findings of the imaging studies were recorded. The performance parameters of the diagnostic test such as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated using triphasic CT as a gold standard. Receiver operating characteristic (ROC) curve analysis was done to determine discriminative capacity of SWE stiffness values. **Results:** Triphasic CT identified malignant lesions in 152 (73.1%) patients and benign lesions in 56 (26.9%) patients. Ultrasonography with SWE correctly identified 128 true positive, 45 true negative, 11 false positive, and 24 false negative cases. The sensitivity, specificity, PPV, and NPV of ultrasonography with SWE were 84.2%, 80.4%, 92.1%, and 65.2%, respectively, with an overall diagnostic accuracy of 83.2%. ROC analysis demonstrated excellent diagnostic performance with an area under the curve (AUC) of 0.956 (95% CI: 0.931–0.980, $p < 0.001$). **Conclusion:** Ultrasonography when conducted with the use of shear wave elastography technique, reproduce high diagnostic accuracy in the discrimination of malignant and benign liver lesions. SWE provides useful quantitative information that adds to the diagnostic capability of conventional ultrasound and may prove a useful non-invasive adjunctive test in the evaluation of focal hepatic lesions.

INTRODUCTION

Liver masses are seen with appreciable frequency in clinical practice and represent a wide range of benign and malignant conditions, including hemangiomas, focal nodular hyperplasia, hepatocellular carcinoma and metastatic disease [1]. Precise detection and differentiation of these lesions are indispensable to the optimal management of patients, planning of therapy and prognostication. Imaging modalities are a crucial part of the evaluation of hepatic masses as many cases of hepatic masses can be diagnosed, or highly suspected, based on diagnostic imaging findings, thus eliminating the need for invasive procedures [2].

Ultrasonography (USG) is routinely used as the first line imaging modality for the evaluation of hepatic pathology due to its widespread availability, noninvasiveness, cost-efficiency and lack of ionizing radiation. Conventional B-mode ultrasound allows assessment of the hepatic size, parenchymal echo texture and identification of focal lesions. Nevertheless, the diagnostic ability of the conventional ultrasonography in differentiating benign from malignant lesions is limited by sonographic overlapping characteristics and operator-dependency [3,4]. To overcome the aforementioned disadvantages, the application of elastographic techniques has been described as complementary tools to ultrasound. SWE is a

relatively new ultrasound-based modality that is used to objectively quantify tissue stiffness by measuring the velocity of artificially induced shear waves through the tissue [5,6]. Because malignant neoplasms are often found to have increased stiffness in comparison with benign lesions or normal hepatic parenchyma, SWE has proved to have promising potential in this regard for optimizing the characterization of focal liver lesions and for the evaluation of diffuse hepatic disease [5-7]. Several studies have found elastography, an imaging modality, to provide valuable quantitative information that complements the information provided by conventional ultrasound in hepatic imaging [8].

Despite the improvement in ultrasound technology and cross-section imaging modalities, in particular, CT with contrast remains the cornerstone for evaluating focal liver lesions. Although histopathology is traditionally considered the gold standard for the diagnosis of hepatic lesions, it is not always possible or ethically appropriate to perform a histopathology in all patients, especially when lesions have characteristic imaging findings. In clinical radiology, a non-invasive reference modality for detection and characterization of focal lesions of the liver has emerged in the form of contrast-enhanced triphasic computed tomography which is generally accepted due to the enhancement pattern visible during arterial, portal venous, and delayed phase to obtain diagnostic information for distinguishing benign from malignant lesions [9]. Triphasic CT of the liver involves acquisition in arterial, portal venous, and delayed phases after the administration of contrast and thus allows evaluation of lesion vascularity and enhancement patterns. These enhancement characteristics are extremely important for distinguishing benign from malignant lesions and are regularly included with diagnostic algorithms and reporting schemes for hepatic imaging [10]. As a result, triphasic CT has become a widely accepted and reliable method of detecting and characterizing hepatic lesions, which has a high sensitivity and diagnostic accuracy in differentiating benign and malignant masses [9,10].

Given the current predominate use of ultrasonography as the first imaging modality used in many healthcare settings, an evaluation of the performance of this modality, especially when coupled with more advanced imaging techniques such as shear wave elastography, is crucial for assessing its reliability in the detection and characterization of liver lesions. Accordingly, the present study was undertaken to evaluate the diagnostic accuracy ultrasonography in the diagnosis of liver masses in using triphasic computed tomography as the reference standard in our local patient cohort.

MATERIAL AND METHODS

This cross-sectional validation study was carried out in the Radiology department of Islamabad Diagnostic Centre (IDC), Islamabad from 22nd June 2024 to 30th December 2024. Ethical approval for the study was sought from the Ethical Review Committee of Islamabad Diagnostic Centre before the data collection was started. Written informed consent was obtained from all patients before inclusion in the study and before performing the imaging procedures. We enrolled 208 patients using non-probability consecutive sampling technique, while, sample size was calculated with the help of Buderer's formula for sensitivity specificity sample size calculator, based on the expected sensitivity and specificity of 78.05% and 71.43% [11] with confidence interval of 95% and precision of 10%. Assuming the prevalence of the disease of 62% [12], the sample size was calculated to be 208 patients and this sample size was used for the study.

Patients presenting to the radiology department with clinical suspicion of focal liver lesions who were referred for imaging evaluation were considered for inclusion in the study. Adult patients aged 18 years and above who received ultrasonography with shear wave elastography as well as triphasic CT scan of the liver during the study period received an invitation. Patients with a history of previous liver surgery, those with known hepatic malignancy and already on treatment, patients with severe renal impairment contraindicating contrast administration, known hypersensitivity to iodinated contrast agents, pregnant patients and patients with incomplete imaging records were excluded from the study.

Ultrasonographic study of the liver was carried out by using high resolution ultrasound machine with convex transducer of 3.5-5 MHz frequencies. Conventional B-mode ultrasonography was initially applied to assess the size and parenchymal echotexture of the liver and detection of focal hepatic lesions. Once any lesion was detected, SWE was used to determine the stiffness characteristics of the lesion. SWE measurements were made by having the region of interest in the lesion, when large vessels and areas of necrosis or calcification were avoided. Multiple measurements were taken and the average measure of stiffness in kilo Pascals (kPa) was recorded. Additional lesion characteristics such as size, number, location, echogenicity, margins and internal architecture were also recorded.

All patients then underwent triphasic computed tomography of the liver, by multidetector computed tomography using intravenous administration of iodinated contrast material. CT images were obtained on arterial, portal venous and delayed phases based on standard triphasic liver imaging protocols. The CT images were evaluated for the presence, number, size, location and enhancement pattern of hepatic lesions. Characteristic enhancement pattern in different phases was used to classify the lesions and make the final diagnosis. Triphasic CT findings were taken as the reference standard for comparison in this study.

The data obtained was entered and calculated with the help of statistical package for social sciences (SPSS) version 25. Quantitative variables were expressed as mean and standard deviation while categorical variables were expressed as frequencies and percentages. Diagnostic performance parameters of ultrasonography with shear wave elastography have been obtained by comparing the results of ultrasound with triphasic CT, sensitivity, specificity, positive, and negative predictive value, and total diagnostic accuracy using the 2x2 contingency table. ROC curve analysis was also performed. Stratification analysis was done for all the confounding variables and post-stratification diagnostic accuracies were determined.

RESULTS

A total of 208 patients were included in the study. The mean age of the participants was 53.75 ± 11.72 years with an age range of 29–75 years. The mean body mass index (BMI) was 27.88 ± 4.10 kg/m^2, while the mean shear wave elastography (SWE) stiffness value was 49.15 ± 22.79 kPa. Cirrhosis (22.6%) was the most common underlying liver disease among patients, followed by chronic hepatitis B (21.2%) and chronic hepatitis C (16.3%). Other etiologies are graphically presented in figure 1. Among the participants, 58.7% were male and 41.3% were female. Most patients belonged to the 56–75 years age group (43.8%) followed by 41–55 years (38.9%). The majority of participants were overweight (38.9%) or obese (35.6%), while 25.5% had normal BMI. Most participants were married (78.8%). Regarding liver lesion location, the right lobe was most commonly involved (53.4%), followed by both lobes (24.5%) and left lobe (22.1%).

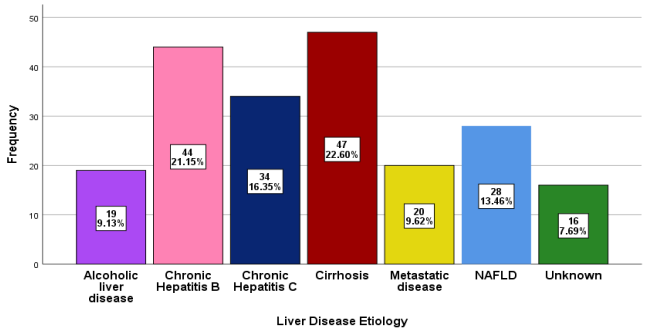
Table 1

Distribution of Patients According to Various Demographic and Clinical Variables

Variable	Category	Frequency	Percentage (%)
Gender	Male	122	58.7
	Female	86	41.3
Age group	25–40 years	36	17.3
	41–55 years	81	38.9
	56–75 years	91	43.8
BMI group	Normal	53	25.5
	Overweight	81	38.9
	Obese	74	35.6
Marital status	Married	164	78.8
	Unmarried	44	21.2
Liver lobe involved	Right lobe	111	53.4
	Left lobe	46	22.1
	Both lobes	51	24.5

Figure 1

Distribution of Patients According to the Etiology of Liver Disease



Triphasic CT identified malignant lesions in 152 patients (73.1%) and benign lesions in 56 patients (26.9%).

Table 2

Frequency of Malignant and Benign Findings on Ultrasound and Triphasic CT

Imaging Modality	Findings	Frequency	Percentage
Ultrasound finding	Benign	69	33.2
	Malignant	139	66.8
Triphasic CT finding	Benign	56	26.9
	Malignant	152	73.1

Cross-tabulation between ultrasonography with shear wave elastography and triphasic CT findings demonstrated 128 true positives, 45 true negatives, 11 false positives, and 24 false negatives.

Table 3

Diagnostic Accuracy Analysis of Ultrasound for Diagnosing the Malignant Liver Mass

Ultrasound	CT Benign	CT Malignant	Total
Benign	45 (True Negative)	24 (False Negative)	69
Malignant	11 (False Positive)	128 (True Positive)	139
Total	56	152	208
Sensitivity		84.2%	
Specificity		80.4%	
Positive Predictive Value		92.1%	
Negative Predictive Value		65.2%	
Overall Diagnostic Accuracy		83.2%	

Receiver operating characteristic (ROC) analysis was performed to evaluate the diagnostic performance of SWE stiffness values in differentiating malignant from benign liver lesions using triphasic CT as the reference standard. The area under the ROC curve (AUC) was 0.956 (95% CI: 0.931–0.980, $p < 0.001$), indicating excellent diagnostic performance (figure 2). Based on ROC coordinates, several cutoff values were identified. A clinically useful threshold was approximately 40.8 kPa, which yielded 84.2% sensitivity and 94.6% specificity.

Figure 2

ROC Analysis for Shear Wave Elastography to Detect Malignant Liver Mass

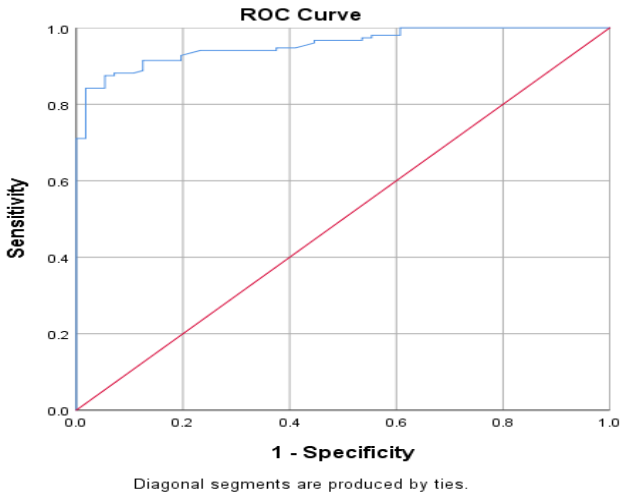


Table 4

Selected SWE Cutoff Values from ROC Analysis

SWE Cutoff (kPa)	Sensitivity	Specificity
28.05	93.4%	78.6%
36.75	87.5%	92.9%
40.80	84.2%	94.6%
44.25	80.3%	98.2%

Stratified analysis was performed to assess the diagnostic accuracy of ultrasonography across potential confounding variables including gender, BMI groups, marital status, age

groups, and liver lobe involvement. Sensitivity ranged from 70.6-88.7 while specificity ranged from 66.7-96.0.

Table 4
Stratified Diagnostic Accuracy Analysis

Variable	Category	Sensitivity (%)	Specificity (%)	Accuracy (%)
Gender	Male	86.9	83.3	86.1
	Female	80.0	76.9	79.1
BMI	Normal	72.4	75.0	73.6
	Overweight	88.7	84.2	87.7
	Obese	85.2	84.6	85.1
Marital status	Married	84.6	80.5	83.5
	Unmarried	82.8	80.0	82.0
Age group	25–40 years	70.6	68.4	69.4
	41–55 years	83.9	96.0	88.9
	56–75 years	87.3	66.7	84.6
Liver lobe involved	Right lobe	81.7	86.2	83.8
	Left lobe	86.7	93.8	89.1
	Both lobes	87.5	45.5	78.4

DISCUSSION

The current study assessed the diagnostic accuracy of ultrasonography using shear wave elastography (SWE) technique in the detection of malignant lesions in the liver using triphasic CT as the reference standard. In this study, ultrasonography with SWE showed a sensitivity of 84.2%, 80.4% specificity and 83.2% overall diagnostic accuracy levels, and ROC analysis showed a very good diagnostic performance with an AUC value of 0.956. These results support the emerging role of ultrasound techniques based on elastography as reliable non-invasive tools for discrimination of benign and malignant hepatic lesions. SWE quantitatively measures tissue stiffness and malignant tumors often have higher stiffness than benign lesions because of a higher cell density, fibrosis, and desmoplastic reaction. Therefore, SWE adds extra objective information in addition to traditional ultrasound for better lesion characterization and increased diagnostic confidence [13,14]. Furthermore, triphasic CT has been established as an imaging modality for characterization of hepatic lesions because enhancement patterns in the arterial, portal venous, and the delayed phases help distinguish malignant from benign lesions with high diagnostic accuracy [14,15]. Our results are consistent with results from previous studies reporting good diagnostic performance of SWE in the evaluation of hepatic lesions. A meta-analysis by Hu et al. found pooled sensitivity and specificity in distinguishing malignant liver lesions from benign ones was close to 82% and 82%, respectively, in favor of its diagnostic utility in clinical practice [13]. Similarly, Ferraioli and colleagues have shown that the ultrasound elastography techniques are reliable sources of quantitative assessment of liver stiffness and can aid in the characterisation of hepatic pathology [16]. Samir et al. also reported that shear wave elastography has great diagnostic ability in determining the liver tissue stiffness and correlates well with pathologic changes in hepatic diseases [17]. In another investigation, the role of SWE in determination of severity of liver disease and detection of diagnostic improvement compared with traditional ultrasound only was highlighted by Ozturk et al. [18]. Studies evaluating imaging of focal hepatic lesions have also emphasized on the diagnostic value of multiphasic CT in characterization of the lesion, with high sensitivity for malignant lesions due to evaluation of vascular enhancement patterns [19,20]. Moreover, investigations evaluating the combined use of the two technologies have shown that the combination of ultrasound elastography with cross-sectional imaging modalities improves the overall diagnostic capabilities for hepatic lesions [15]. The clinical implications of these findings are important for the non-invasive evaluation of patients with suggested hepatic masses. Early and accurate disease discrimination between benign and malignant liver lesions is imperative in order to determine the proper management strategy (surveillance, biopsy, surgical intervention, or oncologic treatment). Conventional ultrasound is often the first modality of imaging employed in routine clinical practice because of its accessibility and effectiveness in terms of cost; however, its differentiating capability is sometimes suboptimal. Incorporating SWE into routine ultrasound examination improves the ability to provide quantitative measurement of stiffness that will increase the diagnostic confidence and potentially decrease the need for invasive procedures such liver biopsy. Additionally, SWE may be a useful screening and triaging strategy especially in settings where access to advanced imaging modalities may not be readily available [13,16]. When used in conjunction with triphasic CT, elastography provides complementary diagnostic information with the added benefit of improving lesion characterization and aiding in clinical decision making [14]. Despite these promising results, there are some limitations to the present study. First, the study was done at one centre with a small sample size, which may limit the generalisability of the results. Second, while triphasic CT was used as the reference standard in this study, histopathological confirmation was not available on all the lesions, which is the ultimate diagnostic method. Third, measures of elastography can be affected by several variables including lesion depth, background liver fibrosis, and operator technique which may affect the measures of stiffness. It is suggested to do further multicenter studies with larger patient populations and histopathological correlation are suggested to further validate the diagnostic performance of SWE in focal liver lesions. Additionally, emerging technologies such as artificial intelligence-assisted imaging analysis and radiomics may increase the diagnostic accuracy of elastography-based imaging in the evaluation of liver disease even further.

CONCLUSION

Ultrasonography when performed using the shear wave elastography technique, demonstrated high diagnostic accuracy in differentiating malignant from benign lesions in the liver where triphasic CT scanning considered as reference standard. The technique had a good sensitivity and specificity, and ROC analysis indicated an excellent discriminative ability of SWE stiffness measurements. These results indicate that SWE can substantially improve the diagnostic capability of the conventional ultrasonography by adding information on the quantitative tissue stiffness. Consequently, SWE may be a

useful non-invasive adjunct in the initial evaluation and characterization of focal hepatic lesions that may aid in clinical decision-making and optimize patient management.

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