Role of real-time shear-wave elastography in differentiating hepatocellular carcinoma from other hepatic focal lesions

Magdy A. Mawgood Gad, Tamer E. Eraky, Hazem M. Omar and Hazem Maarouf Abosheaishaa

Introduction

Hepatocellular carcinoma (HCC) has a rising incidence worldwide and now is considered the second cause of cancer-related death [1,2]. In Egypt, HCC is the second most common cancer in men and the sixth most common cancer in women [3]. HCC is considered the main complication of cirrhosis, and shows a growing incidence in Egypt, which may be the result of the shift in the relative importance of hepatitis C virus (HCV) and hepatitis B virus (HBV) as the main risk factors and also the improvement in the screening programs and the diagnostic modalities [4]. Patients with chronic infection with HBV or HCV are at higher risk for developing HCC, and should be enrolled in surveillance programs using ultrasound and serum α-fetoprotein (AFP) [5]. Patients with focal lesions in ultrasound require further evaluation with triphasic computed tomography (CT), and either MRI, liver biopsy or both to confirm HCC diagnosis [6].

Elastography is a technique that uses an intrinsic tissue property, the elasticity – the capacity to deform and to return to the initial shape when a stress is applied. In order to obtain an elastographic assessment, the tissue is mechanically stressed and this induces a displacement that can be measured, allowing an estimation of the tissue stiffness. It is a noninvasive method, well accepted by majority of patients. Most elastographic techniques available today are ultrasound-based [7]. Elastographic strategies using ultrasound waves for the evaluation of liver fibrosis can be partitioned into [8]:

1. strain elastography (or quasi-static elastography)
2. shear-waves elastography (SWE):
   (i) transient elastography (FibroScan),
   (iii) shear-wave speed imaging (supersonic shear-wave imaging) – two-dimensional-SWE.

pSWE was the second technique with a chance to be acquainted as an instrument for liver fibrosis evaluation [9,10]. Otherwise known as ARFI imaging [11]. There are two techniques: virtual touch tissue quantification
(VTTQ) technique that expresses the results in meters per second and elastogaph point quantification (ElastPQ) that gives the results in meters per second or in kilopascals. There are numerous reports of studies performed using the VTTQ technique that was commercially available since 2009, but only a few using ElastPQ that has been acquainted in 2012 [12]. Dependent on the preliminary results of the study of focal liver lesions, it can be concluded that SWE seems to be helpful in the following scenarios [13,14]:

(1) In differential diagnosis between adenomas and focal nodular hyperplasia (FNH).
(2) For detection of liver metastases.
(3) For the diagnosis of HCC on top of liver cirrhosis.

Numerous studies have been published, which proved the real-time elastography efficiency in differentiating the stiffness of the prostate, breast, thyroid, or pancreatic tumors [15]. A small number of studies have investigated the stiffness of focal liver lesions quantitatively [16].

Patients and methods

Patients

This is a prospective cross-sectional study that was conducted on 110 patients in addition to 10 healthy subjects, divided into four groups. Group I: 30 patients with liver cirrhosis diagnosed by ultrasonography and/or CT. Group II: 40 patients with HCC on top of liver cirrhosis diagnosed with triphasic CT (enhancement in the arterial phase and rapid washout in portovenous or delayed phases) ± elevated AFP. Group III: 40 patients with hepatic focal lesions other than HCC [hemangioma (14)/liver metastases (10)/cystic focal lesions (10) (6 abscesses and 4 simple cysts)/cholangiocarcinoma (4)/FNH (2)]. Group IV: 10 healthy subjects – age and sex-matched – were served as a control group. The study was carried out at the National Liver Institute at Shebeen El-kom, Egypt after informed consent from all patients and controls was obtained. Inclusion criteria included patients with hepatic focal lesions that were well visualized on conventional ultrasonography. Exclusion criteria included patients younger than 18 years, lesions in left hepatic lobe of the liver (oscillation of the left liver by cardiac activity may interfere with stiffness measurements), lesions deeper than 8 cm and patients who cannot hold the breath for 5 s.

Methods

All patients and controls were subjected to complete history taking, the thorough clinical examination included general examination (jaundice, pallor, and lower-limb edema) and local examination (ascites, hepatomegaly, and splenomegaly).

The following investigations were done:

(1) Lab:
   (a) Complete blood count.
   (b) Erythrocyte sedimentation rate.
   (c) Liver function tests: alanine aminotransferase–aspartate aminotransferase (ALT-AST)–serum bilirubin–serum albumin–international normalized ratio (INR).
   (d) Kidney function tests: serum creatinine – blood urea.
   (e) Random blood sugar.
   (f) AFP.

(2) Radiology:
   (a) Abdominal ultrasound (echo pattern, size, site, and number of each focal lesion).
   (b) Abdominal triphasic CT (pattern of enhancement of each focal lesion).
   (c) Elastographic assessment using pSWE elastography technique ElastPQ (Philips iu22 ultrasound system, USA).

Technique

In pSWE, an ARFI pulse is used to generate shear waves in the liver in a small (approximately 1 cm³) region of interest (ROI). B mode imaging is used to monitor the displacement of liver tissue due to the shear waves. From the displacements monitored over time at different locations from the ARFI pulse, the shear-wave speed is calculated in meters per second. Assumptions can then be made that can convert the shear-wave speed in meters per second to the Young modulus, $E = \frac{3(vS^2\cdot r)}{1-2\cdot v}$ where $E$ is the Young modulus, $V$ is the shear-wave speed, and $r$ is the density of the tissue in homogeneous isotropic tissues. The assumption is made that the density is 1 g/mL [17].

The optimal conditions to perform shear-wave elastography according to World federation for ultrasound in medicine and biology guidelines should include fasting, putting the patient in the dorsal decubitus position in resting respiratory state (breath-hold without deep inspiration), placing the ROI beneath Glisson’s capsule by 1.5–2.0 cm to avoid reverberation artifacts and increased subcapsular stiffness, adjusting the ROI to avoid large liver vessels and then the median value of 5–10 measurements are considered [12].

Statistical analysis

The clinical data were recorded on a report form. These data were tabulated and analyzed using the computer program Statistical Package for Social Science (SPSS) version 20 to obtain.

Descriptive data

Descriptive statistics were calculated for the data in the form of the following:
1. Mean and ±SD. Median and interquartile range for quantitative data.
2. Frequency and distribution for qualitative data.

Analytical statistics

In the statistical comparison between the different groups, the significance of difference was tested using one of the following tests after establishing their nonnormality by one-sample Kolmogorov–Smirnov test of normality.
(1) Student’s t-test and Mann–Whitney test: used to compare mean of two groups of quantitative data of parametric and nonparametric, respectively.
(2) Analysis of variance test (F value) and Kruskal–Wallis test: used to compare mean of more than two groups of quantitative data of parametric and nonparametric, respectively.
(3) Intergroup comparison of categorical data was performed by using chi-square test (χ²-value) and Fisher’s exact test.
(4) The Wilcoxon sign-rank test: statistical hypothesis test used to compare two related samples, matched samples, or repeated measurements on a single sample to assess whether their population mean ranks differ.
(5) Correlation coefficient: measures the closeness of the association between two continuous variables. This association is measured by the correlation coefficient (r).
(6) Probability (P) value: a P value < 0.05 is considered statistically significant while > 0.05 is statistically insignificant.

Results
A total of 110 patients 70 male and 40 female, in addition to 10 healthy subjects have been studied. The patients were divided into the following groups: patients with liver cirrhosis, patients with HCC, and patients with studied hepatic focal lesions other than HCC included hemangioma, liver metastasis, cystic focal lesions, cholangiocarcinoma, and FNH. The proportion of male patients have the higher predominance with statistical significance in HCC group (72.5%) in comparison to patients with hemangioma (14.3%). The median ages were as follows: 57 years in HCC, 41 years in hemangioma, 34 years in liver metastasis, 35 years in cystic lesions, 65 years in cholangiocarcinoma, and 38 years in FNH. Based on age statistics, significant variance has been found between the patients with ‘HCC and hemangioma’ and ‘HCC and cystic lesions’. Based on occupation statistics, another considerable difference has been noticed between the patients with ‘HCC and hemangioma’ and ‘HCC and cystic lesions’. Based on smoking history statistics, another considerable difference has been observed in patients with HCC compared to patients with liver parenchyma in other studied hepatic focal lesions. Table 3 shows a significantly higher stiffness in liver parenchyma in comparison to focal lesion in the following groups: HCC, cystic lesions, and cholangiocarcinoma. Table 3 also shows a significantly higher stiffness over focal lesion in comparison with the surrounding liver parenchyma only in FNH. Table 4 shows a significantly higher liver parenchymal stiffness in patients with liver cirrhosis in comparison with liver parenchymal stiffness in all other patients (Fig. 2). Table 5 shows no correlation between the elasticity of different hepatic focal lesions and their size or number.

Discussion
The accurate characterization and the differential diagnosis between different types of hepatic focal lesions are important goals, that all available imaging modalities should satisfy [18].

Conventional ultrasonography is the first imaging modality with low cost and wide availability used to screen for or study of hepatic focal lesions [19]. Triphasic CT enables characterization of a wide range of different hepatic focal lesions by scanning the liver after contrast injection and evaluation of enhancement of each lesion in each phase (arterial, portal, and equilibrium) [20].

Elastography is an imaging method that estimates tissue elasticity. Numerous studies have been reported, which prove the role of real-time elastography in differentiating the stiffness of the prostate, breast, thyroid, or pancreatic tumors [15]. SWE has been described in the assessment of the mechanical properties of liver tissues as regard liver fibrosis stage but there is limited data on its role in assessing the elasticity of hepatic focal lesions [21].

SWE is a technology involving the remote generation of transient mechanical forces into the tissue by a transducer. The resulting shear waves are imaged with the same transducer at an ultra-fast imaging sequence to provide quantitative elasticity maps [22]. SWE is integrated into an ultrasound device that provides real-time two-dimensional B-mode images to identify the area of interest [23]. The calculation of the shear-wave speed mainly reflects both the elasticity and viscosity of the target tissue [13].

Having applied SWE, we assessed the median stiffness of each focal lesion. The median stiffness of HCCs in this study was 4.94 kPa (Fig. 3). This finding goes in agreement with Hasab Allah et al. [21], who used pSWE ElastPQ.
(iU22 x MATRIX, Philips, USA) and reported (5.43 kPa) as a median stiffness of HCC. But this is on the contrary to Guibal et al. [16] who used Aixplorer ultrasound system (SuperSonic Imagine, Aixen-Provence, France) and reported (14.86 kPa) as a median stiffness of HCC.

Hemangioma in this study had 4.91 kPa as a median stiffness (Fig. 4). This finding goes in accordance with Hasab Allah et al. [21] who reported 4.94 kPa as a median stiffness of hemangioma, which contradicted the finding of Guibal et al. [16] who reported a higher stiffness for hemangioma (13.8 kPa).

In this study, the origin of liver metastasis were mainly colorectal adenocarcinoma (4), followed by invasive ductal carcinoma of the breast (3), and adenocarcinoma of the gall bladder (2), then pancreatic adenocarcinoma (1), and metastatic gastrointestinal stromal tumor (1). This finding goes in agreement with Schiff et al. [24] who reported that the most common primary tumors of liver metastases are colorectal cancer and breast cancer.

The median stiffness of metastatic focal lesions in this study was 4.83 kPa, which goes in agreement with Hasab

<table>
<thead>
<tr>
<th>Lab investigations</th>
<th>HCC (40)</th>
<th>Hemangioma (14)</th>
<th>Metastasis (10)</th>
<th>Cystic lesion (10)</th>
<th>Cholangiocarcinoma (4)</th>
<th>FNH (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab investigations</td>
<td>Median</td>
<td>IQR</td>
<td>Median</td>
<td>IQR</td>
<td>Median</td>
<td>IQR</td>
</tr>
<tr>
<td>Hemoglobin, mean ± SD (g/dL)</td>
<td>11.4</td>
<td>1.35</td>
<td>12.04</td>
<td>1.16</td>
<td>9.63</td>
<td>1.51</td>
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<tr>
<td>WBCs (µL)</td>
<td>5.6</td>
<td>4.5–8.0</td>
<td>5.35</td>
<td>4.78–6.23</td>
<td>4.85</td>
<td>4.14–6.23</td>
</tr>
<tr>
<td>Platelets, mean ± SD (µL)</td>
<td>132.85</td>
<td>42.28</td>
<td>262.36</td>
<td>44.11</td>
<td>183.3</td>
<td>39.59</td>
</tr>
<tr>
<td>Creatinine (md/dL)</td>
<td>1.0</td>
<td>0.8–1.18</td>
<td>0.88</td>
<td>0.64–1.03</td>
<td>1.1</td>
<td>0.9–1.43</td>
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<tr>
<td>FBS (mg/dL)</td>
<td>102.0</td>
<td>92.0–115.75</td>
<td>94.5</td>
<td>83.25–107</td>
<td>95.5</td>
<td>87.25–128</td>
</tr>
<tr>
<td>ALT (µ/L)</td>
<td>61.0</td>
<td>41.25–75.0</td>
<td>20.0</td>
<td>16.75–33.5</td>
<td>33.5</td>
<td>27–57.5</td>
</tr>
<tr>
<td>INR</td>
<td>1.21</td>
<td>1.12–1.34</td>
<td>1.0</td>
<td>1.0–1.01</td>
<td>1.27</td>
<td>1.14–1.45</td>
</tr>
<tr>
<td>Albumin, mean ± SD (mg/dL)</td>
<td>3.43</td>
<td>0.57</td>
<td>4.05</td>
<td>0.35</td>
<td>3.14</td>
<td>0.53</td>
</tr>
<tr>
<td>Bilirubin (mg/dL)</td>
<td>1.8</td>
<td>1.35–2.21</td>
<td>0.79</td>
<td>0.69–0.9</td>
<td>1.25</td>
<td>0.85–5.3</td>
</tr>
<tr>
<td>AFP (&lt;10 ng/mL)</td>
<td>126.5</td>
<td>18.88–903</td>
<td>1.69</td>
<td>1.1–4.49</td>
<td>2.28</td>
<td>0.67–3.8</td>
</tr>
</tbody>
</table>

*P1 – HCC and hemangioma; P2 – HCC and metastasis; P3 – HCC and cystic lesions; P4 – HCC and cholangiocarcinoma; P5 – HCC and FNH.

AFP, alpha fetoprotein; ALT, alanine aminotransferase; AST, aspartate aminotransferase; FBS, fasting blood sugar; FNH, fine nodular hyperplasia; HCC, hepatocellular carcinoma; INR, international normalized ratio; IQR, interquartile range; WBCs, white blood cells.
Table 2. Comparison between patients with hepatocellular carcinoma (group I) and patients with studied hepatic focal lesions (group III) according to shear-waves elastography of the focal lesion and shear-waves elastography of liver parenchyma

<table>
<thead>
<tr>
<th>Group</th>
<th>Median (kPa)</th>
<th>IQR</th>
<th>Statistical test (Mann–Whitney test)</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWE of the focal lesion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCC (40)</td>
<td>4.94</td>
<td>4.4–6.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemangioma (14)</td>
<td>4.91</td>
<td>3.95–5.45</td>
<td>0.98</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Metastasis (10)</td>
<td>4.83</td>
<td>3.96–6.67</td>
<td>0.55</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>Cystic lesion (10)</td>
<td>1.48</td>
<td>1.29–2.9</td>
<td>4.80</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Cholangiocarcinoma (4)</td>
<td>6.78</td>
<td>5.42–7.42</td>
<td>2.5</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>FNH (2)</td>
<td>8.87</td>
<td>6.95–10.8</td>
<td>3.4</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Control (10)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>SWE of liver parenchyma</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCC (40)</td>
<td>14.07</td>
<td>13.13–18.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemangioma (14)</td>
<td>4.44</td>
<td>4.05–5.39</td>
<td>5.53</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Metastasis (10)</td>
<td>4.15</td>
<td>3.9–4.88</td>
<td>4.85</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Cystic lesion (10)</td>
<td>4.3</td>
<td>4.03–5.52</td>
<td>4.85</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Cholangiocarcinoma (4)</td>
<td>11.93</td>
<td>11.1–19.58</td>
<td>2.51</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>FNH (2)</td>
<td>4.8</td>
<td>3.31–6.29</td>
<td>5.85</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Control (10)</td>
<td>3.91</td>
<td>3.6–4.18</td>
<td>4.85</td>
<td>&lt;0.05*</td>
</tr>
</tbody>
</table>

*Statistically significant result.

Fig. 1. SWE values of HFL in all groups. FNH, fine nodular hyperplasia; HCC, hepatocellular carcinoma; HFL, hepatic focal lesion; SWE, shear-wave elastography.

Allah et al. [21] who reported 5.28 kPa as a median stiffness of metastatic focal lesions; however, this contradicted with Gerber et al. [25] who used Aixplorer ultrasound system (SuperSonic Imagine) and reported 29.5 kPa as a median stiffness of metastatic focal lesions.

The median stiffness of cystic focal lesions including simple cysts and liver abscesses in this study was 1.48 kPa. As far as we are aware, no published studies including stiffness evaluation of this type of liver lesions have been carried out.

The median stiffness of cholangiocarcinoma was 6.78 kPa, which goes in agreement with Hasab Allah et al. [21] who reported 6.84 kPa as a median stiffness of cholangiocarcinoma, which contradicted the finding of Guibal et al. [16] who reported 56.9 kPa as a median stiffness of cholangiocarcinoma.

Lastly, we had two cases of FNH, thses lesions needed biopsy and histopathological examination for diagnosis. The median stiffness of FNH was 8.87 kPa, which goes in accordance with Hasab Allah et al. [21] who reported 9.2 kPa as a median stiffness of FNH. This can be explained with the well-known high fibrotic content of this type of lesion.

Then, we aimed to compare the stiffness of HCC with the stiffness of other hepatic focal lesions included in this study using SWE. SWE showed inability to differentiate between HCC and hemangioma, as there was no statistically significant difference between SWE readings of the two groups (P value >0.05). This finding goes in agreement with Hasab Allah et al. [21] but on the contrary to Hee et al. [26] who used Aixplorer system (SuperSonic Imagine) and reported a significantly higher stiffness in HCC than in hemangioma.

SWE showed inability to differentiate between HCC and liver metastases, as there was no statistically significant difference between the readings of the two groups (P value >0.05). This finding goes in accordance with Choong et al. [23] who reported that the difference in elasticity values between HCC and liver metastases were not statistically significant. On the contrary, Hee et al. [26] reported a significantly higher stiffness in HCC than in metastasis.

SWE was able to differentiate between HCC and cystic focal lesions, as there was statistically significant difference between the readings of the two groups (P value <0.05), with cystic lesions being less stiff than HCC.

SWE was able to differentiate between HCC and cholangiocarcinoma, as there was statistically significant difference between the readings of the two groups (P value <0.05), with cholangiocarcinoma being more stiff than HCC. This finding goes in agreement with Gerber et al. [25] who reported that cholangiocarcinoma has the highest SWE values among malignant focal lesion.

SWE was able to differentiate between HCC and FNH, as there was statistically significant difference between the readings of the two groups (P value <0.05), with FNH being more stiff than HCC. This finding goes in agreement with Gallotti et al. [18] who reported a significant difference between SWE readings of the two groups.

Finally, we aimed to compare the stiffness of each focal lesion with that of the surrounding liver parenchyma using SWE. In this study, a statistically significant difference (P value <0.05) was found between values of liver parenchymal stiffness (14.7 kPa), compared to the focal HCC lesion (4.95 kPa). This finding goes in agreement with Hasab Allah et al. [21]. The lower stiffness values observed in HCCs compared to the surrounding liver parenchyma could be due to the presence of necrosis, hemorrhage, peliosis and presence of some fibrotic bands in HCCs as well as the great abundance of fibrosis in the surrounding liver, almost always a cirrhotic parenchyma (Popescu et al., 2013) [7]. This finding goes in agreement with Fahey et al. [13]. On the contrary, Cho et al. [14] showed that 76% of HCC lesions were as hard as, or even harder than...
the background liver, as in Asia, most HCCs develop in noncirrhotic liver being caused by HBV.

The median stiffness of liver parenchyma surrounding HCC (14.7 kPa) was found higher than that of liver parenchyma surrounding other studied hepatic focal lesions. This finding goes in agreement with Hasab Allah et al. [21].

In this study, there was no statistically significant difference between stiffness in hemangiomas (4.91 kPa) and the surrounding liver tissue (4.44 kPa). This finding goes in agreement with Hasab Allah et al. [21], but on the contrary to Cho et al. [14] who used ultrasound system Acuson S2000 US unit (Siemens, Mountain View, California, USA) and Heide et al. [27], who used ultrasound system Acuson S2000 (Siemens Medical Solutions, Erlangen, Germany) in the ‘VTTQ mode’ and their studies described that hemangiomas have slightly elevated stiffness compared with the surrounding liver. Guibal et al. [16], explained this elevation in stiffness due to the presence of fibrous septae separating the blood-filled spaces.

There was no difference in stiffness between metastatic focal lesions (4.83 kPa) and the surrounding liver tissue (4.15 kPa). This finding goes in agreement with Hasab Allah et al. [21], but on the contrary to Cho et al. [14], and Heide et al. [27] whose studies reported that metastatic focal lesions had the higher SWE values.

Cystic focal lesions were softer than the surrounding liver tissue with a statistically significant difference (P value <0.05). Cystic lesions showed a median elasticity value of 1.48 kPa, compared to 4.3 kPa as a median elasticity value of the surrounding liver parenchyma.

Cholangiocarcinoma was also softer than the surrounding liver tissue with a statistically significant difference (P value <0.05). Cholangiocarcinoma showed a median elasticity value of 6.78 kPa, compared to 11.93 kPa, as a median elasticity value of the surrounding liver parenchyma. This finding goes in agreement with Hasab Allah et al. [21].

In cases of FNH, it was harder than the surrounding liver tissue with a statistically significant difference (P value <0.05). FNH showed a median elasticity value of 8.87 kPa, compared to 4.8 kPa as a median elasticity value of the surrounding liver parenchyma. This can be explained with the well-known high fibrotic content of this type of lesion according to Gallotti et al. (2012) [18].

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**Table 3.** Comparison between shear-waves elastography of the focal lesion and shear-waves elastography of the surrounding liver parenchyma in different groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>SWE of focal lesion</th>
<th>SWE of liver parenchyma</th>
<th>Statistical test (Wilcoxon)</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (kPa)</td>
<td>IQR</td>
<td>Median (kPa)</td>
<td>IQR</td>
</tr>
<tr>
<td>HCC (40)</td>
<td>4.94</td>
<td>14.07</td>
<td>4.4–6.46</td>
<td>13.13–18.19</td>
</tr>
<tr>
<td>Hemangioma (14)</td>
<td>4.91</td>
<td>4.44</td>
<td>3.59–5.45</td>
<td>4.05–5.39</td>
</tr>
<tr>
<td>Metastasis (10)</td>
<td>4.83</td>
<td>4.15</td>
<td>3.96–6.87</td>
<td>3.9–4.88</td>
</tr>
<tr>
<td>Cystic lesion (10)</td>
<td>1.48</td>
<td>4.3</td>
<td>1.29–2.9</td>
<td>4.03–5.52</td>
</tr>
<tr>
<td>Cholangiocarcinoma (4)</td>
<td>6.78</td>
<td>11.93</td>
<td>5.42–7.42</td>
<td>11.1–19.58</td>
</tr>
<tr>
<td>FNH (2)</td>
<td>8.87</td>
<td>4.8</td>
<td>6.95–10.8</td>
<td>3.30–6.29</td>
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<tr>
<td>Control (10)</td>
<td>–</td>
<td>3.91</td>
<td>–</td>
<td>3.6–4.18</td>
</tr>
</tbody>
</table>

FNH, focal nodular hyperplasia; IQR, interquartile range; SWE, shear-waves elastography; Wilcoxon test, Wilcoxon signed-rank statistical test.

*Statistically significant result.

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**Table 4.** Comparison between shear-waves elastography of liver parenchyma in cirrhosis patients (group I) and shear-waves elastography of liver parenchyma in other groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>SWE of liver parenchyma</th>
<th>Median (kPa)</th>
<th>IQR</th>
<th>Statistical test (Mann–Whitney test)</th>
<th>P value*</th>
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<tr>
<td>LC (30)</td>
<td>23.66</td>
<td>23.66</td>
<td>17.84–28.23</td>
<td>4.52</td>
<td>&lt;0.05*</td>
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<tr>
<td>HCC (40)</td>
<td>14.07</td>
<td>14.07</td>
<td>13.13–18.19</td>
<td>5.3</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Hemangioma (14)</td>
<td>4.44</td>
<td>4.44</td>
<td>4.05–5.39</td>
<td>4.69</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Metastasis (10)</td>
<td>4.15</td>
<td>4.15</td>
<td>3.9–4.88</td>
<td>4.69</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Cystic lesion (10)</td>
<td>4.3</td>
<td>4.3</td>
<td>4.03–5.52</td>
<td>4.69</td>
<td>&lt;0.05*</td>
</tr>
<tr>
<td>Cholangiocarcinoma (4)</td>
<td>11.93</td>
<td>11.93</td>
<td>11.1–19.58</td>
<td>3.27</td>
<td>&lt;0.05*</td>
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<tr>
<td>FNH (2)</td>
<td>4.8</td>
<td>4.8</td>
<td>3.31–6.29</td>
<td>4.35</td>
<td>&lt;0.05*</td>
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<tr>
<td>Control (10)</td>
<td>3.91</td>
<td>3.91</td>
<td>3.6–4.18</td>
<td>4.89</td>
<td>&lt;0.05*</td>
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</tbody>
</table>

FNH, focal nodular hyperplasia; IQR, interquartile range; SWE, shear-waves elastography.

*Statistically significant result.

---

**Fig. 2.** SWE values of liver parenchyma in all groups. SWE, shear-wave elastography.
No correlation was noticed between the elasticity of different focal lesions and their size and number. Choong et al. [23] revealed the same finding between the size of the lesion and its elasticity.

**Conclusion**

The study showed that ElastPQ (iU22x MATRIX, Philips) was unable to differentiate between stiffness in both ‘HCC and hemangioma’ and ‘HCC and metastatic focal lesions’. ElastPQ showed that HCC, cystic focal lesions, and cholangiocarcinoma had lower stiffness in comparison to the surrounding liver parenchyma, while FNH had higher stiffness in comparison to the surrounding liver parenchyma.

ElastPQ showed that the surrounding liver parenchyma of the HCC group had the highest stiffness amongst all studied hepatic focal lesions surrounding liver parenchyma.

**Acknowledgements**

**Conflicts of interest**

There are no conflicts of interest.

**References**


<table>
<thead>
<tr>
<th>Correlation factor</th>
<th>HCC</th>
<th>Hemangioma</th>
<th>Metastasis</th>
<th>Cystic lesion</th>
<th>Cholangiocarcinoma</th>
<th>FNH</th>
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<tr>
<td>Size in cm</td>
<td>(P &gt; 0.05^*)</td>
<td>(P &gt; 0.05^*)</td>
<td>(P &gt; 0.05^*)</td>
<td>(P &gt; 0.05^*)</td>
<td>(P &gt; 0.05^*)</td>
<td>(P &gt; 0.05^*)</td>
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<tr>
<td>Number of focal lesions</td>
<td>(P &gt; 0.05^*)</td>
<td>(P &gt; 0.05^*)</td>
<td>(P &gt; 0.05^*)</td>
<td>(P &gt; 0.05^*)</td>
<td>(P &gt; 0.05^*)</td>
<td>(P &gt; 0.05^*)</td>
</tr>
</tbody>
</table>

HCC, hepatocellular carcinoma; FNH, focal nodular hyperplasia.

*Statistically significant result.