Shear Wave Elastography In Characterization Of Liver Tumours

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Aims and objectives

**Introduction**

Conventional ultrasound is being used widely for screening patients who are at high risk of hepatocellular carcinoma (HCC) [Chalasani N 1999]. Elastography is a stiffness imaging modality [Ophir J 2000] which is based on the premise that tissue elasticity can be changed by pathological conditions such as neoplasm or inflammation [Yeh WC 2002]. An excitation force is applied and the tissue response is measured to infer the mechanical properties of the tissue.

Supersonic shear wave elastography (SWE) is a novel 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 in order to provide quantitative elasticity maps [Bercoff J 2004]. SWE is integrated into an ultrasound machine which provides real-time two-dimensional B-mode images to identify the area of interest. The principle of SWE is demonstrated in Fig. 1.

SWE has been described in the assessment of the mechanical properties of liver tissues [Muller M 2009]. A previous study evaluated liver stiffness in chronic hepatitis C using SWE in comparison with TE [Bavu E 2011]. The intra-observer and inter-observer variability for assessment of liver fibrosis has also been reported [Ferraioli G 2012]. However, there is limited data on the role of this relatively new technology in assessing the elasticity of focal liver lesions.

**Objectives**

The objective is to determine the elasticity values of HCC and liver metastases, and also to evaluate the potential role of SWE in the characterization of these tumours.

**Images for this section:**
Fig. 1: Schematic diagram shows principles of supersonic SWE. Transmission of shear wave leads to tissue displacement, which results in propagation of shear waves away from region of excitation. Tissue response to the excitation force is measured and used to infer the elasticity properties of the tissue. A colour elastography map is produced.
Methods and materials

This was a prospective study approved by the local research ethics committee, University of Malaya, and informed consent was obtained from all patients. Patients referred to the Department of Biomedical Imaging, University Malaya Medical Centre, Malaysia for multiphase computed tomography (CT) liver examinations from July 2012 to March 2013 were screened.

The patients were then divided into the following groups based on the CT findings: newly diagnosed hepatocellular carcinoma (HCC), liver metastasis and control (patients with no focal liver lesion seen) (Refer Fig. 2).

Ultrasound and SWE were performed on these groups of patients using Aixplorer™ machine (SuperSonic Imagine, Aix-en-Provence, France) with liver scanning protocol. Convex SC6-1 probe was used to acquire the baseline ultrasound B-mode images and to perform the elastography study.

Statistical analyses were performed with SPSS software (version 20.0, IBM SPSS Statistics). Two-sided statistical significance was defined as \( p < 0.05 \).

Images for this section:

![SWE images of patients with HCC (left), liver metastasis (middle) and control group (right). For each image, an elasticity map (top panel) is displayed for the area corresponding to the region of interest in the B-mode image (bottom panel). Another smaller ROI called the "Q-box" with an arbitrary size can be set to calculate the average value of the stiffness within the area. The colour scale and calculated elasticity values (kPa) are seen on the right side of each image.](image-url)
Results

41 patients (30 male, 11 female, aged 59.7 ± 12.5 years) completed the SWE examination. Patients are categorised to HCC, liver metastasis and control groups (Refer Fig. 2).

17 patients (29.3%) of patients did not complete the SWE examination (Refer Fig. 3).

Table 1 and 2 show the mean and maximum elasticity values for HCC, metastasis and control group. Fig. 4 shows the box plot for comparison of the elasticity values.

There were significant differences (p<0.05) in tissue elasticity between HCC and the control group, as well as liver metastases with the control group (Table 1 and 2). However, the differences in the elasticity values between HCC and liver metastasis groups were not statistically significant.

Mean size of the HCC and metastatic lesions was 8.44 ± 4.70 and 4.56 ± 2.09 cm respectively. There is no correlation between the lesion elasticity and the lesion size.

Mean depth of the lesions was 4.33 ± 1.68 and 3.60 ± 1.51 cm respectively for HCC and liver metastases.

Table 3 shows the mean elasticity and standard deviation (SD) within the ROIs of the liver lesions. The lesions were categorized as homogenous when SD < 5kPa inside the ROI and heterogeneous when SD > 5kPa.

27.8% (13 nodules) of the HCC and 40% (4 nodules) of the liver metastases were noted to be heterogeneous (Refer Table 4). However the difference in the lesion heterogeneity in the two groups was not statistically significant (p = 0.68).

Discussion

This study demonstrated a significant difference in the stiffness of the HCC and metastatic lesions as compared to the control group respectively. The elasticity values for the HCC and metastatic lesions were slightly higher in this study as compared to a recently
published study, which reported 14.86 ± 10 kPa and 28.8 ± 16 kPa for HCC and metastases, respectively [Guibal A 2013]. However, both studies did not show significant difference between the HCC and metastatic lesions. Both studies also reported no significant correlation between lesion stiffness and size.

For qualitative SWE assessment, 27.8% (13 nodules) of the HCC and 40% (4 nodules) of the liver metastases were noted to be heterogeneous. This is in comparison with the previous study [Guibal A 2013] which reported 38.5% (10 nodules) of the HCC and 86.8% (46 nodules) of the liver metastases to be heterogeneous. The differences could be due to the sample size as the previous study assessed a total of 26 HCC and 53 metastatic lesions from various primary tumours.

**Images for this section:**

![SWE images of patients with HCC (left), liver metastasis (middle) and control group (right). For each image, an elasticity map (top panel) is displayed for the area corresponding to the region of interest in the B-mode image (bottom panel). Another smaller ROI called the "Q-box" with an arbitrary size can be set to calculate the average value of the stiffness within the area. The colour scale and calculated elasticity values (kPa) are seen on the right side of each image.](image-url)
Fig. 3: Flow chart showing patient selection in the study.
**Fig. 4:** Box plot demonstrating distribution of lesion stiffness in the HCC, metastasis and control groups. The box ends represent the first and third quartiles of the mean elasticity values. The end points of each graph represent the smallest and largest values.

<table>
<thead>
<tr>
<th></th>
<th>HCC (Group 1)</th>
<th>Control (Group 3)</th>
<th>Metastasis (Group 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean elasticity (kPa)</strong></td>
<td>51.45 ± 14.96</td>
<td>27.08 ± 18.51</td>
<td>49.89 ± 13.82</td>
</tr>
<tr>
<td>P value</td>
<td>Group 1 vs 3</td>
<td>Group 3 vs 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p = 0.000</td>
<td>p = 0.003</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1:** Comparison of mean elasticity values (kPa) for HCC, metastasis and control groups. There is no significant difference (p = 0.79) of the mean elasticity value between HCC and metastasis groups.

<table>
<thead>
<tr>
<th></th>
<th>HCC (Group 1)</th>
<th>Control (Group 3)</th>
<th>Metastasis (Group 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Max elasticity (kPa)</strong></td>
<td>58.88 ± 18.27</td>
<td>30.54 ± 21.41</td>
<td>52.30 ± 21.69</td>
</tr>
<tr>
<td>P value</td>
<td>Group 1 vs 3</td>
<td>Group 3 vs 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p = 0.000</td>
<td>p = 0.02</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2:** Comparison of maximum elasticity values (kPa) for HCC, metastasis and control groups. There is no significant difference (p = 0.40) of the max elasticity value between HCC and metastasis groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean elasticity ± SD (kPa)</th>
<th>SD within lesions (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCC</td>
<td>51.45 ± 14.96</td>
<td>3.91 ± 2.21</td>
</tr>
<tr>
<td>Metastasis</td>
<td>49.89 ± 13.82</td>
<td>4.25 ± 3.19</td>
</tr>
</tbody>
</table>

**Table 3:** Means and standard deviations (SDs) of the lesion stiffness in kPa for HCC and liver metastases.

<table>
<thead>
<tr>
<th>Group</th>
<th>Homogeneous</th>
<th>Heterogeneous</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCC</td>
<td>13</td>
<td>6</td>
<td>19</td>
</tr>
<tr>
<td>Metastasis</td>
<td>5</td>
<td>4</td>
<td>9</td>
</tr>
</tbody>
</table>

**Table 4:** Distribution of qualitative stiffness pattern (homogenous, heterogeneous) for HCC and liver metastases.
Conclusion

SWE is a non-invasive, quantitative and non-radiating method which provides additional information to characterise HCC and metastatic liver nodules based on the tissue elasticity values. Further studies with larger patient population should be performed to determine its diagnostic role in assessing focal liver lesions including other malignant and benign liver lesions.

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References


