Strain elastography in the characterization of renal masses: preliminary results

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Aims and objectives

Ultrasound (US) elastography is a new imaging mode that displays tissue softness or hardness in real time as a color map that translucently overlays the conventional B-mode image. Because malignant tumors predominantly are harder than benign tissues, this technique significantly improves the differentiation between benign and malignant tissues. Itoh et al. (1) reported a good correlation between strain elastography and histologic analysis, with high sensitivity and specificity for classifying benign versus malignant masses in breast. We hypothesized that evaluation of tissue elasticity might be useful for renal mass characterization. The aim of our study, therefore, was to prospectively determine the diagnostic efficiency of sonoelastography for differentiating benign from malignant renal lesions.
Methods and materials

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<td>Sensitivity (%)</td>
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<tr>
<td>Specificity (%)</td>
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<tr>
<td>Positive predictive value (%)</td>
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</tr>
<tr>
<td>Negative predictive value (%)</td>
<td>88</td>
</tr>
</tbody>
</table>

Table 1

Study population

The study population comprised 69 (30 men and 39 women) patients who underwent US, including elastography of a renal mass, within the authors’ institution between March 2012 and February 2013. The mean age of the population was 56.1 ± 12.5 (range 32-81 years). The study population had various renal masses, including 41 renal cell carcinomas (RCCs), 24 angiomyolipomas (AMLs), 2 oncocytomas, 1 transitional cell carcinoma (TCC) and 1 renal metastasis. The RCCs and TCC were diagnosed by resection. The oncocytomas and metastasis were diagnosed by biopsy. Histological subtype was clear cell carcinoma in 26 patients, papillary cell carcinoma in 7 patients, chromophobe cell carcinoma in 5 patients, and mix cell carcinoma in 3 patients. The 24 AMLs were diagnosed by presence of bulk fat on computed tomography (CT) and/or magnetic resonance imaging (MRI) (2, 3). This prospective observational study was approved by the Institutional Review Board. All patients gave informed consent.

Equipment and scanning

One radiologist (SK) with 9 years of experience in conventional sonography and 2 years experience in elastography carried out the sonoelastography examinations. The patients experienced both B-mode and elastographic sonography in the supine and lateral decubitus position with a digital sonography scanner (Aplio XG; Toshiba Medical Systems, Tokyo, Japan) supplied with strain elastography software and a convex 2.5-5 MHz multifrequency transducer. All assessments were executed during breath holding after deep inspiration. After recognition of a target lesion on a B-mode US image, strain elastography was executed using the same probe. The probe was manually moved to compress and relax the underlying tissue. Both elastographic and B-mode images were demonstrated at the same time as a two-panel image during the performance of sonoelastography. Only solid portions of the lesions were evaluated when determining the elastographic pattern. The elastogram was exhibited over the B-mode image in a color scale: red (greatest strain, softest component) and blue (no strain, hardest component).
tissue. Green indicated average strain (4). Both renal lesions and normal surrounding tissue were comprised in the elastographic box.

**Data analysis**

The presence of fluid areas was noted, but only the solid portions of the lesion were evaluated when determining the elastographic pattern (5). One radiologist who was blinded to the pathologic findings or final diagnoses reviewed the static images except for those of 23 patients who were previously diagnosed as AML with CT. The strain ratio was measured by comparing the tumor (B) to the renal cortex for all renal lesions. The first region of interest (ROI) was placed in the renal cortex. The second ROI was placed in the renal mass (6). The radiologist noted the elasticity values in the ROI placed over the stiffest areas on the elastography image for renal cortex and renal mass. The strain ratio (A/B), reflecting the stiffness of the lesion, was then automatically calculated on the US machine (Figs. 1-4).

**Statistical analysis**

Statistical analysis was performed using SPSS version 20 software (SPSS Inc, Chicago, IL, USA). The numerical variables were declared as either mean ± standard deviation or number (percentage), where appropriate. Subsequently, the lesion size was categorized as less than 20 mm, 20-40 mm, or greater than 40 mm to assess the competence of this modality for various lesion sizes (7). We used the Mann-Whitney U test to analyze each lesion size category (for strain ratio and pathology) and strain ratio (for gender). Kruskal-Wallis tests were conducted to compare strain ratio and the ordinal variables among the lesion size category and lesion subtypes. The Mann-Whitney U test was performed to test the significance of pairwise differences using Bonferroni correction to adjust for multiple comparisons. Two-tailed $P$ values less than 0.05 were accepted to be statistically significant. We used receiver operating characteristics (ROC) curve analysis to assess diagnostic value of strain ratios for differentiation between benign and malignant masses. When a significant cut-off value was observed, the sensitivity, specificity, positive predictive value, and negative predictive value were presented (Table 1). While evaluating the area under the curve, a 5% type I error level was used to accept a statistically significant predictive value of the test variables.
Fig. 1: A 43-year-old woman with angiomyolipoma (arrows)

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Fig. 2: To estimate strain ratio on an elastography image, the first ROI (A) was placed in the renal cortex and the second ROI (B) was drawn in the neoplasm. The strain ratio was calculated automatically as an A/B

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Fig. 3: A 51-year-old woman with clear cell renal cell carcinoma (arrows)

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Fig. 4: To estimate strain ratio on an elastography image, the first ROI (A) was placed in the renal cortex and the second ROI (B) was drawn in the neoplasm. The strain ratio was calculated automatically as an A/B.

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Results

Table 2

The descriptive data for strain ratios and lesion diameter was shown Table 2.

The mean size for benign lesions was 33.3 ± 5.3 mm (range 7-105 mm) and for malignant lesions was 54.1 ± 3.4 mm (range 8-109 mm). There was a significant difference in tumor size between the benign and malignant lesions ($P < 0.01$).

The mean strain ratio for benign lesions was 1.2 ± 0.2 (range 0.06-4.06) and for malignant lesions was 3.4 ± 0.3 (range 0.08-9.92). When benign and malignant lesions were compared, there was a statistically significant difference in the strain ratio between the two groups ($P < 0.01$).

The mean strain ratio for <20 mm lesions was 1.5 ± 0.5 (range 0.06-5.92), for 20-40 mm lesions was 2.7 ± 0.4 (range 0.17-9.92), and for >40 mm lesions was 2.7 ± 0.3 (range 0.08-6.15). When benign and malignant lesions were compared, there was a statistically significant difference in the strain ratio between the three groups ($P < 0.01$).

When lesion subtypes were compared, there was a statistically significant difference in the strain ratio between the AML and the clear cell RCC ($P < 0.01$). When lesion size categories were compared, there was a statistically significant difference in strain ratio between <20 mm lesions and 20-40 mm lesions ($P = 0.021$).

When female and male gender were compared, there was a statistically significant difference in the strain ratio between the two groups ($P = 0.029$).

Using ROC analysis, the best cut-off value was 1.67. The area under the ROC curve was 0.925 with a 95% confidence interval of 0.853-0.998 (Fig. 5).
**Fig. 5:** Characteristic curve of strain ratio measurements in differentiating malignant lesions from benign lesions

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Conclusion

Strain elastography measures the degree of distortion of a tissue under compression and is based on the principle that the softer parts of tissues deform more easily than the harder parts. In recent years this technique has been successfully applied to breast lesions, prostate, pancreas, lymph nodes, thyroid gland, testes, and liver. Evaluation of deep tissues is more feasible, and this approach has been successfully applied in clinical studies to investigate intra-abdominal tissues (8-11). Pallwein et al. (12) reported that strain elastography allows the detection of prostate cancer and estimation of tumour location and size. Salomon et al. (13) reported that elastography could detect prostate cancer foci within the prostate with good accuracy and had potential to increase ultrasound-based prostate cancer detection. Zhang et al (14) showed that there was significant difference of strain ratio values between the benign and malignant prostate lesions. Dudea et. al (15) reported that sonoelastography definitely improves the detection of prostate cancer. Onur et al. (16) showed that strain elastography might be helpful for differentiating benign and malignant liver masses. Tan et al. (17) reported a study in which strain elastography had been used to evaluate renal tumors. Their results showed that strain elastography might be useful in differentiating angiomyolipomas from renal cell carcinomas, by use of both elasticity patterns and strain ratios. In contrast with, we did not use elasticity patterns. We searched whether strain elastography was a useful method in differentiating benign from malignant renal lesions. In our study, strain ratio values suggest a benefit method for differentiation between renal benign and malignant lesions, with high sensitivity and specificity. We recommend this technique for patients with kidney lesions newly diagnosed on US as an incidental finding that can potentially be used to avoid requiring a follow-up CT or MRI for further evaluation. In addition, sonoelastography may be used in place of CT or MRI to arrive at a diagnosis in patients with iodine-based contrast allergy, renal insufficiency, or urinary tract obstruction, which may be contraindications for contrast-enhanced studies. Several limitations in our study warrant consideration. First, there were significant differences in size between the benign and malignant renal lesions; the performance of sonoelastography may not have been as high in two size-matched groups. Second, our study population was not a large group and not enough of the patients had histological subgroups; the diagnostic performance of elastography may vary with different histological subgroups of malignant and benign tumors. In addition, elastography itself has certain limitations. Elastography for pure cystic lesions does not give useful information, and the compression of the solid portion may be affected by the lack of strain of the fluid portion. Elastography in terms of the application of pressure to the probe has a relatively greater operator dependency, and strain values may change with different degrees of manual compression as well as with the composition and structure of tissues (18, 19). Furthermore, various factors, such as lesion size, depth, and density, can affect the performance of elastography, and it can be difficult to achieve optimal image quality for every case.
In conclusion, our prospective study showed that strain elastography may be useful for differentiating between benign and malignant renal lesions. Being a noninvasive and low-cost imaging modality, we propose that US elastography may improve accuracy in the differential diagnosis of renal tumors.
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References


