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**Case Report**  
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# Measurement of Tissue Stiffness with Virtual Touch Tissue Quantification in Two Cases of Spleen Tumor

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## SUMMARY

We performed non-invasive measurement of tissue stiffness in the spleen for two patients using virtual touch tissue quantification (VTTQ). Case 1 was an 82-year-old woman with Hodgkin lymphoma. Stiffness measured using VTTQ was lower than normal spleen in tumor areas and higher than normal spleen in non-tumor areas. Case 2 was a 66-year-old man with ascites and gastric cancer involving the entire spleen. Stiffness of the spleen tumor as measured by VTTQ was higher than normal spleen. These cases demonstrated two new factors associated with elevated spleen stiffness : compression of healthy spleen tissue by tumor and cancer invasion.

**Key Words** : virtual touch tissue quantification, spleen, tissue stiffness

## INTRODUCTION

Recent advances in ultrasound technology have enabled the non-invasive measurement of tissue stiffness in various organs. Virtual touch tissue quantification (VTTQ) is a new technique that can measure tissue stiffness by measuring the velocity at which shear waves produced by acoustic radiation force impulse (ARFI) are propagated in the tissue. Measurements are expressed as shear wave propagation velocity (VS) in meters per second (m/s), with higher VS indicating stiffer tissue. Measurements of liver stiffness with VTTQ are reported useful for evaluating liver fibrosis in chronic liver disease<sup>1,2)</sup> and for distinguishing neoplastic liver tumors<sup>3,4)</sup>.

We measured stiffness with VTTQ and obtained interesting findings in two cases of spleen tumor. An ACUSON S2000 ultrasound system (Siemens Medical Solutions USA, CA, USA) was used. Spleen stiffness was measured 5-10 times at locations 2-4 cm from the body surface under B-mode ultrasonographic guidance, and expressed as mean  $\pm$  standard deviation. Measurements of spleen stiffness were performed after obtaining approval from the Institution Review Board of Dokkyo Medical University Koshigaya Hospital and informed consent from both patients.

## CASE 1

The patient was an 82-year-old woman who presented in May 2011 with a chief complaint of loss of appetite. Computed tomography (CT) showed enlargement of many cervical, supraclavicular, mediastinal, and intraperitoneal lymph nodes. The spleen was enlarged and many tumors with poor contrast enhancement were seen (Fig. 1). Hodgkin lymphoma was diagnosed from a biopsy of cervical lymph nodes. Many hypoechoic lesions were seen in the enlarged spleen

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**Fig. 5** Contrast-enhanced CT shows continuity of the spleen tumor and thickened gastric wall (white arrow).

non-cancerous areas of splenic parenchyma apparent. Stiffness of the spleen tumor as measured by VTTQ was  $4.05 \pm 0.47$  m/s (Fig. 6).

## DISCUSSION

Many splenic lesions related to malignant lymphoma are seen, but few investigations of ultrasonographic findings for these lesions have been reported. Goerg et al. described abnormal splenic findings on ultrasonography in 43 of 900 patients (4.8%) with malignant lymphoma<sup>5</sup>. Sixteen of those patients had Hodgkin lymphoma, with focal ultrasound findings in 7 and diffuse findings in 9. When lesions are focal, the tumor is observed as a hypoechoic lesion. The splenic lesion in Case 1 corresponded with this focal type.

Cancer metastasis to the spleen is rare, occurring in 0.6–7.1% of all cancer cases according to autopsy investigations<sup>6–8</sup>. Metastasis of gastric cancer to the spleen has been found to be relatively high, at 7–16%<sup>7,8</sup>. However, patients with metastasis to the spleen have many metastases to multiple organs<sup>6</sup>, and the spleen is generally the last organ to show hematogenous metastasis of cancer<sup>9</sup>. Case 2 was a rare case in which no distant metastases were identified and the cancer invaded the spleen directly.

In 2003, Sandrin et al. reported the usefulness of liver stiffness measurements with transient elastography in diagnosing fibrosis of the liver in chronic hepatitis C patients<sup>10</sup>. Transient elastography is an ultrasound-based



**Fig. 6** Measurement of spleen tumor stiffness with VTTQ was made using the same method as in Case 1.

technology that measures liver stiffness using differences in the velocity of elastic shear wave propagation across the liver. This new test method is useful in diagnosing chronic liver disease including non-alcoholic steatohepatitis<sup>11</sup> and hepatocellular carcinoma<sup>12–14</sup>, as well as in predicting the development of cancer<sup>15–17</sup>. However, transient elastography is a technique that blindly measures sites marked on ultrasound images, so measurement of stiffness in places other than the right lobe of the liver is difficult. Transient elastography also has the disadvantage of being unable to make measurements when substantial amounts of ascites or adipose tissue are present between the probe and liver. VTTQ can measure stiffness while checking the image in real time with ultrasound monitoring. In addition, shear waves produced by ARFI can be generated laterally at any depth on the observed plane. Using VTTQ thus allows the measurement of stiffness in the left lobe of the liver<sup>18</sup> and other peritoneal organs that are difficult to measure with transient elastography<sup>19</sup>.

Few reports have described the measurement of stiffness using VTTQ in organs other than the liver. Gallotti et al. measured stiffness of peritoneal organs in healthy people, and reported mean values of 1.59 m/s for the liver, 1.40 m/s for the pancreas, 2.44 m/s for the spleen, and 2.24 m/s for the kidney<sup>19</sup>. The highest stiffness was thus seen in the spleen. We found a spleen stiffness of  $2.37 \pm 0.25$  m/s in an investigation of 10 healthy volunteers (data not shown), similar to the results of Gallotti et al.

Of the two cases reported here, Case 1 showed

splenic metastasis of Hodgkin lymphoma. Stiffness of the tumor portion was lower than the stiffness of the spleen in healthy people, while that in the non-tumor portion was higher. In routine medical care, lymphoma often seems softer than cancer or inflammatory tumors, but we have seen no reports of stiffness measured using VTTQ. In Case 1, stiffness of the non-tumor portion was elevated, which was attributed to increased density in the spleen due to pressure on structural components from the tumor. Case 2 involved splenic metastasis of gastric cancer. The entire spleen appeared tumorous on CT and ultrasound examinations, so stiffness of non-tumorous spleen could not be measured. However, stiffness of the tumorous spleen was extremely high.

In cases of chronic hepatitis or cirrhosis, stiffness of the spleen reflects fibrosis of the liver and thus increases<sup>2)</sup>. Measurements of spleen stiffness are thus thought to be useful in predicting esophageal varices<sup>20)</sup>. The elevated pressure in the spleen resulting from congestion caused by increased splenic blood flow due to portal hypertension, as well as fibrosis of the spleen, are thought to contribute to increased spleen stiffness in chronic liver disease, although the details remain unclear. The present study identified two new factors associated with elevated spleen stiffness : invasion of cancer and compression of healthy spleen tissue by tumor. The objective finding of low stiffness for lymphoma compared with cancer was also very interesting.

#### REFERENCES

- 1) Toshima T, Shirabe K, Takeishi K, et al : New method for assessing liver fibrosis based on acoustic radiation force impulse : a special reference to the difference between right and left liver. *J Gastroenterol* **46** : 705-711, 2011.
- 2) Grgurevic I, Cikara I, Horvat J, et al : Noninvasive assessment of liver fibrosis with acoustic radiation force impulse imaging : increased liver and splenic stiffness in patients with liver fibrosis and cirrhosis. *Ultraschall Med* **32** : 160-166, 2011.
- 3) Shuang-Ming T, Ping Z, Ying Q, et al : Usefulness of Acoustic Radiation Force Impulse Imaging in the Differential Diagnosis of Benign and Malignant Liver Lesions. *Acad Radiol* **18** : 810-815, 2011.
- 4) Gallotti A, D'Onofrio M, Romanini L, et al : Acoustic Radiation Force Impulse (ARFI) ultrasound imaging of solid focal liver lesions. *Eur J Radiol* **81** : 451-455, 2012.
- 5) Goerg C, Schwerk WB, Goerg K, et al : Sonographic patterns of the affected spleen in malignant lymphoma. *J Clin Ultrasound* **18** : 569-574, 1990.
- 6) Schon CA, Gorg C, Ramaswamy A, et al : Splenic metastases in a large unselected autopsy series. *Pathol Res Pract* **202** : 351-356, 2006.
- 7) Lam KY, Tang V, Metastatic tumors to the spleen : a 25-year clinicopathologic study. *Arch Pathol Lab Med* **124** : 526-530, 2000.
- 8) Berge T, Splenic metastases. Frequencies and patterns. *Acta Pathol Microbiol Scand A* **82** : 499-506, 1974.
- 9) Chen MJ, Huang MJ, Chang WH, et al : Ultrasonography of splenic abnormalities. *World J Gastroenterol* **11** : 4061-4066, 2005.
- 10) Sandrin L, Fourquet B, Hasquenoph JM, et al : Transient elastography : a new noninvasive method for assessment of hepatic fibrosis. *Ultrasound Med Biol* **29** : 1705-1713, 2003.
- 11) Yoneda M, Fujita K, Inamori M, et al : Transient elastography in patients with non-alcoholic fatty liver disease (NAFLD). *Gut* **56** : 1330-1331, 2007.
- 12) Kuo YH, Lu SN, Hung CH, et al : Liver stiffness measurement in the risk assessment of hepatocellular carcinoma for patients with chronic hepatitis. *Hepatol Int* **4** : 700-706, 2010.
- 13) Nahon P, Kettaneh A, Lemoine M, et al : Liver stiffness measurement in patients with cirrhosis and hepatocellular carcinoma : a case-control study. *Eur J Gastroenterol Hepatol* **21** : 214-219, 2009.
- 14) Masuzaki R, Tateishi R, Yoshida H, et al : Risk assessment of hepatocellular carcinoma in chronic hepatitis C patients by transient elastography. *J Clin Gastroenterol* **42** : 839-843, 2008.
- 15) Fung J, Lai CL, Seto WK, et al : Prognostic significance of liver stiffness for hepatocellular carcinoma and mortality in HBeAg-negative chronic hepatitis B. *J Viral Hepat* **18** : 734-744, 2011.
- 16) Masuzaki R, Tateishi R, Yoshida H, et al : Prospective risk assessment for hepatocellular carcinoma development in patients with chronic hepatitis C by transient elastography. *Hepatology* **49** : 1954-1961, 2009.
- 17) Akima T, Tamano M, Hiraishi H, Liver stiffness mea-

- sured by transient elastography is a predictor of hepatocellular carcinoma development in viral hepatitis. *Hepatol Res* **41** : 965-970, 2011.
- 18) Kaminuma C, Tsushima Y, Matsumoto N, et al : Reliable measurement procedure of virtual touch tissue quantification with acoustic radiation force impulse imaging. *J Ultrasound Med* **30** : 745-751, 2011.
- 19) Gallotti A, D'Onofrio M, Pozzi Mucelli R, Acoustic Radiation Force Impulse (ARFI) technique in ultrasound with Virtual Touch tissue quantification of the upper abdomen. *Radiol Med* **115** : 889-897, 2010.
- 20) Takuma Y, Morimoto Y, Tomokuni J, et al : Comparison of accuracy for prediction of esophageal varices obtained by liver and spleen stiffness measurements via virtual touch tissue quantification. *Kanzo* **52** : 258-259, 2011.