MR Elastography of Peritoneal Tumor

R. N. Low[1,2], M. J. Austin[3], L. Estkowski[4], and R. Ehman[5]
[1]Sharp and Children's MRI Center, San Diego, CA, United States, [2]San Diego Imaging, San Diego, CA, United States, [3]Radiology, Universit y of California at San Diego, San Diego, CA, United States, [4]General Electric Healthcare, [5]Mayo Clinic

Purpose: To evaluate the feasibility of MR Elastography (MRE) of peritoneal tumors.

Background: MRE is a phase contrast MRI technique that evaluates the stiffness of tissues by directly visualizing and measuring propagated mechanical shear waves in tissues. MRE generates quantitative measurements and colorized spatial maps of shear wave displacement. The initial wave images are processed to generate an elastogram, which displays the quantitative values of the shear modulus of tissues on a color coded spatial map. MRE has been used to evaluate liver fibrosis which shows higher stiffness than normal liver parenchyma. Liver tumors also demonstrate increased liver stiffness and preliminary reports suggested that MRE may help to distinguish malignant from benign liver tumors. To our knowledge the use of MRE to evaluate other extrahepatic tumors including peritoneal tumors has not been previously reported.

Materials and Methods: Forty-four oncology patients were referred for abdominal MRI performed in a 1.5T scanner (Signa HD-x GE Healthcare) using a 12 channel phased-array torso coil. Thirteen patients had known peritoneal tumors with primary malignancy of the ovary (3), appendix (7), pancreas (2), and breast (1). The remaining 19 patients had no clinical or imaging evidence of peritoneal metastases. Conventional MR imaging that included coronal SSFSE, axial dual echo T1 SGE, fat suppressed fast triple echo DIXON (fTED) T2-weighted, diffusion-weighted B400 s/m^2, and dynamic gadolinium-enhanced 3D LAVA-Flex imaging. Delayed fat suppressed 2D SGE imaging was performed 5 min after gadolinium injection.

MRE was performed using a 19-cm diameter 1.5-cm thick cylindrical passive driver placed against the abdominal and chest wall overlying the liver at the level of the xiphoid process of the sternum. The passive driver was held in place with an abdominal binder. Continuous acoustic vibration at 60 Hz was transmitted from an active driver to the passive driver through a flexible vinyl tube. The propagating shear waves were imaged with a modified phase contrast, gradient-echo sequence for collection of axial wave images. MRE sequence parameters included TR 50 ms, TE 24.6 ms, bandwidth $\pm$31.25 kHz, flip angle 30 degrees, matrix size 256x64, and slice thickness 10 mm, gap 1 mm. Four axial MRE slices were obtained each requiring a single 20 second breath hold. MR Elastogram was generated by processing the acquired wave image to produce a quantitative map of tissue shear stiffness measured in kilopascals. Mean shear stiffness of liver parenchyma and peritoneal tumors was calculated by manually drawing a region of interest (ROI) over peritoneal tumors and the liver. The colorized MRE images were reviewed for all patients without knowledge of diagnosis or the presence or absence of peritoneal tumors. Areas of perihepatic increased stiffness were recorded as possible peritoneal tumor. The region under the passive driver was not included due to the presence of local disturbances caused by the driver. The results of the blinded review of the MR Elastogram were compared to all other imaging sequences and to the patient's clinical and surgical history to determine the true presence or absence of peritoneal tumor.

Results: The colorized MRE images showed perihepatic areas of focal increased stiffness in 14 patients. In 11 patients the MRE abnormality correlated with peritoneal tumors demonstrated on the conventional unenhanced and gadolinium-enhanced MRI. In 3 patients the results of the MRE were not confirmed on the MRI and were recorded as false positive findings. Twenty-six cases showed no tumor on MRE or MRI. In two cases MRE missed small peritoneal tumors seen on conventional MRI. The overall MRE sensitivity was .85, specificity .90, and accuracy .88. In the quantitative analysis the mean shear stiffness of the peritoneal tumors was 4.37 kPa (SD 0.89) and the mean shear stiffness of the liver was 2.67 kPa (SD 0.72).

Discussion: This feasibility study represents our very early experience using MRE for oncology patients with peritoneal tumors**.** Current MRE techniques will be improved with implementation of a 3D MRE pulse sequence which will improve quantitative measurements and eliminate some of the artifctual areas of increased stiffness we encountered. Potential applications of this new MRE technique might include assessing different grades of peritoneal tumors or determining response to therapy with MRE.

Conclusions: MRE provides a new contrast mechanism to evaluate peritoneal metastases which show increased shear stiffness.

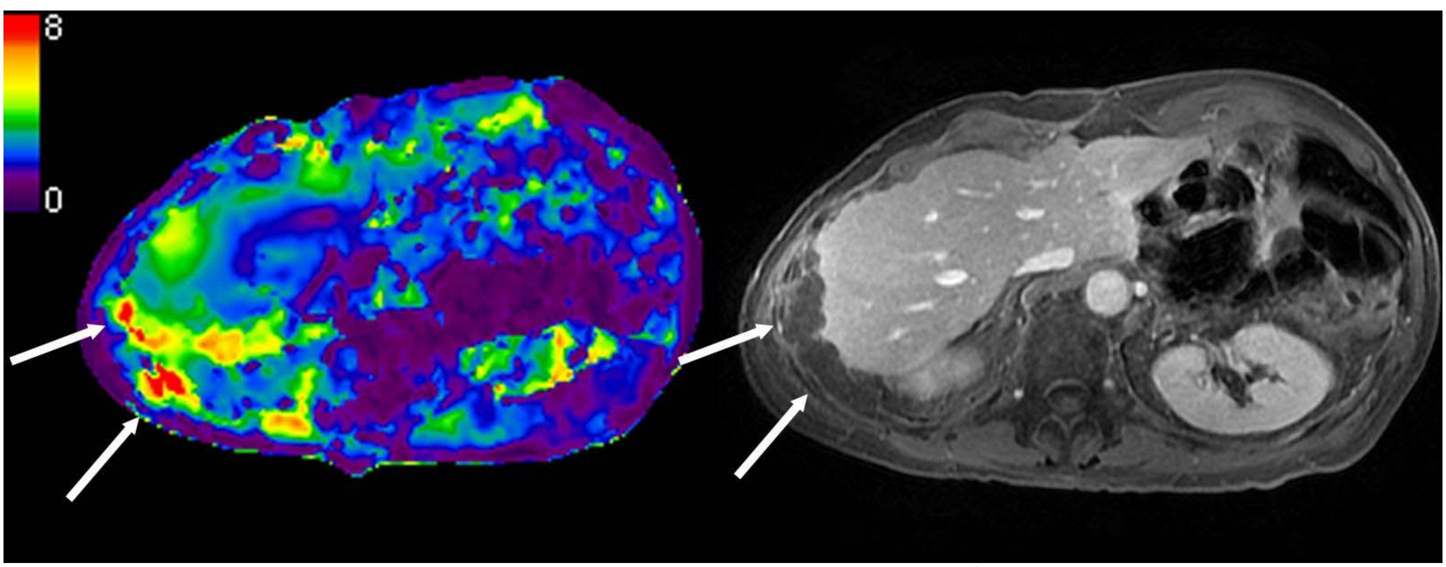

Figure 1: 62 year old male with appendiceal cancer and pseudomyxoma peritonei. MR Elastogram (left) shows perihepatic tumor (arrows) with increased shear stiffness (6.2 kPa) compared to the mean liver 1.8 kPa. Delayed gadolinium-enhanced MRI right confirms the moderately bulky right subphrenic mucinous tumor (arrows).

References: [1] Rouvière O, et al. MR Elastography of the Liver: Preliminary Results. Radiology 2006;240:440-448.
[2] Venkatesh SK et al. MR Elastography of liver tumors: Preliminary results. AJR 2008; 190:1534-1540.