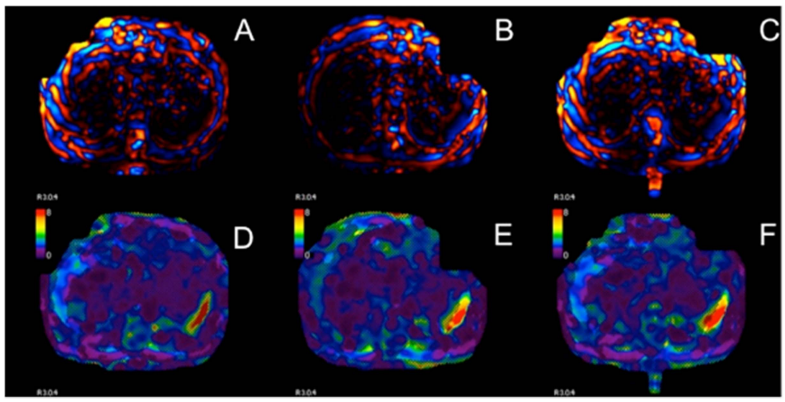
Measurement of liver and splenic stiffness with MR elastography using single or double acoustic excitation.

Hadrien A. Dyvorne[1], Guido H. Jajamovich[1], Richard L. Ehman[2], Ersin Bayram[3], Bachir Taouli[1], and Richard L. Ehman[2]
[1]*Mount Sinai School of Medicine, New York, NY, United States,* [2]*Department of Radiology, Mayo Clinic, Rochester, MN, United States,* [3]*GE Healthcare, Waukesha, WI, United States*

Target audience: Radiologists, MR physicists and technologists interested in MR elastography applications in the liver.

Purpose: Recently, MR elastography (MRE) has been proposed to diagnose liver fibrosis and cirrhosis by measuring liver stiffness, which increases as a function of fibrosis content in the liver parenchyma[1,2]. Portal hypertension (PH) is a complication of liver cirrhosis, diagnosed using hepatic vein pressure gradient, which is invasive. PH may affect liver and splenic stiffness via tissue congestion, thereby offering a non invasive way of estimating portal venous pressure using MRE[3]. To properly measure liver and splenic stiffness, acoustic excitations need to be applied to both organs of interest, which can be done in two different acquisitions by changing the driver location or in the same acquisition by using two drivers in parallel. The purpose of this study is to compare organ stiffness obtained with a single acoustic driver placed on the liver or spleen, or obtained using a double driver excitation in a single acquisition.



MRE wave images (A, B, C) and stiffness maps (D, E, F, in kPa) acquired in a 66 y old patient with HCV, using a single driver excitation on the liver (A, D) or spleen (B, E), or a double driver excitation on both organs in the same acquisition (C, F). Stiffness values measured on four consecutive planes were LS=2.06 and SS=6.87 kPa using single driver, and LS=2.06 and SS=6.75 kPa with double driver excitation.

Methods: 28 subjects (M/F 18/10, mean age 48 y, including 10 healthy volunteers and 18 patients with liver disease, among which 10 with cirrhosis) were enrolled in this prospective IRB approved study. All subjects underwent 3T MRI (MR750, GE Healthcare) including axial MRE sequence (TR/TE 50/22, resolution 1.4 x 2.8 mm^2, 4 slices, thickness 10 mm, 50 Hz, ASSET 2) acquired during 4 breath-holds. 3 MRE acquisitions were performed, using alternatively an acoustic driver on the right chest wall (liver excitation), left chest wall (spleen excitation) or both drivers simultaneously (dual excitation). All sequence parameters were kept identical between acquisitions. LS (liver stiffness) and SS (splenic stiffness) were calculated using MRE Quant (Mayo Clinic), by placing ROIs in the liver or spleen parenchyma. A confidence parameter (from 0 to 100%) was derived in each pixel that reflects data quality (SNR and wave amplitude). LS and SS values were compared between single and double excitation using paired t tests, Pearson correlation and Bland Altman analysis. LS and SS were compared between patients with liver cirrhosis vs. those without cirrhosis.

Table 1	Single driver stiffness (kPa)	Dual driver stiffness (kPa)	p*	Pearson corr.**	Bland Altman Mean (kPa)	Bland Altman SD (kPa)
Liver	3.01 ± 1.39	3.04 ± 1.42	0.560	0.99	0.02	0.20
Spleen	6.00 ± 2.08	6.12 ± 2.04	0.244	0.96	0.12	0.52

Comparison of stiffness values in the liver and spleen using a single and double driver excitation
*paired t test, **p<0.001

Results: LS was measured successfully in 27 subjects (1 subject had iron deposition causing MRE failure). SS was measured successfully in 24 subjects because of weak wave propagation in the spleen in 4 subjects. A double excitation provided high confidence both in the liver and spleen in the same acquisition, whereas a single driver typically provided a high confidence only in the organ covered by the driver. Stiffness values were not significantly different between single and double driver excitation in the liver and spleen **(Table 1)**. LS and SS were significantly higher in cirrhosis using both single and double driver excitation **(Table 2)**.

Table 2	Non cirrhotic	Cirrhosis	p
LS single	2.21 ± 0.61	4.61 ± 1.09	<0.001
LS dual	2.21 ± 0.60	4.68 ± 1.11	<0.001
SS single	5.11 ± 1.18	7.78 ± 2.41	0.016
SS dual	5.29 ± 1.31	7.79 ± 2.29	0.013

Table 2: Comparison of stiffness values between cirrhotic subjects and non cirrhotic subjects
LS and SS in kPa

Discussion: Using a dual acoustic driver that excites both liver and spleen, it is possible to extract hepatic and splenic stiffness values from a single MRE acquisition, with values equivalent to those obtained with a single excitation. Both LS and SS were significantly higher in cirrhotic subjects, signs of organ congestion due to portal hypertension. In future work, we plan to further investigate the performance of liver or splenic stiffness measurement for the diagnosis of portal hypertension.

Conclusion: Liver and splenic stiffness can be measured simultaneously in a single MRE acquisition, using 2 acoustic drivers in parallel, with values equivalent to single driver acquisition. LS and SS values increased significantly in cirrhotic subjects.

References
1) Yin M, et al. *Clin Gastroenterol Hepatol.* 2007;5(10):1207-1213
2) Huwart L, et al. *Gastroenterology.* 2008;135(1):32-40
3) Talwalkar JA, et al. *AJR.* 2009;193(1):122-127

This work was supported by NIDDK grant 1R01DK087877