

# Time-harmonic elastography of the liver and spleen for quantification of portal hypertension

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**Application Area:** Cardiovascular **Modality:** US **Related:** PhD 2, 6, 11, 15

## Background

Quantification of portal pressure and hepatic venous pressure gradient (HVPG) still requires invasive methods. Poroelasticity models predict that hepatic pressure is translated to changes of liver stiffness (LS) through the solid-fluid fraction in the tissue. Therefore, knowledge of the contribution of the hepatic venous vasculature and portal pressure to stiffness of the liver and spleen may enable clinicians to use elastography for pressure measurements in the hepatic-splenic system.

## Hypothesis

The shear modulus is sensitive to pressure changes in the vascular bed of the liver and spleen and can be used for quantification of portal hypertension in patients who need transjugular intrahepatic portosystemic shunt (TIPS).

## Methods

Imaging methods sensitive to pressure in the hepatosplenic hemodynamic system which are based on time-harmonic vibrations, real-time sonography<sup>(1,5)</sup> and MRI<sup>(2-4)</sup> will be used. The capability of time-harmonic elastography to detect elevated HVPG will be tested in patients who need TIPS. The noninvasively derived pressure parameters will be validated by pressure gradient data obtained during TIPS intervention.

## Work Packages

**WP1: Image resolved time-harmonic elastography (2D-THE)**

**WP2: Phantoms and tissue specimens**

**WP3: Volunteer experiments**

**WP4: Pilot study**

← year 1 → ← year 2 → ← year 3 →

**WP1:** Implementation of real-time image-resolved time harmonic elastography (2D-THE) on a clinical ultrasound system.

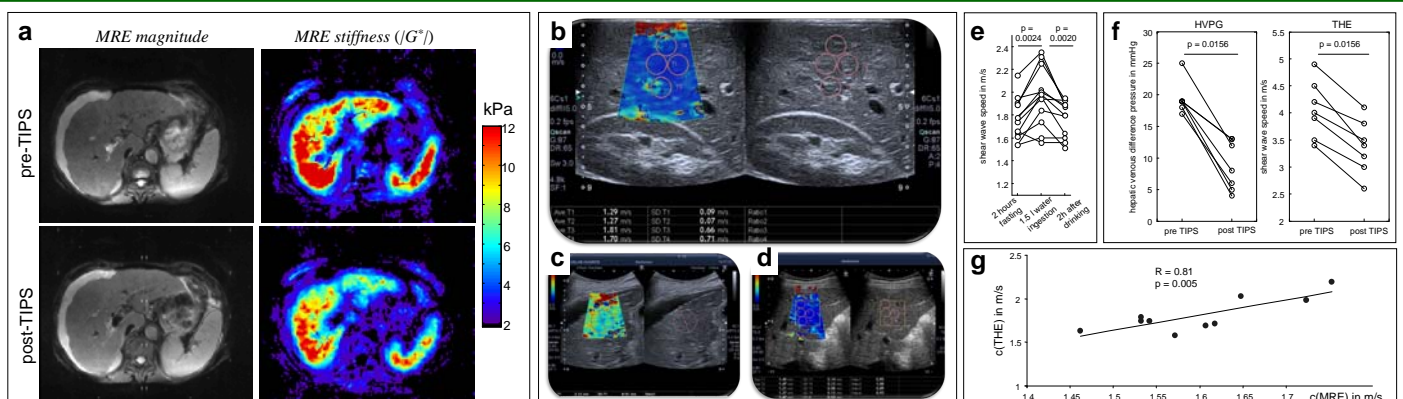
**WP2:** Phantom and specimen experiments using 2D-THE and MRI elastography (MRE). Pressurized liver specimens will be used similar to the method detailed in<sup>(3)</sup>.

**WP3:** Application of 2D-THE and MRE to healthy volunteers under different physiological paradigms such as water ingestion<sup>(4)</sup> to investigate the effect of perfusion pressure on effective LS. Furthermore hepatoportal and splenoportal venous flow is quantified by Doppler sonography.

**WP4:** 2D-THE will be applied to a limited number of patients treated by TIPS and examined by sonography, clinical MRI, tomoelastography, as well as 3D MRE to extract poroelastic parameters for correlation with invasively measured HVPG.

## Clinical Translation

In the follow-up of this PhD project, clinical pilot studies using 2D-THE and MRE are envisioned for the image-based detection of HVPG prior and after TIPS intervention.



Comparison of time-harmonic MR elastography (**a**, from<sup>(4)</sup>) and real-time sono-elastography (**b**) to detect liver stiffness in patients who need TIPS (**c**) and a normal volunteer (**d**). The effect of water ingestion to liver stiffness (**e**), from<sup>(5)</sup>. Decompression of the liver by TIPS reduces liver stiffness (**f**). Correlation between MRE and time harmonic ultrasound elastography (THE)(**g**, from<sup>(1)</sup>).

- Literature**
1. Tzschatzsch, H., Ipek-Ugay, S., Nguyen Trong, M., Guo, J., Eggers, J., Gentz, E., Fischer, T., Schultz, M., Braun, J. & Sack, I. Multifrequency Time-Harmonic Elastography for the Measurement of Liver Viscoelasticity in Large Tissue Windows. *Ultrasound Med Biol* 41, 724-733 (2015).
  2. Hirsch, S., Beyer, F., Guo, J., Papazoglou, S., Tzschatzsch, H., Braun, J. & Sack, I. Compression-sensitive magnetic resonance elastography. *Physics in medicine and biology* 58, 5287-5299 (2013).
  3. Hirsch, S., Guo, J., Reiter, R., Schott, E., Buning, C., Somasundaram, R., Braun, J., Sack, I. & Kroencke, T.J. Towards compression-sensitive magnetic resonance elastography of the liver: Sensitivity of harmonic volumetric strain to portal hypertension. *J Magn Reson Imaging* 39, 298-306. (2014).
  4. Guo J, Buning C, Schott E, Kroencke T, Braun J, Sack I, Althoff C. In vivo abdominal MR elastography for the assessment of portal hypertension before and after transjugular intrahepatic portosystemic shunt (TIPS) implantation. *Investigative Radiology* 2015; 50:347-51.
  5. Ipek-Ugay S, Tzschatzsch H, Hudert C, Marticorena Garcia S, Fischer T, Braun J, Althoff C, Sack I. Time harmonic elastography reveals sensitivity of liver stiffness to water ingestion. *Ultrasound in Med. Biol* 2016; 42:1289-94.