Functional time harmonic elastography of the liver

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Theme: Mechanics/fluid transport

Background: Liver function is characterized by metabolic turnover of nutrients delivered to hepatocytes by blood perfusion. Therefore, liver metabolism is closely related to the perfusion pressure which can be indirectly probed by the hepatic mechanical properties. In addition, recent research has shown that cellular mechanics change with metabolic stress on hepatocytes, due to altered cytoskeleton, swelling, and other factors (1, 2) (Figure 1-2).

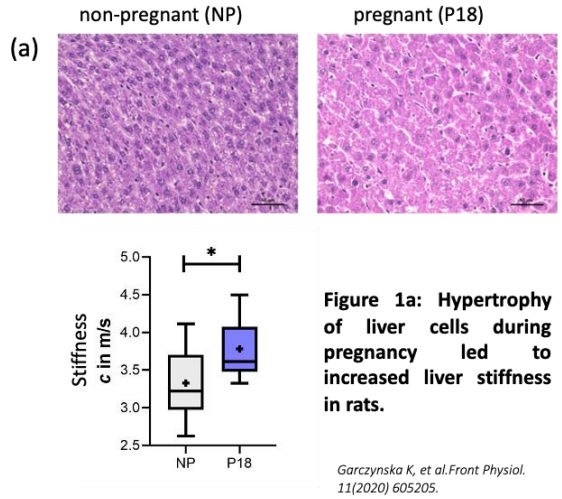

Figure 1a: Hypertrophy of liver cells during pregnancy led to increased liver stiffness in rats.

Garczynska K, et al.Front Physiol. 11(2020) 605205.

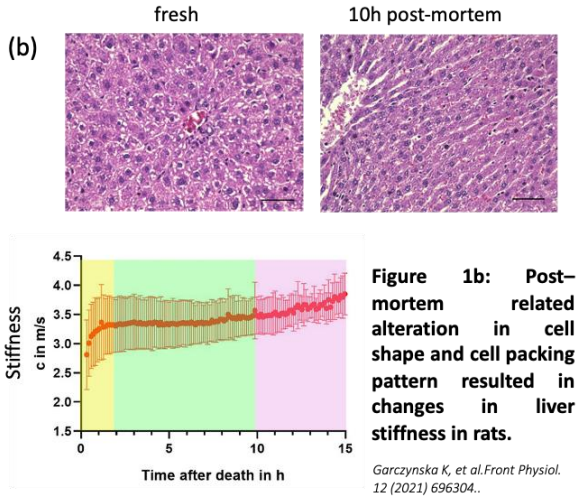

Figure 1b: Post–mortem related alteration in cell shape and cell packing pattern resulted in changes in liver stiffness in rats.

Garczynska K, et al.Front Physiol. 12 (2021) 696304..

Hypothesis: Mechanical parameters quantified by time harmonic elastography are indicative of liver function.

Methods: In this project, we will continue our efforts to sensitize time-harmonic elastography in MRI and ultrasound to blood perfusion, tissue pressure, vascular structure, and portal vein pulsatility. To this end, we will accelerate MRE by using gradient echo sequences with spiral readout that can detect externally induced time-harmonic waves stroboscopically and synchronously with ECG (3). This will allow us to measure the change in shear wave velocity, a surrogate marker of stiffness, following portal venous pulsatility in the liver. We expect that the pulsatility of liver stiffness will change significantly in patients due to inflammation or fibrotic remodeling of liver tissue (4). In parallel with the planned multiparametric MRI and MRE studies, we will use time-resolved, time-harmonic ultrasound elastography, as being developed at BIOQIC for cardiac applications, on the liver. Together, MRE and THE can inform clinicians about liver fibrosis based on stiffness as well as the compliance of liver tissue to pulsation.

Impact: The outcome will enable us to establish a new imaging marker based on biomechanics for the assessment of liver function which has high clinical relevance in terms of the diagnosis and treatment planning.

Collaboration: The PhD students will take part in regular meetings of Prof. Thomas Fischer's team to get clinical feedback on the developed techniques. Furthermore, we will collaborate with other BIOQIC projects which focus on MRI sequence development in terms of fast and multi-parametric data acquisition in order to optimize our method and to obtain a comprehensive discretion of liver function.

References

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