Quantitative 3D Whole Liver T1rho Mapping at 3.0T

Weibo Chen[1,2], Xin Chen[3], Guangbin Wang[3], Queenie Chan[4], He Wang[5], Jianqi Li[1], Xuzhou Li[6], Shanshan Wang[3], Bin Yao[3], and Dongrong Xu[6,7]

[1]Shanghai Key Laboratory of Magnetic Resonance and Department of Physics,East China Normal University, Shanghai, China, [2]Philips Healthcare, shanghai, China, [3]Shandong Medical Imaging Research Institute, Shandong University, Jinan, Shandong, China, [4]Philips Healthcare, Hongkong, China, [5]Philips Research China, shanghai, China, [6]Key laboratory of Brain Functional Genomics (MOE & STCSM), Institute of Cognitive Neuroscience, East China Normal University, shanghai, China, [7]Epidemiology Division & MRI Unit,Columbia University Department of Psychiatry, New York, United States

Target Audience Researchers and clinicians interested in MR quantification methods and liver diseases.

Introduction Liver cirrhosis is an abnormal liver condition that liver experiences irreversible scarring. Once the injury has happened, the liver would repair it through the deposition of collagen, proteoglycans, and other macromolecules in the extracellular matrix. The risk of liver cancer is greatly increased once cirrhosis develops, and therefore cirrhosis should be considered to be a pre-malignant condition. T1rho relaxation time has been proven to relevant with the macromolecular composition of tissues. So far, liver T1rho studies have only been done at 3.0T with a limited coverage of only one to three slices that require patient to hold breath[1], and the whole liver coverage T1rho experiments were only carried out at 1.5T[2]. The purpose of our study was to implement the T1rho method with whole liver coverage and breathing-hold free, and initially apply the method to depict whole liver cirrhosis severity non-invasively at 3.0T.

Materials and Methods This prospective study was approved by the local ethics committee, and written informed consent was obtained from each participants. **Subjects** Thirteen healthy volunteers (Mean age 32.3 yrs; age range 23-56 yrs; 7F/6M) and three patients (Mean age 60 yrs; age range 56-63 yrs; 1F/2M) with clinically diagnosed liver cirrhosis were recruited for the experiments**.** The MR experiment was conducted on a Philips 3.0T clinical scanner (Achieva TX, Best, the Netherlands). A 16-channel SENSE Torso XL coil was used for signal reception. The specific scan parameters for whole liver T1rho sequence(Figure 1) were: 3D T1-TFE, field of view = 400 x 352mm^2, resolution=2.0 x 2.4 x 7.0mm^3, respiratory triggered, duration of saturation pulse=1000ms, principle of selective excitation technique (PROSET) fat suppression was used, TR/TE = 5.1/2.5ms, flip angle=10°, spin lock frequency=500 Hz, spin lock times=0, 10, 20, 40, and 60ms, each spin lock scan time=2 min56sec.

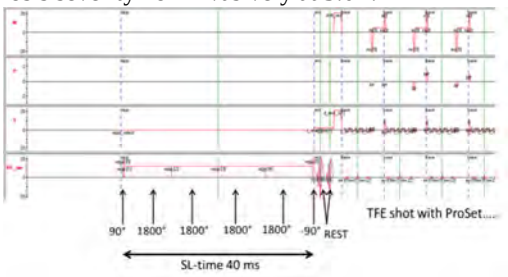

Figure 1, Schematic of 3D whole liver coverage sequence.

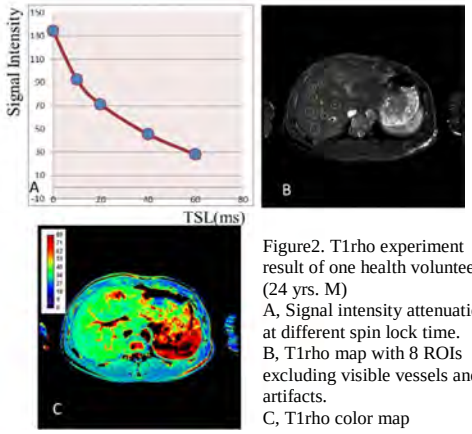

Figure2. T1rho experiment result of one health volunteer (24 yrs. M)
A, Signal intensity attenuation at different spin lock time.
B, T1rho map with 8 ROIs excluding visible vessels and artifacts.
C, T1rho color map

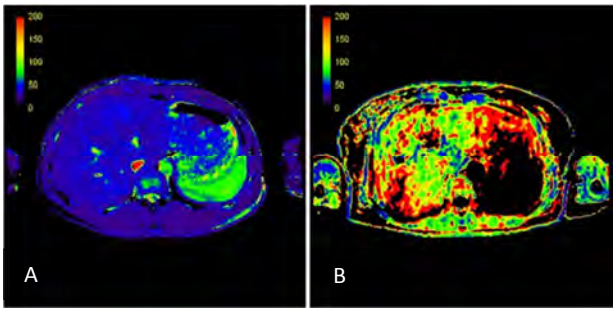

Figure 3, A: Liver T1rho map of a healthy volunteer (24 yrs. M) B: Liver T1rho map of a patient (63 yrs. F) with liver cirrhosis.

Results and Discussion All participants were scanned successfully. The overall imaging quality was acceptably evaluated by two radiologists. Six to eight ROIs were placed on liver parenchyma, which excluded visible image artifacts and large blood vessels. The mean T1rho value (mean ± SD) of the healthy volunteers was 41.9 ± 5.4 ms, (ranged from 34.3 to 54.3 ms). A healthy volunteer's T1rho relaxation curve, ROIs positions and T1rho color map were shown in figure 2. The representative T1rho maps of the healthy volunteers and the liver cirrhosis patients were shown in figure 3. The mean T1rho value of the three patients (56.8 ± 5.3, 120.0 ± 35.7, and 117.9 ± 29.8 ms) were significantly higher than those of the healthy volunteers ($P<0.001$).

Respiratory trigger was used to minimize spatial misregistration of different spin lock times. Our study confirmed that T1rho imaging is feasible, and can be noninvasively used to depict liver cirrhosis in humans at 3.0T. The result from healthy volunteers showed high correlation with previous studies at both 1.5T and 3.0T [1, 2]. This study further demonstrated that T1rho is independent of magnetic field strength, and it could be potential biomarker in reflecting macromolecular composition of the liver parenchyma. We have seen that T1rho values in these three cirrhosis patients were heterogeneous, and whole liver coverage T1rho mapping has provided a possible approach to evaluate cirrhosis severity within different parenchyma segments of liver. In the current study, only three patients were involved, and their status of liver cirrhosis severity stage was quite different. We plan to recruit in future adequate number of patients at different cirrhosis stages, and analyze in depth the relation between the cirrhosis stage and the T1rho values.

Conclusions

We propose for the first time the 3D whole liver coverage T1rho sequences at 3.0T with reliable quantification, and this method thereby provides an alternative approach to non-invasive evaluation of the whole liver cirrhosis.

References

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