Noninvasive Quantification of Hepatic Steatosis in Rats with 1.5 T MRS and MRI: Feasibility, Early Results and Optimization

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Purpose: To validate and optimize a routine 1.5T MRI method to detect and measure liver steatosis in an experimental glucolipotoxic rat model by using [1]H-magnetic resonance spectroscopy (MRS) as the reference standard.

Materials and Methods: Steatosis was induced in 24 rats with a 72 h intravenous infusion of glucose and Intralipid fat emulsion and compared with 17 control rats receiving a saline infusion. Dual-echo in/out of phase MRI and ^{1}H-MRS measurements of hepatic fat content were compared. MR experiments were performed on a 1.5 T MR unit (Signa EchoSpeed version 9.1; GE Medical Systems, WI, USA). Dual-echo magnetic resonance imaging (MRI) was performed on the ex-vivo liver with a 2D spoiled GRE sequence (TR/TE 150/2.2 and 4.5 msec, slice thickness/gap 2/0 mm, matrix 256 x 160, Field of view 16 x 16) with two flip angle (FA) of 90 ° and 20 °. Additional IP/IP (4.5/18.5 msec) T1-weighted dual-echo images were obtained to calculate T2*. [1]H-MR spectra were obtained from a 1 x 1 x 1 cm voxel positioned at the center of the liver using a PRESS sequence (TR/TE = 1200/30 msec; 16 acquisitions) and treated with the LCModel software. In [1]H-MR spectra, L/(L+W) ratios were estimated, L being the areas of the lipid peaks (0.9, 1.3 and 2.0 ppm), and W, the area of the water peak (4.7 ppm) both being corrected for T1 and T2*. Regression analysis and Pearson correlation coefficient were used to compare 20° and 90° flip angle MRI sequences with ^{1}H-MRS. Independent T test was used to compare treatment and control group according to MRI and ^{1}H-MRS fat quantification.

Results: Regression analysis between 1H-MRS, 90° and 20°MRI results is shown in Fig. 1. Pearson correlations between 90° and 20°dual-echo MRI and ^{1}H-MRS were respectively r = 0.776, *P* < 0,001 and r = 0.693, *P* < 0.001. MRI T2* correction did not improve the correlation with ^{1}H-MRS (r = 0.749, P < 0.001 and r = 0.651, P < 0.001 for 90° and 20° FA MRI respectively). As summarized in Fig 2., MRI and MRS accurately distinguished the rats receiving the infusion of glucose + Intralipid from those receiving the saline control.

Conclusion: Non invasive quantification of hepatic steatosis is feasible in an experimental rat model with a human 1.5 T MRI. A routine dual-echo MRI sequence is able to distinguish steatotic from non steatotic liver. 90° FA MRI showed higher correlations than 20° MRI with ^{1}H-MRS, possibly due to increase of the signal to noise ratio with a higher flip angle.
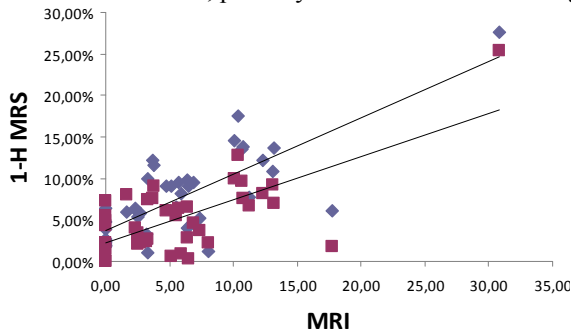

Figure 1 : Regression analysis between ^{1}H-MRS, 90° MRI ◆ and 20° MRI ■
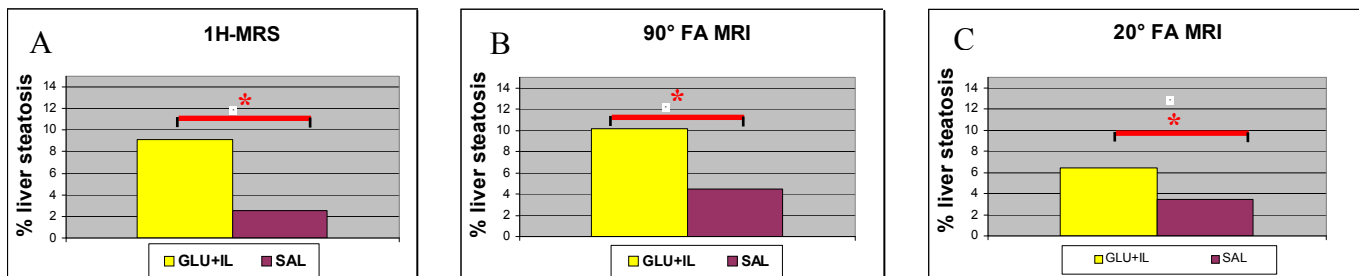

Figure 2. Bar graphs of rat liver fat fraction (%) as determined by ^{1}H-MRS (**A**), 90° flip angle GRE MRI (**B**) and 20° flip angle GRE MRI (**C**) for 2 groups of rats : glucose + Intralipid fat emulsion (GLU+IL ▢) and saline control (SAL ■). *P* <0.05.