Cardiac / respiratory double triggering for ^{1}H MR spectroscopy of the liver

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Introduction

Intrahepatocellular lipid [IHCL] content has been recognized in recent years to be implicated in diabetes and the metabolic syndrome (refs. in [1]). Its non-invasive determination by MR methods is playing a major role. Acquisition of reproducible and reliable MR spectra from the liver is hampered by effects of respiratory, and potentially cardiac motion. Most previous studies have used respiratory triggering or acquisitions in breath hold [2-4], one has applied navigator filtering [5]. However, effects of cardiac motion have not been addressed. We suggest a cardiac/respiratory double-triggering technique, previously implemented for ^{1}H-MRS of the heart [6].

Methods

Spectra were recorded at 1.5 T (Signa, GE) using a flexible receive coil. Data acquisition was double-triggered to both, respiration and ECG, exploiting the fact that the ECG amplitude depends on respiratory motion, and restricting acquisition to periods of expiration. Based on axial MRIs obtained in breath hold, a volume of 4.3 cm^3 was placed in a lateral area of the liver and repositioned at the same location in follow-up examinations. Major vessels were avoided. Spectra were recorded with a short TE PRESS sequence (TE 20 ms) [7]. 64 acquisitions with water presaturation were stored individually. Effects of residual motion, evidenced by shifts in resonance frequency, were accounted for by realigning individual scans if they fell within ±6 Hz and by discarding them otherwise. Spectra were processed, fitted and quantitated similarly to muscle spectra [7]. Quantitation to units of mmol/kg used a median water signal from 8 separate scans without water suppression, a T_2 of 50 ms for water (defined by further separate scans with varying TE), an assumed liver water content of 71% and a lipid T_2 of 80 ms. Reproducibility was established by investigating 4 healthy subjects twice in 2 subsequent independent examinations. In a physiologic study including determination of insulin sensitivity (IS) 7 healthy subjects (70±3kg BW, 17±1% body fat) were examined 3 times under conditions of differing dietary regimes. Hepatic IS was estimated from hepatic glucose production (HGP by 6,6-$^2H_2$ glucose), muscle IS from whole body glucose disposal rate (GDR) during a 2-step hyperinsulinemic euglycemic clamp. Spearman rank correlations were used.

Results

Fitting error (Cramer Rao lower bounds) for IHCL (CH_2) and TMA were 2% and 7%, respectively. Reproducibility for IHCL and TMA was 10% and 22%, respectively (variation between subjects 69% and 36%). Using this methodology, significant correlations were found between whole body IS and IHCL ($p<0.01$, Fig. 2), as well as between hepatic IS and IHCL ($p<0.05$) in the second cohort of subjects. Additionally, further resonances at ~3.6 ppm were consistently observed.

Discussion & Conclusion

Double triggered short TE MRS enables acquisition of reliable and reproducible spectra of human liver from fairly small volumes. Beside lipids, also TMA is readily quantifiable. A relation between IHCL and IS could be established even in a small number of healthy non-obese subjects.

References

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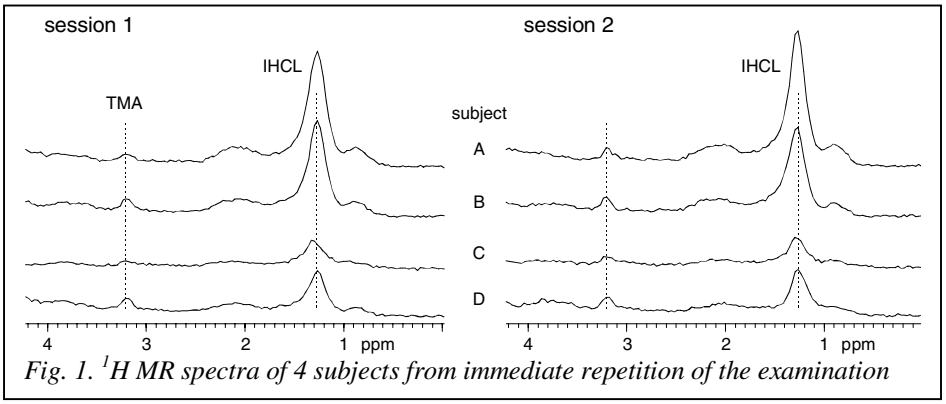

Fig. 1. ^{1}H MR spectra of 4 subjects from immediate repetition of the examination

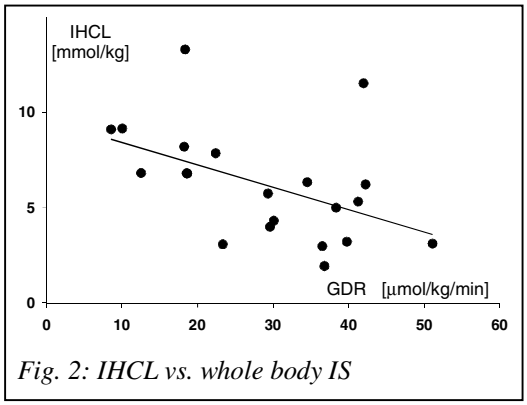

Fig. 2: IHCL vs. whole body IS