Fast ^{1}H-MRS measurement of pancreatic fat content in a single breath-hold

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PURPOSE– To develop an accurate measurement of lipid content of the pancreas in order to examine the relation of pancreatic fat, metabolic health and endocrine function[1] in humans[2,3]. For ^{1}H-MRS measurements of pancreatic fat content the results may need to be corrected for differences in relaxation parameters of the water and fat signals. To overcome limitations due to the size and location of the pancreas and errors caused by breathing motion the efficiency of a single volume ^{1}H-MRS method for measuring T_2 corrected fat fractions (ff) in liver was improved to allow measurement of pancreatic ff within one eighteen second breath-hold.

METHODS–Twenty healthy subjects (age 39±10, range 19-61, BMI range 16-49 kg/m^2) were scanned in a 3T Siemens Verio. Subject were placed supine on a spine phased array with a 16-channel phased array over the midriff. Using scout images oriented transverse and oblique along the pancreatic body a 35x10x10mm volume was positioned in the pancreatic body. The first, fully relaxed, spectrum was recorded at TE 24ms and a series of seven PRESS[4] spectra with logarithmically spaced TE (24, 32, 43, 58, 79, 107, 144 ms) were recorded in an SNR efficient steady state with TR=0.6s [5], averaging four signals at each TE all within a single 18s expiration breath-hold. The fully relaxed scan was used to obtain estimates for the T_1 of the water and fat signals. TE series were corrected for T_1 relaxation during the spin-echoes and repetition delays with the estimated T_1s. The T_2 and T_1 relaxation corrected water and fat signals were determined with a linear regression of the ^{N}log of the (saturation corrected) signals of water and summed lipid CH_2 and CH_3 signals fitted in the time-domain with AMARES[6]. Lipid T_2 and T_1 measurements with a regression correlation $R^2<$ 0.7 or saturation factor > 1 were rejected. Relaxation corrected ff were calculated from fitted water (w) and fat (f) at TE=0 as ff= f/(w+f) %.

RESULTS– Figure 1 shows results in a subject with a low pancreatic ff. The correlation for the linear regression fit of the lipid signal is high and the SNR of the lipid signals is adequate for an accurate time domain fit in all spectra except perhaps at TE 144ms. Lipid results of two subjects were rejected on the basis of lipid T_2 fit $R_2<0.7$. One water T_2 fit failed likely due to breathing motion. In nineteen subjects the T_1 of water was 1.07±0.21s (range 0.73 - 1.61s). The T_1 of lipid could only be determined in fifteen subjects 0.40±0.07s (range 0.22 - 0.50s) due to a relatively low signal of fat in the single shot fully relaxed spectrum in five subjects leading to saturation factors > unity. In these cases the median T_1 for fat of 0.40s was used for saturation corrections of the TE series. The T_2 of water was 50.7±5.9ms (range 42 - 71ms N=19) and the T_2 of lipid was 71±14ms (range 40 - 110ms N=18). The ff in the pancreas was 4±5% (range 0.2 -16% N=18.We found no correlation with BMI (N=18) or Hb1AC and Hb1AC derived estimated average blood glucose(N=13).

DISCUSSION–The measurement of water and lipid T_2s in the human pancreas in a single breath-hold was made possible by efficient steady state signal averaging and reducing the total variance in the data for the regression fit by using a log-spaced series of TE values. At low ff the lipid T_1s cannot always be measured but a fixed T_1 of 0.4s can be substituted. The saturation of the fat signal at about TR≈1.25×T_1 is low, so the impact such a substitution or of errors in T_1on the fat T_2 and ff measurement is limited. Alternatively, the lipid T_1 can be measured more accurately with a fully relaxed spectrum in a separate breath-hold.(e.g. 8 averages at TR=2s).

CONCLUSIONS –The fat fraction of the human pancreas can be measured in a single breath-hold. The T_2 of pancreatic lipid is longer than that water and thus ^{1}H-MRS measurement of pancreatic ff need to be corrected for T_2 relaxation, Knowledge of the T_1 and T_2 for water and fat in the human pancreas allow for further optimization of fast pancreatic fat fraction measurement by MR and relaxation correction of pancreatic ^{1}H-MRS data collected at short TR or fixed TE.

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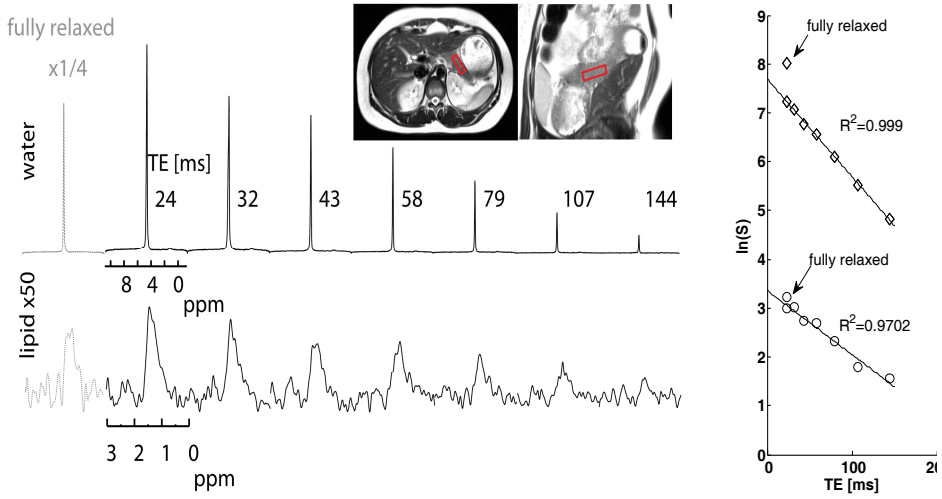

Figure 1. *Fully relaxed signals (×1/4 vertical scale) and TE series from the pancreas of a 42 y.o. female,BMI 29 kg/m^2 and pancreatic ff of 0.7%. Water T_2= 50ms, T_1=1.04s; lipid T_2=76ms, T_1=0.39s. Top: Complete spectra (2Hz lb).* ***Inserts****: axial scout, oblique scout along the pancreatic body and volume placements.* ***Bottom:****lipid signals shown at 50× vertical scale* ***Right****: Linear regression plots of the Nlog of the water (◇) and fat (O) signals.*