Toward an improved quantification of adipose tissue components: T1 assessment in morbidly obese, non-obese NAFLD and healthy lean subjects at 1.5 T

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Introduction/Purpose

Accurate quantification of liver fat from in-phase/opposed-phase (IP/OP) imaging data requires the correction for T1 and T2* relaxation effects [1]. While T2* relaxation has normally been estimated individually in liver parenchyma, T1 relaxation times of adipose tissue were often taken from the literature [1,2]. These reference values in fatty tissue, however, were determined in healthy lean subjects and are likely to differ from those in morbidly obese patients. To the best of our knowledge, T1 reference values in adipose tissue of obese subjects have not been reported before. The purposes of this study therefore were (1) to calculate the T1 times in subcutaneous (SAT) and visceral (VAT) adipose tissue of morbidly obese patients and non-obese subjects with NAFLD and (2) to compare these results with the corresponding values in healthy lean volunteers.

Materials and Methods

Twenty morbidly obese patients (8 male, 12 female, BMI 40.7±5.2, age 42.2±10.3 years), eight non-obese NAFLD patients (4 male, 4 female, BMI 26.9±1.4, age 56.3±10.5 years, steatosis grade 2 in six and 3 in two patients, respectively), and six healthy controls (5 male, 1 female, BMI 22.9±2.3, age 41.2±10.8 years) have been imaged with the body coil at 1.5 T (Philips Achieva XR). Estimation of T1 relaxation times was based on a single-shot fast spin-echo sequence (STIR, TR/TE=5000/60 ms, FOV=500×500 mm^2, MTX=352^2) with inversion-recovery preparation at variable inversion times TI (100, 150, 250, 500, 750, 1000 ms). At each TI, transverse 10-mm-thick slices on the level of the mid-liver were acquired in breath hold (Fig. 1). A custom-made tool (Matlab, The Mathworks, Natick, MA) computed the T1 relaxation times by fitting the MR signal intensity vs. TI data across a user-defined ROI [2]. Statistical analyses were performed with SPSS (Version 20, IBM SPSS, α=0.05) and involved paired t-tests as well as independent-sample t-tests with prior testing for equal variances (F-test).

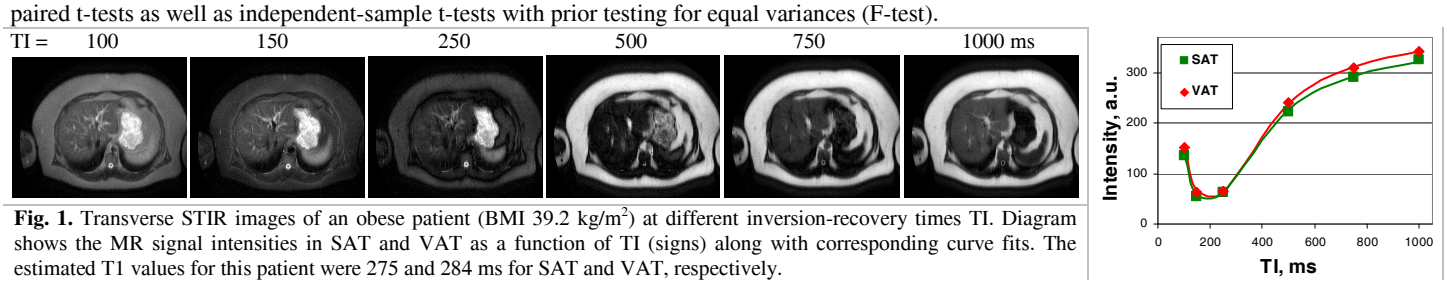

Fig. 1. Transverse STIR images of an obese patient (BMI 39.2 kg/m^2) at different inversion-recovery times TI. Diagram shows the MR signal intensities in SAT and VAT as a function of TI (signs) along with corresponding curve fits. The estimated T1 values for this patient were 275 and 284 ms for SAT and VAT, respectively.

Results

The resulting T1 relaxation times in different adipose tissue are given in Tab. 1. In obese and NAFLD patients, the T1 times of SAT were significantly (both $p<0.01$) shorter than those of VAT. The respective values for controls did not differ significantly ($p=0.168$). More important, T1 differences of SAT between obese patients and healthy subjects as well as between NAFLD patients and controls were highly significant ($p<0.01$). The respective comparison for VAT revealed no significant differences (obese vs. controls: $p=0.066$, NAFLD vs. controls $p=0.110$). Adipose tissue of obese and NAFLD patients had a similar T1 relaxation time and showed no significant differences (SAT: $p=0.508$, VAT: $p=0.388$).

Table 1. T1 relaxation times of adipose tissue

Subjects	T1 relaxation time, ms (mean ± SD and range)	
	SAT	VAT
Obese	280 ± 12 (262 – 309)	294 ± 20 (272 – 343)
NAFLD	277 ± 9 (261 – 280)	301 ± 16 (281 – 332)
Controls	308 ± 16 (292 – 330)	337 ± 45 (273 – 396)

Discussion

The previously published T1 literature values of SAT (343±37 ms) [2] were slightly higher than those estimated in healthy lean subjects (308±16 ms) here. T1 relaxation times of adipose tissue in morbidly obese patients were generally shorter than those in healthy lean controls. A similar effect was also seen between NAFLD patients and controls, although the BMI of our NAFLD patients was almost normal. The T1 differences between obese patients and lean healthy subjects could be explained by a different tissue composition with less unsaturated fatty acids in obese patients [3]. This, in turn, could be the result of an altered metabolism caused by hepatic steatosis which affects up to 90% of obese individuals [4]. On the other hand, this would also explain why T1 relaxation times in the adipose tissue of lean NAFLD patients are close to those observed in morbidly obese subjects.

Conclusions

Our preliminary results indicate that T1 relaxation times in adipose tissue of morbidly obese and lean NAFLD patients are 11-14% shorter than those of healthy lean subjects. In addition, the T1 values of SAT showed significant differences compared to VAT in both obese and NAFLD patients. This could be attributed to an altered fatty acid metabolism due to hepatic steatosis. Moreover, the presented fat T1 values for morbidly obese patients could contribute to improve quantification of liver fat content from IP/OP imaging techniques.

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