The Effect of J-coupling on Absolute Quantification of Liver Fat using MRS: A Phantom Study.

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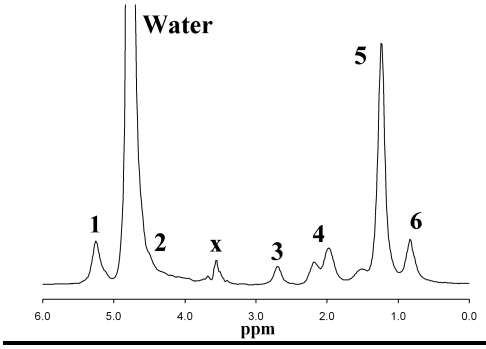
Introduction: The two main ^{1}H MRS sequences used to measure liver fat are PRESS (Point Resolved Spectroscopy) and STEAM (Stimulated Echo Acquisition Mode). Because the water and various fat peaks have different T2 values, accurate fat quantification requires correction for T2. It is known that PRESS and STEAM differ in their sensitivity to j-coupling and as TE increases so does the effect of j-coupling[1]. Further, it is known that all the fat peaks are j-coupled[2]. Thus, in liver fat spectroscopy the choice of STEAM or PRESS and the range of TEs used to measure and correct for T2 relaxation may affect the observed fat T2 value as well as the calculated T2-corrected fat peak area. The purpose of this water-fat phantom study was to examine, for both STEAM and PRESS, the effect of TE range on the observed fat T2 and on the calculated T2-corrected fat-water peak area ratio



Peak	Location	Assignment	Peak Type
1 {	5.30 ppm	-C**H**=C**H**-	Multiplet
	5.19 ppm	-C**H**-O-COR	Multiplet
Water	4.70 ppm	$\mathbf{H_2}$O	-
2	4.20 ppm	-C$\mathbf{H_2}$-O-CO-R	Multiplet
3	2.75 ppm	-CH=CH-C$\mathbf{H_2}$-CH=CH-	Multiplet
4 {	2.20 ppm	-CO-C$\mathbf{H_2}$-CH$_2$-	Multiplet
	2.02 ppm	-C$\mathbf{H_2}$-CH=CH-C$\mathbf{H_2}$-	Multiplet
5 {	1.60 ppm	-CO-CH$_2$-C$\mathbf{H_2}$-	Multiplet
	1.30 ppm	-(C$\mathbf{H_2}$)$_n$-	Multiplet
6	0.90 ppm	-(CH$_2$)$_n$-C$\mathbf{H_3}$	Triplet

Figure: Typical 3T ^{1}H MR Spectra from Intralipid with peak assignments shown in the table. All the fat peaks exhibit j-coupling. It is not possible to accurately delineate peak 2 due to its proximity to the water peak. x - non-triglycerides.

Methods: ^{1}H MR spectra (**Figure**) were collected at 3T on a GE Signa scanner on a sample of Intralipid, which is a stable emulsion of water and triglycerides. STEAM spectra were collected every 5 ms over the TE range 10 – 70 ms, while PRESS spectra were collected every 5 ms over the TE range TE 20 – 80 ms (the minimum TE using PRESS is 20 ms). A spectroscopic spin-echo sequence (TE 2.5 ms), localized on a 20-mm slice through the phantom, was collected as a reference. The spectra were quantified in the time domain, using the AMARES algorithm[3] included in MRUI[4]. The fat signal was calculated as the sum of the peaks in the range 0.5-3.0 ppm. The T2 and T2-corrected peak area of the water and fat peaks was then calculated by non-linear fitting of spectra at 5 different TEs separated by a fixed time interval (ΔTE). The minimum TE and ΔTE used in these analyses were altered systematically.

Results: The effect of changing the TE range and ΔTE is shown in the **Table**. Water was not affected by j-coupling and the T2 of water in the phantom was sufficiently long (>250 ms) that changes in the measured T2 had little effect on the T2-corrected peak area. There was good agreement between the fat-water ratio given by the spin-echo (TE 2.5 ms) sequence and that given by PRESS and STEAM for minimum TE and ΔTE = 5 ms. However, for both PRESS and STEAM, as either the minimum TE or ΔTE increased, the observed T2 of the fat peak decreased, and there was a corresponding increase in the observed T2-corrected fat peak area. The fat peak area overestimation was most apparent at minimum TE = 30 ms, where even for ΔTE =5 ms, the fat water ratio was considerably higher than the spin-echo value.

Conclusions: When performing T2-corrected liver fat spectroscopy, some investigators use a broad range of TEs, perhaps because the relatively long T2 values of fat in-vivo suggest that a broad range of TEs is appropriate for accurate measurement of and correction for T2. However, as shown here, using a long minimum TE or a broad range of TEs leads to underestimation of the observed T2 relaxation and overestimation of the fat peak area. By comparison, using a short minimum TE and a narrow range of TEs provided greater accuracy, both for STEAM and for PRESS. The dependency of the observed T2 and T2-corrected fat peak area on the TE range is probably explainable by j-coupling, the effects of which are known to be accentuated at long TE, although this was not directly assessed in this study. Regardless of the explanation, our empirical observations indicate that a narrow range of relatively short TEs should be used in liver fat spectroscopy.

Sequence	**Spin Echo**	**STEAM**							**PRESS**				
TE range (ms)	2.5	10-30	10-50	10-70	20-40	20-60	30-50	30-70	20-40	20-60	20-80	30-50	30-70
ΔTE (ms)	-	5	10	15	5	10	5	10	5	10	15	5	10
Fat T2 (ms)	-	51.8	48.2	46.5	49.3	45.1	41.4	40.1	45.1	41.2	39.6	34.7	35.1
Fat Water Ratio	**0.272**	**0.271**	**0.280**	**0.296**	**0.276**	**0.296**	**0.338**	**0.347**	**0.267**	**0.292**	**0.301**	**0.360**	**0.364**

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