How much fat is under the water peak in liver fat MR spectroscopy?

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Introduction: Fat/water quantification in liver using MRS is determined from the ratio of peak areas of the fat peaks to the area of the water peak (**FIGURE 1**). It is usually impossible to distinguish fat peaks 1 & 2 from the water peak and so these peaks may be erroneously counted as water. Previously, signal from fat under the water peak was estimated from high field spectroscopy to represent 15% of total triglyceride signal[1]. The behavior of fat has been modeled theoretically at high field in adipose tissue.[2] In this abstract we expand on those theoretical arguments to estimate liver fat areas for peaks 1 & 2 from accurate analysis of the observable fat peaks in the range 0.5 - 3 ppm.

Methods: To validate the model, ^{1}H MRS of corn oil was obtained on a 3.0T GE Signa using the STEAM sequence at 5 TEs to correct T2 decay. A short TE range (10 - 30 ms) was chosen to minimize *j*-coupling effects, and a long TR (3.5 s) was chosen to minimize T1 effects. The expected and measured fat peak areas are shown in **TABLE 1**. Using the same experimental method, the observable (0.5 - 3 ppm) peak areas were measured *in-vivo* in a fatty liver and used to estimate peak areas of 1 & 2.

Results: Measured peak areas and theoretical calculations for corn oil are shown in **TABLE 1**.[3] There is close agreement between the measured peak areas and those calculated theoretically, except for peak 2. This peak is strongly coupled resulting in T2 underestimation and hence peak area overestimation, and so we consider the measured value unreliable†. Using the same approach for the *in-vivo* spectra, we used the measured areas of peaks 3, 4, 5 and 6 to estimate x = 2, y = 0.2 for a fixed value of z = 17.5.[2] From these, we generated the theoretical areas for all the peaks (shown in **TABLE 2**). Compared with corn oil, the human liver has similar T2s, however the liver spectrum has lower levels of unsaturated fat as can be seen from the relative intensity of peaks 1 and 3.

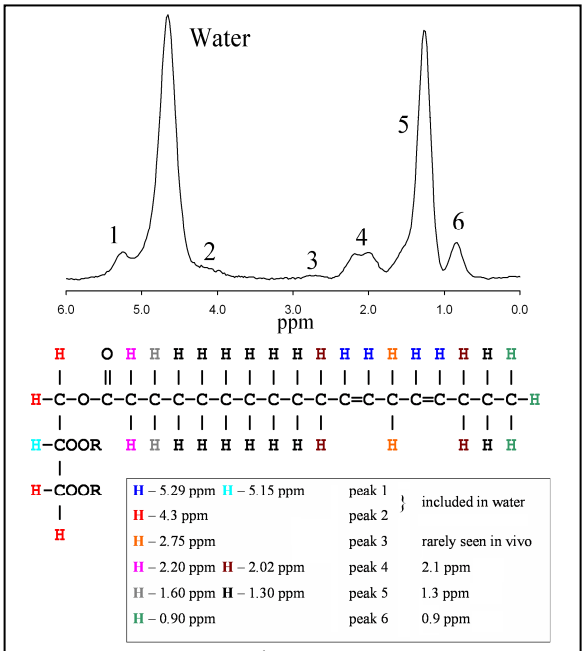

Figure 1: Liver 3T ^{1}H MR spectrum of subject examined in this study, with a diagrammatic representation of triglyceride indicating the source of the signals. "R" indicates other fatty acid chains.

Table 1: Peak areas for corn oil. The theoretical values are determined by only 3 parameters: x = the number double-bonds, y = the number times double bonds are separated by a single CH_2 group, and z = the average fatty acid chain length. For corn oil x = 4.25, y = 1.72, z = 17.75[3].

Peak	Location	Assignment	Expected Area	Theoretical Area	T2 (ms)	Measured Peak Area
1	5.29 ppm 5.19 ppm	-CH=CH- -CH-O-CO-	2x +1	0.164	48	0.181
2	4.3 ppm	-CH_2-O-CO-	4	0.069	10†	0.170†
3	2.75 ppm	-CH=CH-CH_2-CH=CH-	2y	0.059	48	0.065
4	2.20 ppm 2.02 ppm	-CO-CH_2-CH_2- -CH_2-CH=CH-CH_2-	6 + 4(x-y)	0.278	49	0.295
5	1.6 ppm 1.3 ppm	-CO-CH_2-CH_2- -$(CH_2)_n$-	6(z-3) - 8x + 2y + 6	1.000	71	1.000
6	0.90 ppm	-$(CH_2)_n$-CH_3	9	0.155	112	0.156

Conclusions: Theoretical modeling based on counting triglyceride hydrogens reveals that peak area relationships depend upon only 3 parameters: number of double bonds, number of adjacent double bonds separated by a single -CH_2- group, and chain length. Phantom results validate that this model accurately predicts peak area ratios for corn oil. Extrapolation of this method to human liver fat allows the estimation of fat peak areas that are near, or under the wings of the water peak.

Table 2. T1s, T2s, and measured peak area, and extrapolated percentage of fat spectrum for human subject.

Peak	T2 (ms)	Measured Peak Area	Extrapolated Fat Spectrum
1	-	-	4.8%
Water	21	1.000	-
2	-	-	3.9%
3	56	0.003	0.4%
4	58	0.086	12.8%
5	74	0.469	69.3%
6	130	0.065	8.7%

REFERENCES

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