Multi-component transverse relaxation in egg yolk: Relaxations times, relative amplitudes and spectral assignments

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Introduction: Since MacKay et al (1) reported a moderately short (5-40ms) brain T2 component believed to be myelin-associated water (MAW), numerous methods have been proposed to extract information regarding it, including the "myelin fraction" as a powerful biomarker of disease. Phantom materials that would allow for "gold standard" calibration of such methods have been proposed, such as dairy cream (2). We demonstrate that raw egg yolk also serves this purpose, with even greater versatility in control of the components under observation.

Methods: Two raw eggs equilibrated to room temperature were scanned on a 3T GE HDx system with a wrist receive coil. A 3D CPMG imaging sequence based upon the principles discussed by Poon and Henkelman (3) (composite nonselective refocusing pulses, variable and alternating crushers, phase encoding prior to 1st refocusing pulse) was used to gather 32-echo images at 11ms echo spacing with 3sec TR and 0.66x0.66x2 mm^3 voxels. Decay curves in 6x6 voxel ROIs in the yolk were fit with mono-, bi- and tri-exponential functions. An F-test was used to determine which fit was statistically appropriate. An additional 3D CPMG data set was acquired with a chemical fat saturation pulse preceding each excitation. Single voxel PRESS spectra (32 signal averages, TR/TE = 3/30 sec/msec) were acquired from another raw egg using a 3T Siemens TRIO system.

Results: SNR of the 1st CPMG echo was >800 and 400, without and with fat suppression, respectively. No oscillations were observed along the echo train, indicating signal decays were largely free of stimulated and indirect echo effects (Fig. 1a). F-tests of the decay curves without fat suppression revealed a tri-exponential fit, with component relaxation times of 12±2ms, 23±2ms, and 294±48ms, and relative amplitudes of 34±12%, 64±12% and 2±1% was most appropriate. Fat saturation decimated the second component to the degree that bi-exponential fits became the statistically significant fit, with a large fast decaying fraction of 97±1% at 11±1ms T2, and a small 3±1% component at a long T2 of 301±43ms (Fig. 1b). The yolk spectrum in Fig 1c demonstrates roughly equal water and methylene lipid peak resonances, consistent with the water and lipid T2 component amplitudes.

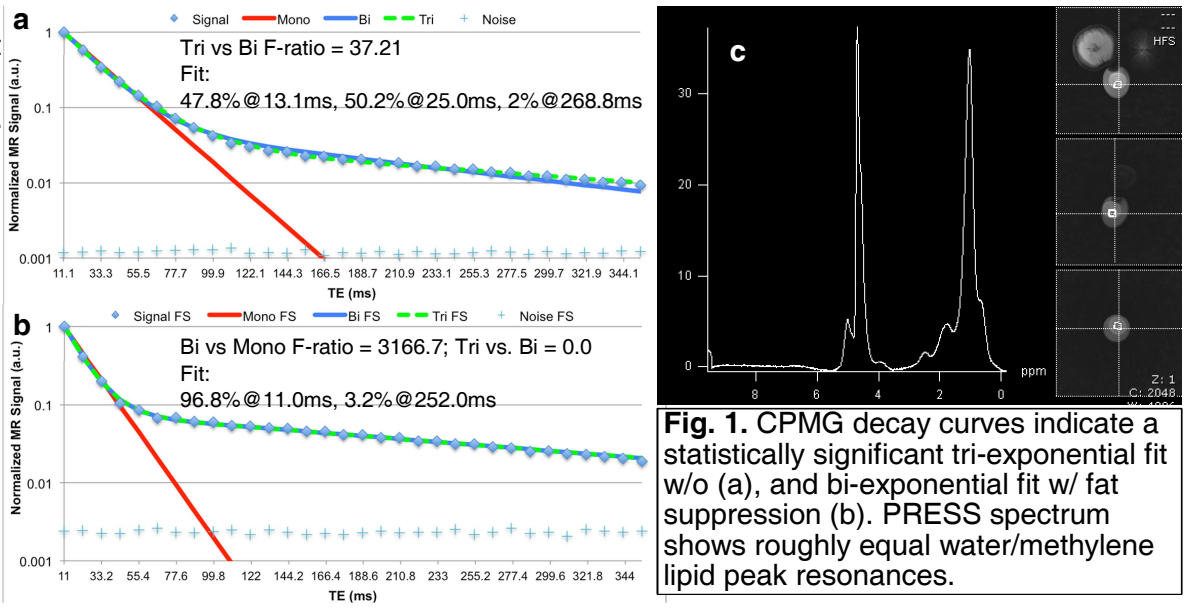

Fig. 1. CPMG decay curves indicate a statistically significant tri-exponential fit w/o (a), and bi-exponential fit w/ fat suppression (b). PRESS spectrum shows roughly equal water/methylene lipid peak resonances.

Discussion: Egg yolk consists of roughly 50% water, 34% lipids and 16% proteins, and other minor, MR invisible, components. Egg yolk T2 decay exhibits tri-exponential behavior with two reasonably fast decaying components and a 3rd much more slowly decaying component. The fat saturation pulse eliminated the 2nd-fastest component, identifying it as lipid protons from methylene/methyl resonances. Thus the two primary fast decaying components in yolk consist of water and fat, respectively, while a third water component is also observable. The CPMG imaging sequence is designed to provide ground truth or "gold standard" properties of the phantom and would be difficult to use in clinical whole-brain exams due to scan length (90min per acquisition). Fast methods for extracting moderately short T2 components such as MAW are continually being proposed, based on gradient echo or steady state methods. The characterization of egg yolk as having convenient, moderately short T2 components, may prove useful in assessing new methods designed to perform whole brain MAW studies in clinically feasible scan times.

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1.MacKay AL et al. MRM 1994;31:673 2.Jones C et al. MRI 1998;16:83 3.Poon C et al. JMRI 1992;2:541