Fat Quantitation Using Chemical Shift Imaging and 1H-MRS in Vitro Phantom Model

S. Ju[1], X. Peng[1], F. Fang[1], and G. Teng[1]

[1]Radiology, Zhongda Hospital, Southeast University, Nanjing, Jiangsu, China, People's Republic of

INTRODUCTION
Adipose mass, the anatomic distribution and fatty acid composition of adipose tissue strongly influence the risk of multiple diseases. Noninvasive analysis of fat quantification and composition by MR would have major advantages. Present study aims to evaluate the accuracy of chemical shift imaging (CSI) and MR spectroscopy (MRS) in fat quantification and composition by using phantom model at high field 7.0 Tesla MR.

METHODS
Experimental paradigm was proposed based on single-voxel proton MRS, water or fat selective CSI method. Localized proton MRS method was used to collect ^{1}H spectra in very small voxel (1.5 mm×1.5 mm×1.5 mm). Phantoms were made according to the volume percentage of fat (0%-100%). The fat fractions in the phantoms were measured and calculated respectively by CSI and MRS, and then compared to the known prepared fractions using one-sample *t* test and correlation test. The correlation between the two methods was also analyzed. Fractions of saturated fatty acids (FS), unsaturated fatty acids (FU) and polyunsaturation degree (PUD) were calculated by using MRS, and compared to the known composition as well.

RESULTS
CSI data presented a little underestimation of fat concentration when fat fraction was >50% (one-sample *t* test, $P<0.05$); while MRS underestimated fat concentration a little when fat fraction was <60% (one-sample *t* test, $P<0.05$). Both CSI and MRS had a high linear correlation with the gravimetric known fat fraction (CSI: $r^2=0.998$, $P=0.000$; MRS: $r^2=0.994$, $P=0.000$). The two methods correlated linearly very well ($r^2=0.990$, $P=0.000$). There was no statistically significant difference between the CSI and MRS data (paired-samples *t* test, $t=-0.125$, $P>0.05$). By using MRS, the relative ratios of FS, FU and PUD of fat were 0.15, 0.85, and 0.03, respectively, exactly the same as known fat composition.

CONCLUSION
The ability for quantitative fat measurement is verified in phantoms. Both CSI and MRS are efficient and accurate methods in fat quantification at 7.0 T MR. Localized ^{1}H-MRS is possible at high spatial resolution with voxel size down to 3.4cm^3. They are promising for further application in vivo quantitation of fat composition.

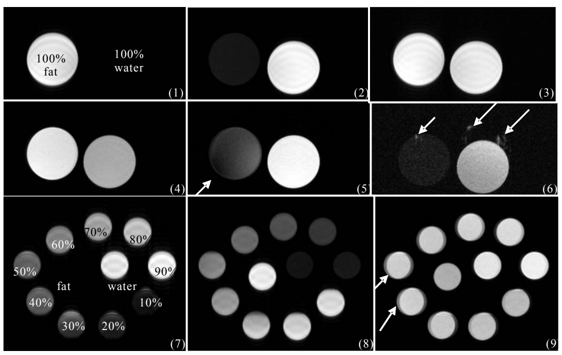

Fig 1. Panels from (1) to (6)are images of 100% water and 100% fat phantoms. (1) Fat-selective image; (2) Water-selective image; (3) sum of fat and water images; (4) SE T_1WI; (5) SE T_1WI with fat presaturation, arrow points to the area with inhomogeneous fat suppression; (6) arrows point to the artifact caused by inhomogeneous magnetic filed. Panels from (7) to (9) are images of phatoms with known prepared fat fraction from 0% to 100%; (7) Fat-selective image; (8) Water-selective image; (9) SE T_1WI, arrow points to the artifact from chemical shift.

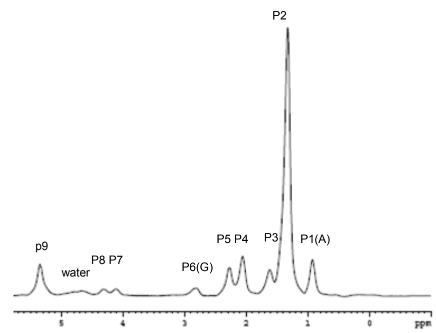

Fig 2. ^{1}H MRS analysis of fat. $FU=AUC_4/(2\times AUC_5)$, FS=1-FU, PUD=G/(2/3)A, AUC_4 is area under P_4 peak. AUC_5 is area under P_5 peak; G represents P_6 (2.8ppm), A represents P_1 peak (0.88ppm)

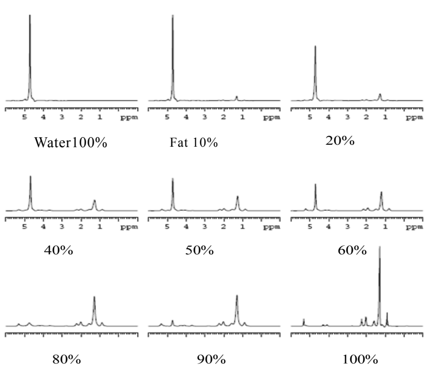

Fig 3. ^{1}H MRS of phatoms. Phantoms contain 0% to 100% fat

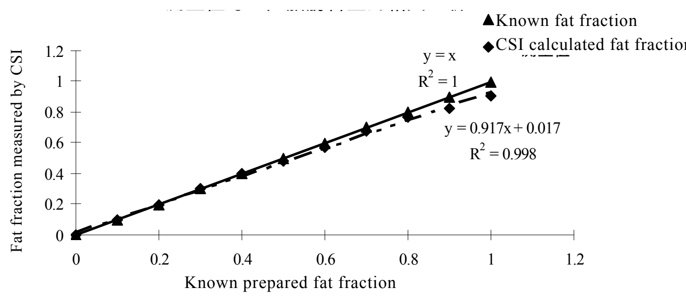

Fig 4. Correlation between CSI and the known prepared fat fraction

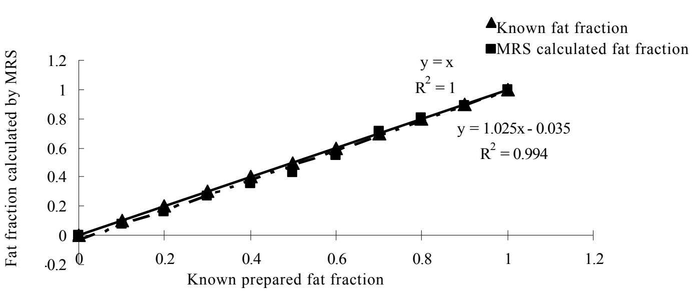

Fig 5. Correlation between MRS and the known prepared fat fraction

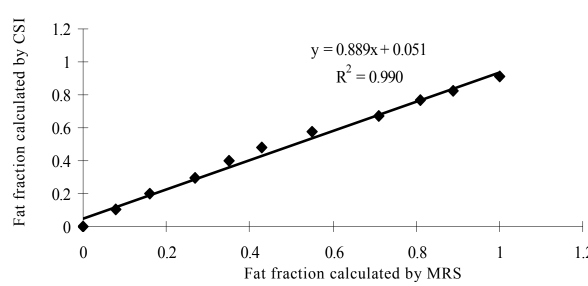

Fig 6. Correlation between CSI and MRS

REFERENCES: (1) Bottomley PA et al. *Lancet* 1984, 19: 1120 (2) Haase A et al. *Phys Med Biol* 1985, 30:341-4 (3) Lunati E et al. *Magn Reson Med* 2001 , 46: 879-83 (4) Reeder SB et al. *Magn Reson Med* 2005, 54: 636–44 (5) He J et al. *Biochim Biophys Acta* 2006, 1761:247-55 (6) Tang H et al. *J Magn Reson Imaging* 2007, 26:1064-70 (7) Strobel K et al. *J Lipid Res* 2008, 49:473-80