Hepatic parenchymal visibility and ADC quantification on diffusion-weighted MRI at 3T: influence of age, gender and iron content in normal subjects

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Objective: To investigate whether normal liver parenchymal visibility on 3T diffusion-weighted images (DW) and apparent diffusion coefficient (ADC) are influenced by age, gender and corresponding iron content in a cohort of normal subjects.

Introduction: Liver signal intensity on DW images is quite variable: in liver diseases the ADC is influenced by many factors including fibrosis, steatosis, necrosis, cirrhosis and iron load [1-3 In absence of liver disease however, the normal liver parenchyma visibility on DWI remains paradoxically variable among individuals. Since DW images are also $T2^*$-weighted, a possible explanation could be find in the variability of liver $T2^*$ that has been shown to be gender and age dependent within normal values in healthy individuals [4].
The purpose of this study is twofold: first we aim to assess whether liver parenchymal signal intensity changes are associated with gender and age in subjects with normal liver. Second, as normal liver iron load and associated $T2^*$ value depend on gender and age, we propose to verify if there is an association between liver signal intensity, iron content, age and gender.

Methods: In this IRB approved study, 103 patients (60 women) with no liver disease who underwent 3T DWI of the liver (b 0, 150, 1000, 1600 s/mm2) were included. (Achieva dual transmit, Philips Healthcare, Best, The Netherlands). SE-EPI DW images were obtained using a 16 channel torso coil (TR=respiratory synchronized, TE=77ms, ETL=47, sense factor=2.4). Liver parenchyma visibility was assessed in five segments (2,4,6,7,8) and averaged by two independent readers using an ordinal five score scale as follows: no signal=0, poor&noisy signal=1, signal well above noise=2, intense signal= 3, very intense signal=4. ADC values were measured in segments 4,6,7 and averaged, the corresponding averaged ROI standard deviation was defined as the square root of the averaged ADC variances in the three ROI's (each 1-2cm^2). Visibility scores and ADC were correlated with age and gender. Furthermore, in two subgroups, visibility scores were correlated with iron content, estimated by $T2^*$ (from 12 echoes sequence, same ROI's, range 13.2-31ms, N=45) or by recent serum ferritin (SF, 31± 30 days, N= 34). Non-parametric statistical analysis was performed (Spearman rank correlation coefficient R, Mann-Whitney test). Inter-observer reproducibility was assessed with a linearly weighted Cohen's Kappa coefficient. Statistical significance with P<0.05 was corrected as P<0,0125 for repetition of the analyses for the four b values.

Results: The inter-observer reproducibility for liver visibility scoring was better for high b value images: respectively for b= 0, 150, 1000, 1600 s/mm^2, Kappa was 0.31-0.59-0.70-0.69, R was 0.62-0.84-0.95-0.93 (all P<0.0001). Liver visibility scores in b1000 s/mm^2 images correlated with age (Fig 1, Spearman R=-0.60 in women; P<0.0001, -0.46 in men; P<0.002), $T2^*$ (Fig 2, R=0.77; P<0.0001) and SF (R=-0.62; P<0.0001). Scores were significantly higher in women (Fig 3, P<0.01, gender groups were age matched). Also in women, $T2^*$ decreased significantly with age (R=-0.63, P=0.001). ADC correlated with visibility scores (R=0.56; P<0.0001) and $T2^*$ (Fig 4, R= 0.66), but was not age or gender dependent. ADC ROI standard deviation negatively correlated with visibility scores (R=-0.60; P<0.0001) and $T2^*$ (R=-0.61).
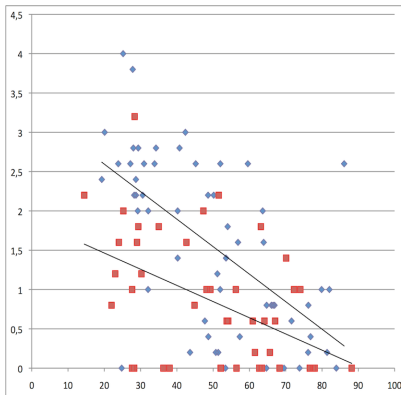

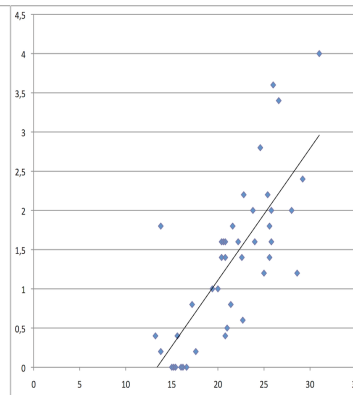Fig 1 Correlation between liver visibility scores and age in women and men (squares & lower regression)

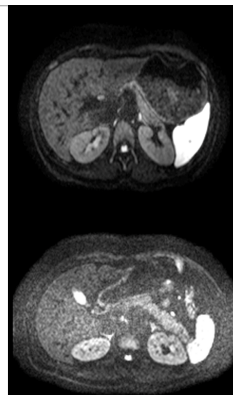Fig 2 Correlation between visibility score and $T2^*$ (ms)

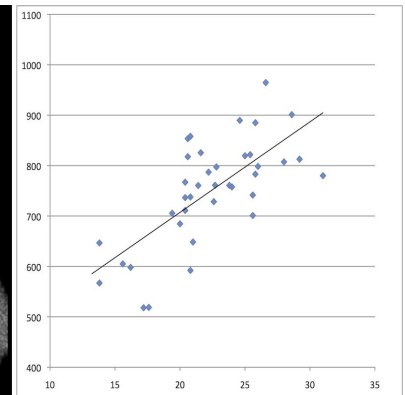Fig 3 b1000 s/mm^2 with average scores 3,2 (Woman 42y) and 1,6 (Man 29 y)

Fig 4 ADC (10^{-6} mm^2/s) correlation with $T2^*$ (ms)

Conclusions: Normal liver parenchyma visibility in DWI has a significant degree of correlation with age and gender, and depends accordingly to the iron content. Visibility scores and iron content affect significantly ADC measurements in normal liver.

References : [1] Wagner M Radiology 2012;264: 464-472. [2] Bulow R. Eur Radiol 2013; 23:1281-1287. [3] Do RK Am J Roentgenol. 2010;195(3): 671-676. [4] Schwenzer NF et al. Invest Radiol. 2008;43:854–860.