

Comparison of Water R₂ Spectroscopy Measures in the Liver at 1.5T and 3T

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Target Audience: Radiologists.

Purpose: Iron overload is a consequence of several clinical disorders that can lead to liver deterioration. There are several methods for diagnosing and monitoring iron content like serum ferritin, liver biopsy, Human hemochromatosis protein and MRI. MRI has been shown to be a non-invasive and accurate method for assessing the iron content [1]. The R₂ of water in the liver is an important indicator of iron presence since it has been shown that an increase in iron concentration would result in an increased R₂ of the water in the liver [2]. However in order to be able to compare clinical results across different magnetic field strengths, there is a need for a better understanding and validation of the relationship between the R₂ of the water at 1.5T and at 3T in the liver. While comparisons of R₂* values were made based on multi-echo GRE imaging sequences (for example in [3], it is shown that liver R₂* at 3T is approximately the double of its value at 1.5T), there are very few studies addressing the R₂ values in imaging [1] or spectroscopy [4]. The purpose of this study was to validate the relationship between the R₂ of water in the liver at 1.5T and at 3T using MR spectroscopy.

Methods: The HISTO sequence [5, 6] is used to assess liver R₂ and its accuracy has been clinically proven for liver fat measurement [7]. It is based on a five-echo STEAM single voxel spectroscopy sequence. The following parameters are used: TR = 3s, TEs are equal to 12ms, 24ms, 36ms, 48ms and 72ms, voxel size = 30mm x 30mm x 30mm, 1 average per echo, resulting in a 15s breath-hold measurement. The measurement is preceded by a 30s standard shimming. For every spectrum, simple linear baseline correction and low-pass sliding window filtering are applied. The water and fat peaks are then searched as maxima of the magnitude spectra in specific ranges, where water (resp. fat) are expected. The integration interval for water (resp. fat) is determined and the water peak is integrated for each measured echo. An exponential T₂ decay fit for the obtained five water integrals based on the log-linearized equations leads to an estimation of the R₂ value of the water. The quality of the fit is assessed using the R-squared measure of goodness of fit. Fourteen subjects underwent a HISTO liver measurement on 1.5T and 3T scanners (MAGNETOM Aera and MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany), and the voxel positioning was kept as consistent as possible across the different measurements, as can be seen in Fig.2. The R₂ values for a total of 34 voxels were therefore obtained at 1.5T and 3T. Three voxels were discarded due to a relatively low quality of fit (R-square below 0.95). A linear fit is performed for the remaining 31 voxels to obtain the relationship between liver R₂ at 3T and at 1.5T.

Results and Discussion: Fig. 3 shows the obtained linear fit of the R₂ of water at 3T as a function of the R₂ of water at 1.5T. The fitted data show only one outlier (the point has the lowest R-squared goodness of fit among all the fitted points). The linear fit equation is as follows:

$$R_2(3T) = 1.467R_2(1.5T)$$

A Monte-Carlo modelling was proposed to compare relaxivities in [8]. It was validated on six subjects using a spin-echo sequence. The model predicts a highly linear relationship between R₂ at 3T and its corresponding value at 1.5T, with a regression slope of 1.47.

In summary, using a spectroscopy-based technique, we were able to confirm the linear relationship between liver R₂ values at 3T and 1.5T as well as the value of the regression slope, even if the selection of TR = 3s could have an effect on signal saturation at 3T. Possible applications for this study are the extrapolation of iron overload level classification at 1.5T to 3T based on the R₂ values as well as the liver fat content assessment at 3T.

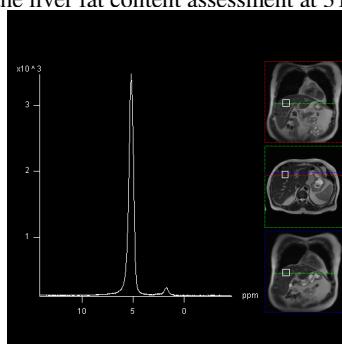


Fig. 2: Right (resp. left): spectrum at 3T (resp. 1.5T) with corresponding positioning. We tried to achieve consistent positioning across the measurements.

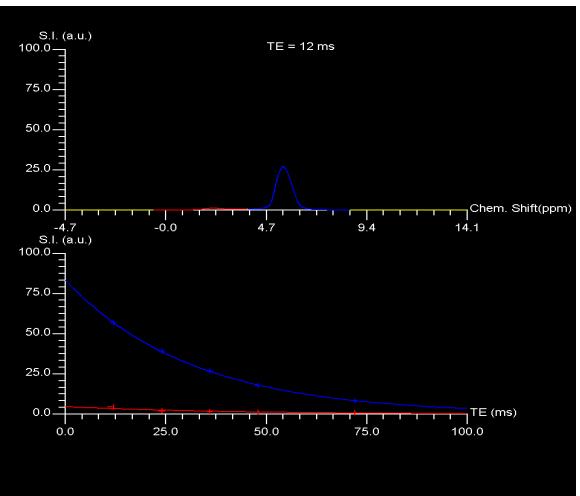


Fig. 1: The STEAM spectrum at TE = 12ms is displayed (water in blue, fat in red). A five-point fit allows the estimation of the R₂ of water. The blue curve is the result of the exponential T2 decay fit.

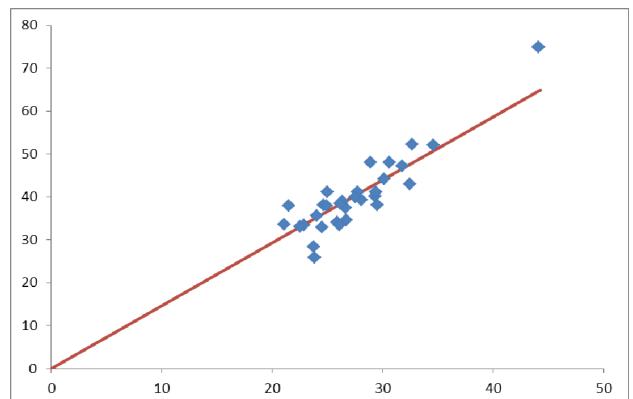


Fig. 3: Linear fit of the liver R₂ at 3 T (vertical axis) as a function of the liver R₂ at 1.5T (horizontal axis). Values are given in s⁻¹.

References:

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