Functional study of the liver parenchyma using T1 mapping on GD-EOB-DTPA-enhanced MRI

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PURPOSE

Functional hepatic evaluation has an important role both for clinical routine and surgical planning.
At present, biopsy is the reference gold standard for liver fibrosis evaluation despite the consistent number of limitations (bleeding, infection, patient discomfort and lack of panoramicity), therefore it is often replace by other less invasive (although less accurate) measurement techniques as Indocyanine green clearance and Child-Pugh classification.
GD-EOB-DTPA MRI showed potential efficacy for an alternative assessment of hepatic function, since contrast agent's uptake was reduced in cirrhotic livers.
The purpose of this study was to evaluate feasibility of T1 mapping of the liver with GD-EOB-DTPA MR imaging as a semiquantitative method to analyze the hepatic function.

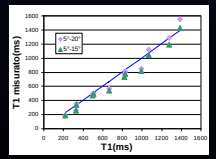
MATERIALS AND METHODS

74 patient with normal (n=19) or cirrotic liver (n=55; Child-Pugh A, n=41; Child-Pugh B/C, n=14) underwent GD-EOB-DTPA-enhanced 1.5 T MRI.
During the MRI examination, two FLASH sequences with variable FA (each one lasting around 15 s) were acquired before, 10 and 20 min after Gd-EOB-DTPA administration to obtain T1 maps.

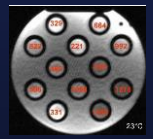
Slice Thickness: 10
Repetition Time: 5
Echo Time: 2
Number of Averages: 5
Echo Numbers(s): 1
Number of Phase Encoding Steps: 187
Echo Train Length: 0
Percent Sampling: 90
Percent Phase Field of View: 81.25

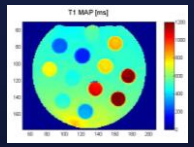
Pixel Bandwidth: 675
Acquisition Matrix: 256 0 0 187
Phase Encoding Direction: COL
Flip Angle: 5
Rows: 208
Columns: 256

These sequences were elaborated by the Health Physics Unit of our hospital and verified with phantom studies on different substances with known and certified T1 at a given temperature.

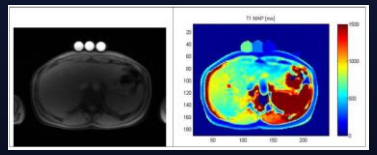


Pre- and post-contrast T1 relaxation times of the liver were measured and reported on colorimetric maps with a Matlab made algorithm also developed by Health Physics Unit's collegues.

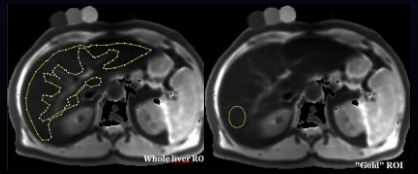




After successfull *in vitro* measures we started to evaluate *in vivo* T1.



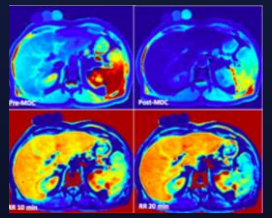
On a selected single slice multiple freehand ROIs were drawn using ImageJ software (1.46 r version, Java) avoiding imaging artefacts, focal hepatic lesions and major branches of the portal or hepatic veins: a "whole liver" ROI and a little "gold" ROI (in the liver region with less artefacts).



The mean T1 reduction rate (RR) between pre- and post-contrast images at 10 and 20 minutes was measured in these ROIs with the following equation:

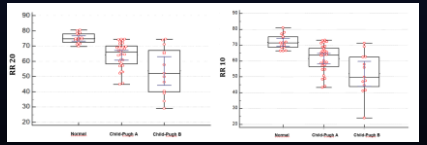
$$RR = T1_{pre} - T1_{post} / T1_{pre}$$

The evaluation of RR instead of post-contrast T1 is unaffected by parenchimal T1 variations due to other factos as iron or fat depostition in the liver.



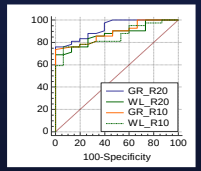
RESULTS

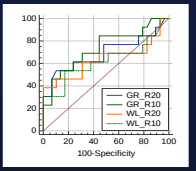
Analysis of variance (ANOVA) was performed to evaluate both the 10 and the 20 minutes acquisitions T1RR values in all the patient groups and showed statistically significant results (F-ratio Significance level: $p < 0.001$). A Levene's test on equality of variances was performed as well.
Games-Howell post-hoc test was applied for all pairwise comparisons.



Games-Howell test showed very strong evidence of differences ($p < 0.001$) between both normal liver - Child-Pugh A and normal liver - Child-Pugh B pairwise comparisons. The "whole liver" ROIs as well as the "gold" ROIs measures showed significant results on both the 10 and 20 minutes acquisition.
A weak evidence of differences was reported between Child-Pugh A and Child-Pugh B patient groups with slightly better accuracy of the "gold" ROIs measures on the 10 minutes acquisitions ($p = 0.066$).

ROC curves were also elaborated and Youden index was adopted to estimate the optimal cut-point to differentiate the patient groups depending on the reduction rates.
All statistical analysis were obtained with IBM SPSS Statistics (ver. 20, Chicago, IL, USA).





The curve with the best performance in differentiating between patient with normal and cirrhotic liver was the one based on the "gold" ROI measures on the 20 minutes T1RR maps (AUC = 0.929; Standard error = 0.0324).
The ROC curve based on the "gold" ROI measures on the T1RR maps obtained from the 10 minutes post-contrast acquisitions showed the best performance among all the other curves to distinguish Child-Pugh A and Child-Pugh B/C patients (AUC = 0,736; Standard error = 0.0905).

LIMITS

Our study had several limitations. The main of them were the limited number of enrolled patients and the lack of a reference gold standard, as the liver biopsy with histopatological confirmation of the degree of fibrosis (Metavir) or a liver functional assessment by Indocyanine green clearance.

CONCLUSION

Gd-EOB-DTPA-enhanced T1 mapping of the liver parenchyma might represent a useful method for hepatic function analysis.
To obtain a better accuracy in separation between patient groups we're looking for a complementary parameter insertion: an assessment of the RR values' inhomogeneity degree with a texture analysis.

REFRENCES

1. *Katsube T, Okada M, Kumano S, et al. (2011) Estimation of liver function using T1 mapping on Gd-EOB-DTPA-enhanced magnetic resonance imaging. Invest Radiol 46:277–283.*
2. *Haimerl M, Verloh N, Zeman F, et al. (2013): Assessment of Clinical Signs of Liver Cirrhosis Using T1 Mapping on Gd-EOB-DTPA-Enhanced 3T MRI; PLoS One / doi: 10.1371/journal.pone.0085658.*
3. *Cheng HLM, Wright A (2006) Rapid High-Resolution T 1Mapping by Variable Flip Angles: Accurate and Precise Measurements in the Presence of Radiofrequency Field Inhomogeneity. Magnetic Resonance in Medicine 55:566–574*