T1 mapping of the whole liver in a single breath hold at 3 T

Claudia Fellner[1], Niklas Verloh[1], Michael Haimerl[1], Miriam Rabea Kubach[2], Marcel D. Nickel[2], Mona Schlabeck[1], Christian Stroszczynski[1], and Philipp Wiggermann[1]
[1]*Institute of Radiology, University Hospital Regensburg, Regensburg, Germany,* [2]*MR Applications Development, Siemens AG, Healthcare Sector, Erlangen, Germany*

TARGET AUDIENCE:

Physicians, physicists and technicians involved in application and optimization of advanced liver imaging.

PURPOSE:

T1 mapping of the liver is an evolving technique to assess liver function by the uptake of Gd-EOB-DTPA. T1 mapping based on a 3D gradient echo sequence with 2 flip angles is very sensitive to B1 inhomogeneities and will therefore yield insufficient results at 3 T. The aim of this study was to apply an optimized technique with 3 flip angles accompagnied a preceding B1 map for inline correction of B1 inhomogeneities and to compare the T1 results to a 2D technique with inversion pulses.

METHODS:

84 patients (45 men, 39 women, age: 58 ± 13 years) underwent MRI of the liver at 3 T (Magnetom Skyra; Siemens Healthcare), 53 patients had normal liver function, 31 had cirrhotic liver (Child-Pugh A, B, or C). In addition to our routine imaging protocol, T1 mapping of the liver was performed before and 20 min. after the application of Primovist (Gd-EOB-DTPA) with 2 techniques: Following a B1 map of the liver (acquisition time: 14 s) a transverse 3D VIBE sequence (TR 5.79 ms, TE 2.46 ms, α 1°, 7°, 14°) with inline T1 calculation was applied with a voxel size of 3.6 mm x 2.5 mm x 4.7 mm (extrapolated to 2.5 mm x 2.5 mm x 3.0 mm). Using parallel imaging (CAIPIRINHA) with an acceleration factor of 4, the whole liver was covered in 17 s (Fig. 1). Furthermore, two 2D TurboFLASH sequences of the porta hepatis (Fig. 1) were acquired with 2 inversion times in one breath hold (TR 4000 ms, TE 1.16 ms, α 8°, TI 400 and 1000 ms, voxel size 2.1 mm x 2.1 mm x 6 mm, acquisition time 16 s; single slice technique).
T1 relaxation time was evaluated for both techniques in circular ROIs, 3 ROIs were positioned in the right liver lobe, 1 ROI in the left liver lobe. Mean values and standard deviation for the right (ROI 1-3) and left (ROI 4) liver lobe as well as for both liver lobes (ROI 1-4) were calculated. Furthermore, the reduction rate (RR) of T1 relaxation times before and after application of Gd-EOB-DTPA was calculated:

$$\mathrm{RR} = \frac{\mathrm{T1\ pre\ contrast} - \mathrm{T1\ post\ contrast}}{\mathrm{T1\ pre\ contrast}}\ 100\%$$

Statistical analysis included paired t-test and Pearson correlation test, P-values < 0.05 were considered statistically significant.

RESULTS:

Both techniques yielded very similar mean T1 relaxation times for the right and left liver lobe (Tab. 1). Standard deviation across ROI 1-4 was 9.2% (pre contrast) and 12.9% (post contrast) of the mean T1 for 3D VIBE and 7.1% and 9.0% for 2D TurboFLASH.
Although the absolute T1 results were significantly different with 3D VIBE and 2D TurboFLASH, the reduction rates RR calculated with both methods were highly correlated (Pearson correlation coefficient 0.90, P<0.001; Fig. 2).

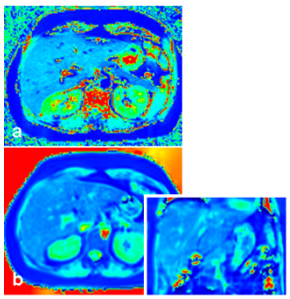

Fig. 1: T1 maps based on 2D TurboFLASH (a) and 3D VIBE (b)

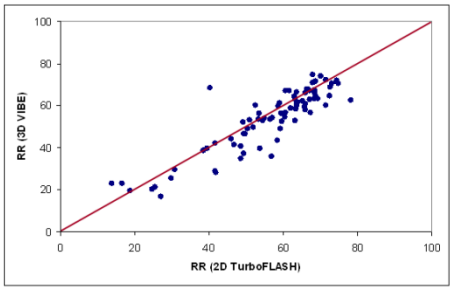

Fig. 2: RR based on 3D VIBE RR based on 2D TurboFLASH

Table 1: T1 [ms]	$T1_{pre\ contrast}$ 3D VIBE	$T1_{pre\ contrast}$ 2D TurboFLASH	$T1_{post\ contrast}$ 3D VIBE	$T1_{post\ contrast}$ 2D TurboFLASH
right liver lobe (ROI 1-3)	843 ± 147	753 ± 116	378 ± 119	322 ± 121
left liver lobe (ROI 4)	836 ± 197	752 ± 133	382 ± 135	320 ± 123

Table 2: T1 [ms]	$T1_{pre\ contrast}$ 3D VIBE	$T1_{pre\ contrast}$ 2D TurboFLASH	$T1_{post\ contrast}$ 3D VIBE	$T1_{post\ contrast}$ 2D TurboFLASH
normal liver (n=53)	858 ± 105	743 ± 93	324 ± 66	265 ± 53
cirrhotic liver (n=31)	817 ± 195	768 ± 145	469 ± 136	419 ± 143

DISCUSSION:

3D VIBE with 3 flip angles and a preceding B1 map for correction of B1 inhomogeneities yielded reliable results for T1 relaxation times in the liver. T1 across both liver lobes was very similar indicating sufficient homogeneity, even in critical anatomical regions. T1 relaxation times for patients with normal liver function was in good agreement with results given by de Bazelaire[1] (809 ± 71 ms) or Katsube[2] (836 ± 69 ms). T1 mapping of the whole liver within a single breath hold is an important prerequisite to include this technique in a clinical protocol – for example before and in the hepatobiliary phase after application of Gd-EOB-DTPA.

CONCLUSION:

T1 mapping based on a 3D VIBE sequence with 3 different flip angles seems to be a promising technique to acquire T1 relaxation times across the whole liver within a single breath hold at 3 T. Due to a preceding B1 map the homogeneity of T1 values is sufficient – even for critical regions like the left liver lobe.

REFERENCES:

[1] de Bazelaire CMJ, Duhamel GD, Rofsky NM, et al. MR imaging relaxation times of abdominal and pelvic tissues measured in vivo at 3.0 T: preliminary results. Radiology 2004;230(3):652-659.
[2] Katsube T, Okada M, Kumano S, et al. Estimation of liver function using T1 mapping on Gd-EOB-DTPA-enhanced magnetic resonance imaging. Invest Radiol 2011;46(4): 277-283.