FREE-BREATHING IMAGING TECHNIQUES FOR LIVER IRON QUANTIFICATION: COMPARISON WITH A VALIDATED BREATH-HOLD TECHNIQUE IN PATIENTS WITH IRON OVERLOAD

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Introduction: Hepatic iron content (HIC) measurements utilizing quantitative T2* maps have become an increasingly used alternative to traditional HIC evaluation obtained by liver biopsy. The advantages of T2* based HIC measurements are the non-invasive nature of the precedure and a relatively short measurement time. Recently several studies were presented, that correlated biopsy based HIC measurements with T2* measurements. These studies showed excellent agreement between biopsy and MRI [1,2]. The validation was, however, only performed for a multi-gradient echo sequence obtained in a single breathhold. With this technique it is not always possible to consistently acquire artifact-free T2* maps, especially in a population of young, sedated, or uncooperative patients. Another study reports a free-breathing approach for iron quantification, but this work was not validated with data from liver biopsies [3]. Therefore, the aim of this study is to implement and compare different free-breathing T2* based HIC techniques with a validated breath-hold method in patients with liver iron overload.

Methods: Our institution currently uses for clinical HIC quantification a T2* exam that has been validated with 47 liver biopsies and is based on the acquisition of a single imaging slice at the height of the portal vein during a breath-hold. We implemented free-breathing alternative methods using the same base sequence (multi-gradient echo sequence, ETL 20, TE[1] 1.07ms, TE_{inter} 0.82ms) as described in the following: (i) a free-breathing single-slice and multi-slice version of the above sequence with multiple averages, (ii) a navigator controlled version of the base sequence, that can also be executed as single- or as multi-slice technique. The navigator technique used in our study acquires a low resolution, low-angle gradient echo image in the area of the diaphragm to avoid magnetization saturation inside the imaging volume. The diaphragm position is tracked on these navigator images and the algorithm automatically selects an acceptance range for the diaphragm position and triggers the image acquisition when the diaphragm is within the acceptance range [4].

3 pediatric patients (age 3, 10 and 15; 2 β-thalassemia, 1 acute lymphoblastic leukemia) with iron overload received their regular scans and - after informed consent was obtained - one or two additional free breathing scans as displayed in table 1. For the analysis a region of interest (ROI) was drawn in a similar fashion as used for the clinical evaluation. Within one patient the identical ROI was applied or the best matching ROIs were chosen on slices where the anatomy was slightly shifted due to the free breathing.

Results and Discussion: Table 1 summarizes the mean values and standard deviation measured in the ROI's with the different T2* quantification techniques in all patients. Figure 1 shows the T2* maps obtained with 3 different methods for patient 1 in matching slices. The blue line in the respective T2* maps indicates the borders of the ROI where respective T2* values have been calculated for comparison.

The T2* values obtained with the different techniques are very close for the two patients with high iron overload. For the patient with moderately high overload (#2) the values obtained with the two different methods are still within 2 standard deviations. It can also be seen from the T2* maps that the values are similar across the whole image plane. The free breathing technique shows artifacts mainly outside of the body (fig. 1c), but these artifacts seem not to influence the quantitative values in the liver, although visual signal differences are also present in the frontal area of the liver.

Patient	1			2		3	
Method	Single slice breathhold	Multi slice navigator	Multi slice free breathing	Single slice breathhold	Multi slice navigator	Single slice breathhold	Single slice free breathing (3 ave)
T2* Value (mean ± std)	(4.3 ± 0.6) ms	(4.3 ± 0.6) ms	(4.4 ± 0.8) ms	(10.9 ± 0.9) ms	(12.6 ± 1.3) ms	(1.9 ± 0.4) ms	(1.7 ± 0.3) ms

Table 1: ROI mean T2* values obtained with different acquisition methods in 3 patients.

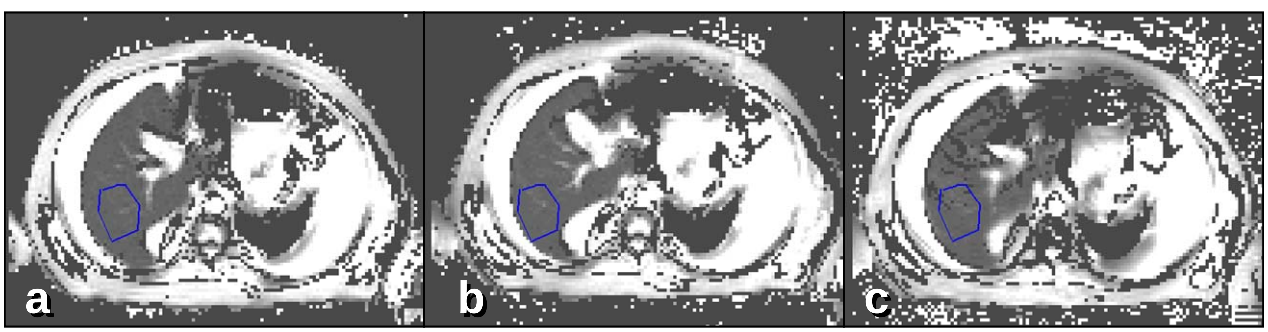

Figure 1: T2* maps of patient #1 obtained from three different imaging approaches; (a) validated single slice breath-hold technique, (b) multi slice free breathing navigator technique, and (c) multi slice free breathing technique.

Conclusion: Our preliminary results indicate that the proposed free-breathing methods for T2* quantification yield comparable results to the breath-hold technique. Currently our sample size is too small to draw any statistical conclusion. These encouraging results will however trigger a study in a larger group of patients in our institution as free breathing techniques will render more patients eligible for non-invasive HIC measurements via T2*-MRI, thus including especially young children that are unable to follow breathing commands. In this patient group the navigator technique can be used for sedated patients or patients under general anesthesia, whereas the free breathing technique can be used for very young, non-sedated patients, when a quick exam is desired to minimize the exam time and maximize patient acceptance.

References: [1] Wood JC, et al. Blood 106:1460-1465 (2005). [2] Hankins JS, et al. Blood 110:Abstract 2670 (2007). [3] Song R et al. JMRI 26:208-14 (2007). [4] Klessen C et al. JMRI 21:576–582 (2005).

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