Comparison between multi-point exponential and two-points logarithmic methods for cardiac T2 measurments.

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Target audience: Scientists interested in quantitative MRI

Introduction: T2 value measurement is a useful method to detect rejections after cardiac transplant [1]. This measure is commonly based on multiple fast spin echo (FSE) sequences with different echo times (TE). Each acquisition is performed during a 20 second-long breath-hold to avoid respiratory motion artefacts. In order to decrease acquisition times, we propose a logarithmic approach based on 2 sequences. Additionally, this method estimates T2 values with a calculation instead of an iterative process which does not require extended post-processing time for T2 mapping generation. We have compared the two methods to assess the reproducibility of each and find the best compromise between sensibility and patient comfort.

Material and methods: As supported in [2] for n repetitions of TE min, 4n repetitions of TE max are required to achieve the optimal measure. Therefore we proposed 2 log-based methods: 1-4 (1 repetition of TE min and 4 of TE max) and 2-8 (2 repetitions of TE min and 8 of TE max) (Figure 1). As the optimal TEs combination depends on the T2 value of interest (from 50ms to 70ms, in our case), we estimated TE min = 10ms and TE max = 80ms.

Experiments were performed on one healthy volunteer on a 1.5T MRI scanner (Signa Excite, GE medical systems). The clinical T2 protocol consisted in 10 black-blood FSE acquisitions with TE ranging from 10ms to 80ms and with repetition time = 2RR, matrix = 256x192, field of view = 42cm², slice thickness = 10mm. Acquisitions at TE = 10ms and 80ms were repeated 2 and 8 times respectively. During one exam, we performed 3 protocols and each time we set the volunteer out of the scanner and unplugged the coil. Thereby, we considered these 3 datasets as independent. We performed 3 exams in 3 weeks to obtain 9 independent acquisitions.

To do the 1-4 log-based measurement, we selected the first, out of 2, TE 10ms and the 4 first, out of 8, TE 80ms. The left ventricle (LV) myocardium had been divided into 6 segments according to the AHA recommendations [3] and for each of them, we computed the mean pixel intensity, for each TE. Then, we calculated the mean (M) and the standard deviation (STD) of the 9 T2 values (Table 1). To determine if the 2 methods were correlated, we performed a paired permutation test (Table 1). Finally we analyzed differences between the exponential and the 1-4 log method using a Bland-Altman graph to identify the bias in the case of significant difference (Figure 2).

Results: We observed (Table 1) a significant difference (p-value < 0.05) between the exponential and the 2 log-based methods for 4/6 segments. In addition, we observed a 1.7ms bias on the graph (Figure 2) and a 2ms bias on mean T2 value estimates on non-split LV (52.5ms for exp, 54.5ms for 2-8 log and 54.7ms for 1-4 log). Indeed log-based methods overestimated the T2 value because of echo-train extremities TEs which were more affected by k-space FSE sequence modifications. We had initially found a bias around 2ms on a theoretical simulation (results not shown). Nevertheless standard deviation of segmented LV (Table 1) and of non-split LV (3.9ms for exponential, 3.3ms for 2-8 log and 4.1ms for 1-4 log) were close. Eventually, we performed a paired permutation test between exponential values and 1-4 log corrected values (subtraction of 1.7ms): no significant difference were found for the 6 segments.

Figure 1: *Illustration of the different calculation methods. All points represent signal intensity mean in the ROI at a specific TE*

	ROI 1		ROI 2		ROI 3	
	M	**STD**	**M**	**STD**	**M**	**STD**
Exp	54.4	5.1	55.4	2.9	54.6	6.0
2-8log	56.2*	4.1	56.5*	2.8	56.4*	7.2
1-4log	56.4*	6.1	57.6*	2.6	56.7*	7.4
	ROI 4		**ROI 5**		**ROI 6**	
	M	**STD**	**M**	**STD**	**M**	**STD**
Exp	49.8	4.0	49.9	4.9	53.8	5.4
2-8log	49.8	4.5	51.8	5.3	56.8*	2.6
1-4log	49.9	4.4	50.9	5.9	56.7*	4.9

Table 1: *T2 estimates on the 6 myocardial segments using the 3 methods: exp, 2-8log and 1-4log. *: p-value < 0.05 (exp vs log).*

Figure 2: *Bland-Altman graph between the exponential and the 1-4 log method.*

Discussion: Using log-based method could be useful to measure T2 values with acquisition time reduction. It does not require iterative process to measure T2 values and T2 mapping could be performed with no computation delay. Additionally, registration work can improved since the technique only requires 5 images. Nevertheless T2 values measurements were biased. An offset correction has shown good results compared to standard exponential results. To conclude, with the log-based T2 estimation using 1 TE min and 4 TE max, we divided per 2 the acquisition time with small reproducibility reduction. This method would be a good compromise between sensibility of the measurement and patient comfort. Further works will focus on optimizing the correction of 1-4 log biased T2 value measurement.

References: [1] Marie and al., *JACC* 37, 825-31 (2001). [2] Fleysher and al., *MRM* 57, 380-387 (2007). [3] Cerqueira 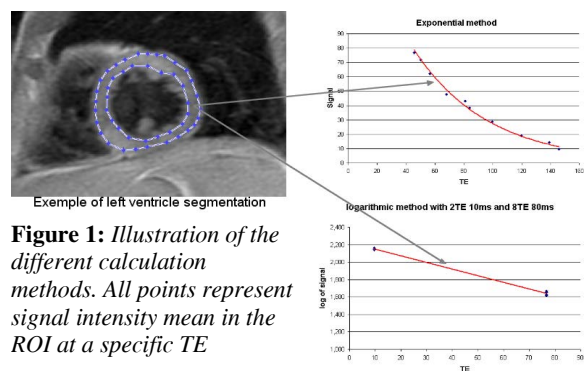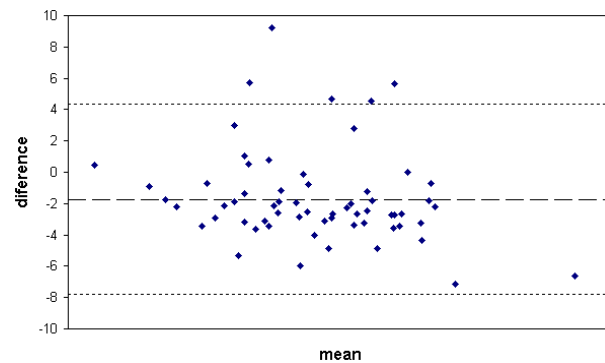and al., *Circulation* 105, 539-542, (2002).