Effect of physiological variation of heart rate on quantitative cardiac T2 mapping

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INTRODUCTION

In heart transplantations and some cardiac pathologies, T_2 mapping is very useful for the patient's follow up **[1]**. Black blood FSE sequence is routinely used for this purpose in order to permit breath-hold data acquisition ; however, patient motion and unwilled trigger events as well as variation in heart rate (HR) may disturb data acquisition and change the repetition time (TR) or heart phase. T_2 were measured to quantify these effects and provide a HR variation compensation method.

MATERIAL AND METHODS

This study was made on a 3 T General Electrics SIGNA Excite HD MR system (General Electrics, Milwaukee, WI). Signals from a respiratory belt and ECG sensor were carried by a custom Maglife patient monitoring system (Schiller Medical, France) and recorded with a dedicated home-made hardware.

1) Evaluation of RR variation (ΔRR) during breath-hold (~30 seconds): 12 healthy subjects performed 2 breath-holds in inspiration and 2 others in expiration.

2) Evaluation of ΔTR on T2 mapping: images were acquired using a standard SE sequence (8 TEs = [9: 70] ms) on a phantom containing 12 tubes of homogeneous gels of different known T1 and T2 ; T2 value range was 40 to 140 ms.
   - inter-acquisition TR variation: first 4 TEs with TR = 1500 ms and the 4 last TEs with TR = 1180 ms .
   - intra-acquisition TR variation: MR system is synchronized to the R peaks of the ECG of a typical subject in relation to breath-hold.

3) Finally, a clinical cardiac T2 mapping protocol (FSE sequence with different TEs) was acquired on a healthy subject.

T2 maps were computed using a mono-exponential fitting method. To compensate TR variation, the following weighting factor was applied: $1/(1-\exp(-TR/T1))$ on the SE signal. For inter- acquisition TR variation, the correction was applied on the image intensity. For intra-acquisition TR variation, the correction was applied before the Fourier Transform. This was possible thanks to our dedicated hardware (2) which tracks instantaneous TR.

Fig. 1: *Classical aspect of RR time plot during a 30-second expiration breath-hold.*

RESULTS

1) RR variation patterns for successive breath-holds were similar (*Fig.1*). Patient group analysis shows significant RR time variation. Mean ΔRR in inspiration and expiration were found equal to 31 % and 23 %, respectively.

2) For inter- and intra-acquisition RR variation, T_2 measurements without correction lead to a systematic error on the T2 estimates between 15 to 35 %. Using the proposed correction on both inter- and intra-acquisition TR variation, the deviation was less than 10 %.

3) Cardiac T_2 maps –without and with the proposed correction- obtained on a healthy subject are presented in *Fig.2*. Contrarily to the T2 values estimated without correction, T_2 values estimated with the corrected method were in accordance with T2 values previously measured on the healthy myocardium [1].
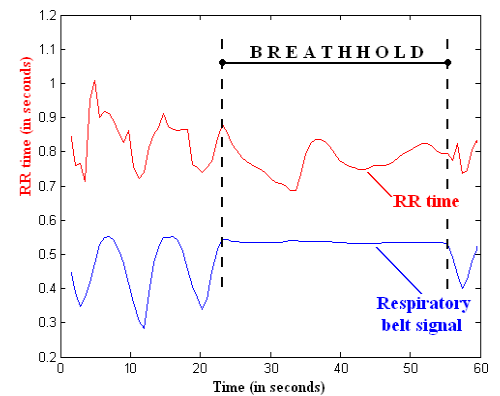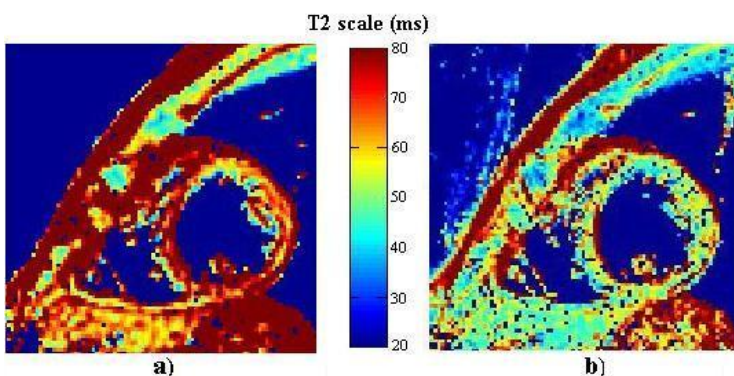

Fig. 2: *a) Unprocessed cardiac T2 mapping on a healthy subject.*
b) RR variation-compensated cardiac T2 mapping on the same subject.

DISCUSSION AND CONCLUSION

In this study, we showed that HR variation is significant during MR acquisition time what strongly affects T2 values estimation during a standard cardiac protocol.

Depending on RR time value during the k-space filling, T2 measurement can be significantly biased, but our method significantly improves the estimates accuracy or at least provides a T2 map acceptance threshold.

The physiological parameter recording enables to introduce a k-space row-by-row RR variation compensation. As a result, we believe to bring here more meaningful diagnosis and better knowledge of its reliability degree. Further work will focus on the evaluation of T2 measurements as a tool for diagnosis heart transplant rejection.

REFERENCES

[1] Perlot P. and *al.*, **Noninvasive detection and control of acute rejection after heart transplant by means of a "black blood" MRI sequence**, Circulation 1997;96(8):1052-1052.
[2] Odille F. and *al.*, **Noise cancellation signal processing method and computer system for improved real-time electrocardiogram artifact correction during MRI data acquisition**, IEEE Trans Biomed Eng. 2007 Apr;54(4):630-40.