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

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INTRODUCTION
In heart transplantations and some cardiac pathologies, T2 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. T2 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 (∆RR) during breath-hold (~30 seconds): 12 healthy subjects performed 2 breath-holds in inspiration and 2 others in expiration.

2) Evaluation of ∆TR 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.

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

2) For inter- and intra-acquisition RR variation, T2 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 T2 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, T2 values estimated with the corrected method were in accordance with T2 values previously measured on the healthy myocardium [1].

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