How Different Data acquisition techniques impact to the Selected Curve fitting models and the Cardiac T2* Measurements

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Introduction

Scanning parameters such as selecting of the first TE, single echo or multiple echo acquisition, black blood or bright blood imaging etc; and fitting models are key parameters to the accuracy and reproducibility of cardiac T2* measurements [1-5]. Generally, data acquisition with breath-holding technique has been used as a standard protocol for scanning. However, in some cases those have difficulty to perform breath hold for a short period of time or those who are not able to cooperate; free breathing could be a better choice. However, to date no study shows that breath-hold and free-breathing technique will provide the same results. Therefore, we aim to compare the robustness of the measured cardiac T2* obtaining from the two techniques when the selected fitting models are changed.

Purpose

The objective of this study was to compare correlations of the two most frequently cited fitting models between the breath-hold and free breathing techniques.

Materials and methods

This study was performed on a MRI scanner, 1.5 Tesla, Achieva, Philips, Netherland. The scanner reproducibility was verified with an in-house building gel phantom doped with 8 different levels of iron concentrations corresponding to the T2* approximately 2 to 45 msec. Human study included 14 normal healthy volunteers (7 males and 7 females, ages between 20-34 years old) and 54 Thalassemia patients (21 males and 33 females, ages between 14-59 years old). The study was reviewed and approved by a local institutional review board. All subjects were explained details, and risks of the study; and signed inform consents. A single short-axis view at the mid left ventricle of ten echo times (1.70 – 26.10 msec. an increment of 2.70 msec.) were represented the cardiac T2*. The scanning protocol encompassed: A double inversion recovery black blood Gradient Echo multi-echoes sequence, flip angle of 25º, matrix 164 x 154, FOV 36 cm, TR 28 msec, and 1 Number of Signal Average (NSA),for the breath-hold technique, but for the free-breathing technique matrix size and NSAs were optimized with the compromise of total acquisition time and image quality. The simple mono-exponential (SME) and exponential plus a constant (Offset) models with Levenberg-Marquardt curve fitting algorithm were used to evaluate T2* values. The correlations between phantom iron concentrations, and the R2*s(1/T2*) in two fitting models were examined. The correlations between the two fitting models of breath-hold, and free breathing techniques were also compared. The data analysis was performed on a PC using MATLAB7.01 (Mathworks, Natick, MA, USA), and SPSS for window V.17.

Results

The correlations between phantom iron concentrations (mg Fe^{3+}/g wet weight) and R2*s(1/T2*) (Fig.1) using Pearson's test showed significant correlations with the correlation coefficients (r) of 0.9462(P=0.0004), and 0.9887 ($P<0.0001$) for the SME, and Offset models respectively. The Wilcoxon signed-rank test showed significant reproducibility of the scanner within one week. There was no significant differences of the T2*s between the first and second scans for the SME, and Offset models (*P*-value = 0.195) and (*P*-value = 0.938) respectively. Fig.2(a)-2(b) showed data of 14 normal volunteers. There were no significant correlations between the 2 fitting models in both free breathing and breath-hold techniques, (p=0.9867), and (p=0.0644) respectively. However, it was found that for the breath-hold technique, the Offset model showed 3 false positives of the T2*(below 20 ms.), while all data from the free breathing technique have normal range (above 20 ms) of T2*s in both fitting models. In 54 Thalassemia group (Fig.2(c)-Fig.2(d)), both free breathing and breath-hold techniques demonstrated significant correlations of the two fitting models with the Pearson's r of 0.5898($p<0.0001$), and 0.7018 ($p<0.0001$) respectively. It was noticed that both fitting models have strongly correlations if the T2* $\leq$ 20 ms in both free breathing and breath-hold techniques. However, for the T2* above 20ms, the Offset and SME fitting models tend to have less correlation corresponding to the normal group results. Fig.3(a)-3(b) showed examples of images in iron overloaded patients, and Fig.4(a)-4(b) demonstrated the examples of normal range T2*.

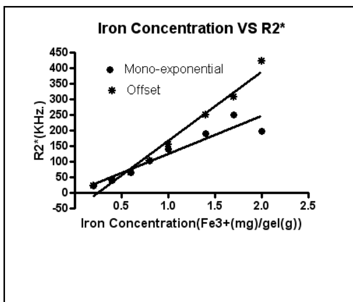

Figure1. shows the correlations of R2* and iron concentration with two fitting models, Offset and SME.

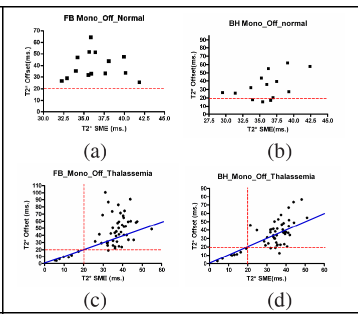

Figure2 shows the correlations between Offset and SME fitting models of Free breathing and breath- hold techniques in normal group (a), and (b); and Thalassemia patients (c), and(d).

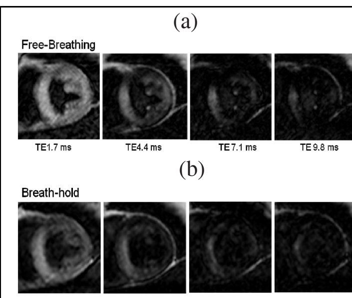

Figure3 (a), and (b) show examples of images of an iron overloaded patient.

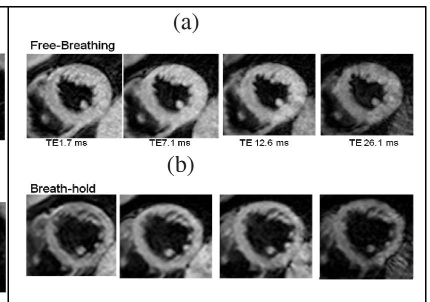

Figure4 (a), and (b) show examples of images of a non iron overloaded patient.

Discussion and Conclusion

The breath-hold technique showed more sensitive to the data fitting than that of the free breathing technique in T2* measurements of normal subjects. There were 3 false positives with Offset model fitting in this group. This may caused by the constant term in the Offset model is more appropriate for the 2 decay components, fast and slow, but in the normal group the decay of T2*s were slow and appeared to be more single component. However, both fitting models and data acquisition techniques showed no problem to distinguish the iron overload group to the normal group.

References

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