A Comparison Study of Myocardial T2* Measurement in Iron Overloaded Thalassemia Patients

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Introduction

Survival of beta thalassaemia major (TM) is dependent upon lifelong blood transfusions which result in iron overload. The validated cardiac magnetic resonance T2* technique allows non-invasive and reproducible quantification of myocardial iron (1), which can improve diagnosis and monitor of patient treatment. In this technique, the blood and motion artifacts can affect the T2* decay curve in a complicated way potentially introducing errors. For the heavily iron loaded heart, T2* is substantially shortened (<10ms) and the signals of later echo images quickly drop to a plateau. An offset model (3) has been proposed to handle this situation; however, we have used an alternative approach of truncating the fit after the first few points to optimise the exponential. We have also developed a black blood technique (2) shown to have improved inter-observer reproducibility presumably because it suppresses blood signal and hence artifacts. In this study we compared the use of the offset and the truncating models on the bright blood data and in turn compared the results with the T2* measurement made using the black blood approach.

Material and Methods

The study was approved by the local ethics committee. The previously described bright blood breath-hold multi-echo T2* technique (1) was implemented on 1.5T MRI scanners at five centres worldwide. Scanner models were Siemens Quantum (Cairo, Izmir and Kula Lumpur), GE Signa (Beirut) and GE CVI (Athens). 5 TM patients at each site were scanned twice locally within 1 week and all patients were subsequently scanned at the standardization centre in London(Siemens Sonata, 1.5T) within 4 weeks of their original scan. All patients were scanned twice in the UK using both the bright and the black blood techniques (1,2). In brief, all sites used a cardiac phased array coil with ECG gating and a single mid-ventricular short axis slice was imaged at eight echo times. The sequence parameters (particularly TE and TR) were not identical in all sites, but were kept similar as described in (1.2) and these variations would not be expected to affect the T2* measurement. A region of interest (ROI) was drawn in the left ventricular septum for T2* measurement. The 12 patients with T2* less than 10ms were selected for this data comparison. Different curve fitting methods were evaluated in the current study: *The mono exponential* decay model with an equation of $SI = P_0 \bullet e^{-TE/T2^*}$, where P_0 is a constant of magnetization, *TE* the echo time and *SI* the signal intensity; The *truncating model* to exclude low SNR data points to make the curve fitting better; The *offset model* of $SI = P_0 \bullet e^{-TE/T2^*} + C$ where C is a constant. The Levenberg-Marquardt method of nonlinear curve fitting was employed for all the models mentioned. Reproducibility (both interscanner and interstudy) is expressed as the coefficient of variation (CoV) defined as the standard deviation of the differences between the two separate measurements divided by their mean. Summary data are displayed graphically using scatter plots with the line of identity. All the analysis was carried out by two independent readers using Thalassemia-Tool software (Cardiovascular Imaging Solutions, London).

Results

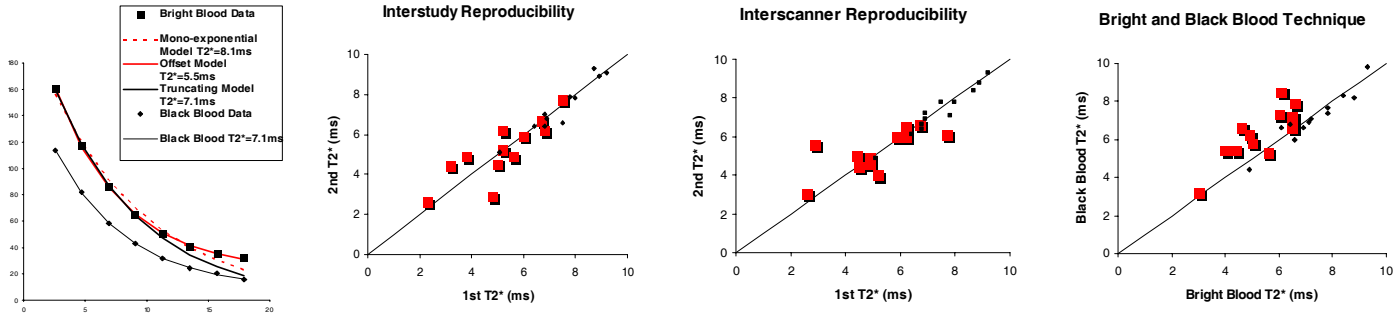

Fig.1 illustrates a typical example showing both the bright and black blood data fitting with different methods. The mono-exponential fit is poor when all points are included, and the offset model fitting is good as is the black blood data fit. Figs.2, 3 and 4 are scatter plots with the line of identity for the reproducibility studies; the big red dots represent the measurements using the offset model and the small black ones the truncating model. The interstudy reproducibility using the truncating model was 4.8% compared with that of 16.9% using the *offset model*. The interscanner reproducibility using the truncating model was 4.5% compared with that of 20.1% using the *offset model*. For reproducibility of the bright and black blood, the CoVs were 5.0% and 18.1% for the truncating and the offset models respectively.

Conclusions

The *mono-exponential model* applied to bright blood images gave rise to a poor curve fitting and generally appeared to overestimate the T2* measurement. The *offset model* fitted the curve well but appeared to underestimate T2* measurement. The *mono-exponential model* applied to the black blood data gave a good fit and produced a T2* value close to that of the *truncating model*. Overall, these results suggest that for bright blood imaging, the offset model seems to be not reproducible (around 20%) and although the truncating model is subjective it appears more reproducible (<5%). The black blood technique can avoid the blood and motion artifacts and we believe give rise to optimal T2* measurement.

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