Myocardial T2* Cut-Off Values Determined by Gaussian Mixtures Models

Taigang He[1,2], Yanqiu Feng[3], Rongrong Liu[4], John-Paul Carpenter[1], Andrew Jabbour[1], Yongrong lai[4], Dudley Pennell[1], and David Firmin[1,2]

[1]CMR Unit, Royal Brompton Hospital, London, United Kingdom, [2]NHLI, Imperial College, London, United Kingdom, [3]School of Biomedical Engineering, Sourthern Medical University, China, People's Republic of, [4]Department of Hematology, The first affiliated Hospital of Guangxi Medical University, China, People's Republic of

Introduction: Cardiovascular magnetic resonance (CMR) can provide a non-invasive means of measuring tissue iron in the heart. The iron deposition results in shortening of proton relaxation times; and both CMR T2* and T2 have been validated as non-invasive means for assessment of myocardial iron overload. (1,2). We have found that T2*< 20ms represents iron overload in the heart, and that T2*<10ms predicts risk of heart faliure (3). These cut-off values proven very useful in clinical practice. However, there is currently no technical development to confirm these important cut-off values which have been widely accepted for early diagnosis of myocardial iron in patients with thalassemia major (TM).

A mixture model corresponds to the mixture distribution that represents the probability distribution of observations in the overall population. We believe myocardial T2* and T2 data may contain some intrinsic patterns which can be explored for clinical diagnosis. In the current study, therefore, we aimed at clustering patients automatically into normal and abnormal groups by using Gaussian mixture models (GMM, 4), the most statistically mature methods for clustering data.

Material and Methods: In total 236 TM patients (age 28±20 years old, 119 males) were scanned on a 1.5T MRI scanner (Siemens Sonata) with a cardiac phased array coil and ECG gating. All patients were scanned using the black blood T2* and T2 sequences, each within a breath-hold. A single mid-ventricular short axis slice was imaged with T2* and T2 measured in the left ventricular septum. The mono-exponential decay model and the nonlinear curve fitting algorithm were employed for T2 and T2* measurement (CMRtools, Imperial College). The clustering algorithm using GMM was developed in Matlab.

Results and discussions: In Figure 1, the 3D histogram of T2* and T2 measured from all patients demonstrates a distinctive pattern. Figure 2 shows that the T2* and T2 data are automatically clustered into two groups (black and green) using GMM. This result agrees well with our previous finding that T2* value of 20ms can be used to distinguish patients with and without myocardial iron overload. When clustered into 3 groups (Figure 3), it can be seen that data of T2*<20ms are further divided into 2 subgoups with a cut-off T2* value of 10ms; this result is consistent with our previous finding that T2*<10ms can predict risk of heart failure. There are a few mismatched samples, which suggests that more patient data are needed and further investigation into T2 relaxometry may provide complementary information in a future study. Another development may be the advanced mixtures models which can better model these patient data.

Conclusions: This study confirms statistically that T2* is a reliable tool for screening patients with iron overload. There exists an intrinsic pattern in 2D T2* and T2 data from TM patients. Gaussian mixture model can automatically cluster the 2-dimensional data and the results agree well with T2* cut-off value of 20ms and 10ms commonly used in clinical practice. There are a few mismatched samples and a further study is needed to clarify and explain this phenomimen in order to provide improved myocardial tissue characterization for patients with TM.

References:
1. Kirk, P., et al. J Magn Reson Imaging 2010; 32:315-9.   **2.** He T, et al. J Magn Reson Imaging. 2006; 24:580-5.
3. Kirk, P., et al. Circulation 2009; 120: 1961-8.   **4.** Bishop C. Pattern recognition and machine learning. 2006; New York: Springer.
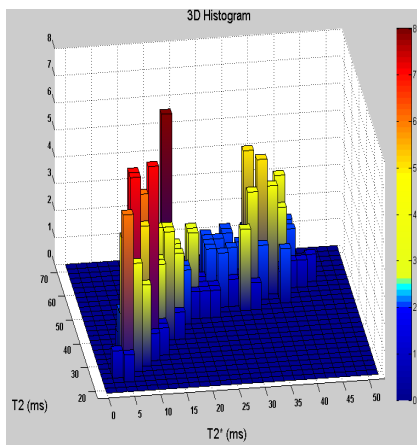
Figure 1. 3D histogram of the T2* and T2 data measured from TM patients (n=236).
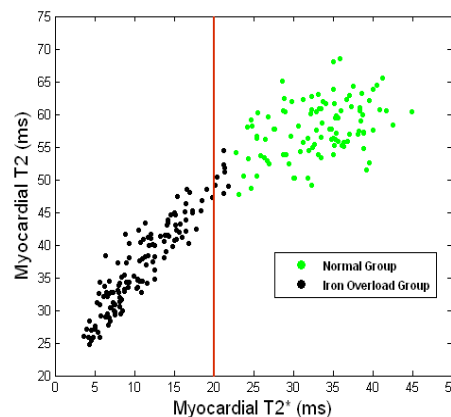
Figure 2. Automated clustering of TM patients (n=236) into 2 groups. T2* value of 20ms is a good cut-off value distingvishing patients with or without myocardial iron overload. There are mismatched samples between 20ms<T2*<23ms but of a limited number. The red line indicates a T2* value of 20 ms.
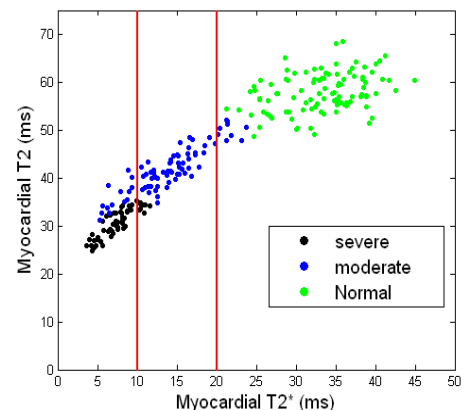
Figure 3. Automated clustering of TM patients (n=236) into 3 groups. T2* cutoff values of 20ms and 10ms are found to be consitentent with previous clinical findings. Again, there are mismatched examples but of a limited number. The redlines indicate T2* values of 10ms and 20ms.