

Mapping Techniques in CMR

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Disclosure

- None

Overview

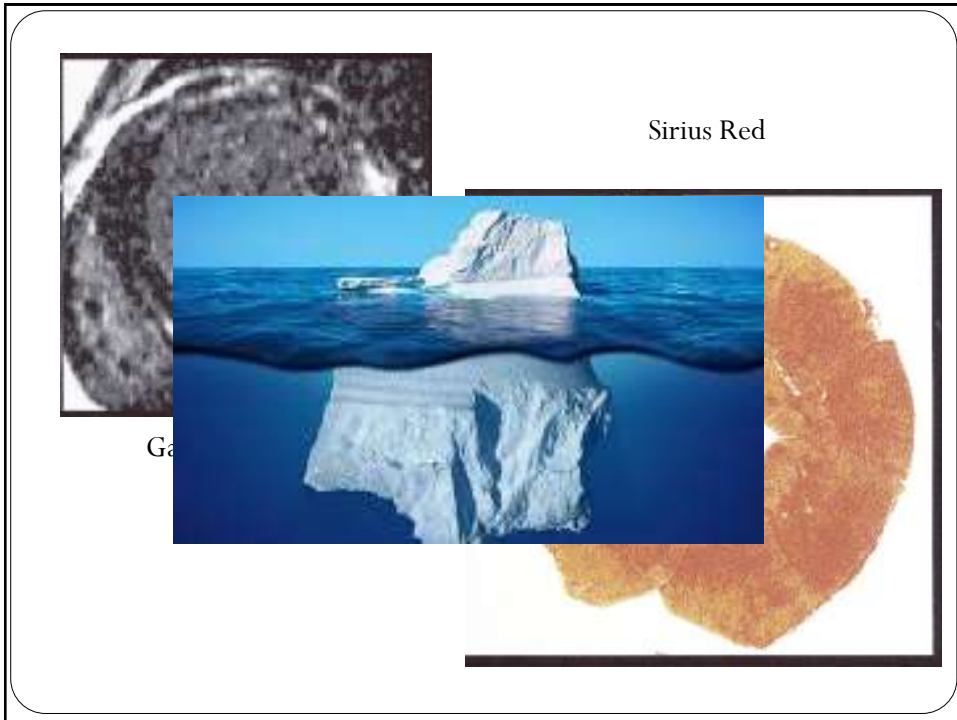
- Tissue characterization by Gadolinium based contrast
- T1 and T2 relaxation
- What are the mapping techniques?
- Clinical applications

Introduction

- CMR is unique by its ability to characterize myocardial tissue architecture in great detail.
- This has been traditionally done using late gadolinium enhancement imaging to detect macroscopic scar.¹
- LGE is thus only useful in cardiac conditions which have sharp demarcation of scarred tissue from the largely unaffected remote myocardium.

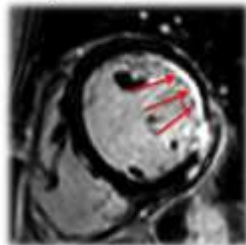
Kim RJ et al. NEJM 2000

What is wrong with what we have
got?

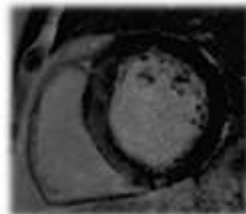


Representative images and concept of regional and diffuse myocardial disease.

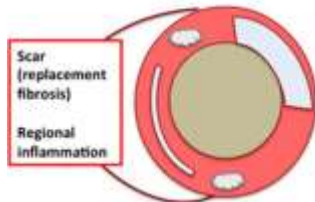
A Regional disease



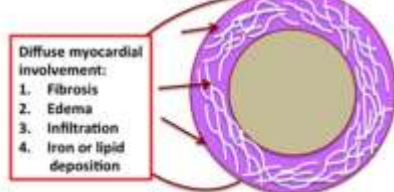
B Diffuse disease



C



D



Valentina O. Puntmann et al. Circ Res. 2016;119:277-299



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Quantitative Parametric mapping

Mapping

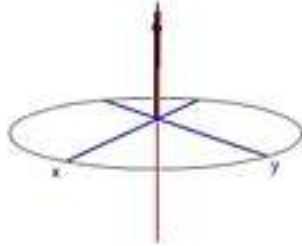
- Provides quantitative measures of T1, T2 and T2*.
- Does not suffer from mixed weighting for T1-W images.
- T1 mapping can be done with or without contrast.
- Can detect myocardial abnormality in subclinical phase of a disease or diffuse affection of the myocardium

What are T1 & T2 Relaxation?

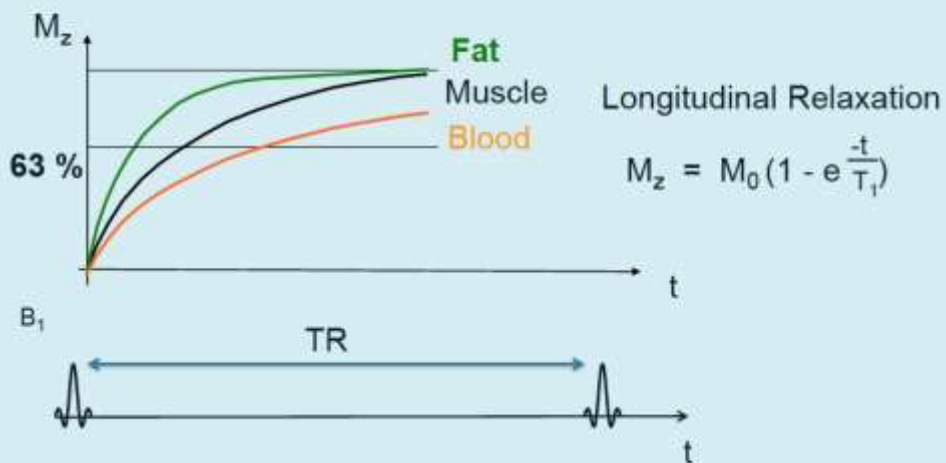
Relaxation

- After the application of RF pulse, magnetization will return into the original state (equilibrium).
- Two independent processes: T1 and T2 relaxation

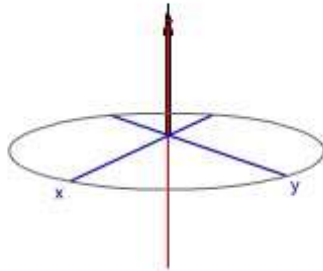
T1 Relaxation



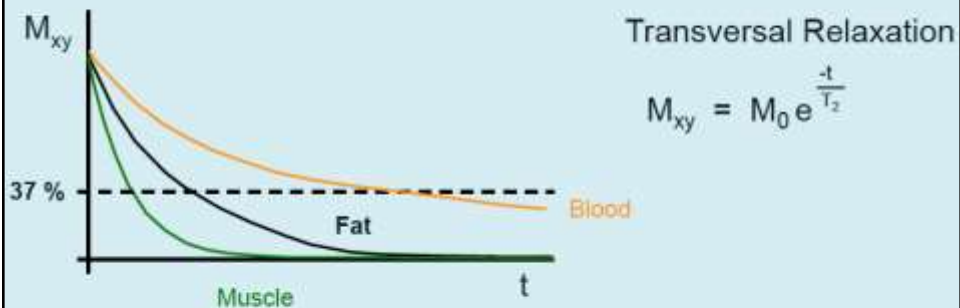
Longitudinal Relaxation (Spin Lattice T_1)

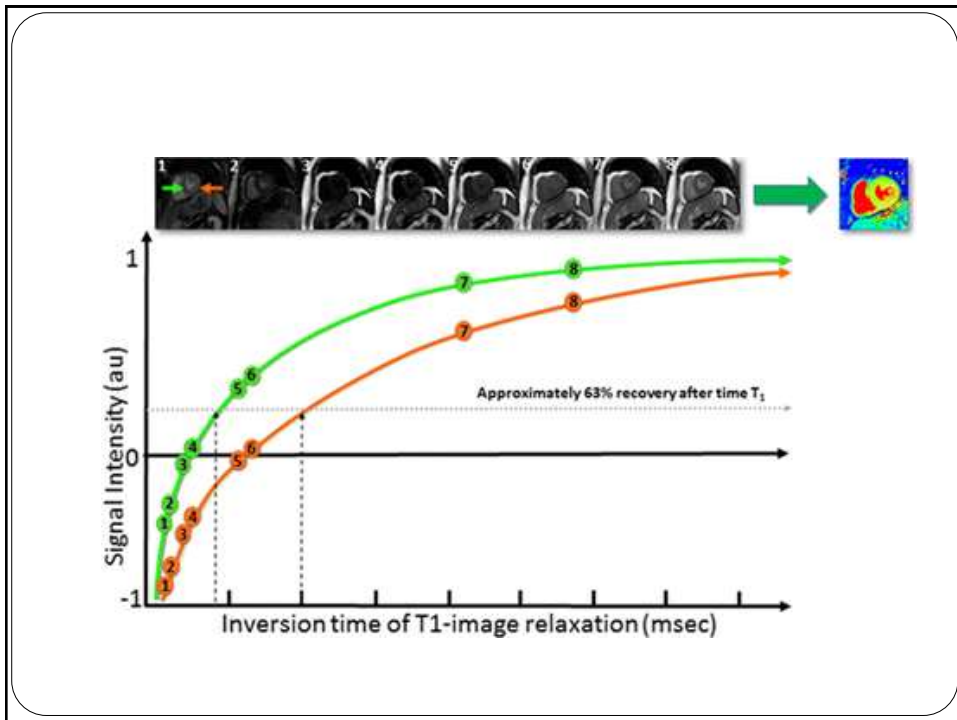


T2 Relaxation (Decay)



Transversal (Spin-Spin) Relaxation





T1 mapping sequences

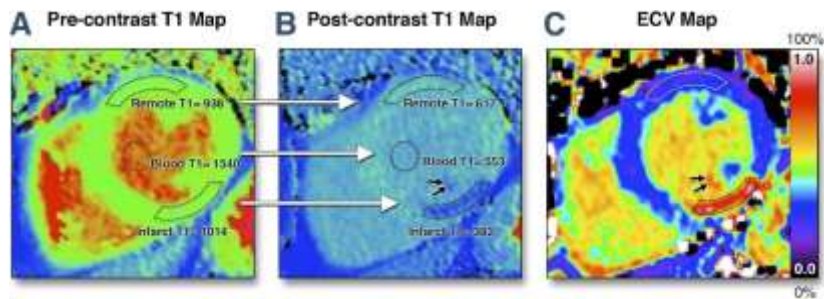
- Molli
- ShMolli
- SASHA
- SAPPHIRE
- SAP-T1
- FLASH multi-breath hold

Why T1?

- Altered in disease states
- Imaging biomarker
- ECV (extracellular volume)

$$\text{ECV} = (1 - \text{haematocrit}) \times (\Delta R1_{\text{myocardium}} / \Delta R1_{\text{blood}})$$

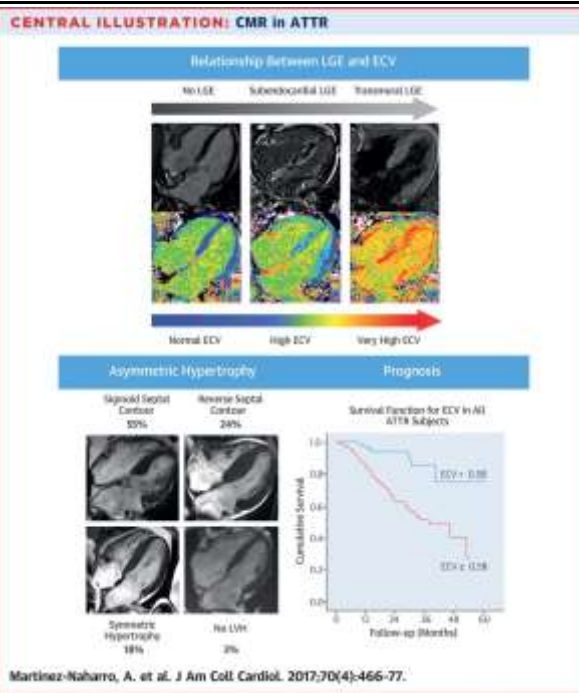
- Fibrosis, oedema, protein



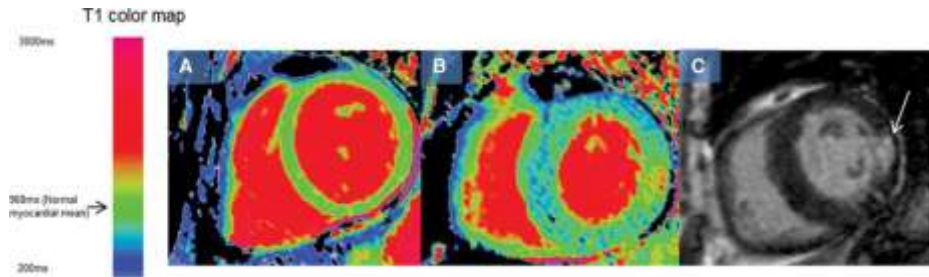
Steven K. White et al. JIMG 2013;6:955-962

Extracellular Volume Fraction

- T1 maps obtained pre contrast (native T1) and post contrast.
- Increased ECV is a biomarker of myocardial remodeling.
- ECV expansion is due to collagen deposition, in the absence of amyloid or edema.
- ECV provides prognostic information related to cardiac morbidity and mortality.
- Normal ECV = $25.4 \pm 2.5\%$ (normal range = 20-30%)



A noncontrast basal short-axis T1 map from a healthy volunteer (A) and a patient with Anderson-Fabry disease (AFD; B).



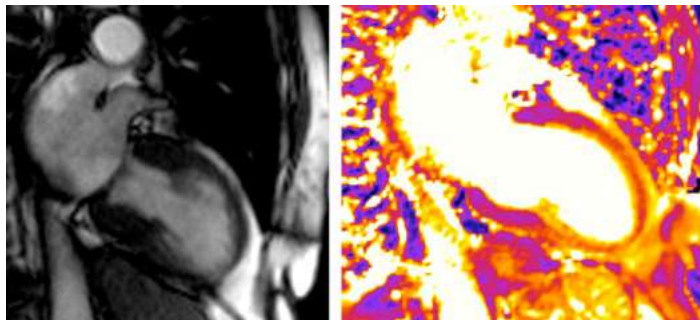
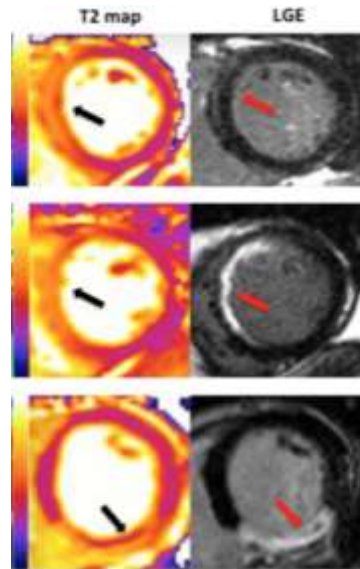
Daniel M. Sado et al. *Circ Cardiovasc Imaging*. 2013;6:392-398

T2 mapping

- T2 preparation pulse followed by subsequent SSFP readout.
- Series of T2 weighted images which are used to generate a T2 decay curve.
- Pixel wise fitting generates a T2 map.
- May be used to detect myocardial oedema from acute MI, myocarditis, Takotsubo cardiomyopathy, sarcoidosis and cardiac allograft rejection.

T2 mapping in clinical practice

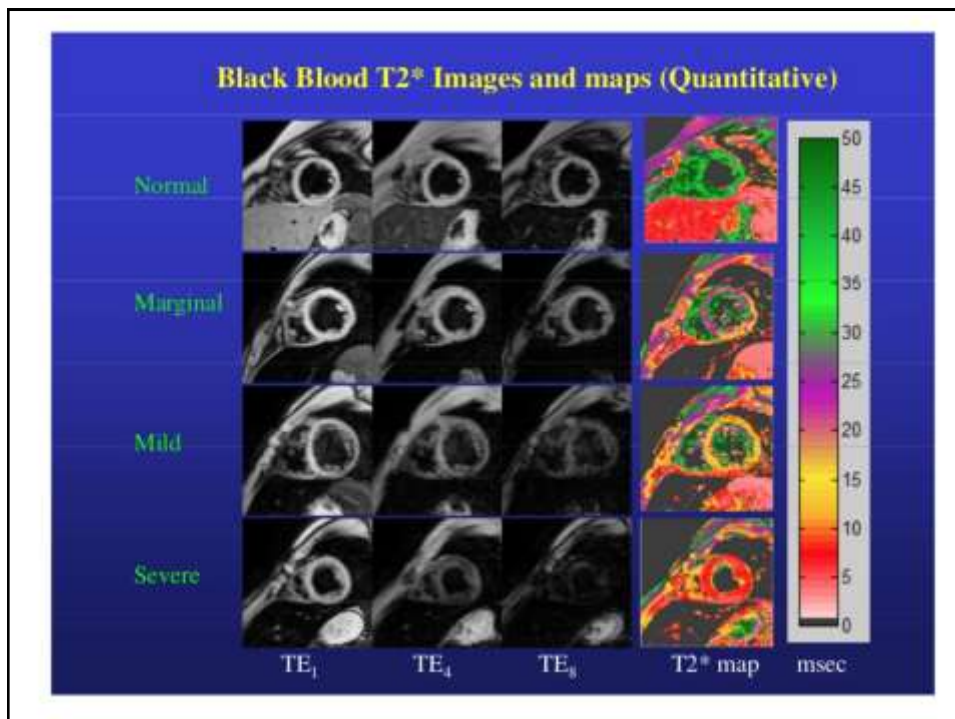
Myocardial salvage index=
 $(AAR-IS)/AAR$



T2 mapping in Takotsubo

T2* mapping

- T2* preparation pulse followed by subsequent SSFP readout.
- Series of T2* weighted images which are used to generate a T2* decay curve.
- Pixel wise fitting generates a T2* map.
- May be used to detect myocardial haemochromatosis and monitor treatment.



Take home Message

- Parametric mapping have emerged as a quantitative imaging biomarker to detect early myocardial affection even in the preclinical phase of a disease and diffuse myocardial abnormality.
- Results from research are beginning to be applied in clinical practice.

Thank You