Cardiac MRI – Echo's Friend on Enemy?

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Disclosures

- **None relevant**

Outline

- **Quantification of LVEF**
- **Assessment of valvular heart disease**
- **Tissue characterization**

Definitions

Friend = someone you can depend on when you need help!

Enemy = someone who is antagonistic, hostile, seeking to overthrow you!

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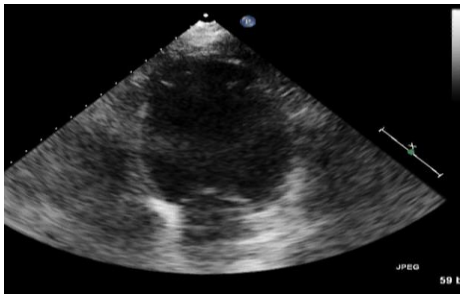
Question 1

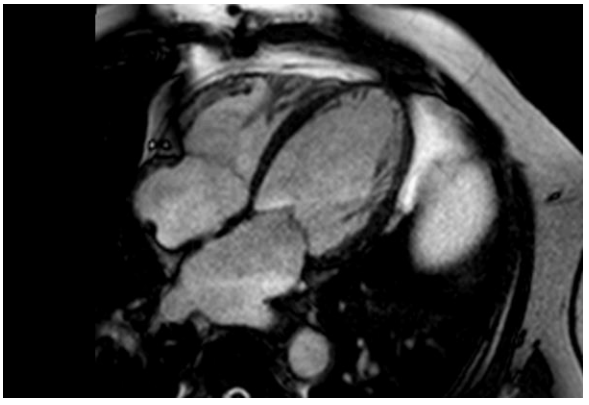
CMR differs from 2D echo in the following ways except:

1. CMR has better contrast to noise and signal to noise ratio
2. CMR has superior inter, intra, test-re-test variability
3. CMR Cine images have similar or worse spatial resolution
4. Analysis of LVEF is faster by CMR

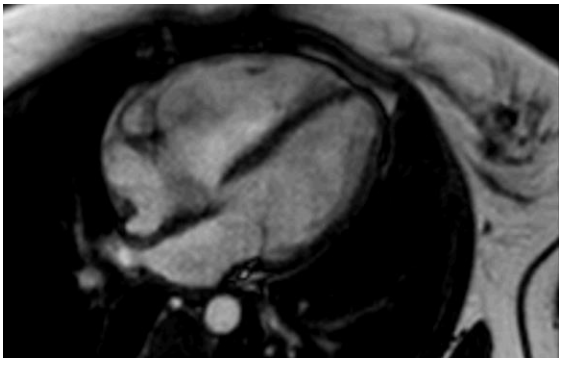
Strengths of CMR for LVEF

No acoustic window limitations

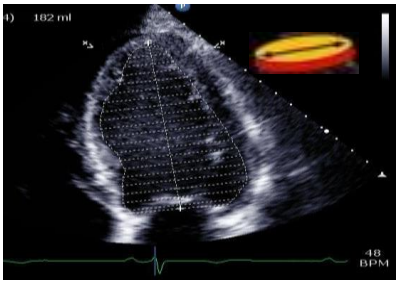


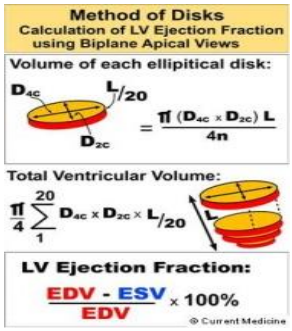


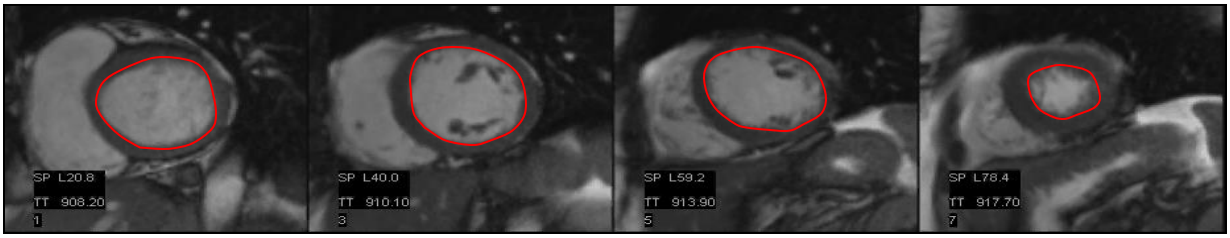
No foreshortening of apex



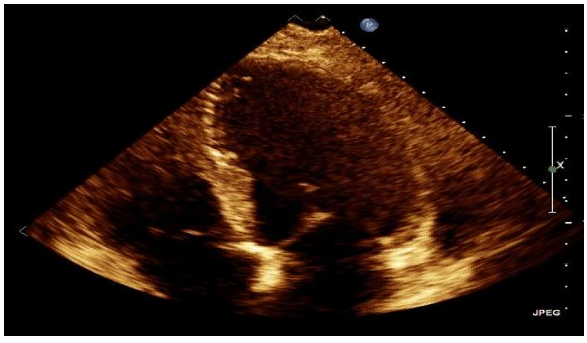
No shape assumptions

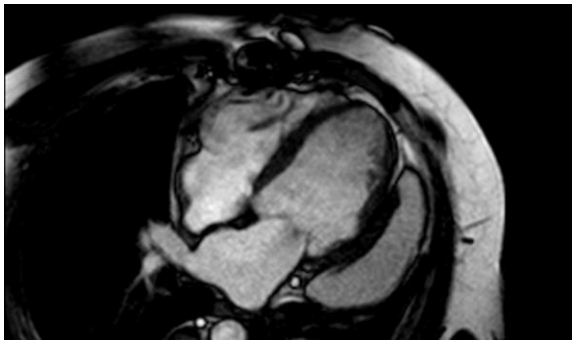


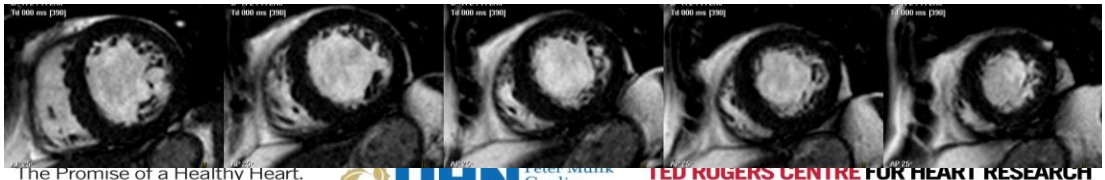




Better Contrast to Noise and Signal to Noise Ratio

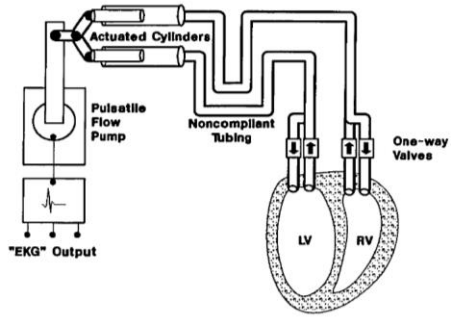


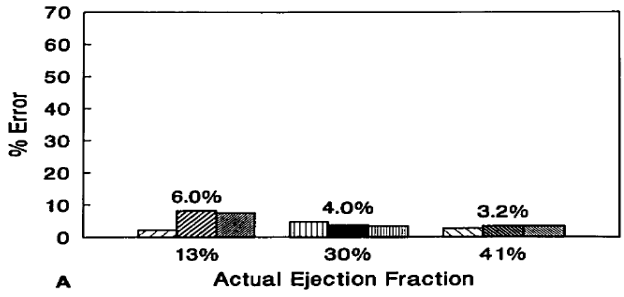




Accuracy - phantoms

- Contiguous 10mm short axis slices





Debatin JF et al. Invest Radiol 1992: 27:198-204

Reproducibility

Test re-test – MRI vs Echo

	MRI (COV)	2D Echo (COV)
EDVi	3.7%	8.7%
ESVi	6.2%	17.3%
EF	3.7%	11.5%

- 60 subjects (20 normal, 20 HF, 20 LVH)
- Studies 15 minutes apart
- FLASH, SAX
- Echo MRI time difference <60 minutes

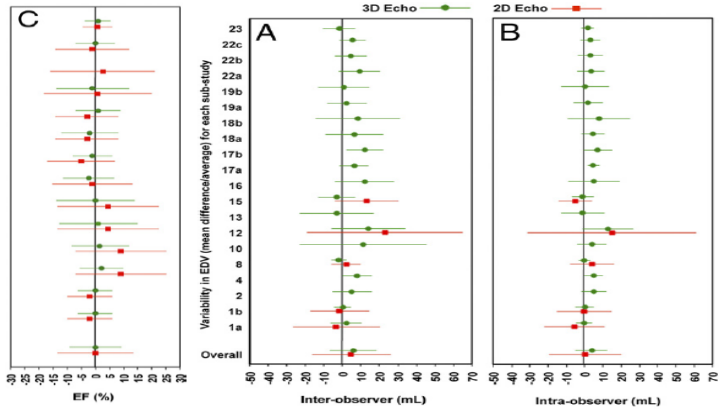
Grotheus et al Am J Cardiol 2002; 90:29-34

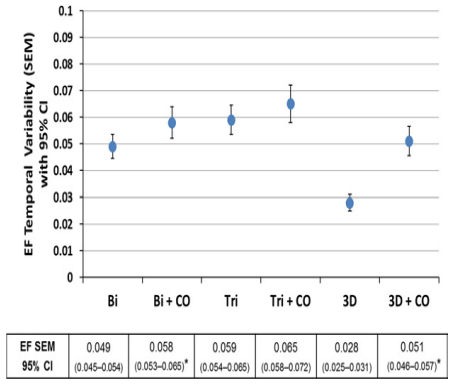
Sample Size for Studies of EF change

	Echo		CMR		Reduction in sample size
	SD	Sample size	SD	Sample size	
3% absolute Δ LVEF	6.1	87	2.1	11	87%

Grotheus et al Am J Cardiol 2002; 90:29-34

3D Echocardiography LVEF





EF SEM	0.049	0.058	0.059	0.065	0.028	0.051
95% CI	(0.045–0.054)	(0.053–0.065)*	(0.054–0.065)	(0.058–0.072)	(0.025–0.031)	(0.046–0.057)*

Dorosz JL et al. JACC, 2012; 15:1799

Thavendiranathan et al, JACC 2013, 8;61(1):77-84.

CMR vs 3D Echocardiography

	Cardiac MRI	3D Echo
Signal to Noise	Excellent	Moderate
Contrast to Noise	Excellent	Moderate
Spatial Resolution	1-2mm	1-2mm
Temporal resolution	25-50ms	20-30ms
Shape assumptions	No	No
True 3D datasets?	Selected sequences	Yes

To A et al. iJACC, 2011; 4:788-98

CMR Limitations

- Manual post processing
- Not portable

	Short axis views	Long axis views	Time saving
Experienced reader	8:42 ± 4:38	6:24 ± 0:49*	26%
Less experienced reader	13:08 ± 7:14	12:42 ± 3:34	3%

Practicality

Availability	Large institutions / Academic Centers	Widely
Cost	++++	++
Rapidity	+	++

LVEF - Summary

- CMR - reference standard for LVEF, mass
- Excellent reproducibility = smaller Ns
- Limitations – availability / portability
- 3D Echo improves reproducibility
- Echo remains primary method for LVEF

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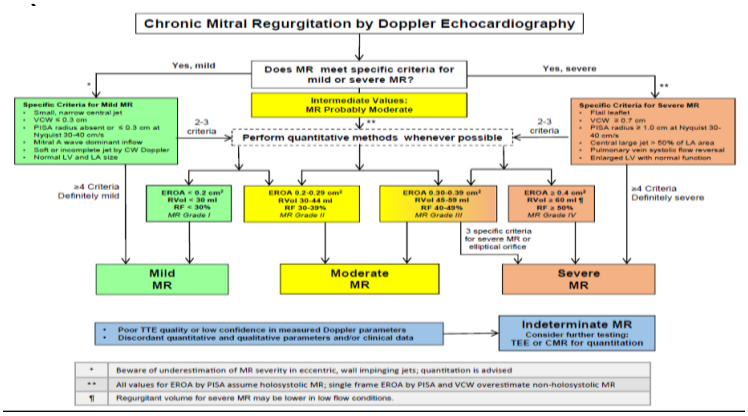
Valvular Heart Disease
Regurgitation / NOT STENOSIS

Echo - strengths



Echo - reproducibility

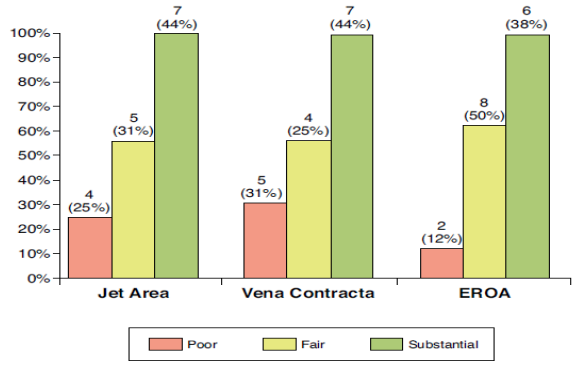
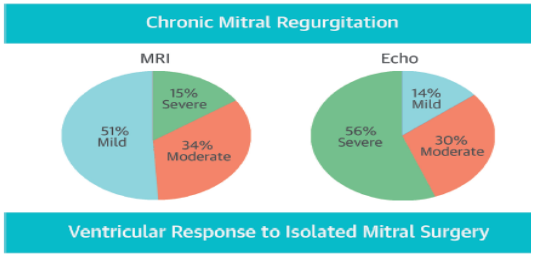


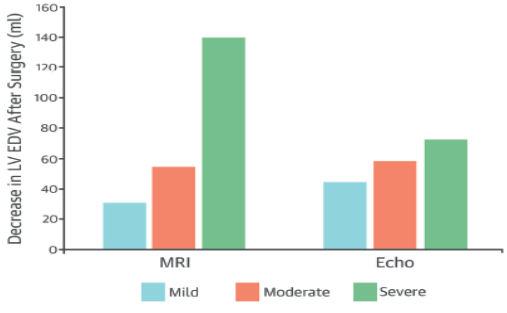
Figure 4. Distribution of Overall Raw Interobserver Agreement for Assessment of MR Severity

- Severe vs non-severe MR
  - Agreement 28% for VC, 37% for PISA

[1]Biner et al, JACC Cardiovasc Imaging. 2010; 3:235-43.
[2]Thomas N et al. AHJ. 2008; 156:1089-1094.

Echo - accuracy

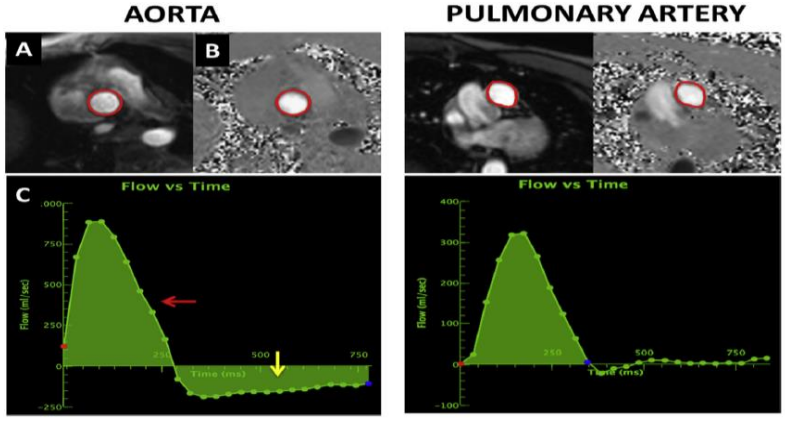




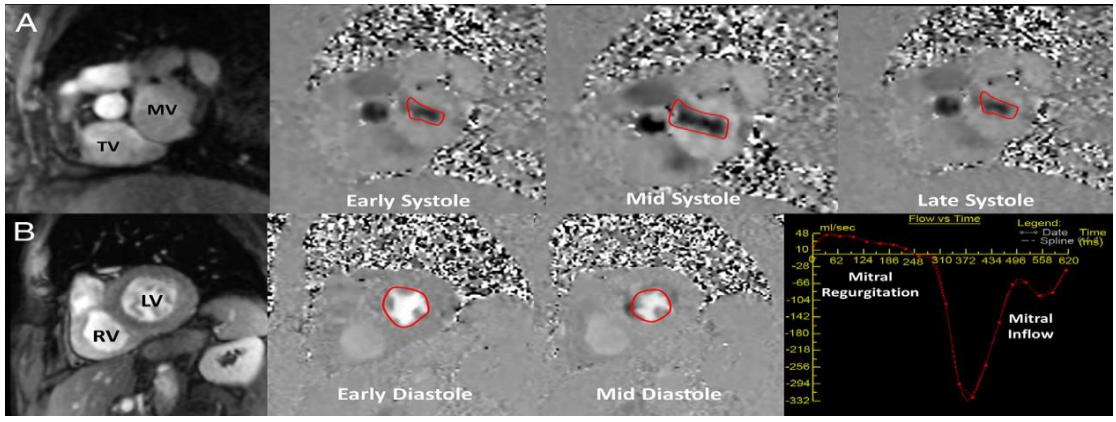
Uretsky et al JACC, 2015

The use of cardiac MRI techniques

- Direct and Indirect Techniques

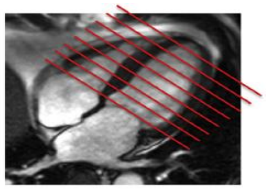


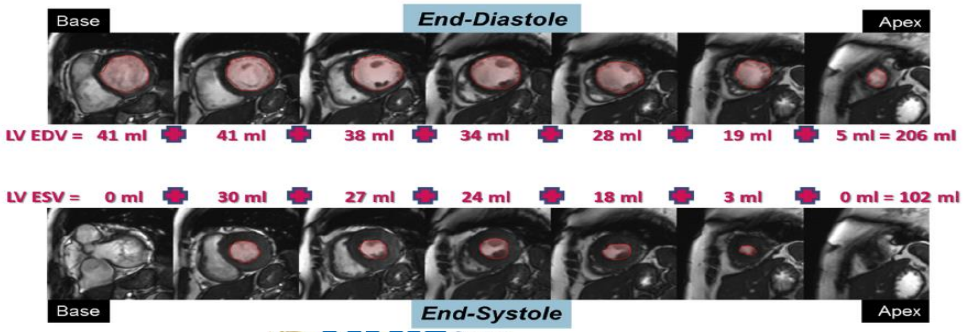
Cardiac MRI techniques - Direct



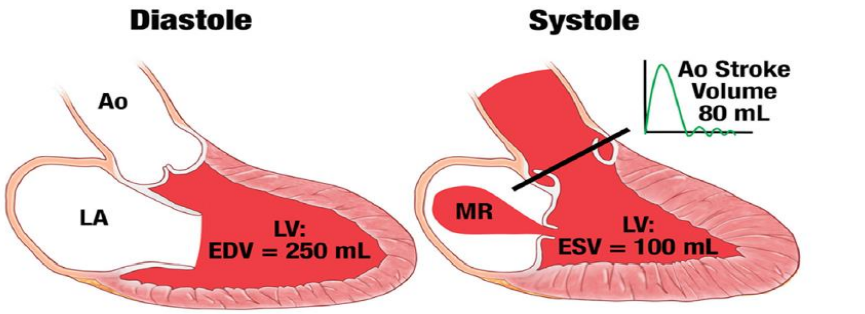
Thavendiranathan et al. JACC, 2012

The use of cardiac MRI techniques





The use of cardiac MRI techniques



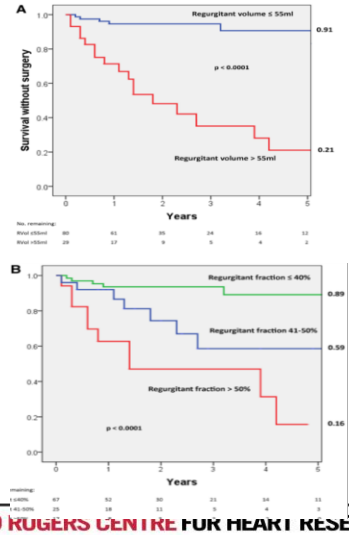
LV Stroke Volume (LVSV):
LVSV = LVEDV-LVESV
LVSV = 250 mL - 100 mL
LVSV = 150 mL

Mitral Regurgitant Volume (M RVol):
M RVol = LVSV - Ao Stroke Volume
M RVol = 150 mL - 80 mL
M RVol = 70 mL

Threshold values?

	RF
Mild	≤15%
Moderate	16-26
Moderate-severe	26-48
Severe	>48

Gelfand EV et al JCMR 2006



Myerson SG et al Circulation 2016

Threshold values?

Table 29 Grading valve disease adapted from echocardiography [39,41]

Valve disease	Indicator	Mild	Moderate	Severe
Aortic stenosis	Peak velocity [m/s]	<3	3-4	>4
	Orifice area [cm^2]	>1.5	1.0-1.5	<1.0
	Orifice area /BSA [cm^2/m^2]			<0.6
Aortic regurgitation	Regurgitant volume [ml/beat]	<30	30-59	≥60
	Regurgitant fraction [%]	<30	30-49	≥50
	Regurgitant orifice area [cm^2]	<0.10	0.10-0.29	≥0.30
Mitral stenosis	Peak velocity [m/s]	<1.2	1.2-2.2	>2.2
	Orifice area [cm^2]	>1.5	1.0-1.5	<1.0
Mitral regurgitation	Regurgitant volume [ml/beat]	<30	30-59	≥60
	Regurgitant fraction [%]	<30	30-49	≥50
	Regurgitant orifice area [cm^2]	<0.20	0.20-0.39	≥0.40
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Orifice area [cm^2]			<1
Pulmonary regurgitation	Regurgitant volume [ml/beat]	<30	30-40	>40
	Regurgitant fraction [%]	<25	20-35	>35
Tricuspid stenosis	Orifice area [cm^2]			<1.0

Kawel-Boehm et al JCMR 2015

When is CMR indicated

- Echo images suboptimal
- Discrepancy between clinical TTE/TEE Discrepancy between quantitative techniques
- To understand mechanism / associations
- Assessment of consequences of regurgitation
  - LV/RV volumes function
  - AO/PA size

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Myocardial Tissue Characterization

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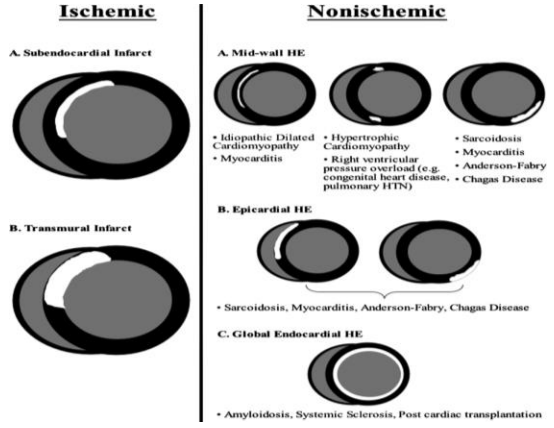
Tissue characterization

- The promise of a non-invasive myocardial biopsy!!

Late Gadolinium Enhancement



Mahrholdt H et al, EHJ, 2005 26(2):45-55, Kellman et al, JMRI, 2012, 36:5 29-542.

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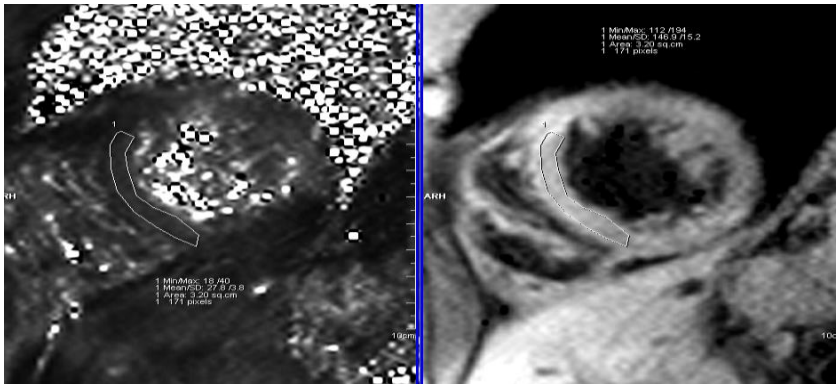
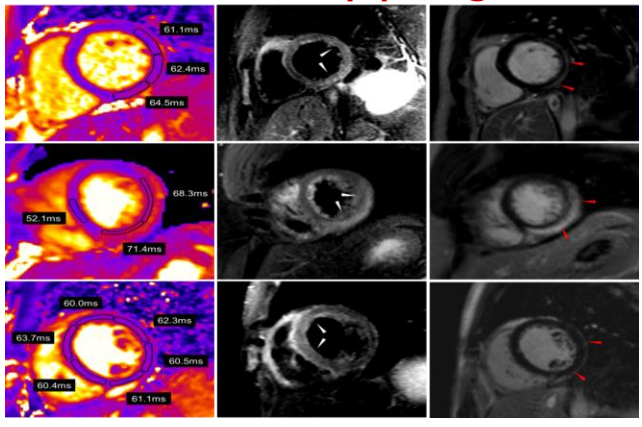
T2* imaging



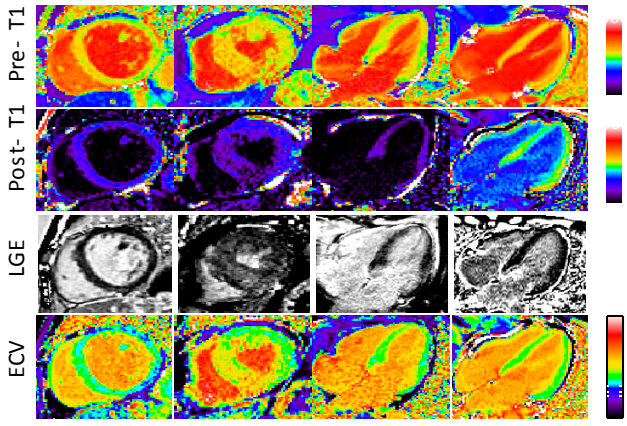
Example in patient with Sickle Cell Disease
T2 values can be read directly from generated T2* map*

T2 mapping



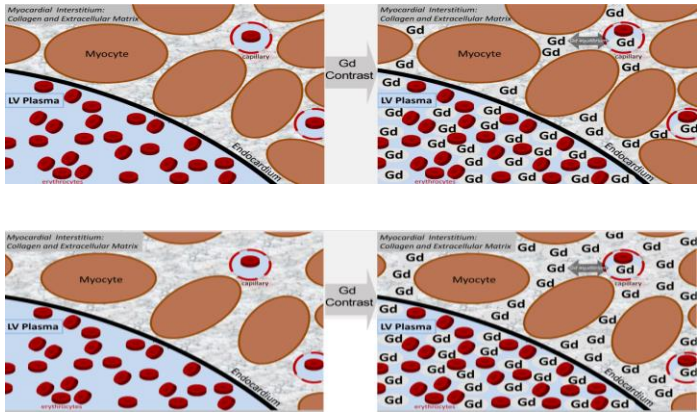
Thavendiranathan et al, Circ CV Imaging: 2012;5;102-110

Native T1 mapping



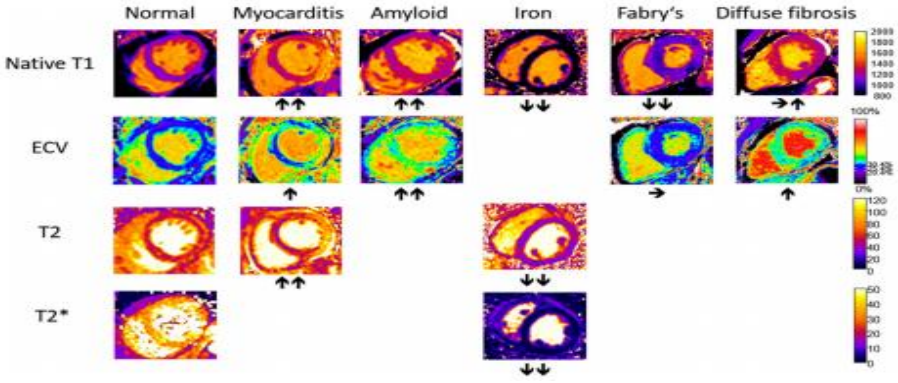
Kellman P, et al. J Cardiovasc Magn Reson. 2012, 14:64

ECV Fraction



Wong T C et al. Circulation 2012;126:1206-1216

Using Tissue Characterization



Messroghli et al, JCMR 2017; 19:75

Tissue characterization

- Opportunity to recognize myocardial changes even in the absence of functional changes
- Use in individual patients?
- Not widely available / multiple sequences

- But not possible with echocardiography

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Conclusions

- CMR has important strengths
  - **LVEF, Valvular regurgitation, tissue characterization**
- Echocardiography readily available, portable, much more experience, prognostic
- 3D echocardiography can help overcome some of limitations
- CMR remains a good friend!

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