CMR and Cardiac Risk Assessment

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WEXNER MEDICAL CENTER

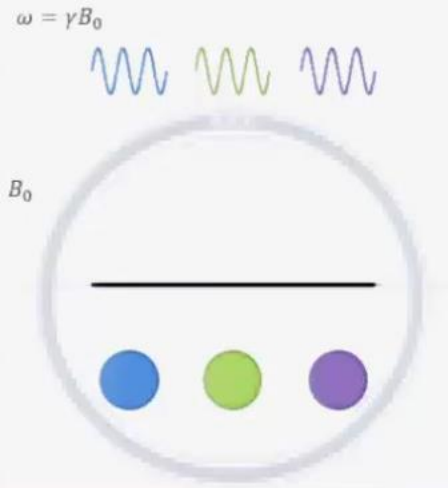
Outline

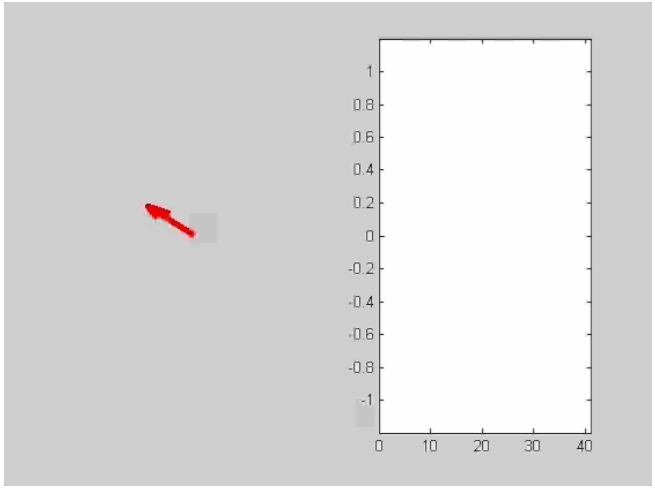
- Introduction
- Clinical scenarios for CMR risk assessment
- Conclusion

Introduction

- Indications
  - Structural heart disease
    - Cardiomyopathies – non-ischemic/ischemic
      - Viability
    - Congenital heart disease
    - Pulmonary hypertension
    - Cardiac masses
    - Pericardial disease
    - Valvular disease

Signal Generation





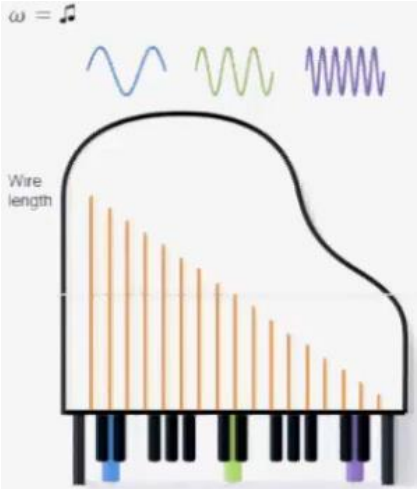


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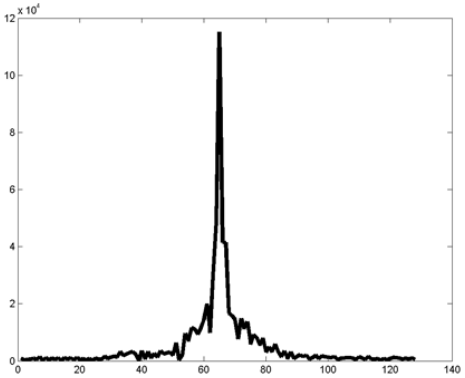
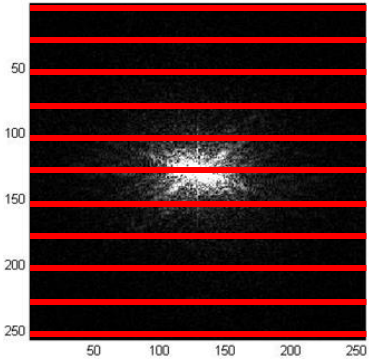
Image Generation





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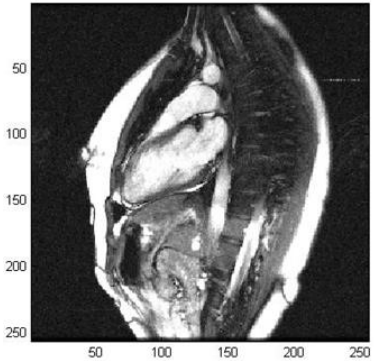

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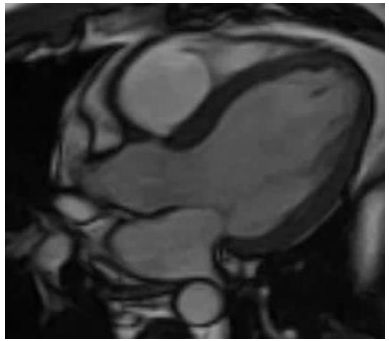
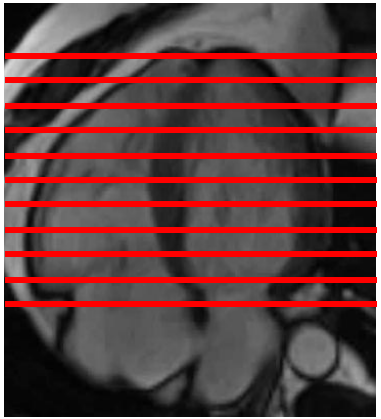
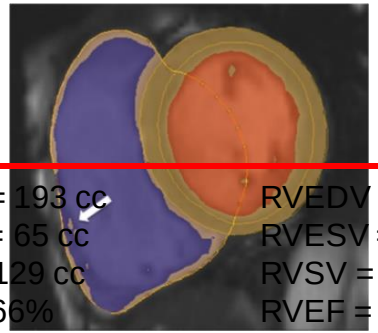
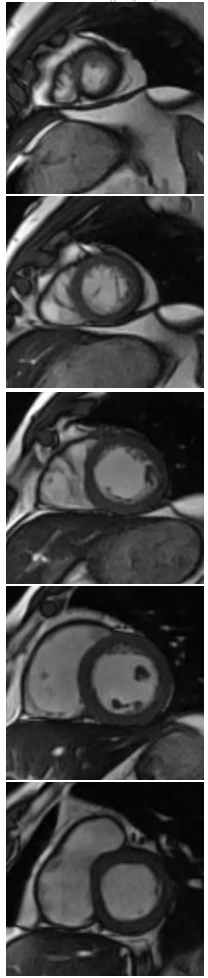






LVEDV = 193 cc	RVEDV = 230 cc
LVESV = 65 cc	RVESV = 101 cc
LVSV = 129 cc	RVSV = 129 cc
LVEF = 66%	RVEF = 56%
LVM = 144 g	RVM = 47 g



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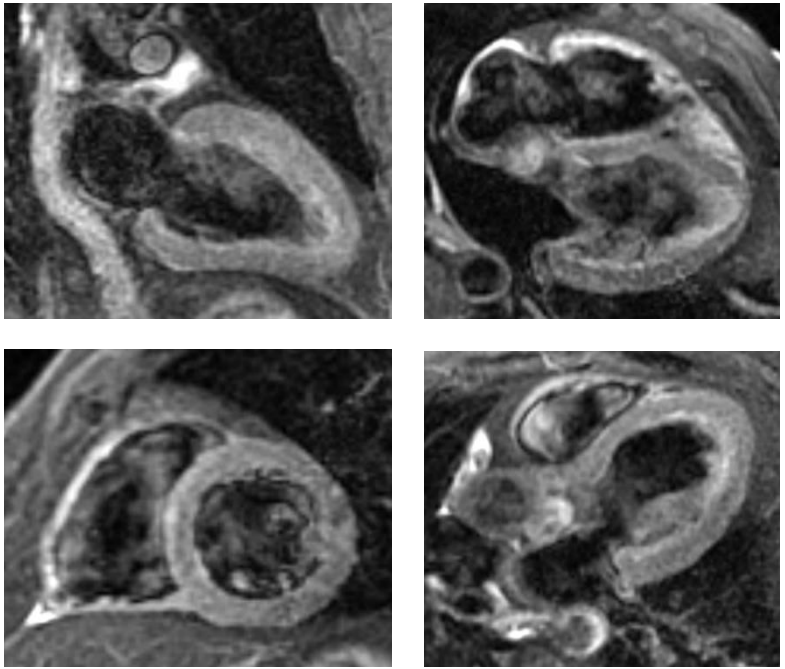
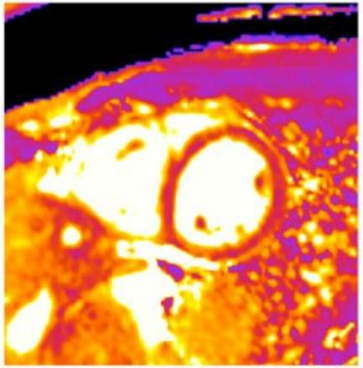
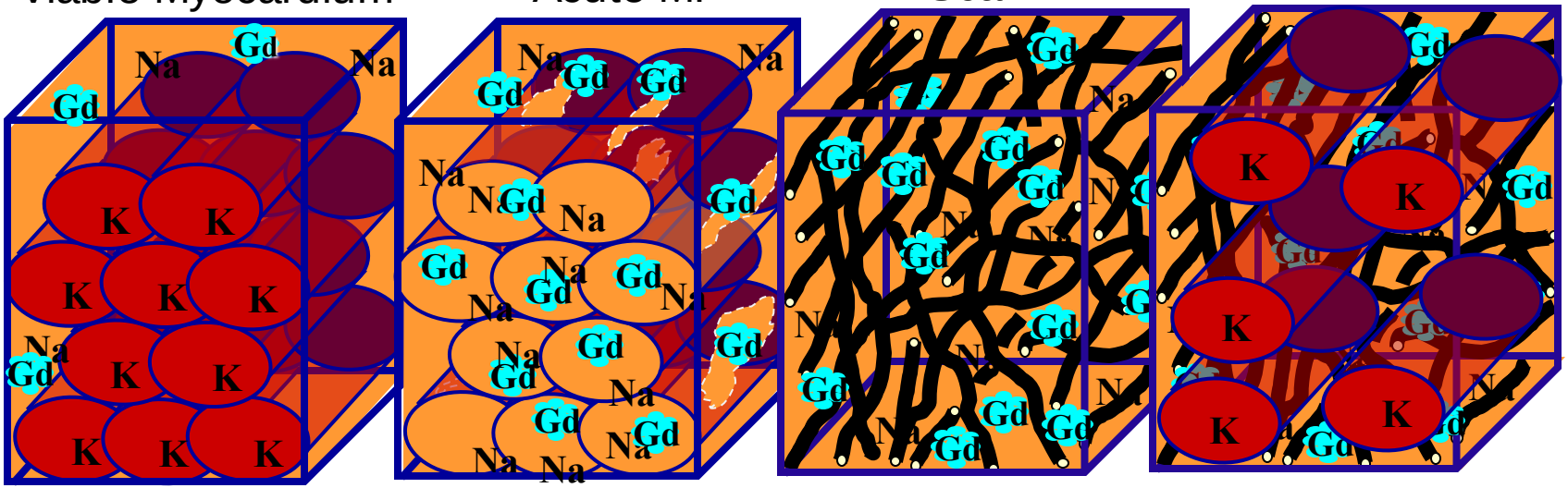




Late Gadolinium Enhancement

Viable Myocardium | Acute MI | Scar | Interstitial Fibrosis



Intact cell membranes

Normal myocardium

Ruptured cell membranes

[Gd] >> normal
T1 << normal

Collagen matrix

[Gd] >> normal
T1 << normal

Mixed cells + collagen

[Gd] > normal
T1 < normal

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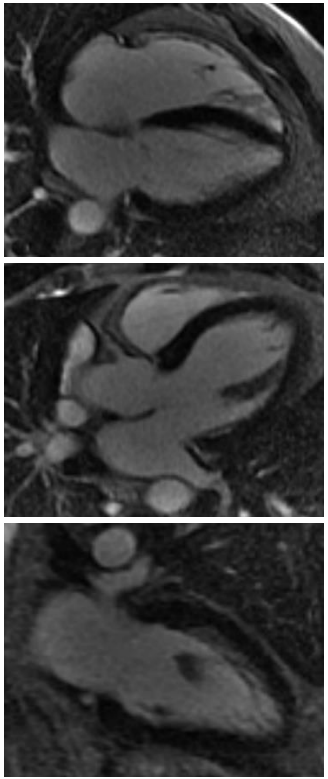
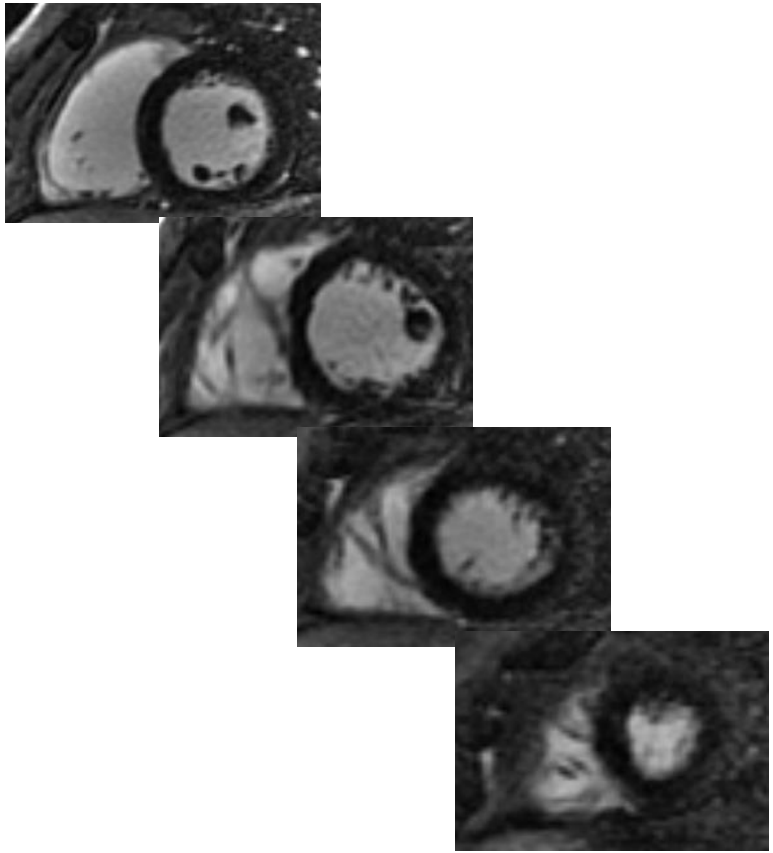
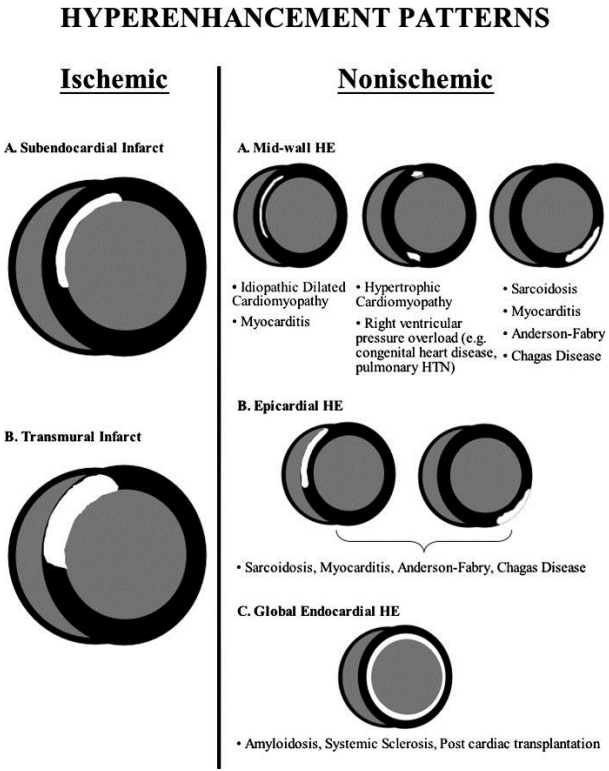
Mahrholdt EHJ 2005

Late Gadolinium Enhancement



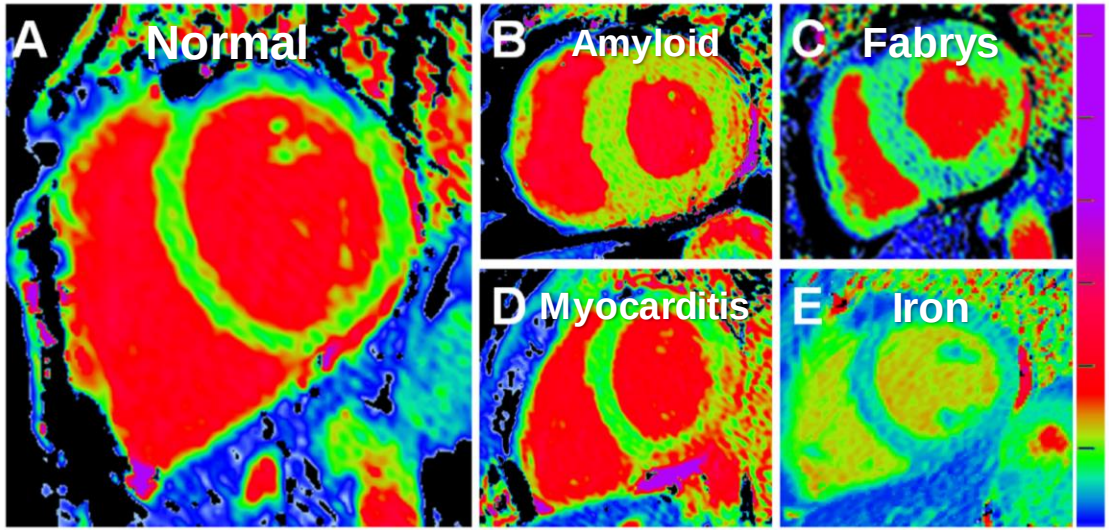


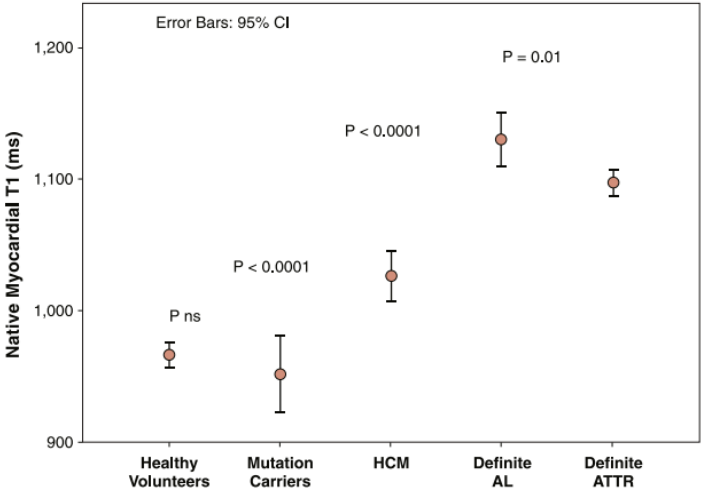
Late Gadolinium Enhancement



Mahrholdt EHJ 2005

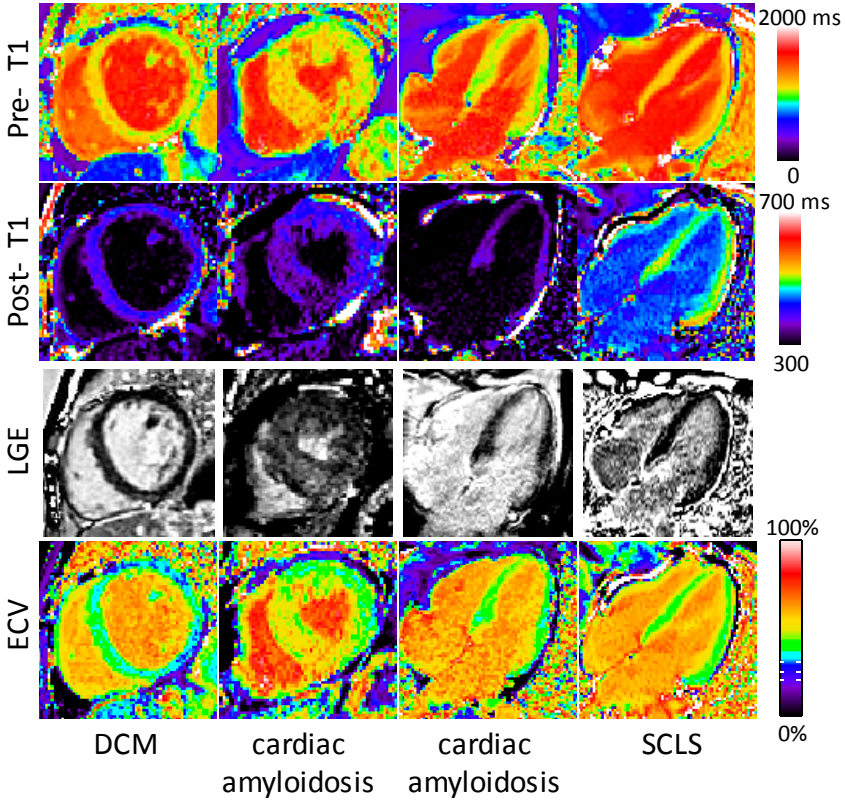
Native T1 Quantification





Fontana JACC Imaging 2014

Extracellular Volume Fraction



Kellman JCMR 2012

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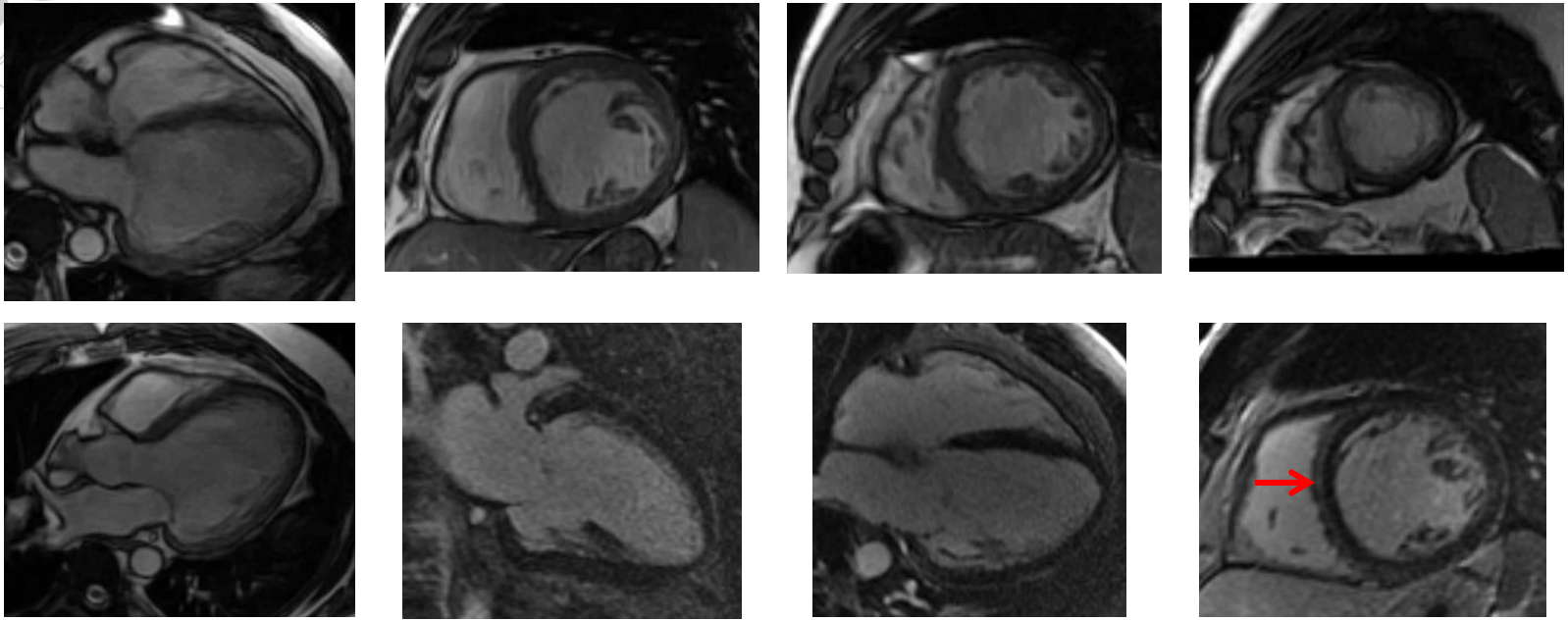
Case 1: CC

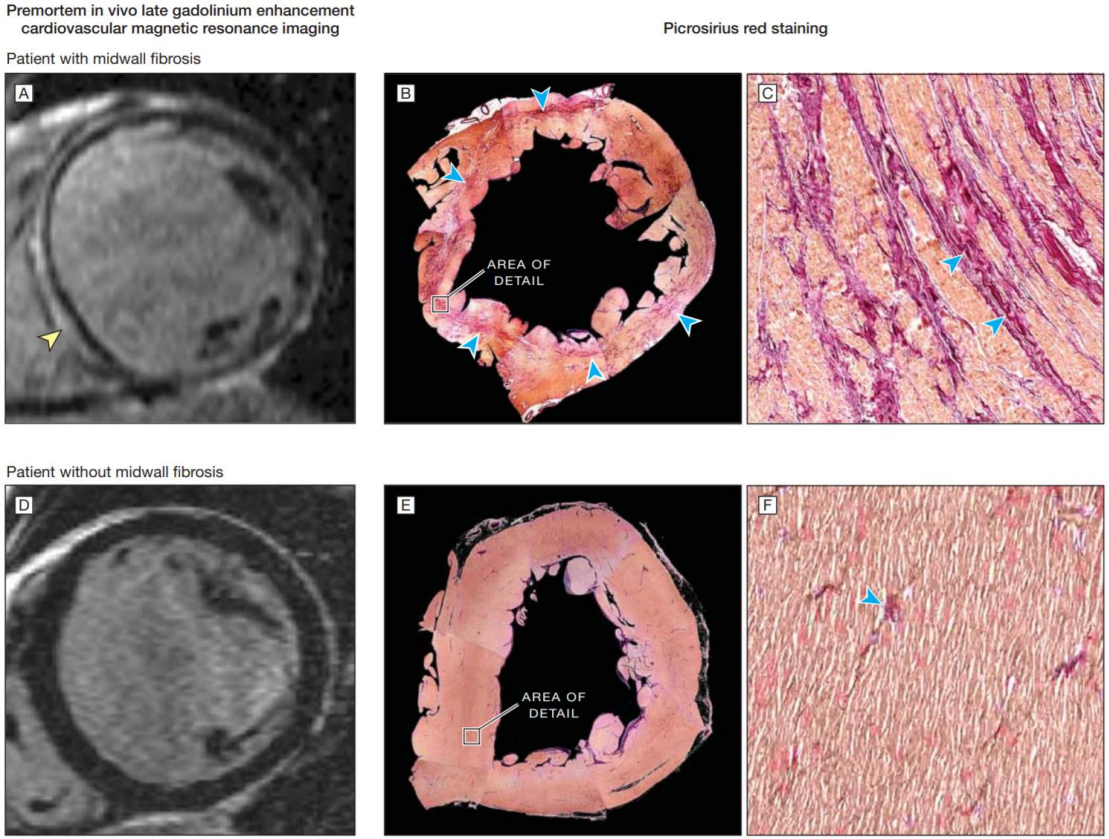
- 54 year old black male with DOE
  - TTE
    - severely dilated LV, LVEF = 25%
    - Moderate to severe MR
  - LHC
    - mLAD 30%; pRCA 30%
    - LVEF = 15%

Case 1: CC



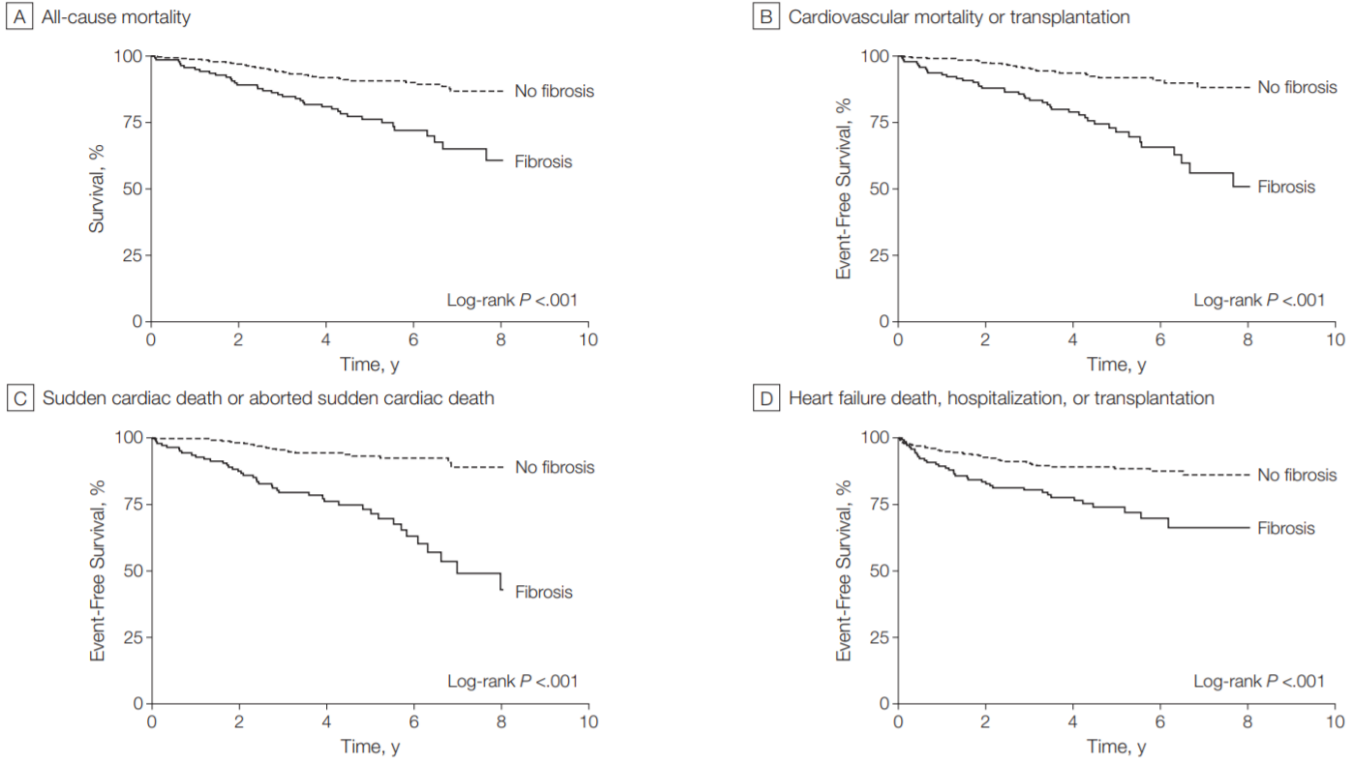
LVEDV = 436 cc	RVEDV = 229 cc
LVESV = 325 cc	RVESV = 110 cc
LVSV = 111 cc	RVSV = 118 cc
LVEF = 25%	RVEF = 52%
LVM = 206 g	RVM = 50 g

Midwall Fibrosis



Gulati JAMA 2013

Midwall Fibrosis



Gulati JAMA 2013

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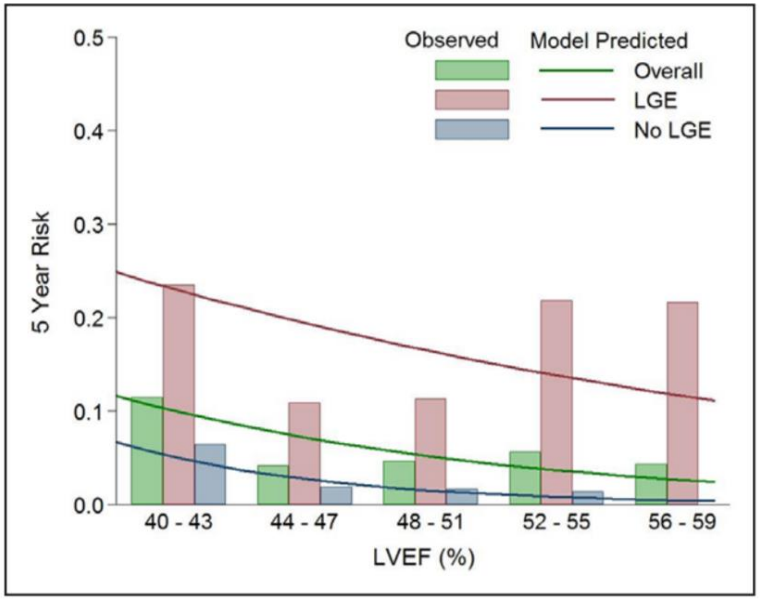
Midwall Fibrosis

Outcome	LGE Status	Events n (%)	Univariable		Multivariable*	
			HR (95% CI)	*P* Value	HR (95% CI)	*P* Value
SCD or Aborted SCD	LGE−	7 (2.3)	9.2 (3.9, 21.8)	<0.0001	9.3 (3.9, 22.3)	<0.0001
	LGE+	18 (17.8)				
SCD	LGE−	6 (2.0)	4.9 (1.8, 13.5)	0.002	4.8 (1.7, 13.8)	0.003
	LGE+	9 (8.9)				
Aborted SCD	LGE−	1 (0.3)	34.8 (4.6, 266.6)	<0.0001	35.9 (4.8, 271.4)	<0.001
	LGE+	10 (9.9)				



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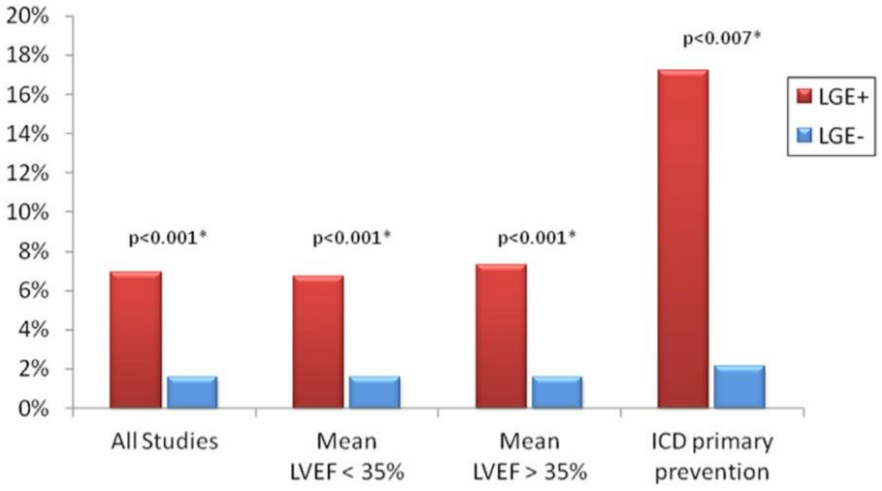
LGE and Ventricular Arrhythmias in NICM

FIGURE 3 Annual Rate of the Arrhythmic Endpoint According to Late Gadolinium Enhancement Status

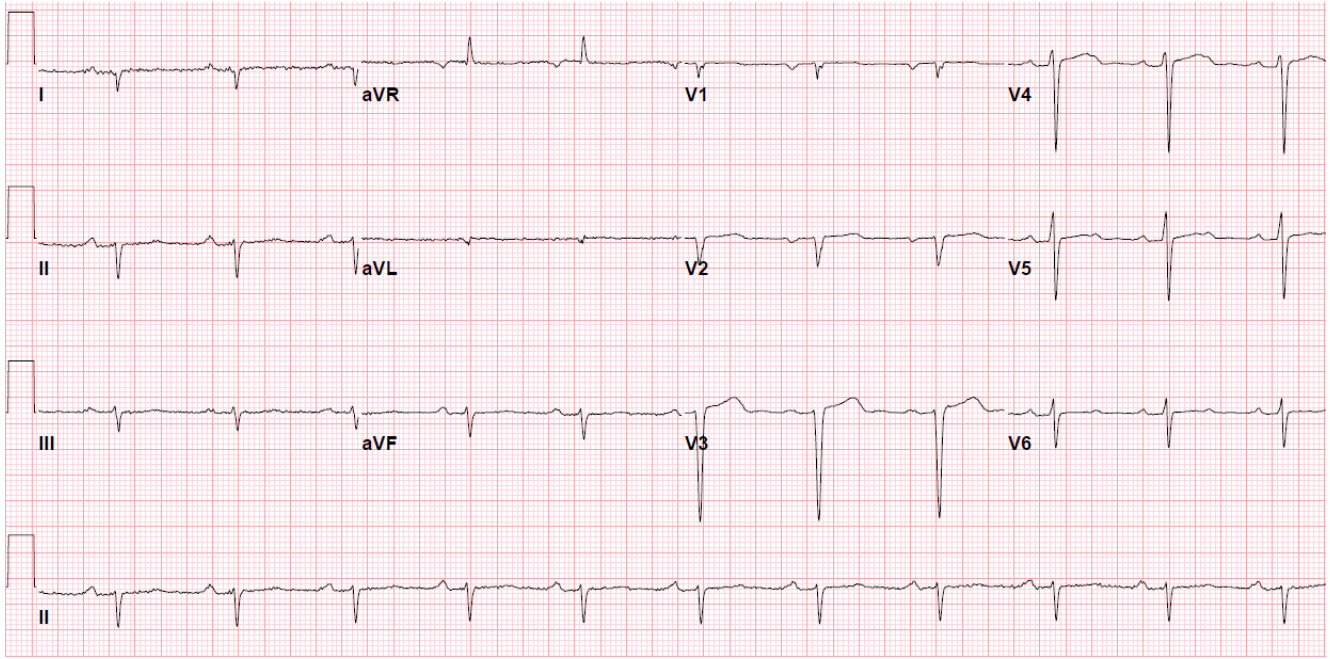


Di Marco JACC HF 2017

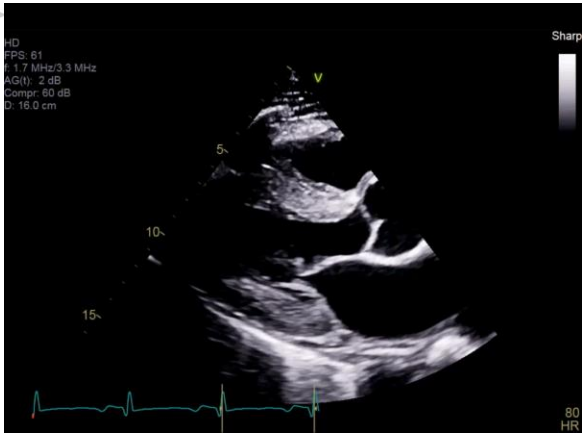
Case 2: WH

- 38 year old black male progressive DOE
- CT Chest mediastinal lymphadenopathy
- AKI – sCr range 1.4 – 1.7

Case 2: WH



Case 2: WH

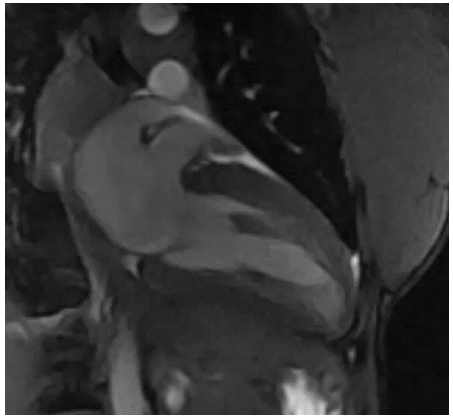

HD
FPS: 61
f: 1.7 MHz/3.3 MHz
AG(t): 2 dB
Compr: 60 dB
D: 16.0 cm
Sharp
V
5
10
15
80
HR

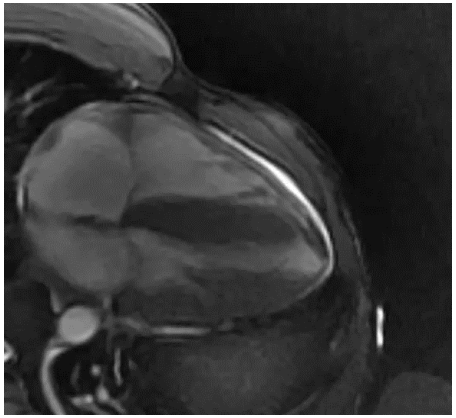
HD
FPS: 51
f: 1.7 MHz/3.3 MHz
AG(t): -2 dB
Compr: 60 dB
D: 17.0 cm
Sharp
V
5
10
15
82
HR

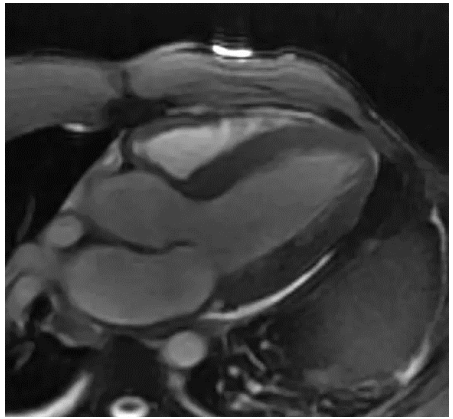
HD
FPS: 61
f: 1.7 MHz/3.3 MHz
AG(t): 0 dB
Compr: 60 dB
D: 14.0 cm
Sharp
V
5
10
78
HR

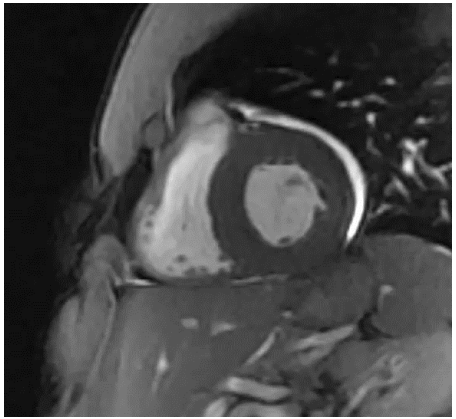
HD
FPS: 51/
f: 1.7 MHz/3.3 MHz
G(t): -14 dB
Compr: 60 dB
D: 17.0 cm
V
5
10
15
78
HR

Case 2: WH

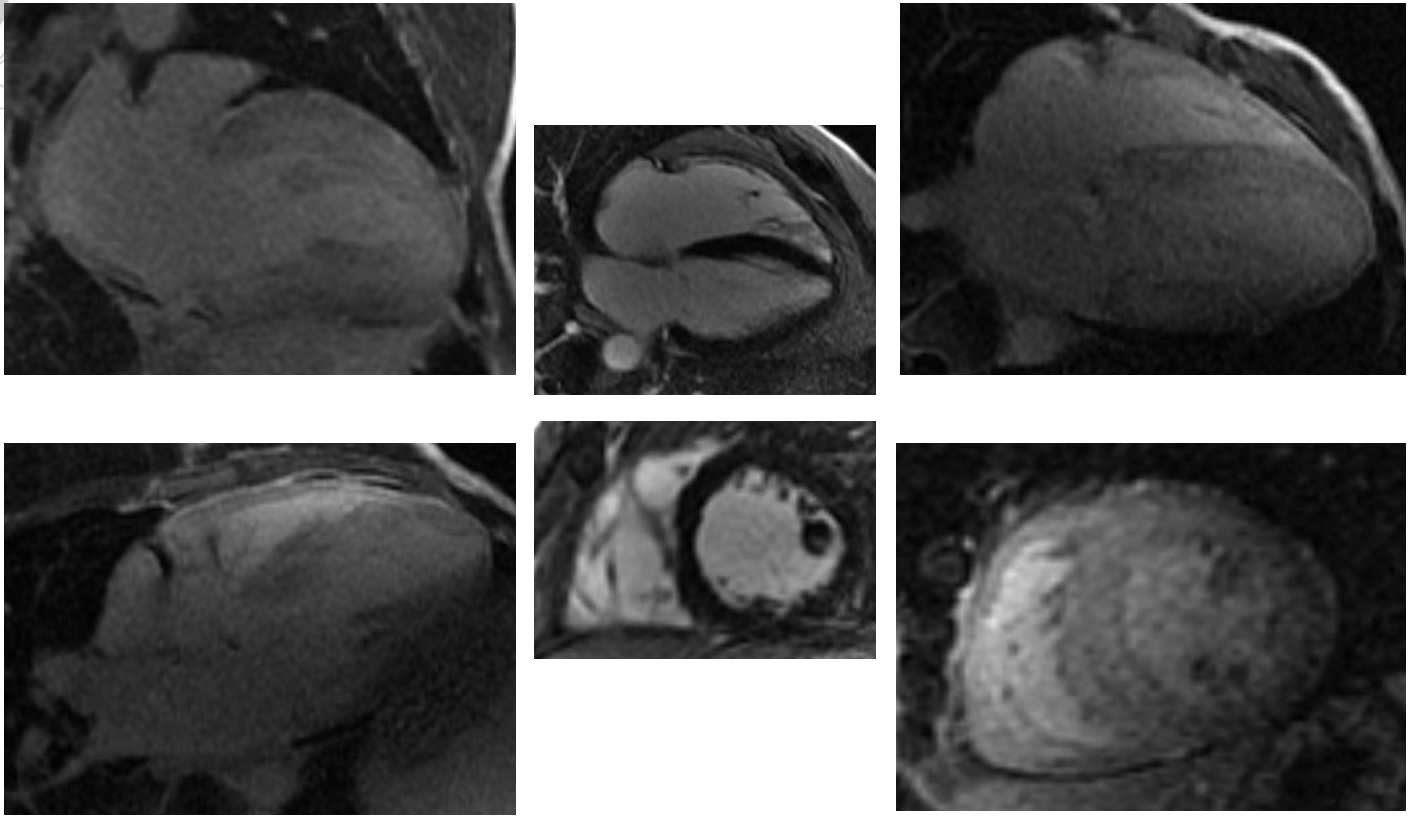






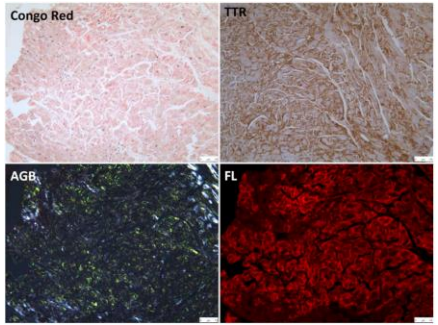


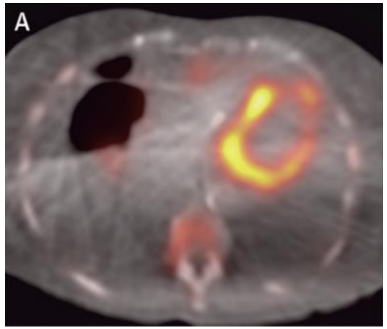
Case 2: WH

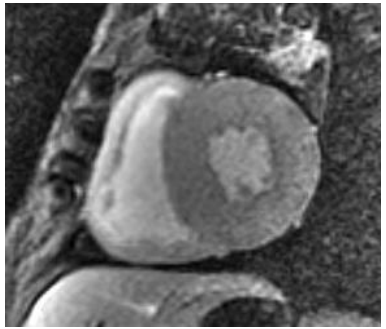


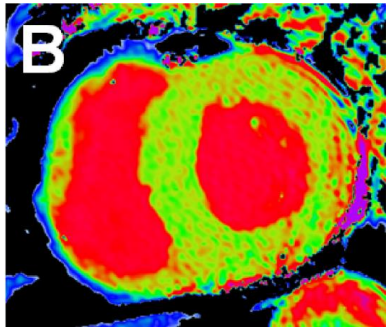
Cardiac Amyloidosis

- Prevalence previously unclear
- Seen in 25% on autopsy for age >85









Tanskanen Ann Med 2008

Cardiac Amyloidosis

- 120 HFpEF patients
  - 13% ATTR-CA

	ATTRwt (^{99m}Tc-DPD+) (n = 16)	Other forms of HFpEF (^{99m}Tc-DPD−) (n = 104)	*P*-value
Age (years)	86 ± 6	81 ± 8	0.121
Male gender, *n* (%)	8 (50)	41 (39)	0.423
Median length of stay, days (range)	8 (6–14)	8 (6–15)	0.994
Mortality, *n* (%)	5 (31)	21 (20)	0.335
Survival			
At 3 months, % (95% CI)	87 (71–100)	90 (84–96)	0.76
At 6 months, % (95% CI)	87 (71–100)	83 (75–91)	0.76
At 12 months, % (95% CI)	73 (51–95)	76 (66–86)	0.76
Comorbidities			
Hypertension, *n* (%)	14 (88)	87 (84)	0.980
Diabetes mellitus, *n* (%)	4 (25)	41 (39)	0.267
CAD, *n* (%)	2 (13)	9 (9)	0.975
Blood test			
Mean CCr (mL/min/1.73 m^2)	50 ± 17	59 ± 24	0.093
Mean haemoglobin (g/dL)	13 ± 1	12 ± 2	0.253
Median NTproBNP, pg/L (IQR)	6467 (2818–13 146)	3173 (1363–7139)	0.019
Median ultrasensitive troponin I (μg/L)	0.135 (0.017–1.91)	0.025 (0.017–1.74)	0.001
Echocardiography			
Mean LVEF (%)	60 ± 7	61 ± 8	0.501
Myocardial contraction fraction (%)	30 ± 14	43 ± 16	0.003
Mean LV end-diastolic diameter (mm)	41 ± 5.5	42 ± 8	0.796
Mean MWT, mm (IQR)	17 ± 3.4	14 ± 2.5	0.001
Median septal MWT, mm (IQR)	18 (15.7–21)	14 (13–16)	0.001
Median posterior wall, mm (IQR)	12.5 (11–17)	11.5 (10–13)	0.028
Symmetric hypertrophic pattern, *n* (%)	8 (50)	59 (57)	0.788
Asymmetric hypertrophic pattern, *n* (%)	8 (50)	45 (43)	0.788
E/A ratio	1.3 ± 0.6	1.1 ± 0.6	0.38
DT (ms)	191 ± 64	204 ± 80	0.639
Lateral *E/E'* ratio	20 ± 9	14 ± 7	0.600
Mean LV mass index (g/m^2)	161 ± 43	115 ± 34	0.001
Pericardial effusion, *n* (%)	7 (44)	19 (19)	0.047

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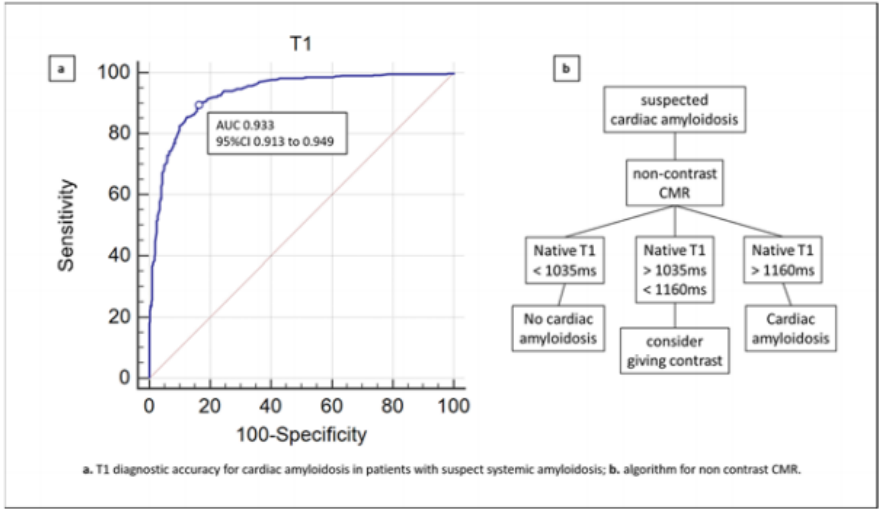
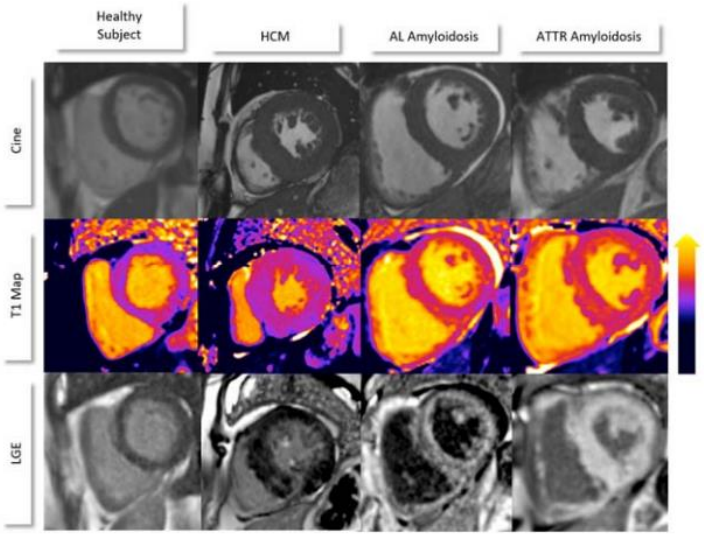
Gonzalez-Lopez EHJ 2015

Native T1 and Cardiac Amyloidosis



a. T1 diagnostic accuracy for cardiac amyloidosis in patients with suspect systemic amyloidosis; **b.** algorithm for non contrast CMR.



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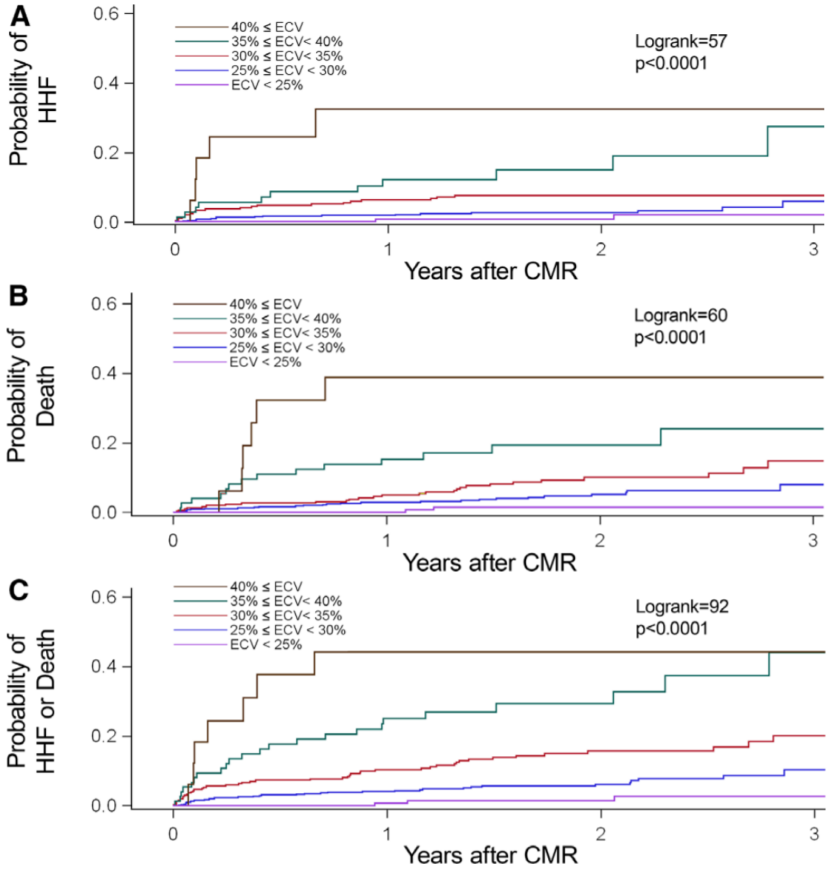
ECV and MACE



Schelbert JAHA 2015

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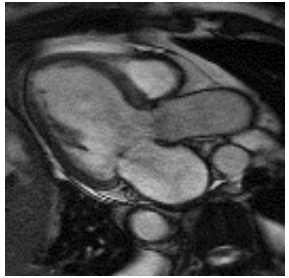
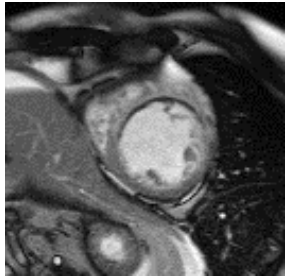
Case 3: NK

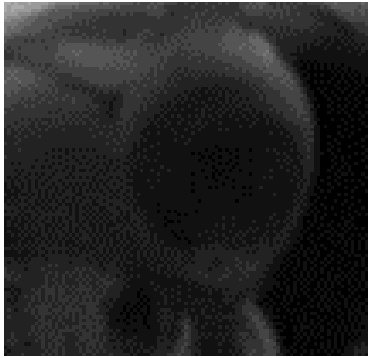
- 62 year old male with CAD with distant MI with PCI to LAD
  - Presented to an outside hospital with acute decompensated CHF with diuresis and decongestion
    - LVEF on echo: 35%
    - LAD on LHC occluded
  - Re-admitted at OSUMC for dyspnea, atypical chest pain, acute decompensated CHF
    - CMR to assess for viability

Case 3: NK

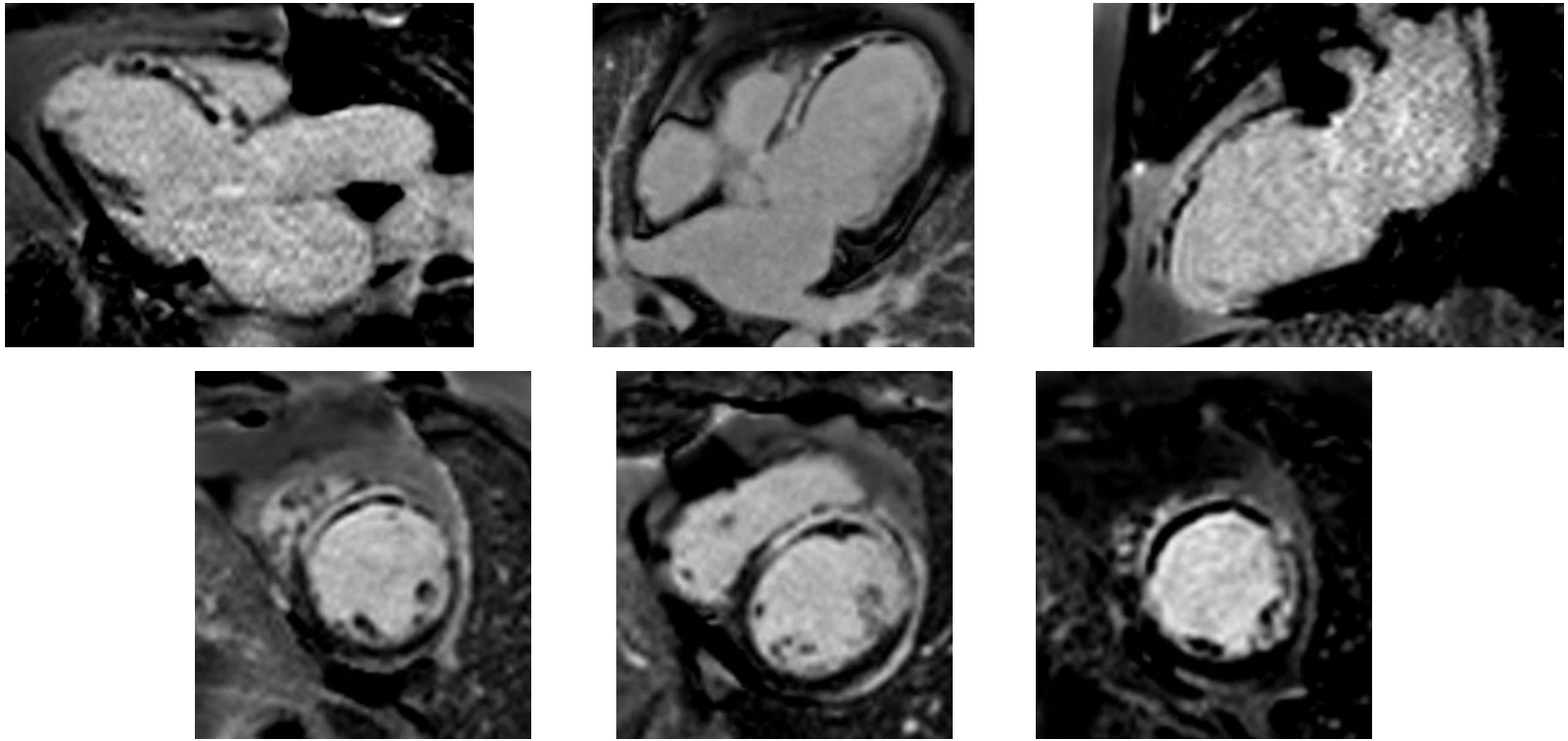




Case 3: NK

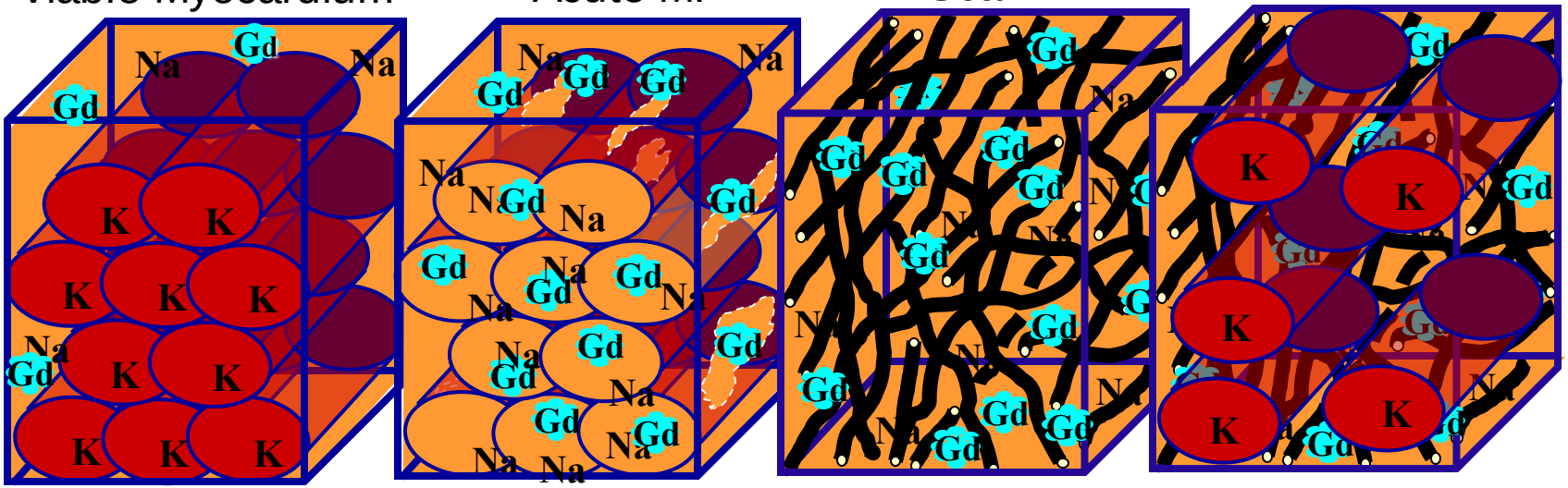


Case 3: NK



Late Gadolinium Enhancement

Viable Myocardium | Acute MI | Scar | Interstitial Fibrosis



Intact cell membranes

Normal myocardium

Ruptured cell membranes

[Gd] >> normal
T1 << normal

Collagen matrix

[Gd] >> normal
T1 << normal

Mixed cells + collagen

[Gd] > normal
T1 < normal

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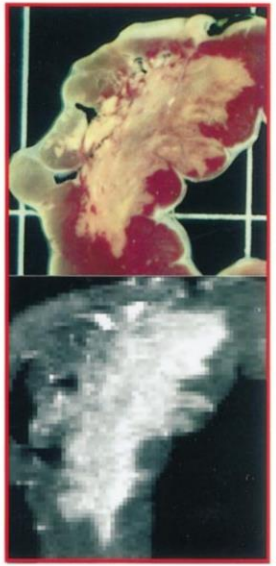
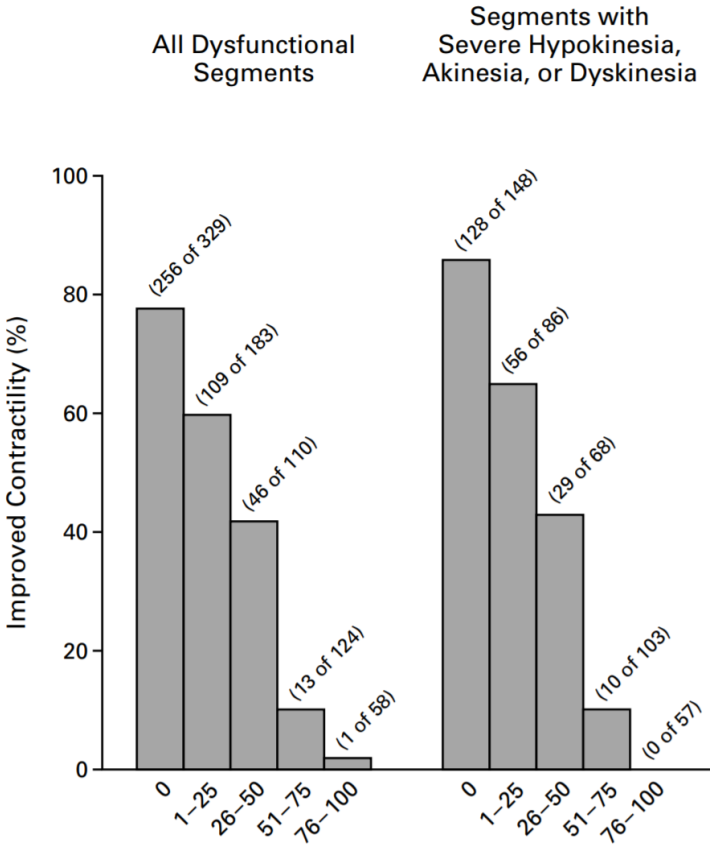
Mahrholdt EHJ 2005

CMR Viability



Kim Circ 1999

CMR Viability



Kim NEJM 2000

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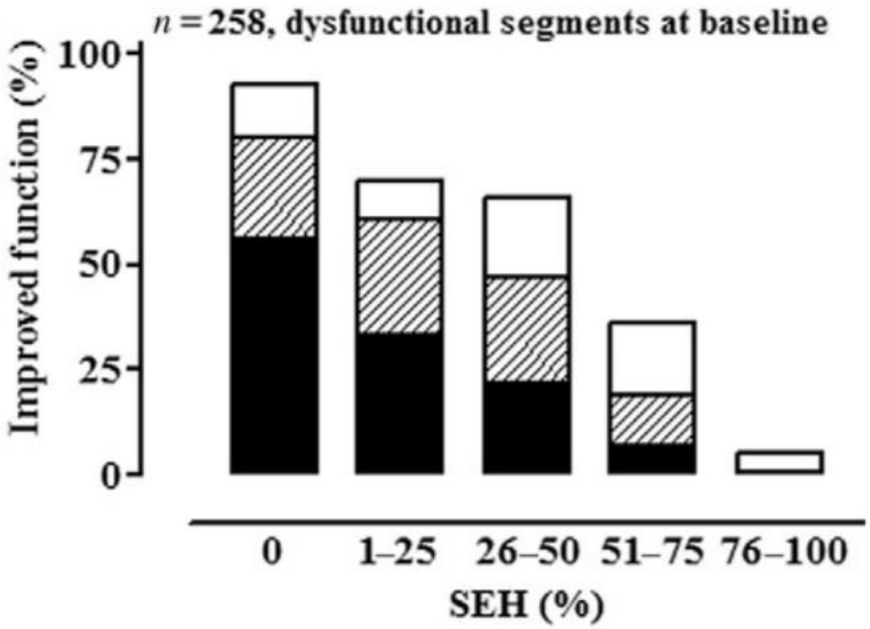
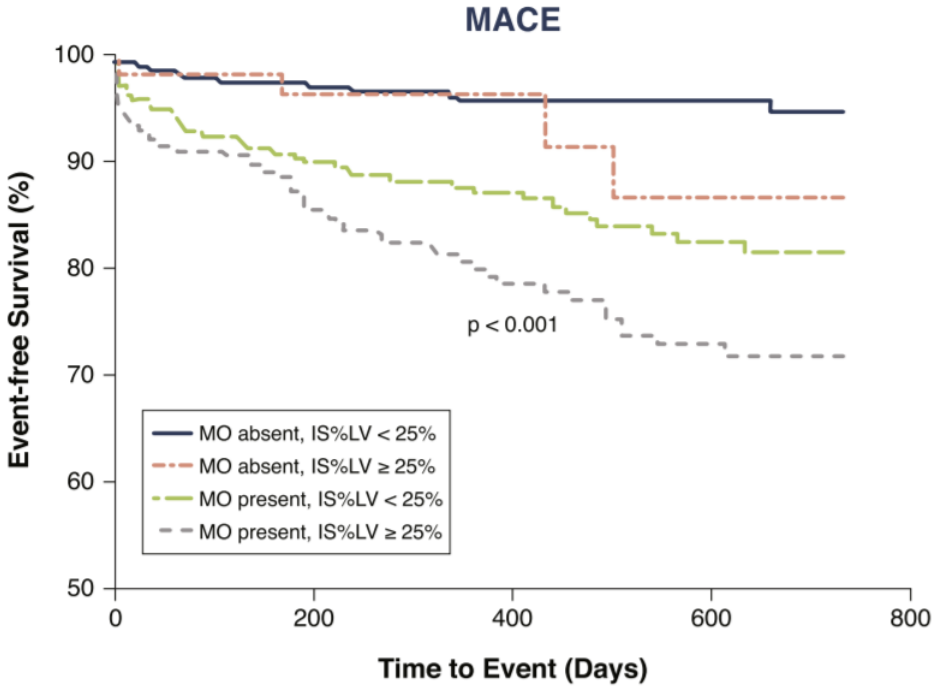
CMR Viability



Bondarenko EHJ 2008

CMR Viability

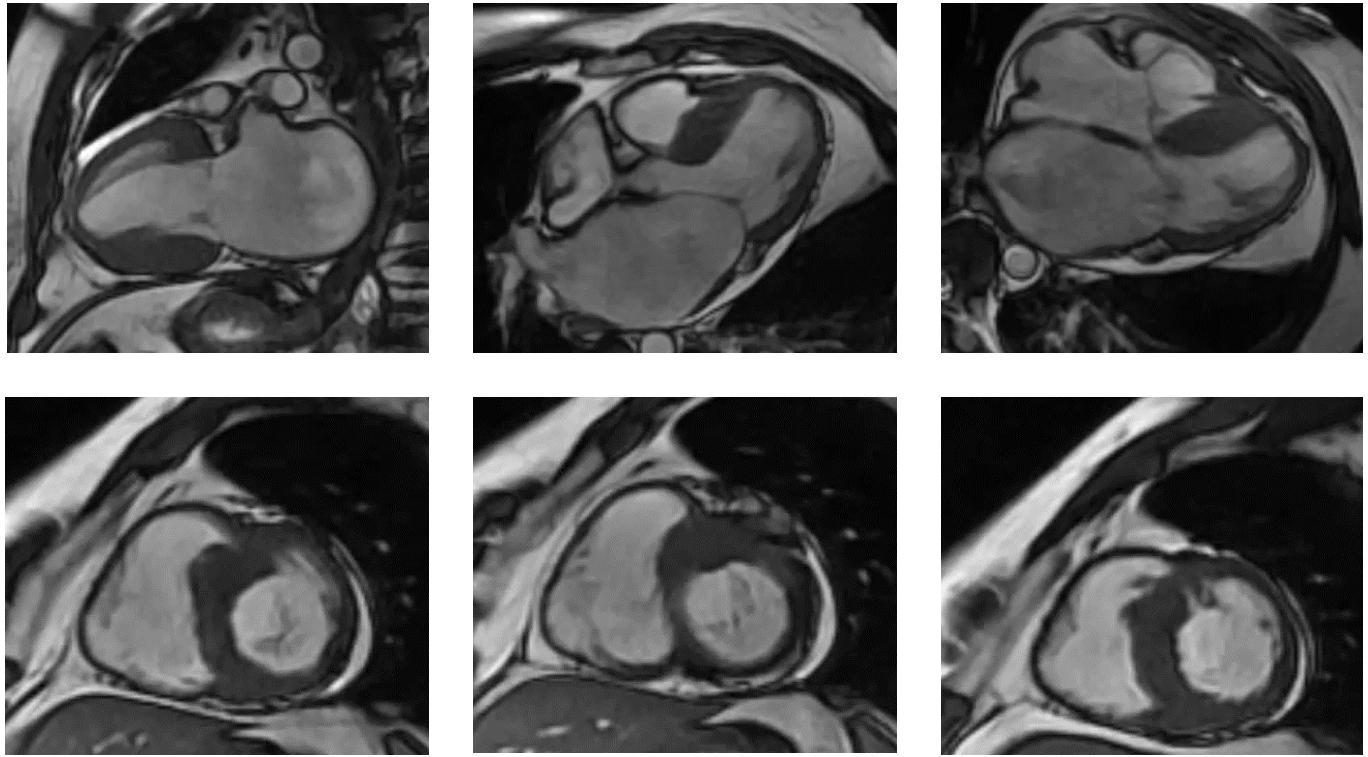


van Kranenburg JACC CVI 2014

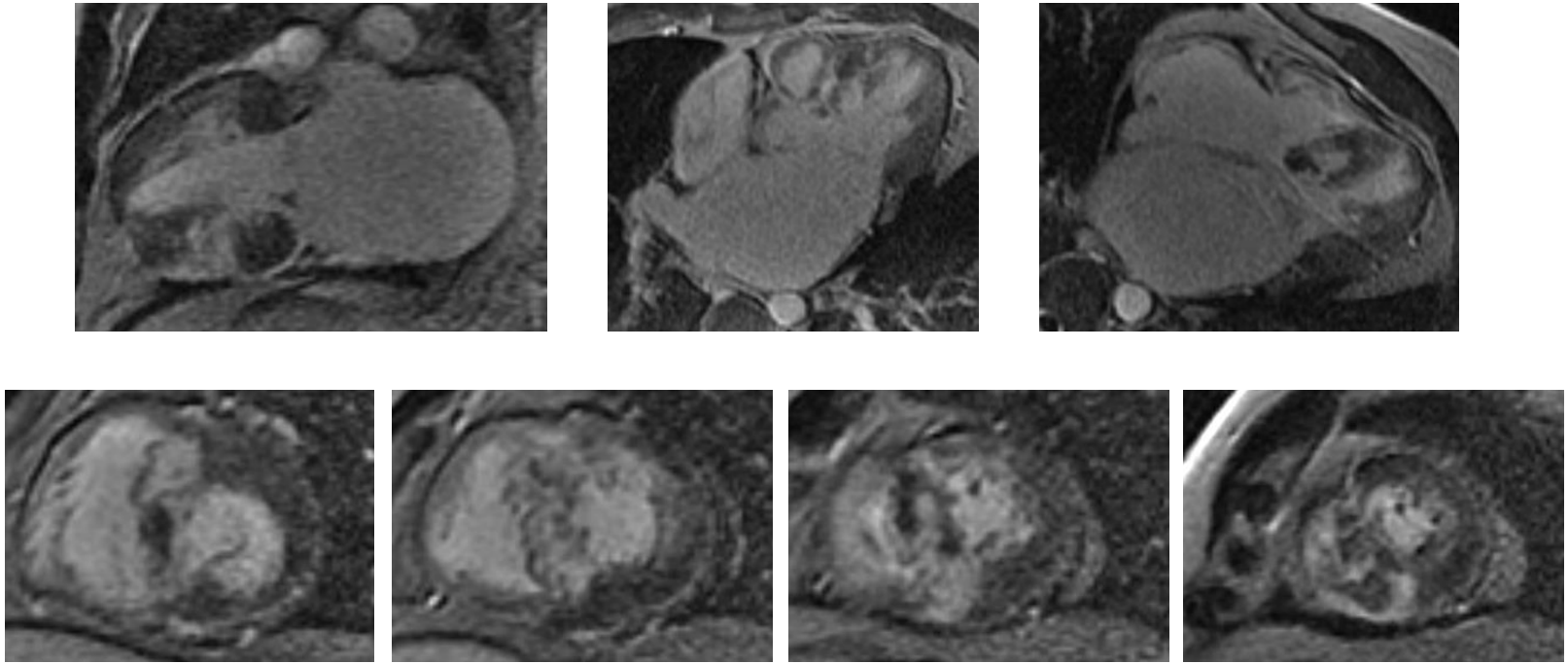
Case 4: RS

- 42 year old male recurrent atrial arrhythmias and AF
  - Pre-PVI
  - Reported abnormal echo

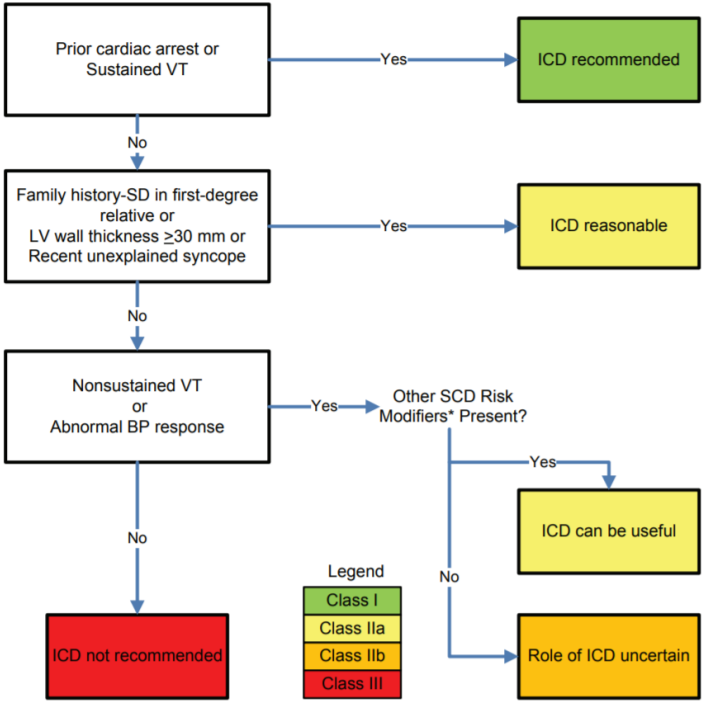
Case 4: RS



Case 4: RS

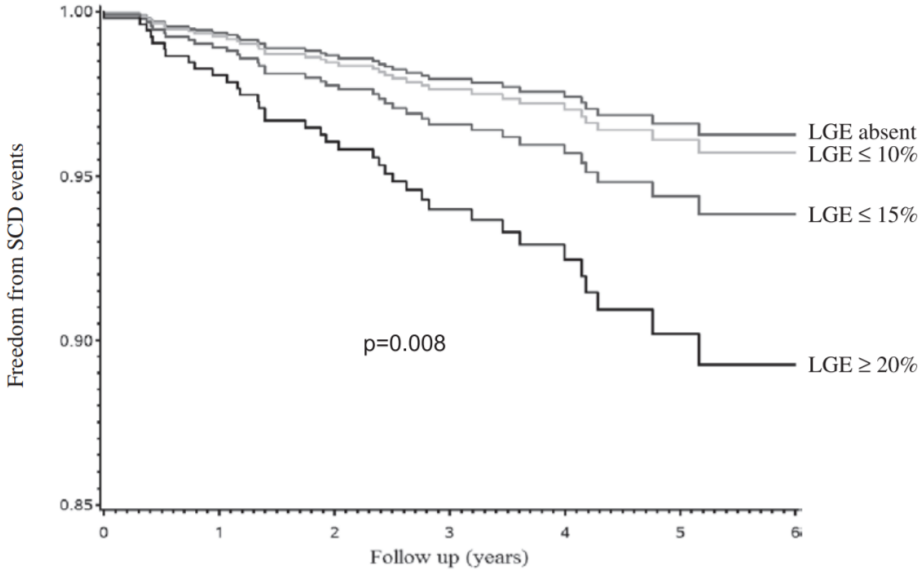


HCM and SCD



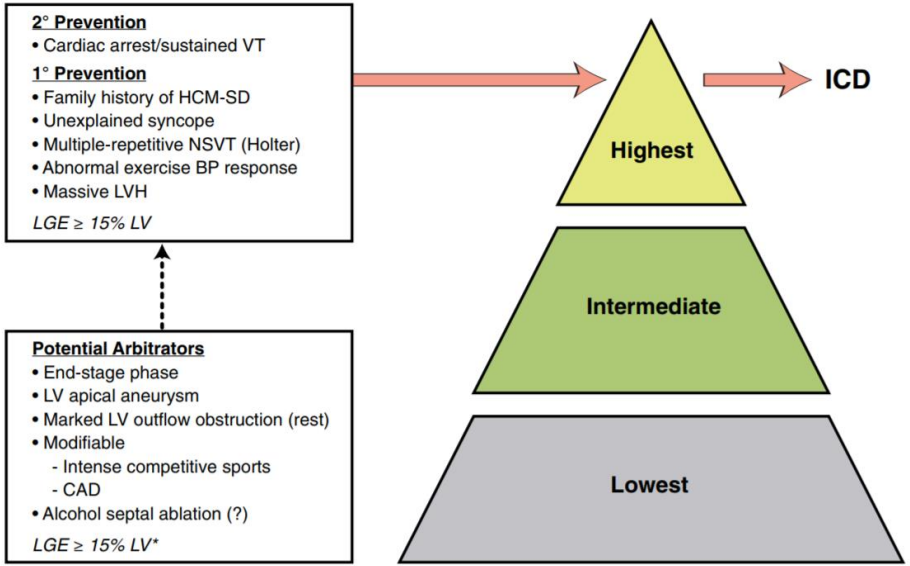
Gersh ACCF/AHA 2011

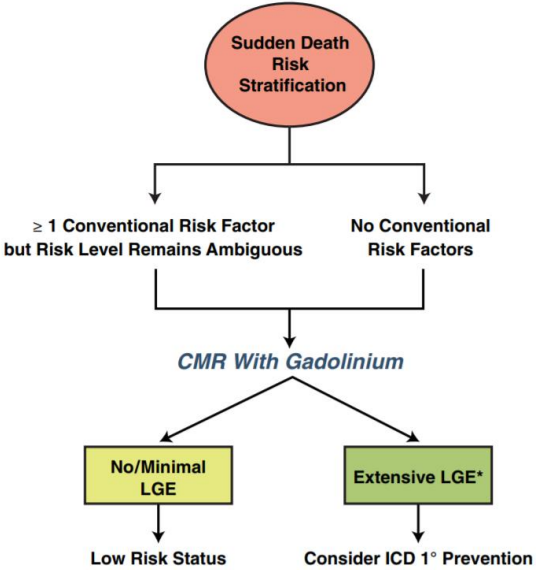
HCM and SCD



Chan Circ 2014

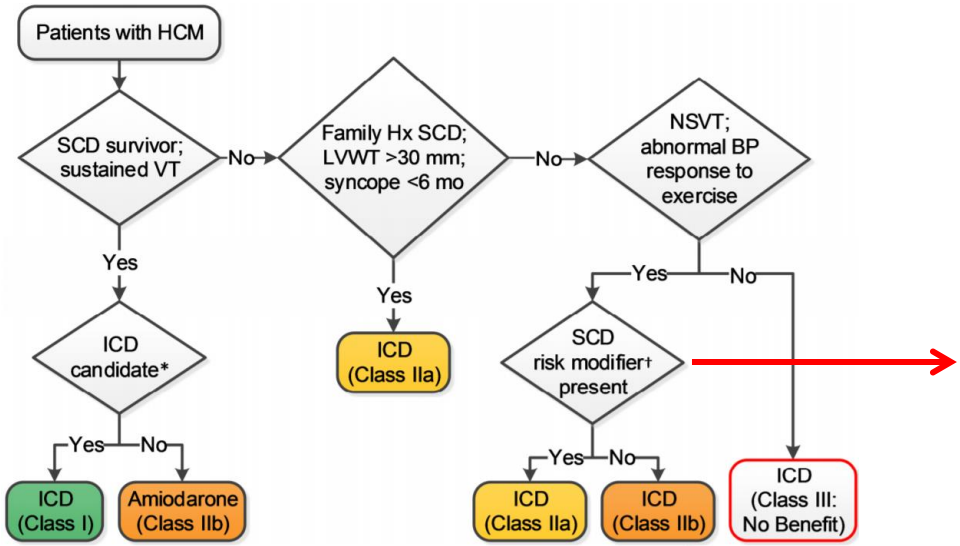
HCM and SCD





Maron JACC CVI 2016

HCM and SCD



Potential risk modifiers‡

- <30 y (5, 26)
- Delayed hyperenhancement on cardiac MRI (37-39, 54)
- LVOT obstruction (2, 4)
- Syncope >5 y ago (8, 26)

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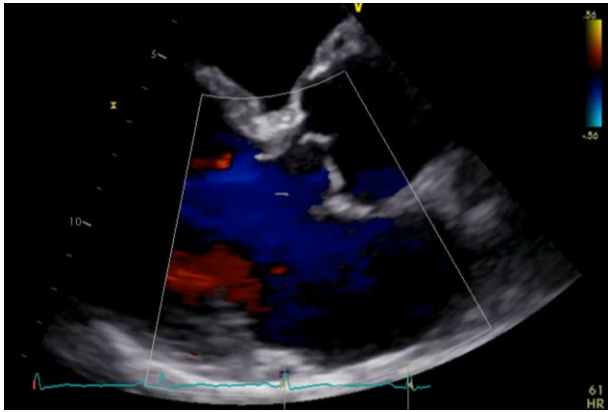
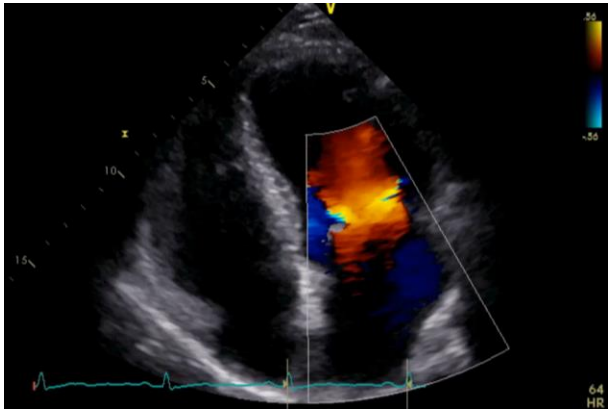
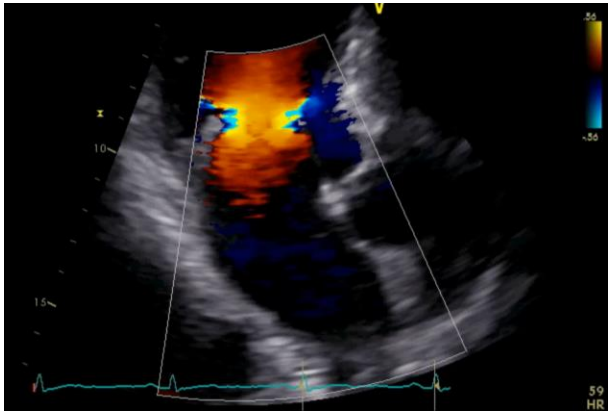
Case 5: DB

- 71 year old male for annual visit for moderate mitral regurgitation
  - No symptoms

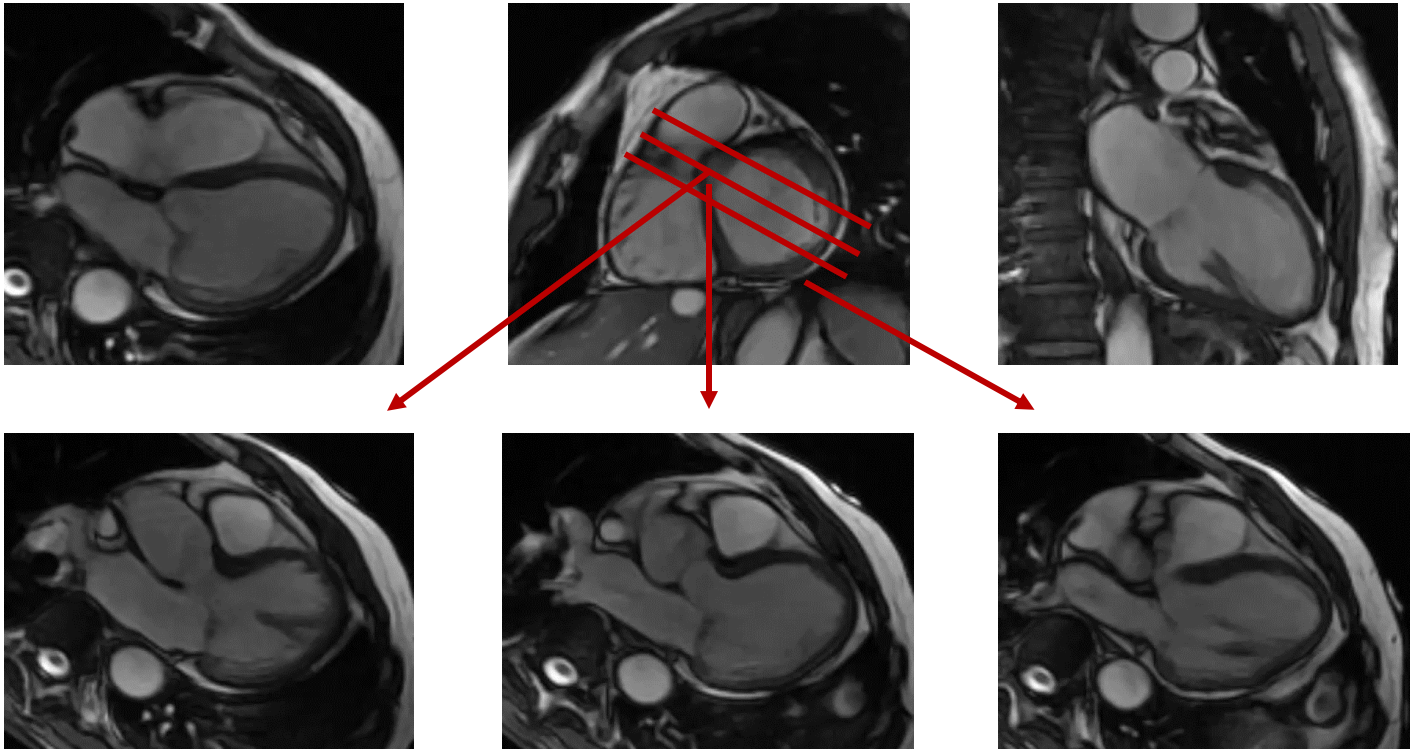
Case 5: DB



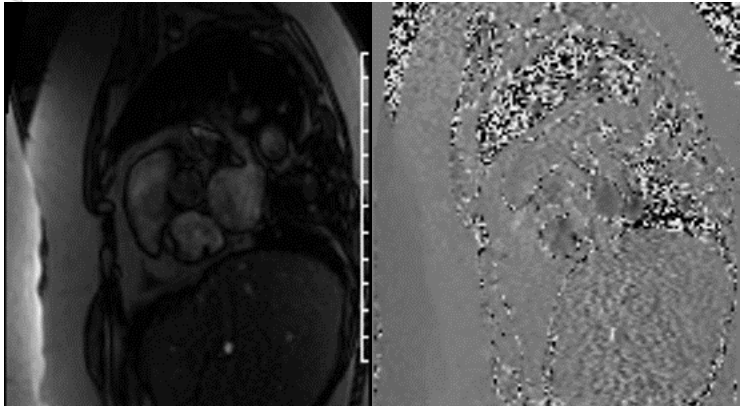


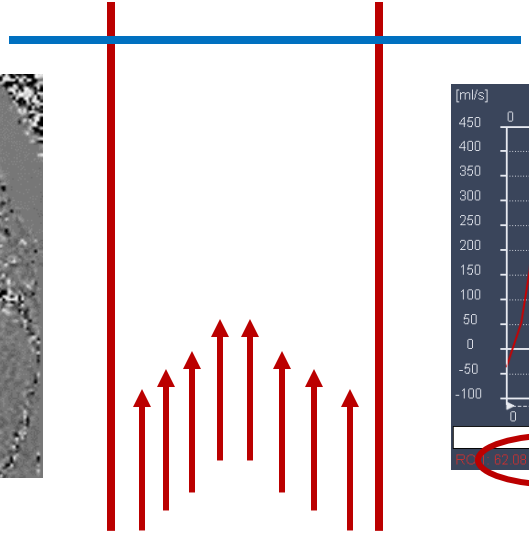


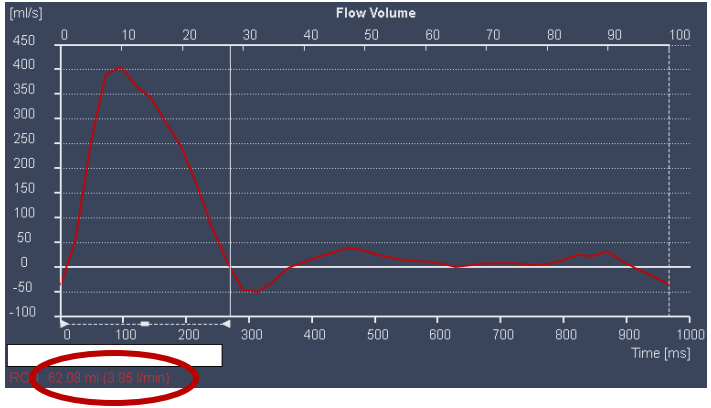
Case 5: DB



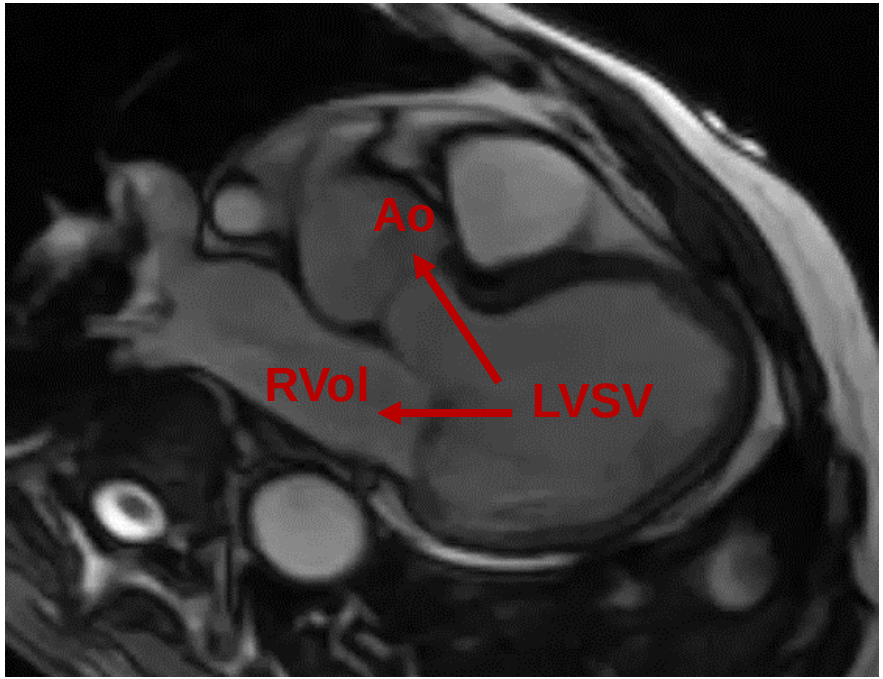
Phase contrast imaging - CMR







Case 5: DB

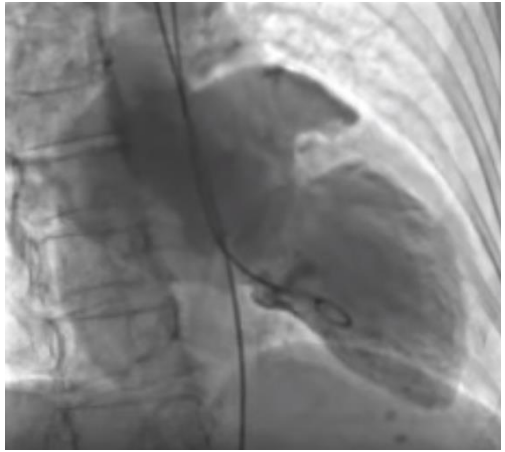


RVol = LVSV – Ao RF (%) = RVol/LVSV

(**69 cc** = 131 – 62) (**53%** = 69/131)

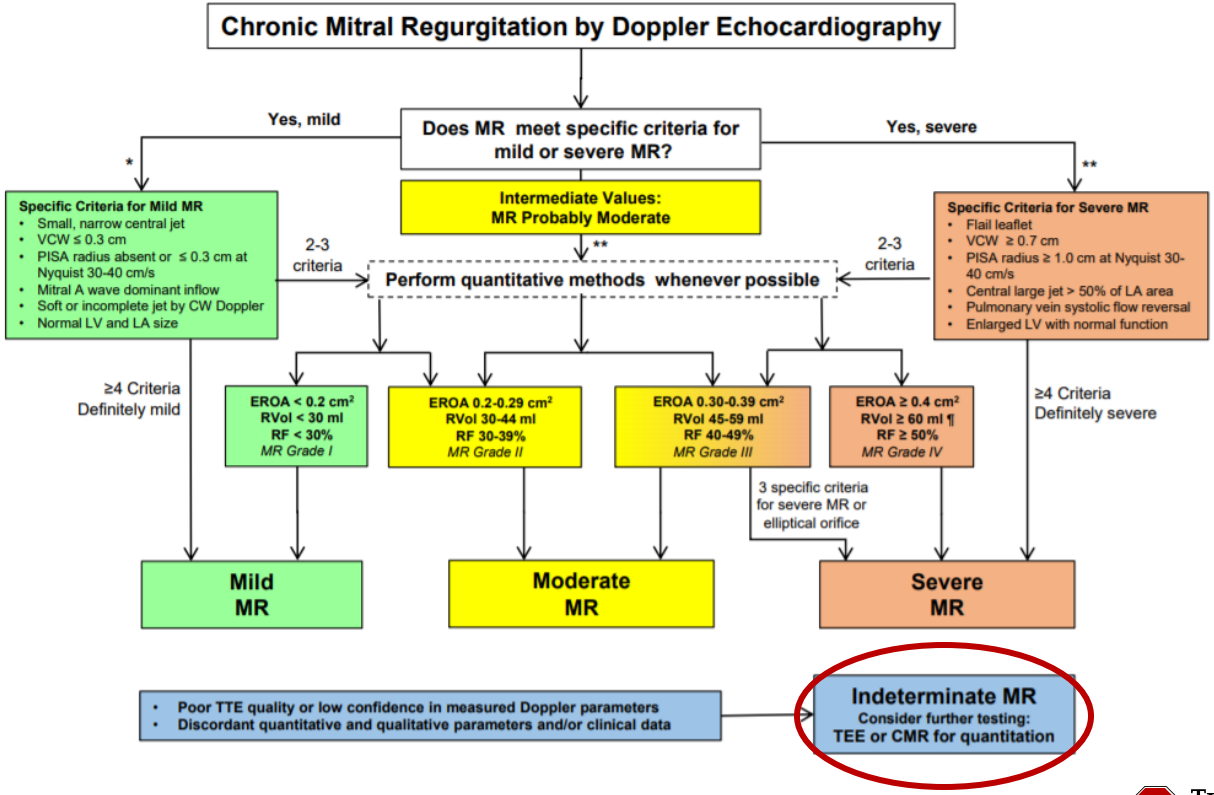
Mitral Valve Disease

- 16,000 mitral valve surgeries in 2015
- Average growth mitral valve surgeries ~4%/year
- No gold standard
  - Physiologic changes
  - Clinical outcomes



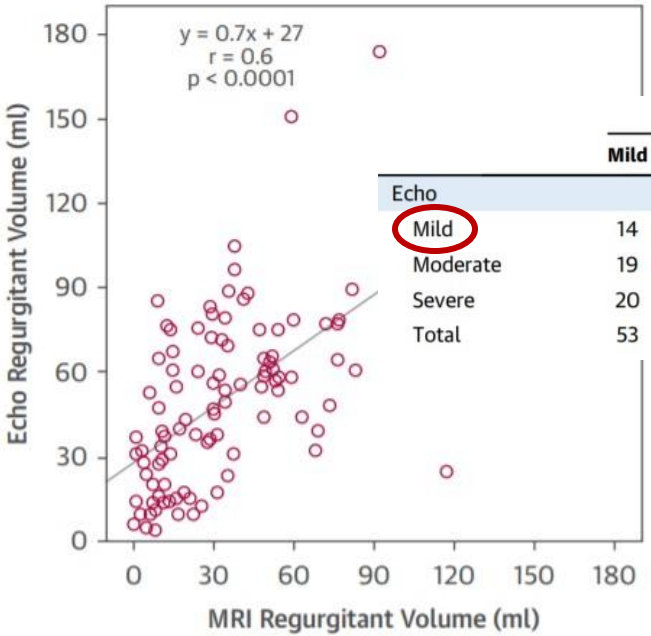
Uretsky JACC 2018

Guidelines

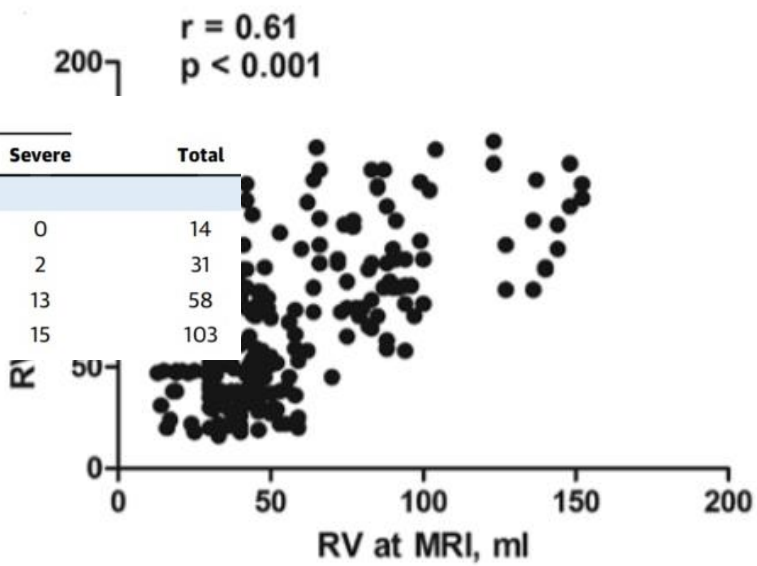


Zogbhi JASE 2017

Echocardiography vs CMR - MR

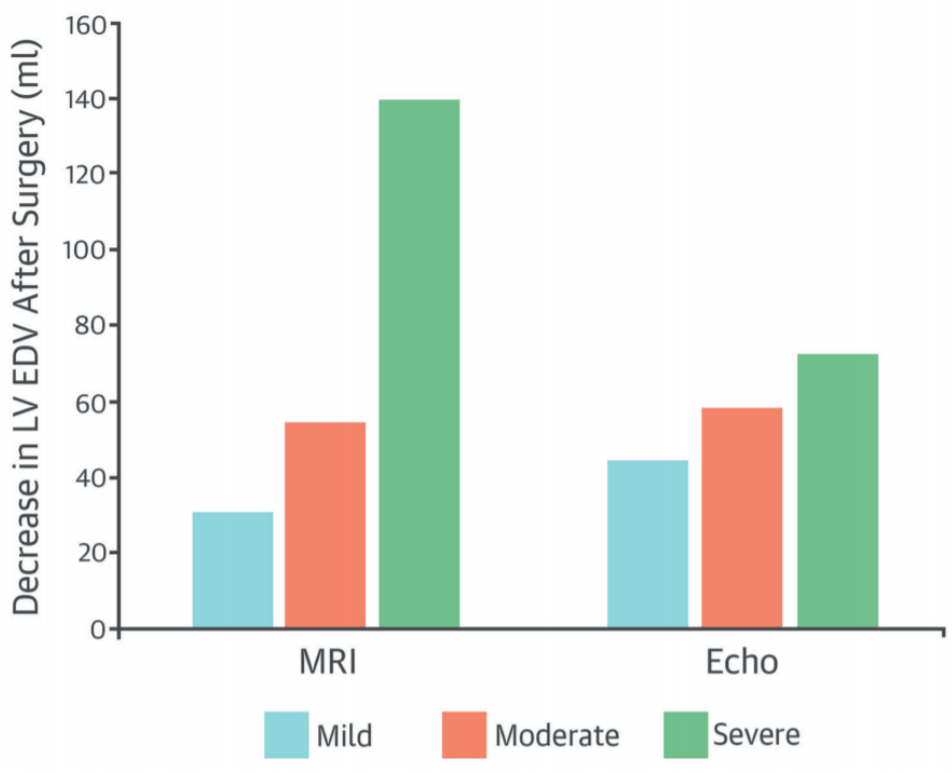


	MRI			
	Mild	Moderate	Severe	Total
Echo				
Mild	14	0	0	14
Moderate	19	10	2	31
Severe	20	25	13	58
Total	53	35	15	103



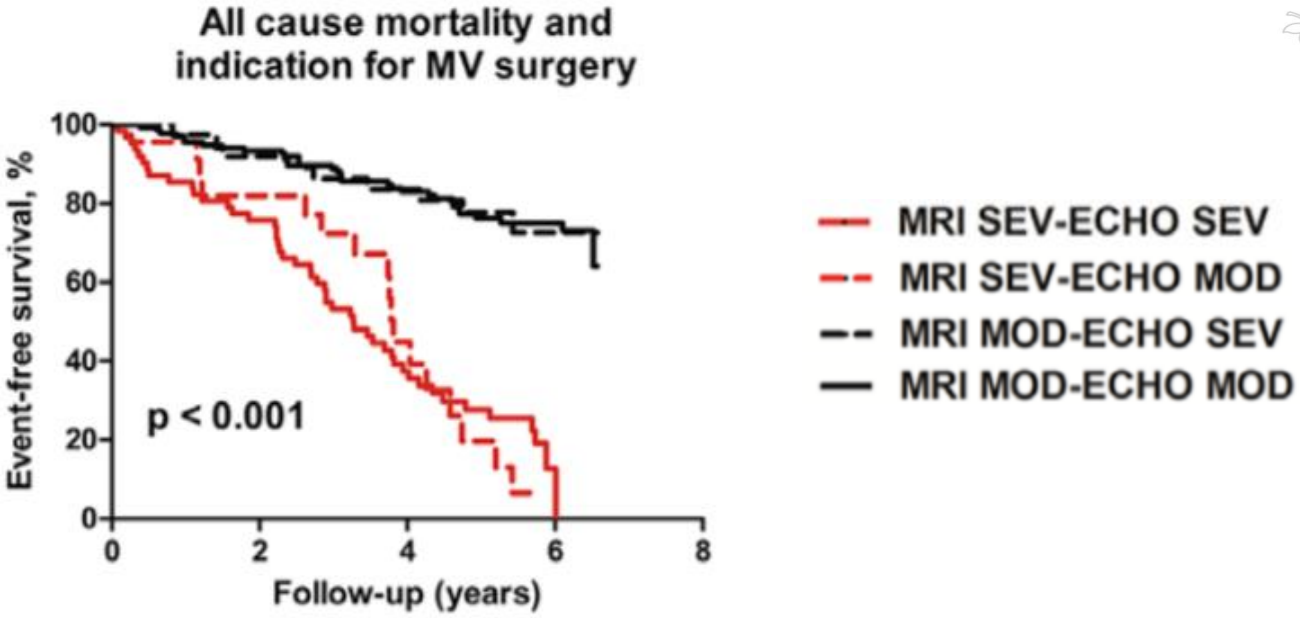
Uretsky JACC 2015, Penicka Circ 2018

Mitral Valve Disease



Uretsky JACC 2015

Mitral Valve Disease



Penicka Circ 2018

Conclusions

- Commonly utilized tool for cardiac evaluation
- Pivotal in diagnosis, management, prognosis
  - New diagnosis in 27% (69/361)
- Cost-saving
  - Reduced further invasive testing (11%) or layered testing (7%)
  - Per patient cost saving $2,300

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Thank You