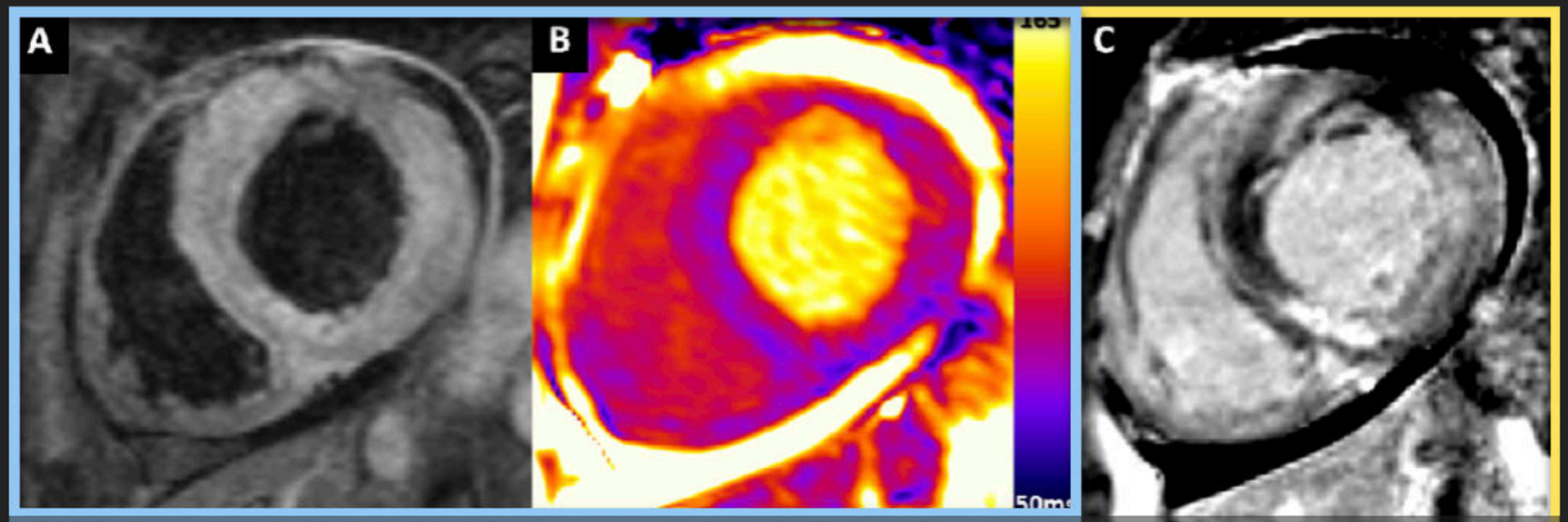

IMAGING FOR ACUTE VS CHRONIC MYOCARDITIS

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DISCLOSURES

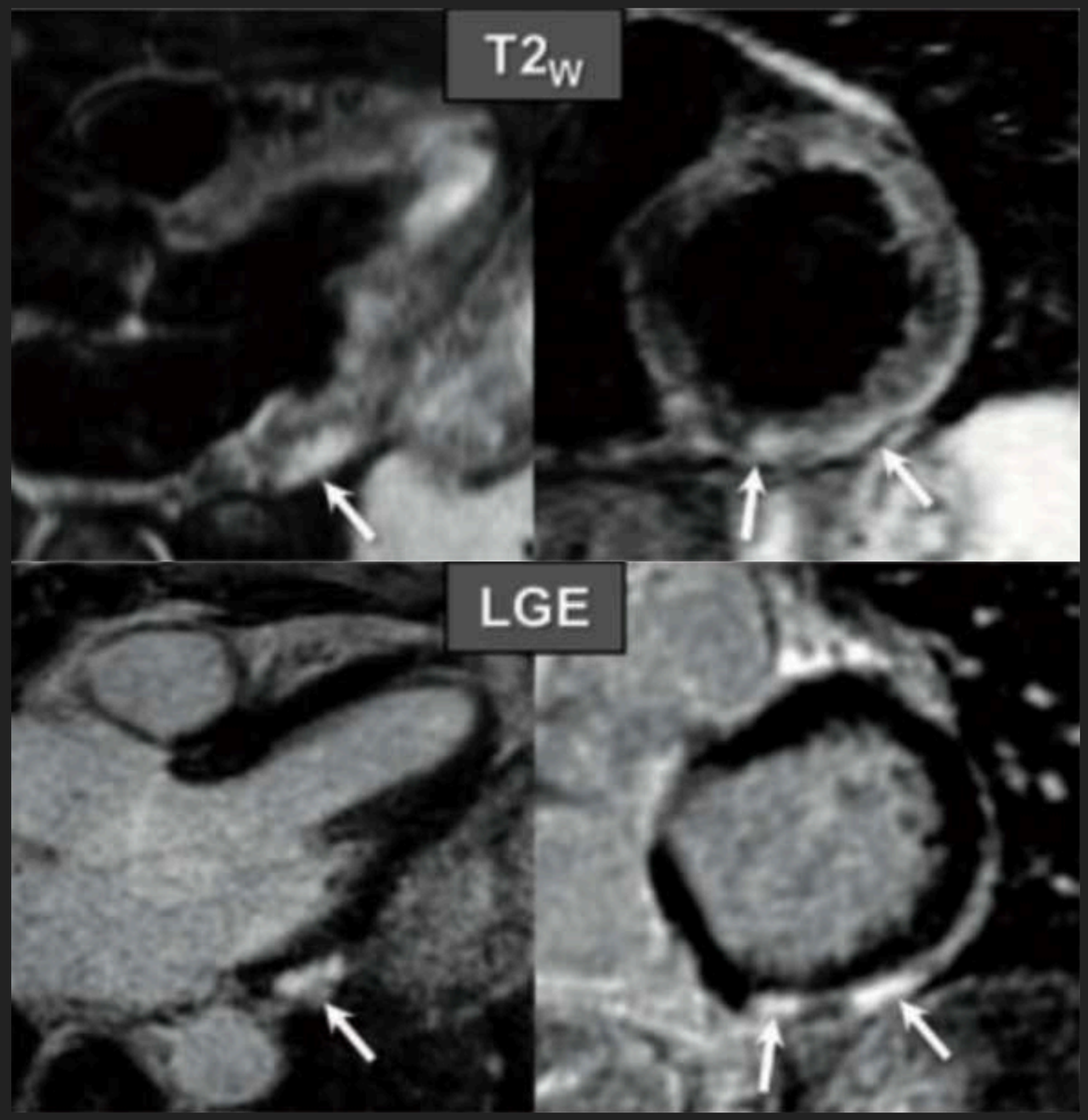
- **Board member, shareholder**
  - Circle CVI
- **Research Agreements**
  - GE, Siemens, Philips
- **Research Support**
  - CIHR, HSFC, McGill Foundation, Circle CVI

IMAGING MODALITIES FOR TISSUE INFLAMMATION

- Radionuclide scintigraphy
- PET
- MRI

Lit

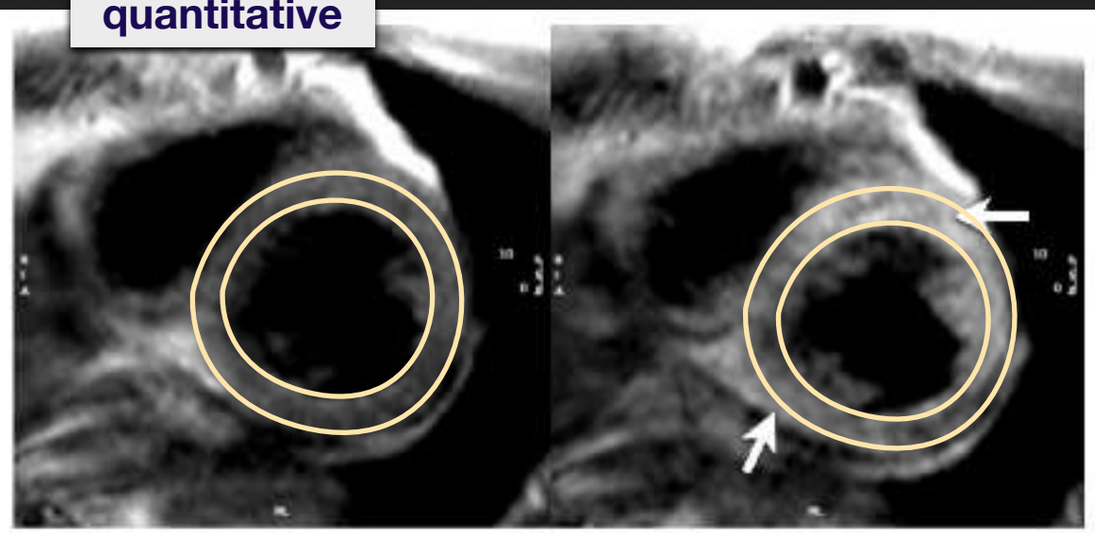
REGIONAL EDEMA AND INJURY IN ACUTE MYOCARDITIS



Biesbroek et al. Eur Heart J: CV Img 2017

CMR IN MYOCARDITIS: ORIGINAL LAKE LOUISE CRITERIA

quantitative

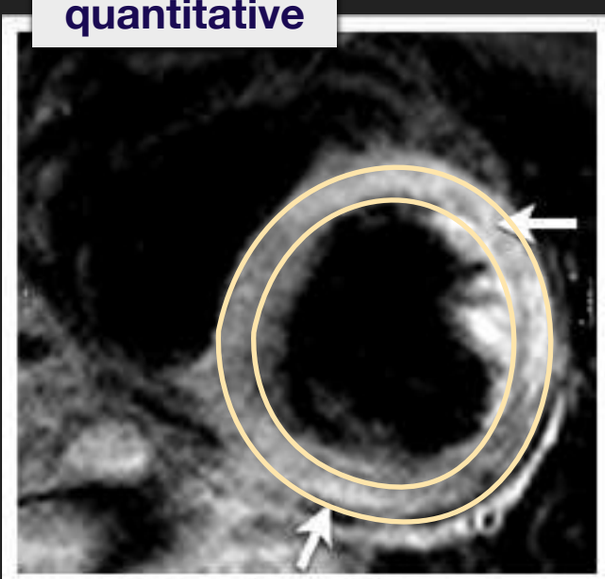


Early enhancement before contrast

Early enhancement after contrast

Hyperemia, capillary leakage

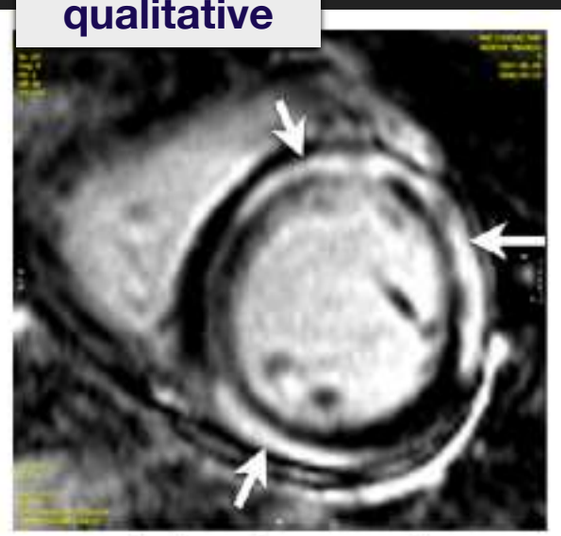
quantitative



T2-weighted image

Edema

qualitative



Late enhancement after contrast

Necrosis/scar

Indicates myocarditis, if 2 out of 3 criteria are positive

Friedrich et al. J Am Coll Cardiol 2009

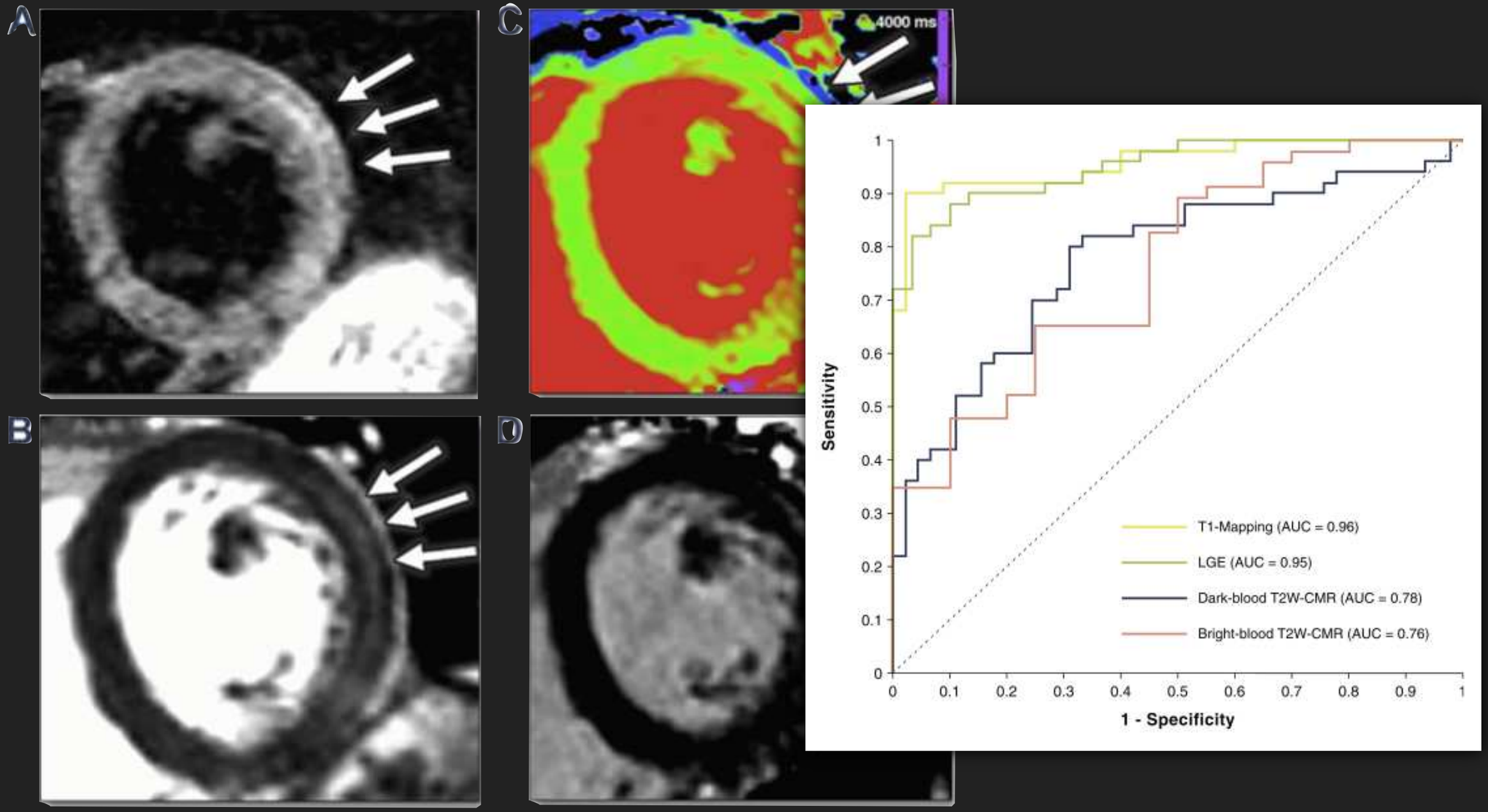
IMPACT OF CMR ON THE OBSERVED INCIDENCE OF MYOCARDITIS

TABLE 2 Comparison of Diagnoses Based on Cardiac Magnetic Resonance Imaging Between 2015 and 2016*

Diagnosis	2015 (n = 88)	2016 (n = 199)	2015 and 2016 (n = 287)
Normal heart	68 (77.3)	110 (55.3)	178 (62)
Coronary ischemia	8 (9.1)	26 (13.1)	34 (11.9)
Pericarditis	0 (0)	4 (2)	4 (1.4)
Amyloidosis	1 (1,1)	2 (1)	3 (1)
Sarcoidosis	1 (1.1)	1 (0.5)	2 (0.7)
Fabry disease	1 (1.1)	1 (0.5)	2 (0.7)
Takotsubo cardiomyopathy	0 (0)	4 (2)	4 (1.4)
Dilated cardiomyopathy	0 (0)	1 (0.5)	1 (0.3)
HCM	2 (2.3)	9 (4.5)	11 (3.8)
Myocarditis	4 (4.6)	26 (13.1)	30 (10.5)
Others	3 (3.4)	15 (7.5)	18 (6.3)

Patriki et al. JACC: Heart Failure 2018

MYOCARDITIS: MYOCARDIAL MAPPING



Ferreira, et al., JACC Img 2013

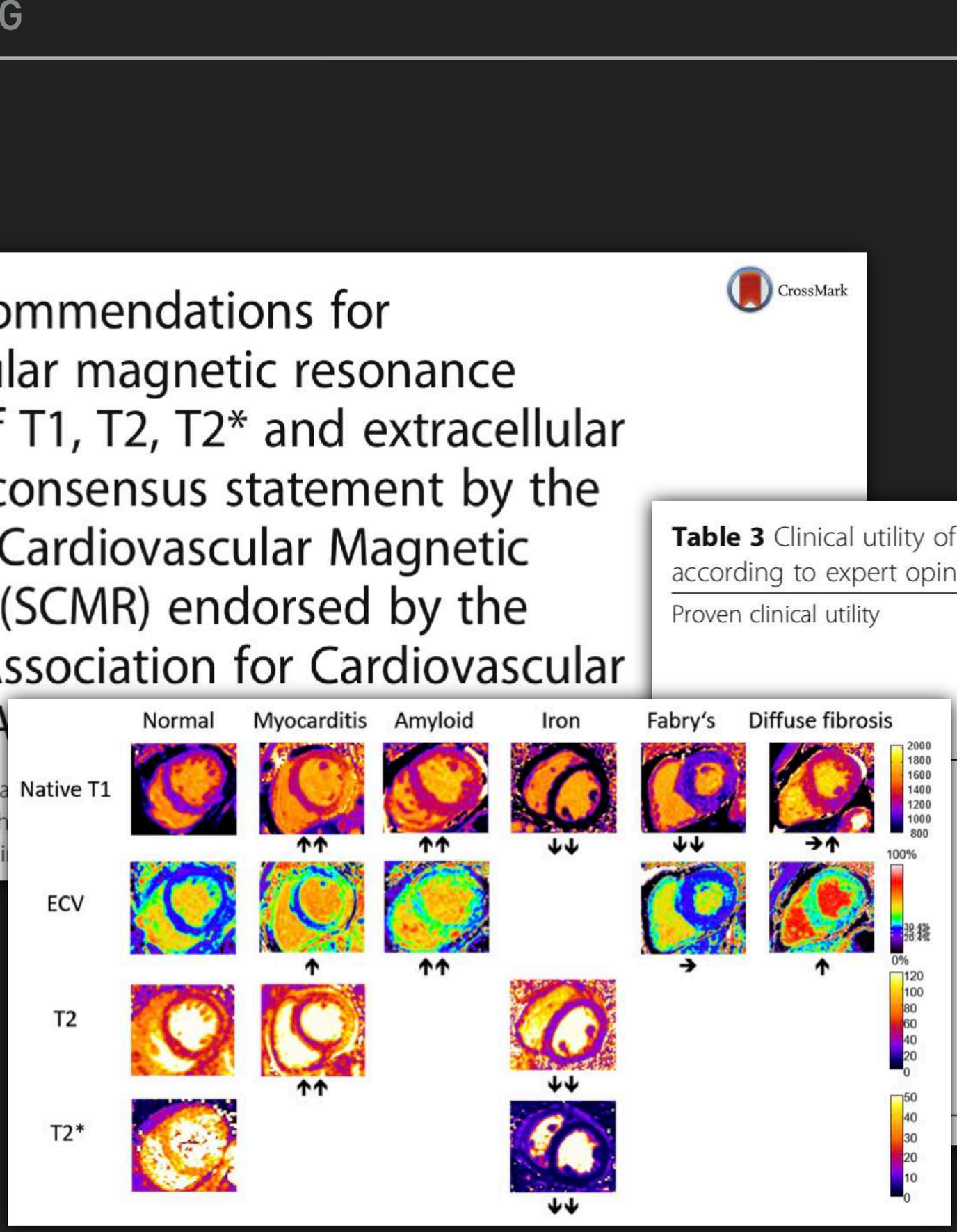
MAPPING

Clinical recommendations for cardiovascular magnetic resonance mapping of T1, T2, T2* and extracellular volume: A consensus statement by the Society for Cardiovascular Magnetic Resonance (SCMR) endorsed by the European Association for Cardiovascular Imaging (EA

Daniel R. Messroghli[1,2,3*], Ja
Peter Kellman[8], Julia Masch
Richard Thompson[16], Marti

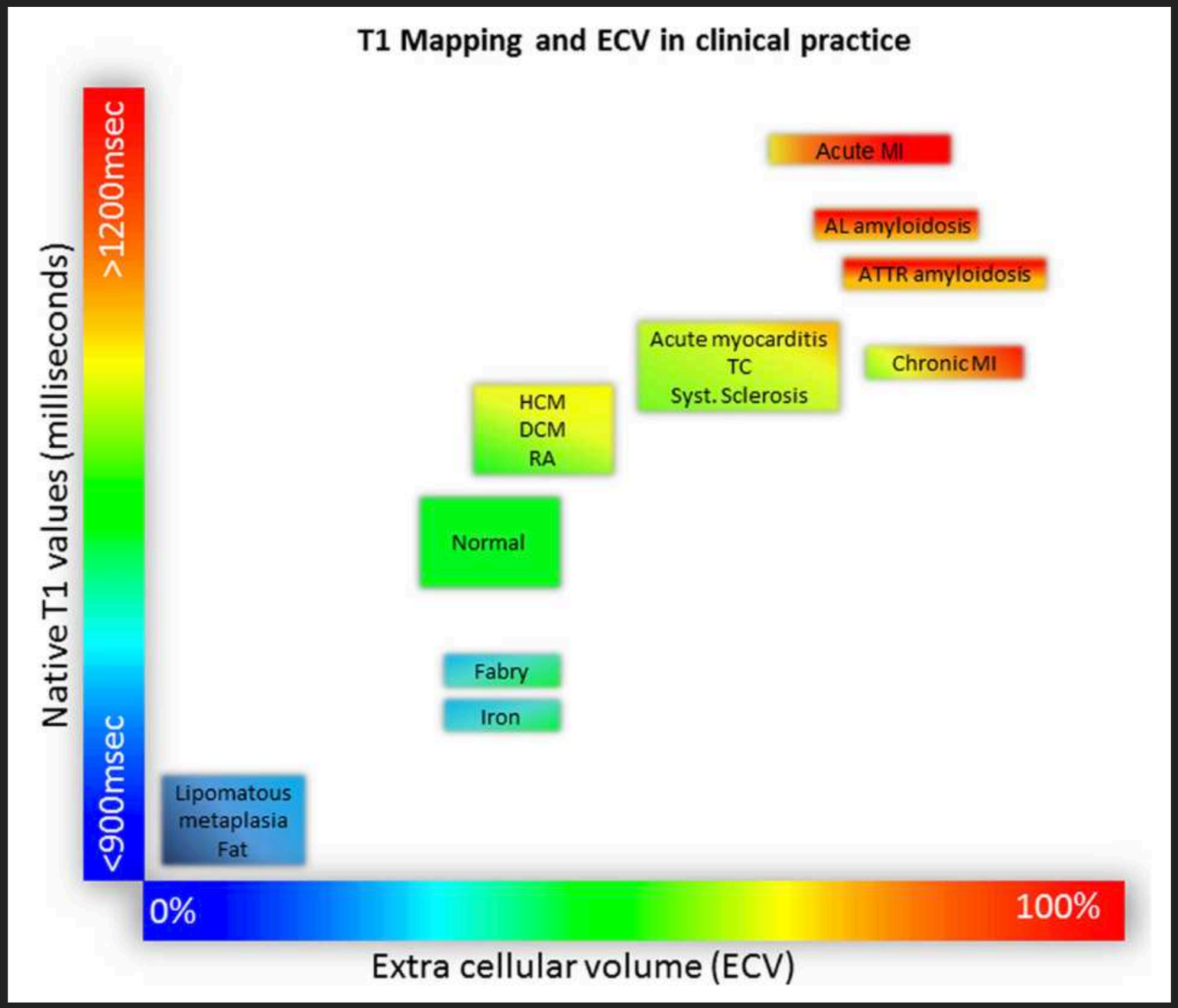
Table 3 Clinical utility of parametric mapping techniques according to expert opinion

Proven clinical utility	Iron deposition
	Amyloid disease
	Anderson-Fabry disease
	Myocarditis
	Cardiomyopathy
	Heart failure
	Congenital heart disease
	Acute/chronic myocardial infarction
	Myocardial ischemia
	Suspected transplant rejection
	Athlete's heart
	(Para-)cardiac masses



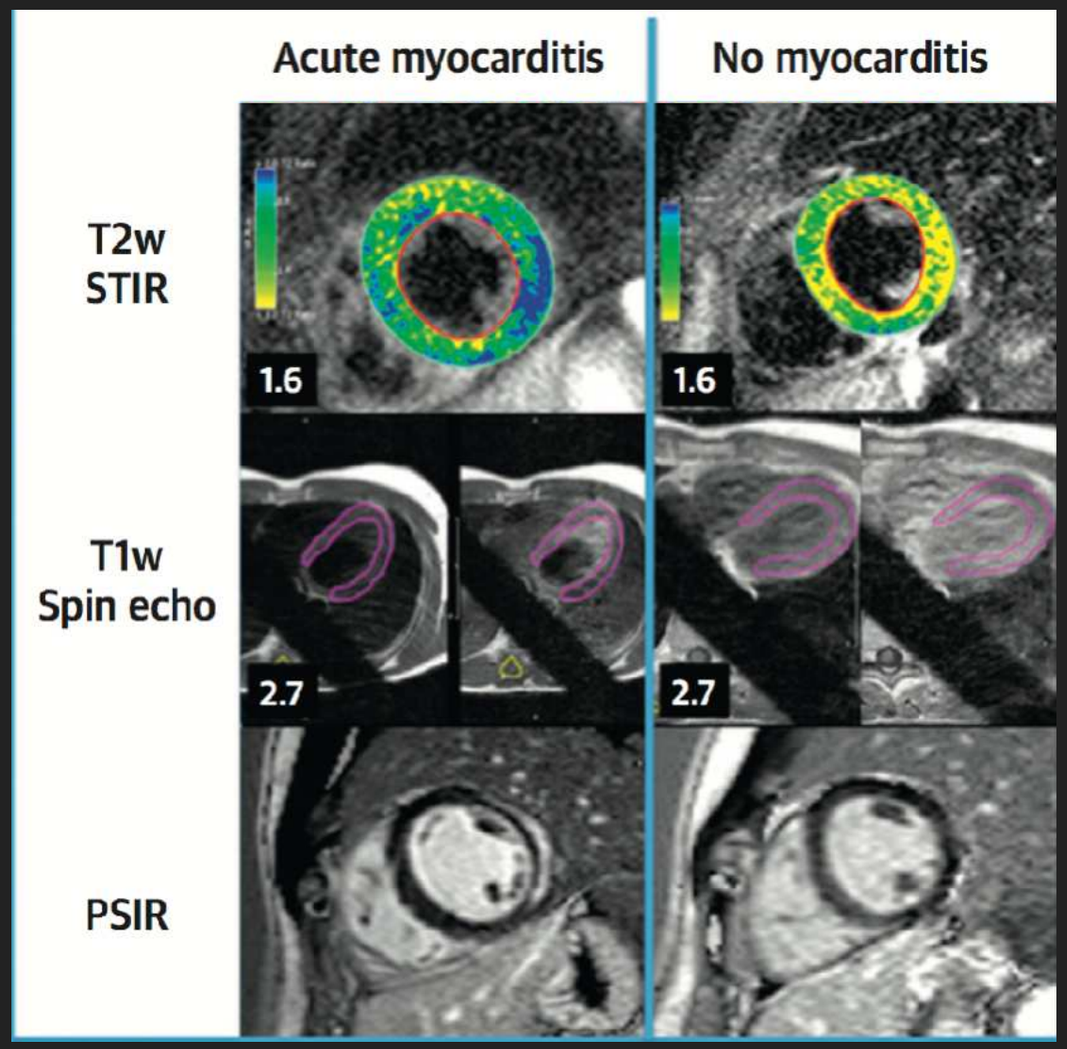
Messroghli et al. JCMR 2017

MYOCARDIAL MAPPING

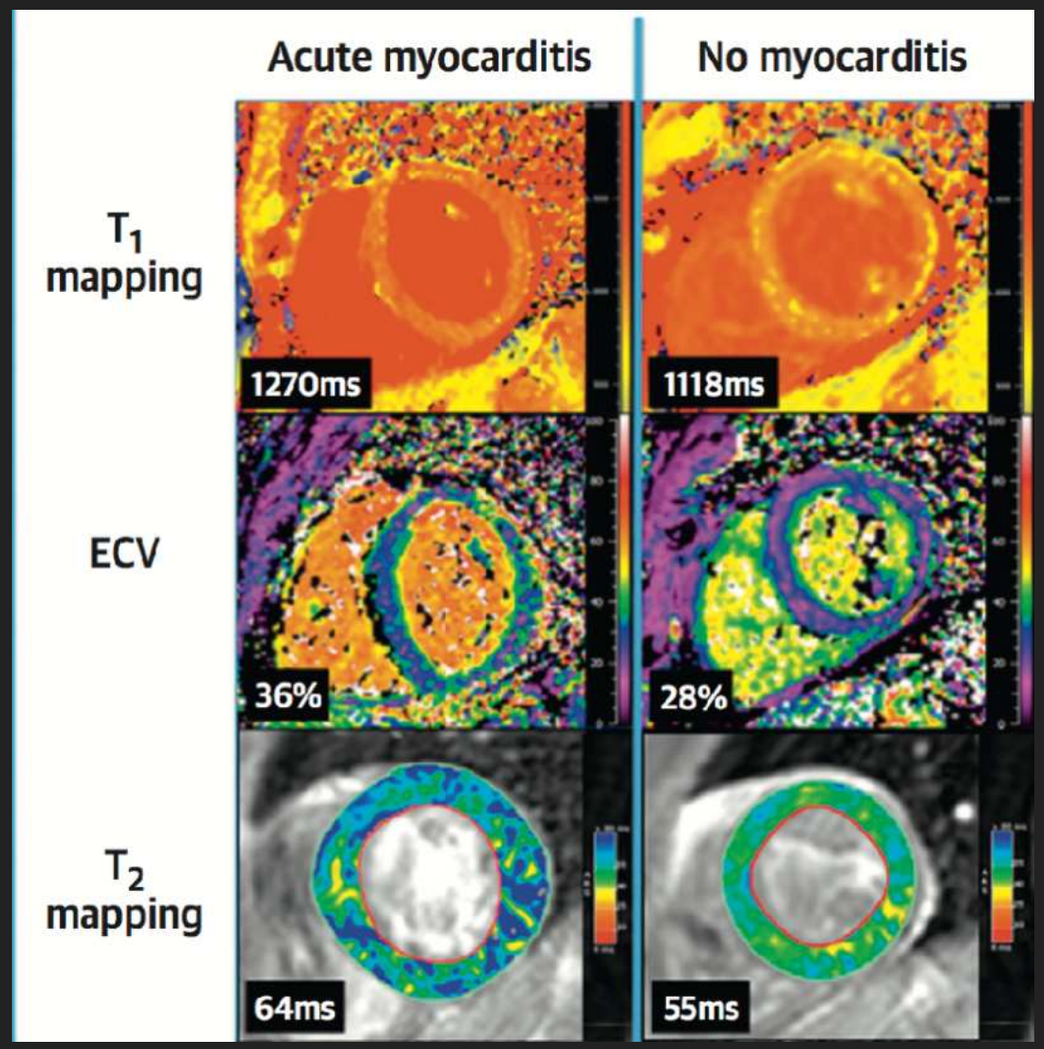


Haaf et al., JCMR 2016

MYOCARDITIS: MAPPING VS CLASSIC CRITERIA



Lake Louise Criteria



Mapping

mod. from Lurz et al. JACC 2016

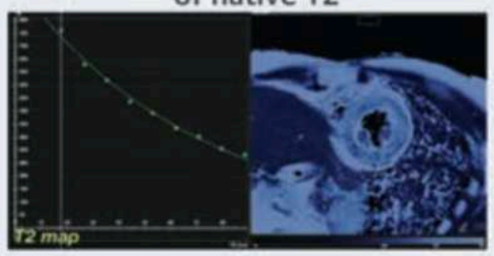
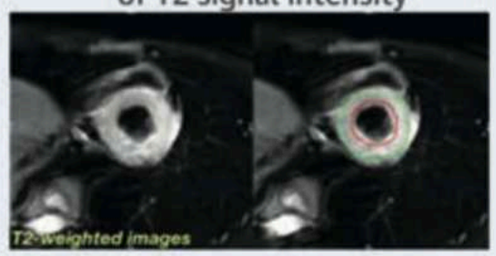
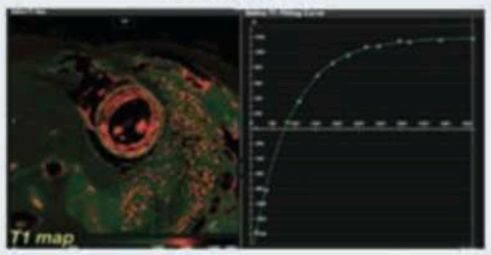
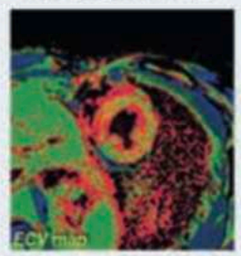
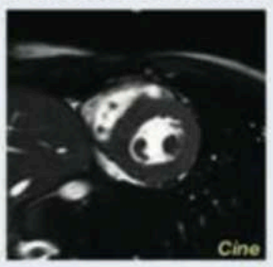
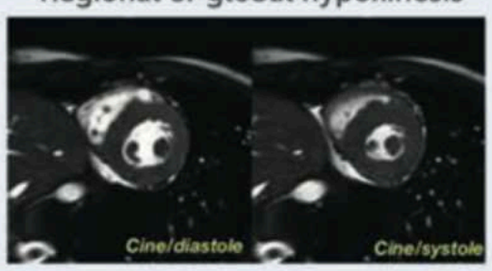
MYOCARDITIS: MAPPING VS CLASSIC CRITERIA

Modality	Sensitivity	Specificity	Diagnostic OR
LLC	74 [67–80]	86 [77–92]	17.7 [9.4–33.2]
ECV	77 [66–85]	76 [60–87]	10.5 [4.6–23.6]
T1	85 [78–90]*	86 [76–93]	36.6 [17.1–78.5]†
T2	76 [65–84]	82 [68–91]	14.4 [6.1–34.2]

Meta analysis
N = 1,308

Pan et al. Circulation: CV Img 2018

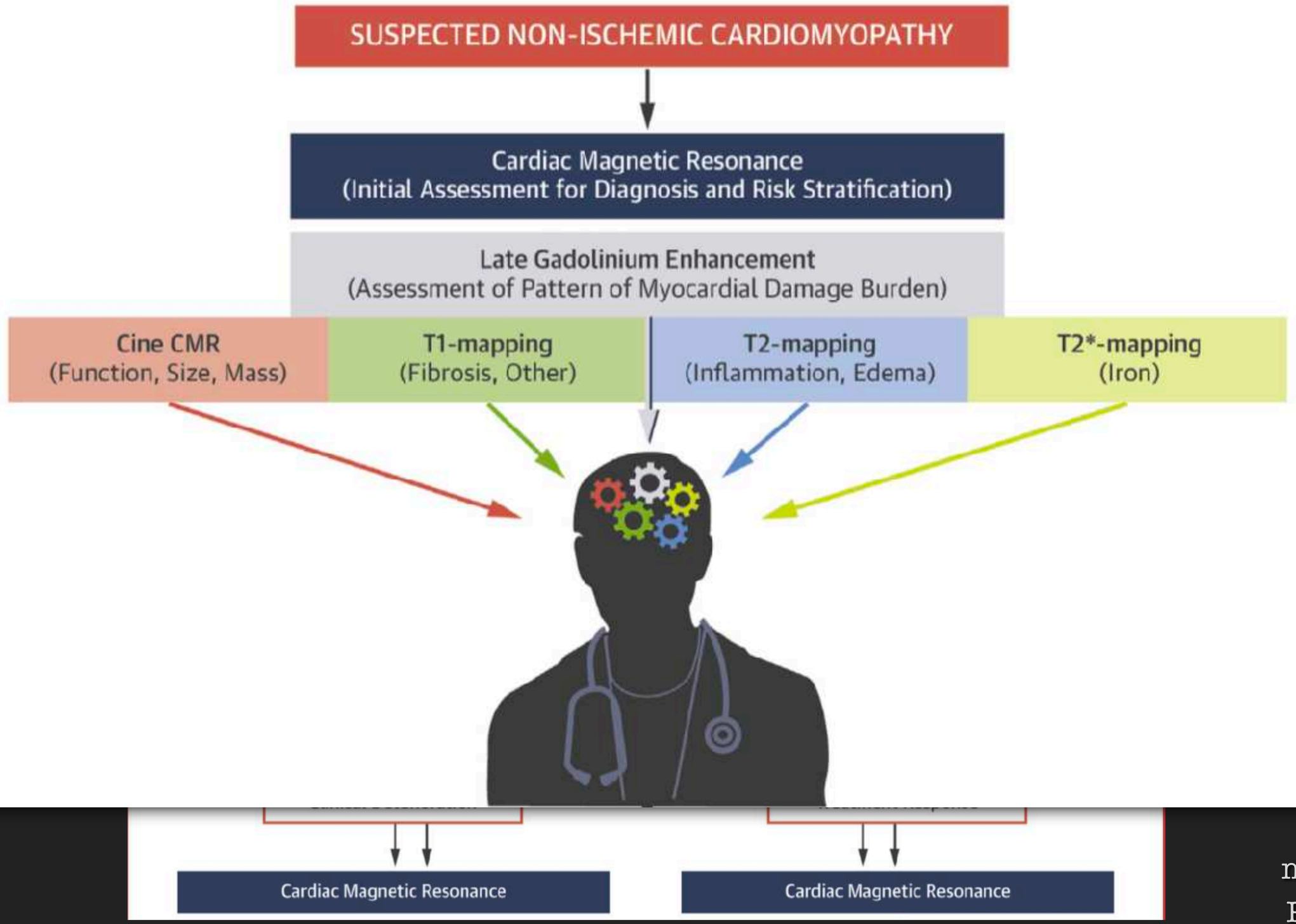
UPDATED LAKE LOUISE CRITERIA

2018 Lake Louise Criteria		CMR Image Examples		
Main Criteria	**Myocardial Edema** (T2-mapping or T2W images)	Regional or global increase of native T2 	or	Regional or global increase of T2 signal intensity 
	Non-ischemic Myocardial Injury (Abnormal T1, ECV, or LGE)	Regional or global increase of native T1 	or	Regional or global increase of ECV 
			or	Regional LGE signal increase 
Supportive Criteria	**Pericarditis** (Effusion in cine images or abnormal LGE, T2, or T1)	Pericardial effusion 		
	Systolic LV Dysfunction (Regional or global wall motion abnormality)	Regional or global hypokinesis 		

Ferreira et al. J Am Coll Cardiol 2018

CMR IN NON-ISCHEMIC CMP

CENTRAL ILLUSTRATION **Evaluation of Nonischemic Cardiomyopathy Using CMR**



mod. From
Patel et al.
JACC: CV Img 2017

MYOCARDITIS: ECV IN CMP WITH AND WITHOUT INFLAMMATION

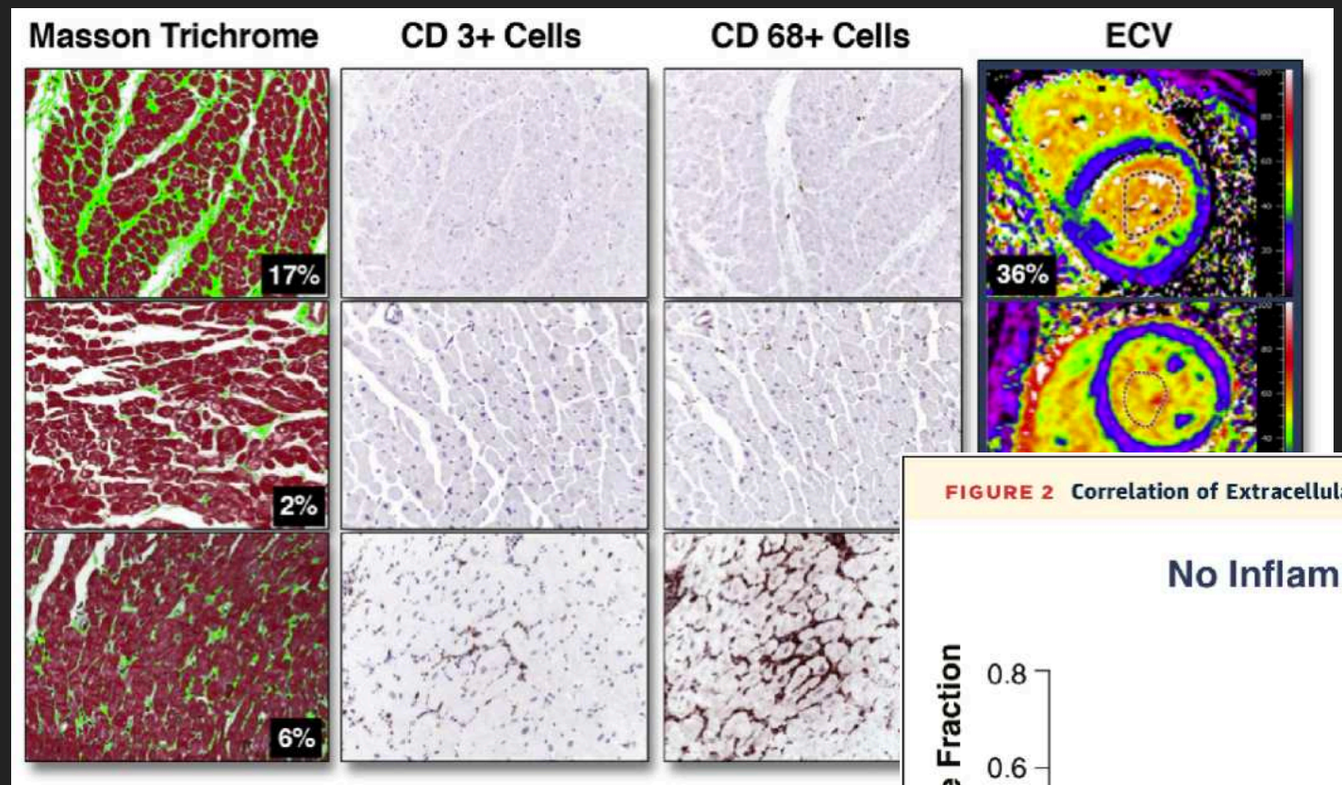
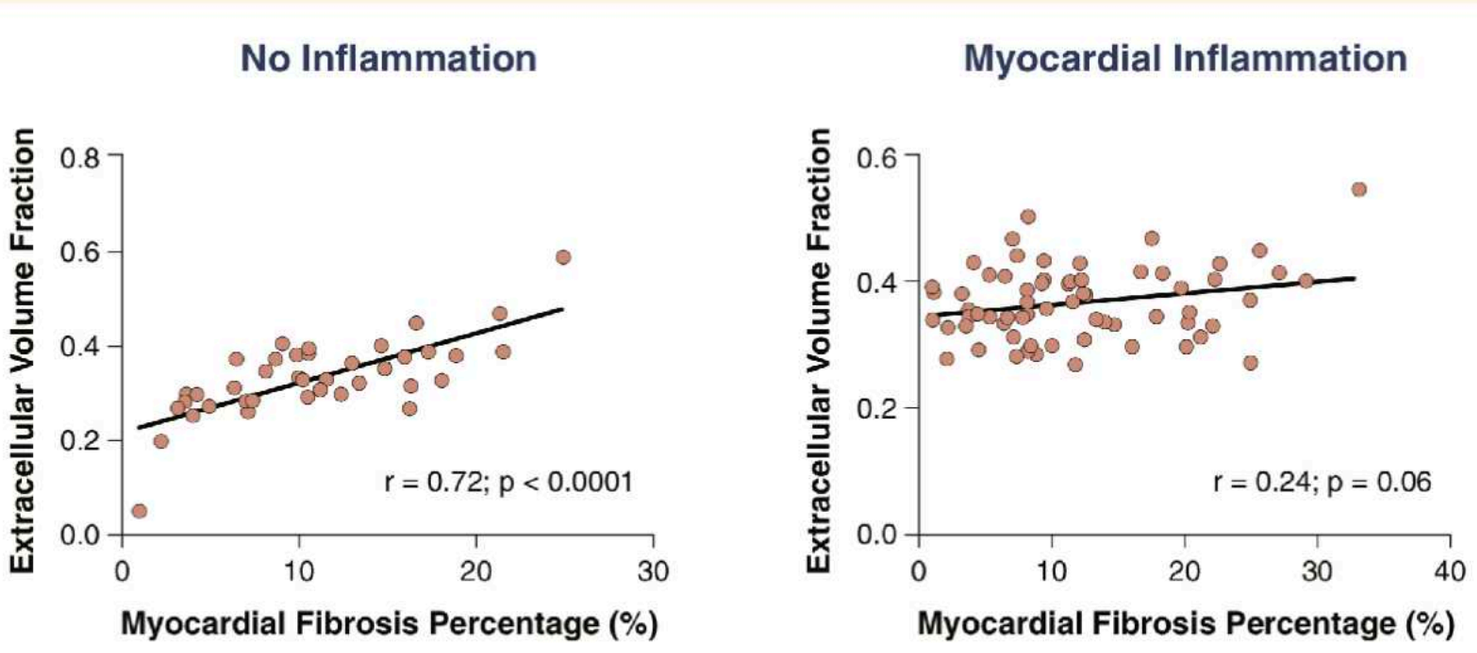


FIGURE 2 Correlation of Extracellular Volume Fraction and Extent of Fibrosis in Patients With and Without Inflammation

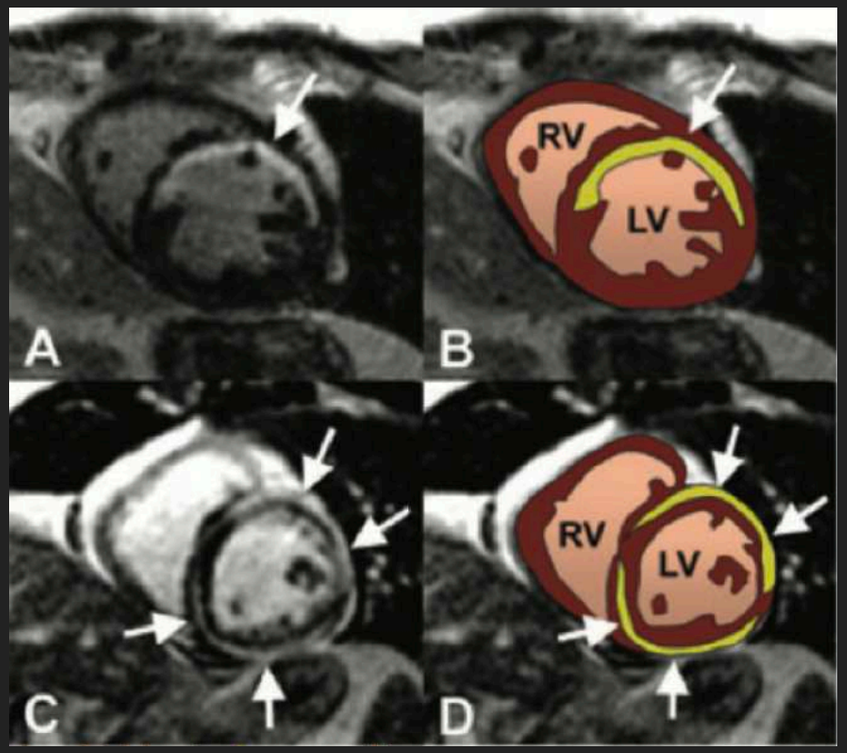


Correlations between myocardial fibrosis percentage and extracellular volume fraction in patients without inflammation **(left)** and with inflammation **(right)**.

n=107

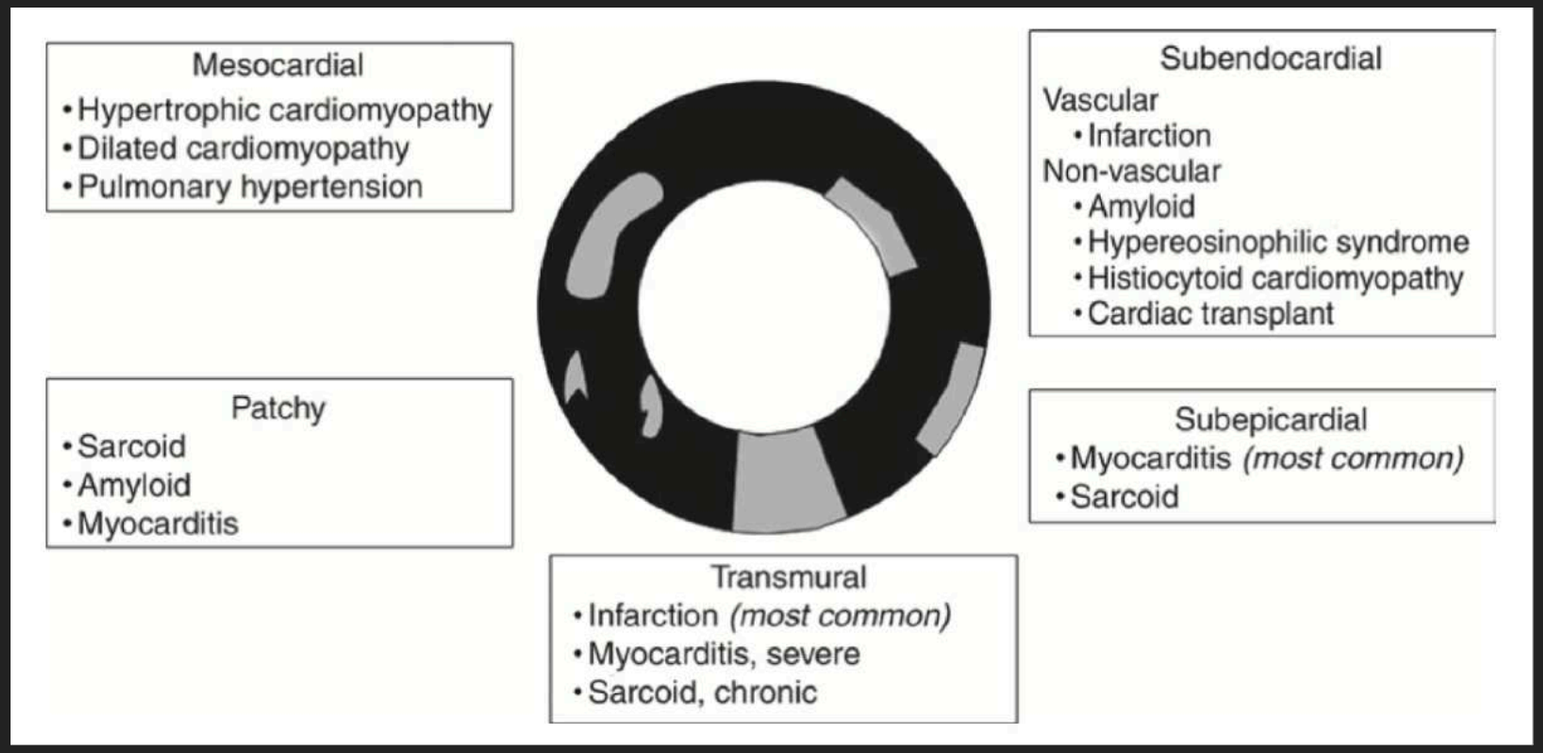
Lurz et al. JACC: CV Img 2018

APPEARANCE OF MYOCARDIAL LESIONS



Sanz. Ann N Y Acad Sci 2012

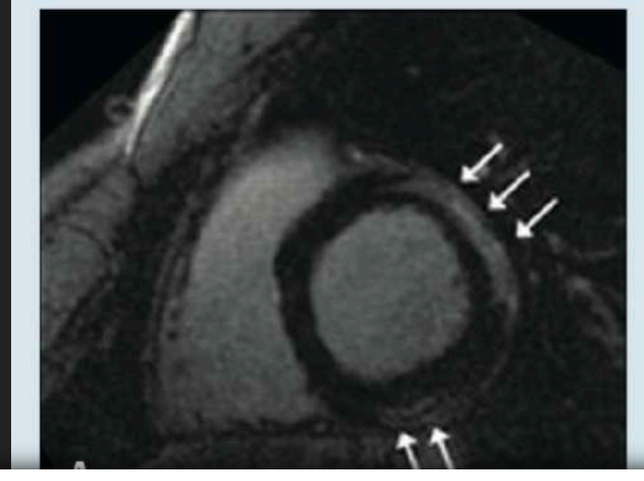
Ischemic vs non-ischemic

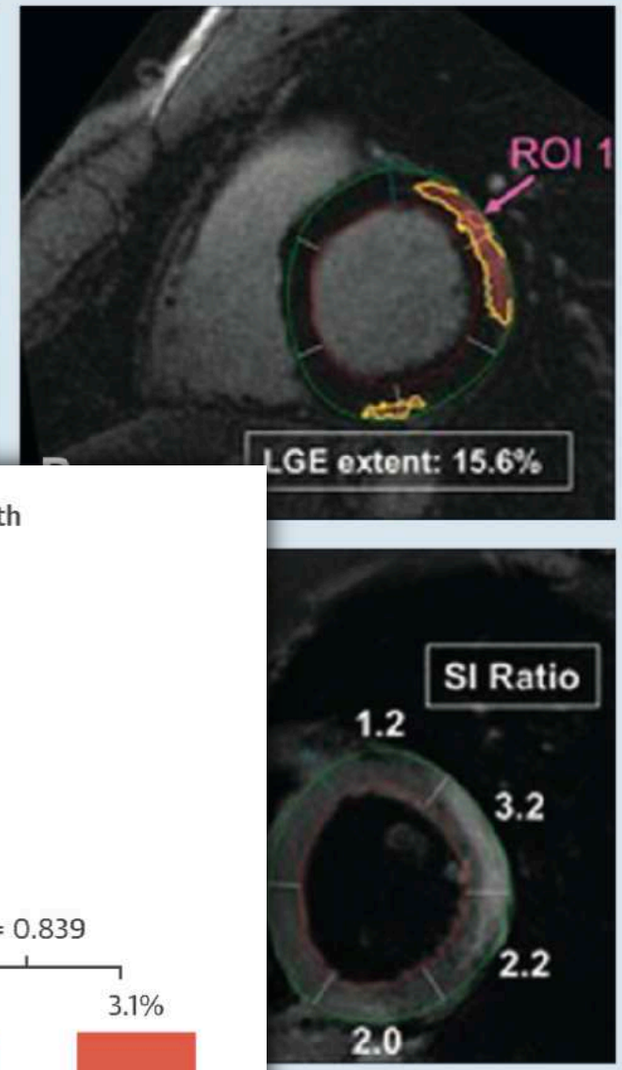


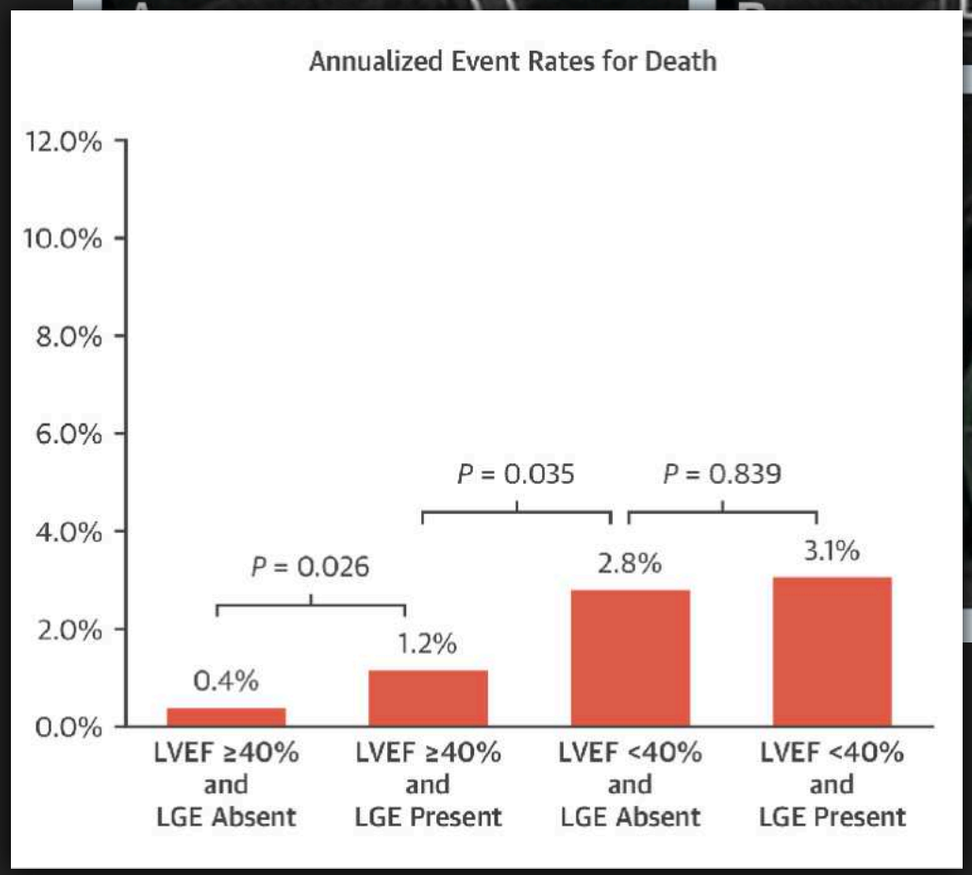
Cummings et al. Radiographics 2009

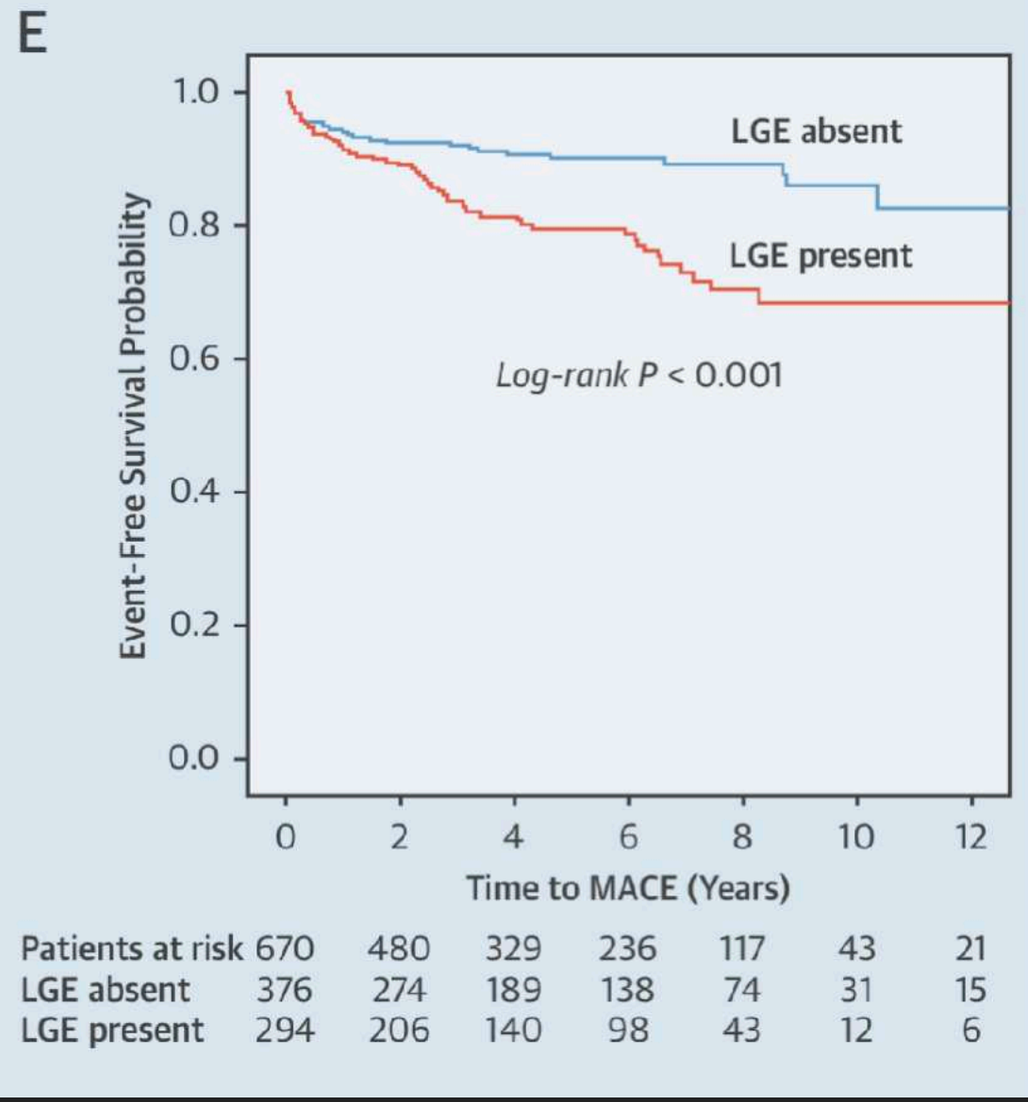
Non-ischemic etiology

CMR IN MYOCARDITIS: PROGNOSTIC VALUE OF SCARS



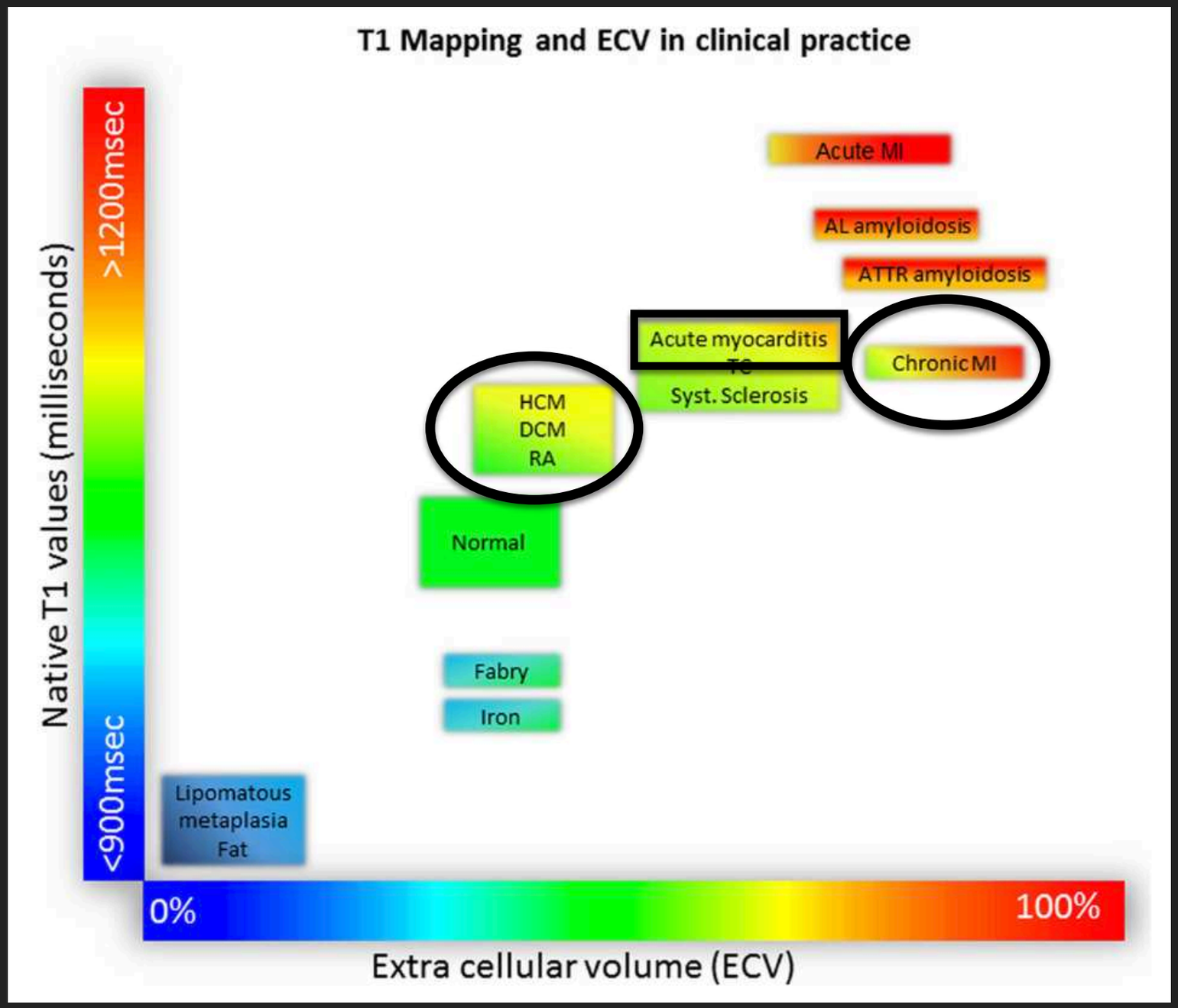






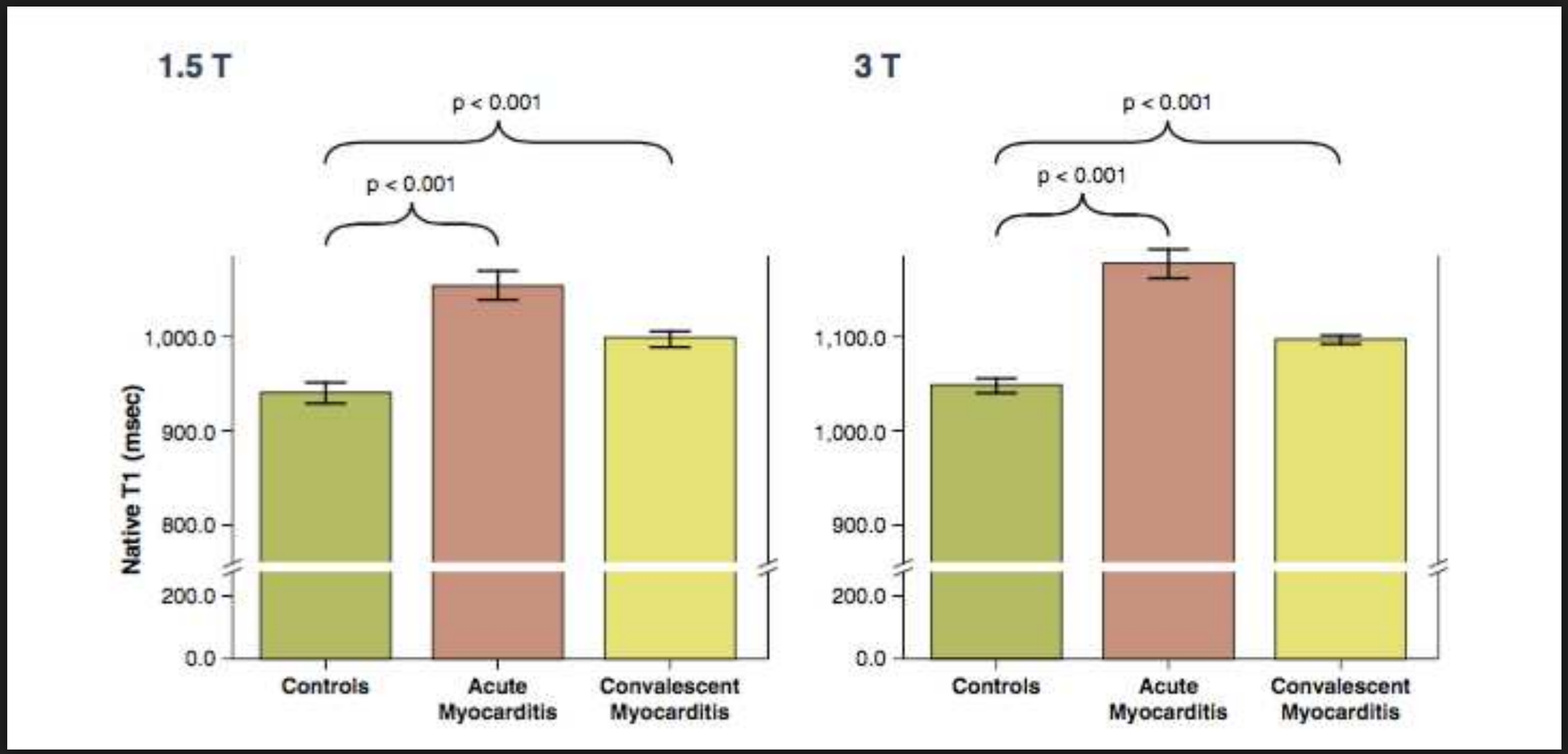
Gräni et al. J Am Coll Cardiol 2017

MYOCARDIAL MAPPING



Haaf et al., JCMR 2016

NATIVE T1 IN MYOCARDITIS



Hinojar et al. EJ Am Coll Cardiol: CV Img 2015

SUMMARY

- Acute myocardial inflammation is characterized by edema and typically by associated irreversible injury (necrosis, scar), while chronic myocarditis is less well defined.
- CMR can identify both, edema (T2) and irreversible injury (T1) and differentiate acute from chronic myocarditis.
- Because of its specificity for edema and thus acute stages, T2 mapping or T2-weighted imaging is required for verifying or excluding acute myocardial inflammation.

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