



Quando Utilizar a Tomografia ou Ressonância Cardíaca no Paciente Hipertenso?

SBC -DCC

October, 2019

Rio de Janeiro - RJ - Brazil

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Procardiaco Hospital, Rio de Janeiro – RJ

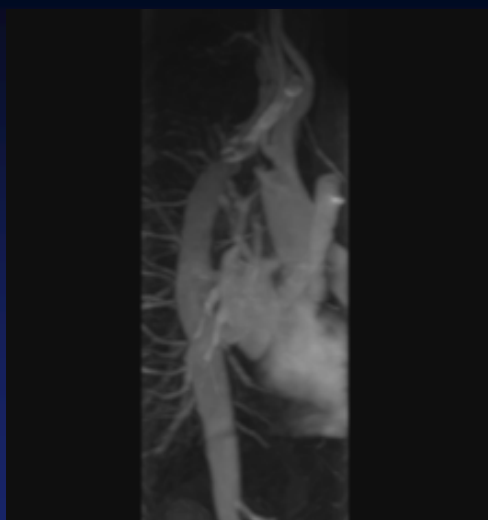
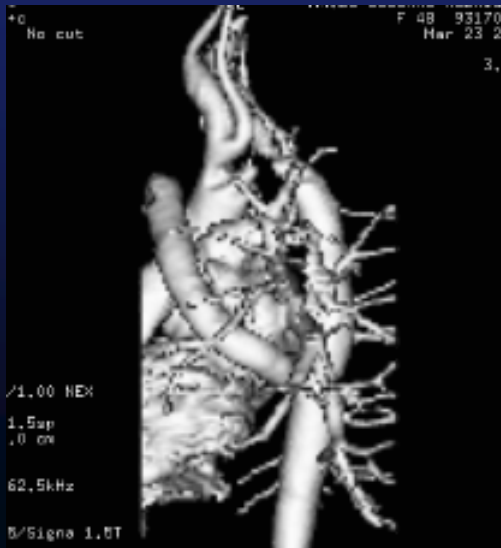
***President of Cardiovascular Imaging Department of Brazilian Society of Cardiology
DIC/SBC (2020-2021)***

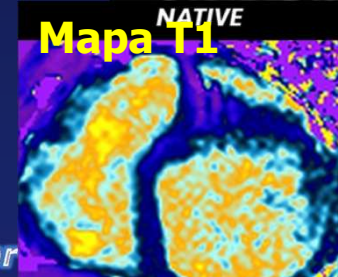
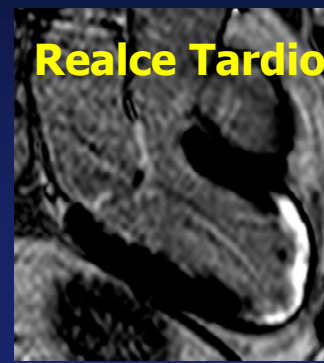
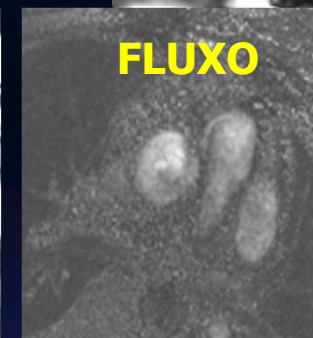
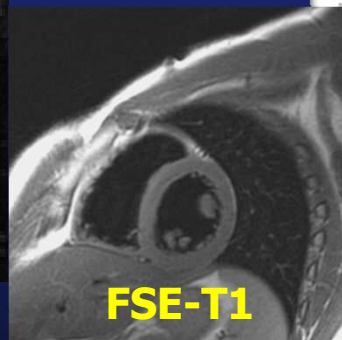
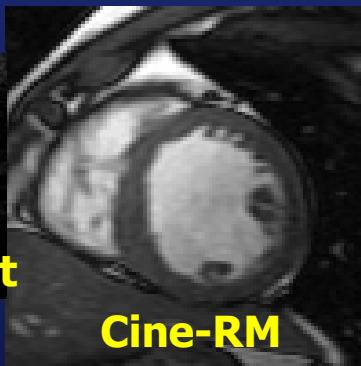
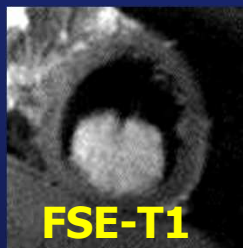
Editor-in-Chief of ABC Cardiol – Arquivos Brasileiros de Cardiologia

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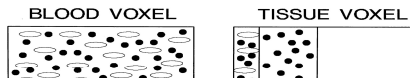
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RM Cardiovascular





Late Enhancement Mechanism ↑ Extracellular Space



HYPERENHANCEMENT PATTERNS

Ischemic

A. Subendocardial Infarct



B. Transmural Infarct



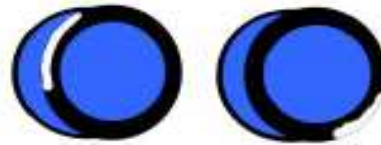
Nonischemic

A. Mid-wall HE



- Idiopathic Dilated Cardiomyopathy
- Myocarditis
- Hypertrophic Cardiomyopathy
- Right ventricular pressure overload (e.g. congenital heart disease, pulmonary HTN)
- Sarcoidosis
- Myocarditis
- Anderson-Fabry
- Chagas Disease

B. Epicardial HE

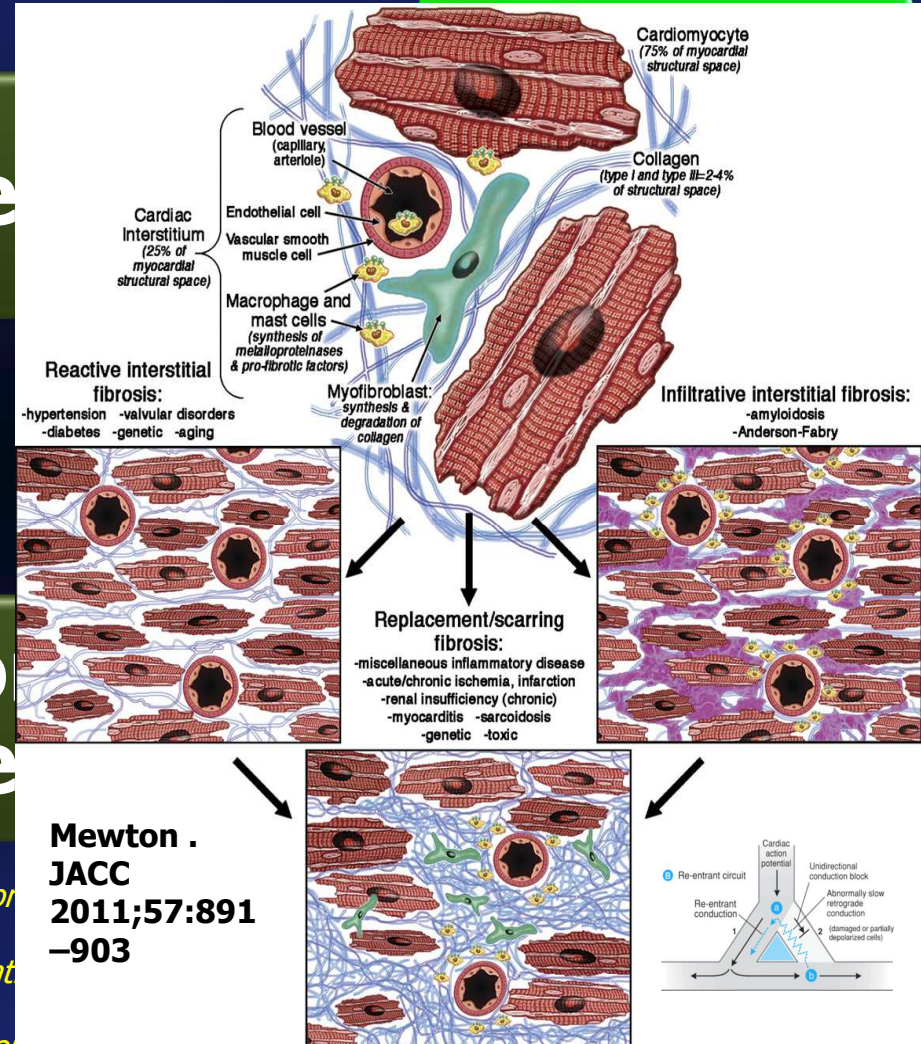


- Sarcoidosis, Myocarditis, Anderson-Fabry, Chagas Disease

C. Global Endocardial HE



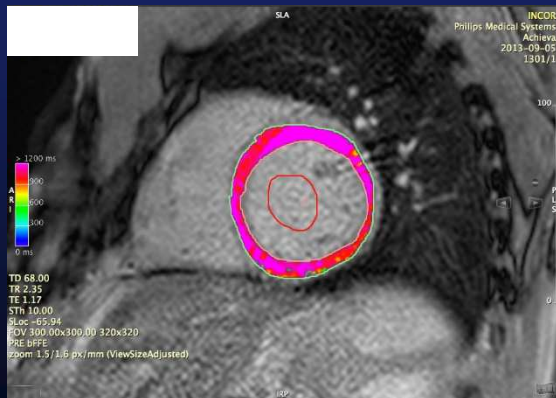
- Amyloidosis, Systemic Sclerosis, Post cardiac transplantation



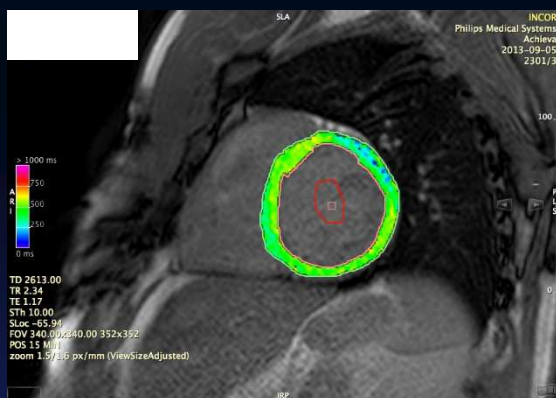
Kim et al., *Circulation* 1999;100:1992-2002.

Mahrholdt H et al *European Heart Journal* (2005) 26, 1461-1474

DIFFUSE FIBROSIS T1 Mapping and ECV



T1 Analysis ECV = 26.7%
 Sequence: Look-Locker/MOLLI
 Heart Rate Correction enabled
 Slice 1
 SAX Myocardial Region
 T1 = 1070.9 ± 113.04 ms R²=0.999
 Freehand ROI 1
 T1 = 1615.7 ± 93.44 ms R²=1.000

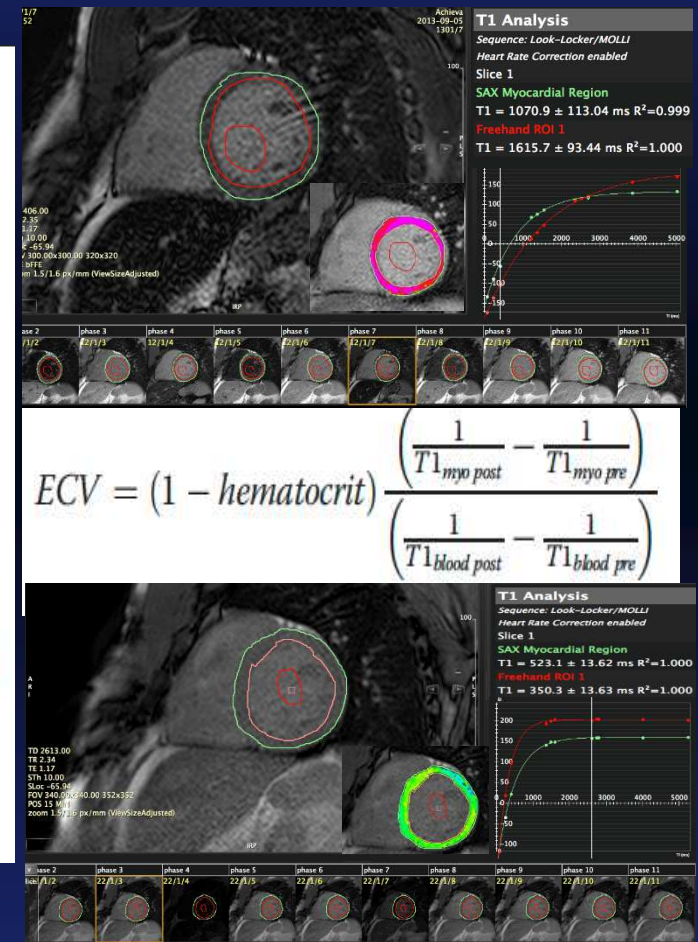
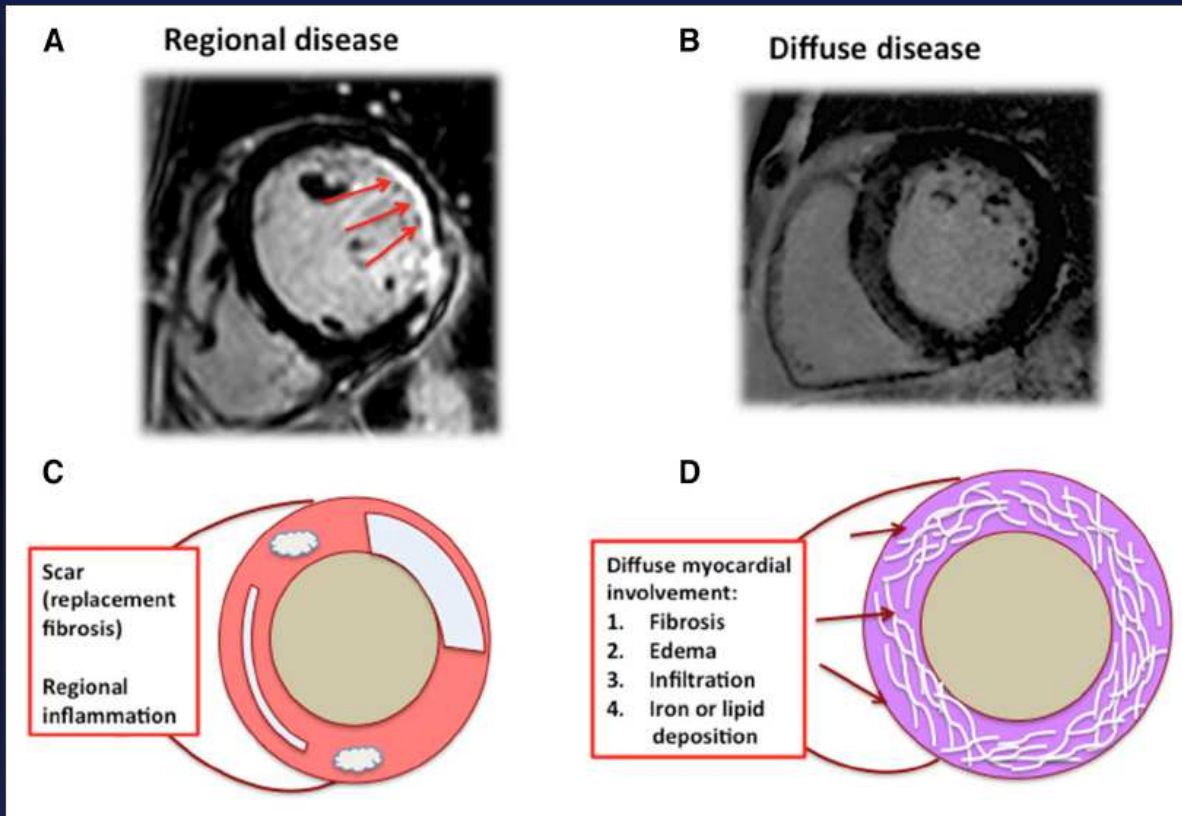


$$ECV = (1 - \text{hematocrit}) \frac{\left(\frac{1}{T1_{myo\ post}} - \frac{1}{T1_{myo\ pre}} \right)}{\left(\frac{1}{T1_{blood\ post}} - \frac{1}{T1_{blood\ pre}} \right)}$$

Slice 1
 SAX Myocardial Region
 T1 = 523.1 ± 13.62 ms R²=1.000
 Freehand ROI 1
 T1 = 350.3 ± 13.63 ms R²=1.000

**T1 Mapping
 Technique and Applications**
 Juliano Lara Fernandes, MD, MBA, PhD^a, Carlos Eduardo Rochitte, MD, PhD^{b,*}

DIFFUSE FIBROSIS T1 Mapping and ECV



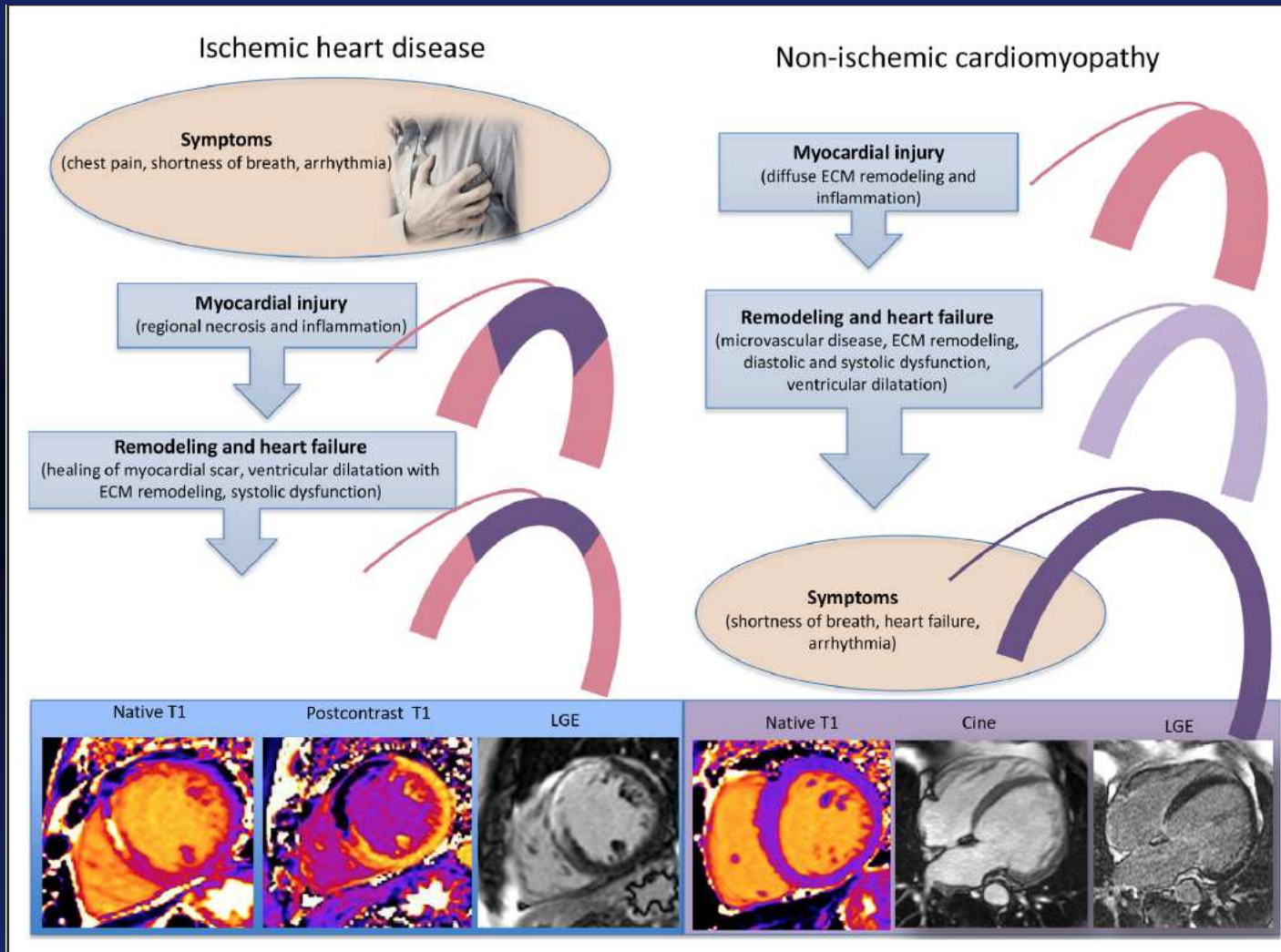
Puntmann V et al. Circ Res. 2016;119:277-299

ECV = 26.7%

Fernandes and Rochitte. Reson Imaging Clin N Am. 2015 Feb;23(1):25-34

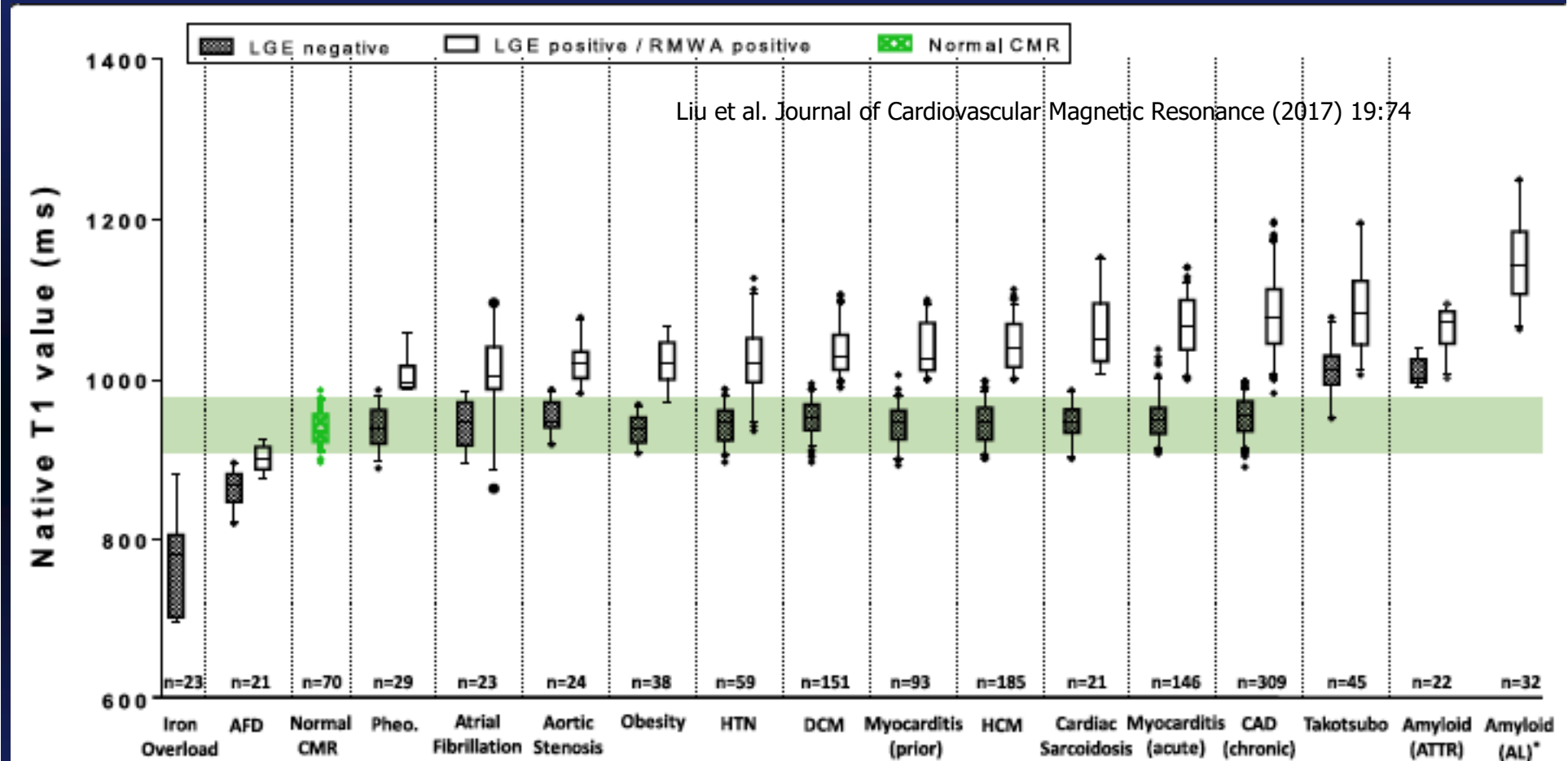
<http://www.rochitte.med.br>

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

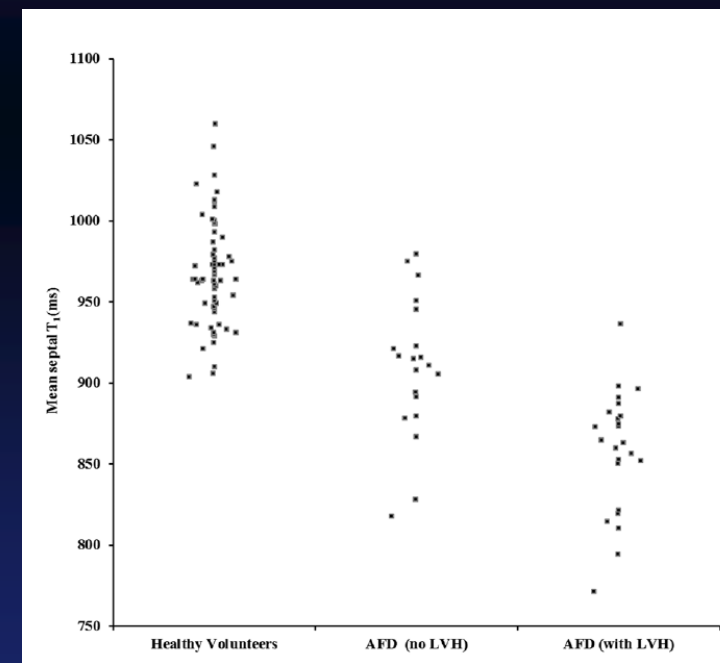
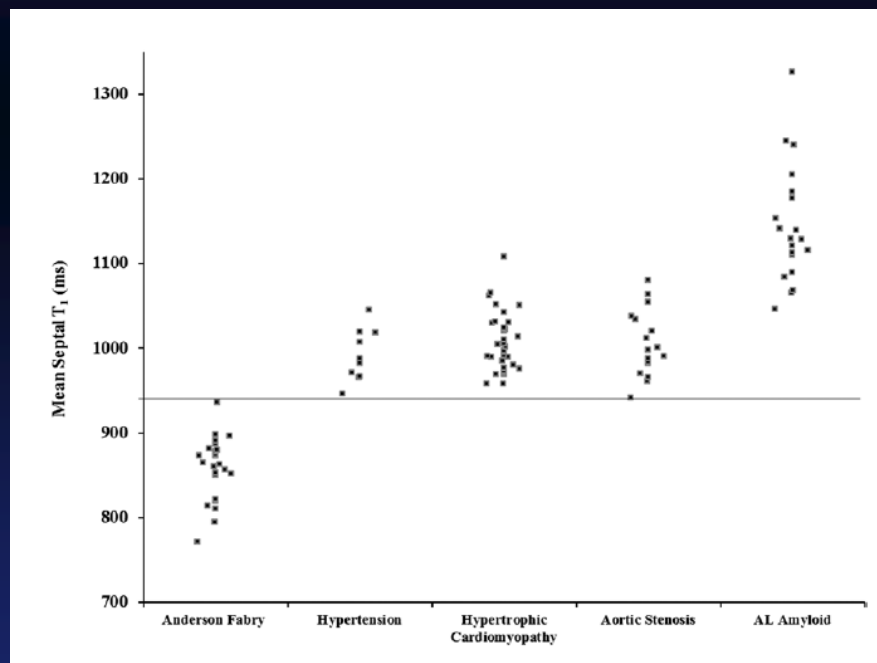
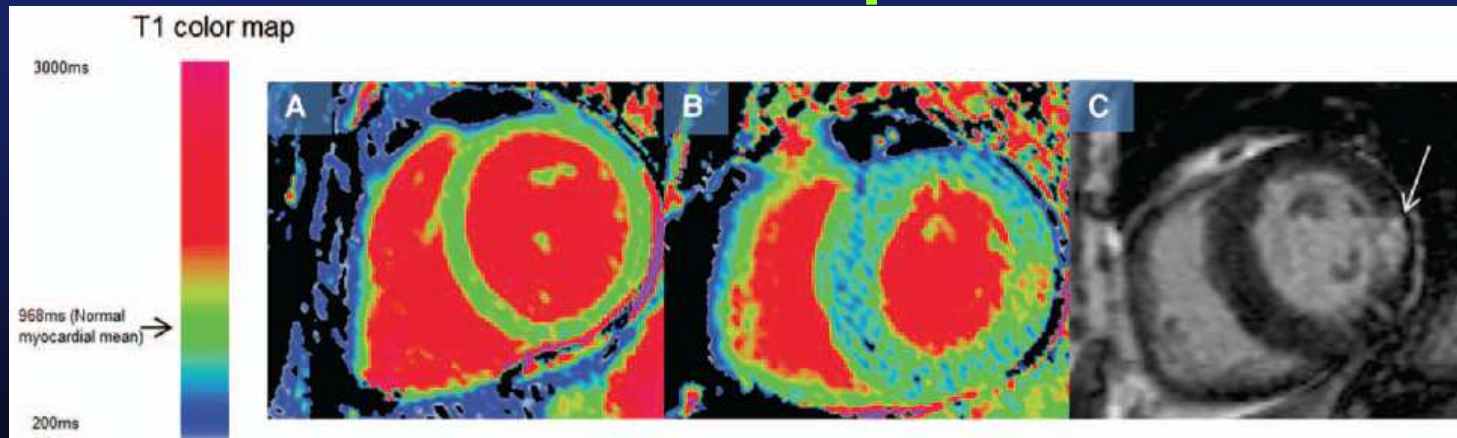
DIFFUSE FIBROSIS T1 Mapping and ECV



17-HB MOLLI (41)	986 ± 45 (51)	1070 ± 55 (56)	23 ± 3 (60)	27 ± 9 (56)
ShMOLLI11 (42)	958 ± 20 (52, 53)	1178 ± 13 (57)	27 ± 2 (43)	Not reported
SASHA14 (43)	1177 ± 27 (54)	1539 ± 50 (58)	22 ± 3 (54)	21.3 ± 2 (49)
SAPPHIRE15 (44)	1212 ± 40 (55)	1578 ± 35 (59)	20 (38)	20.2 ± 2 (49)

Tang CX et al. Trends in Cardiovascular Medicine 0 0 0 (2018) 1–12

T1 Map



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

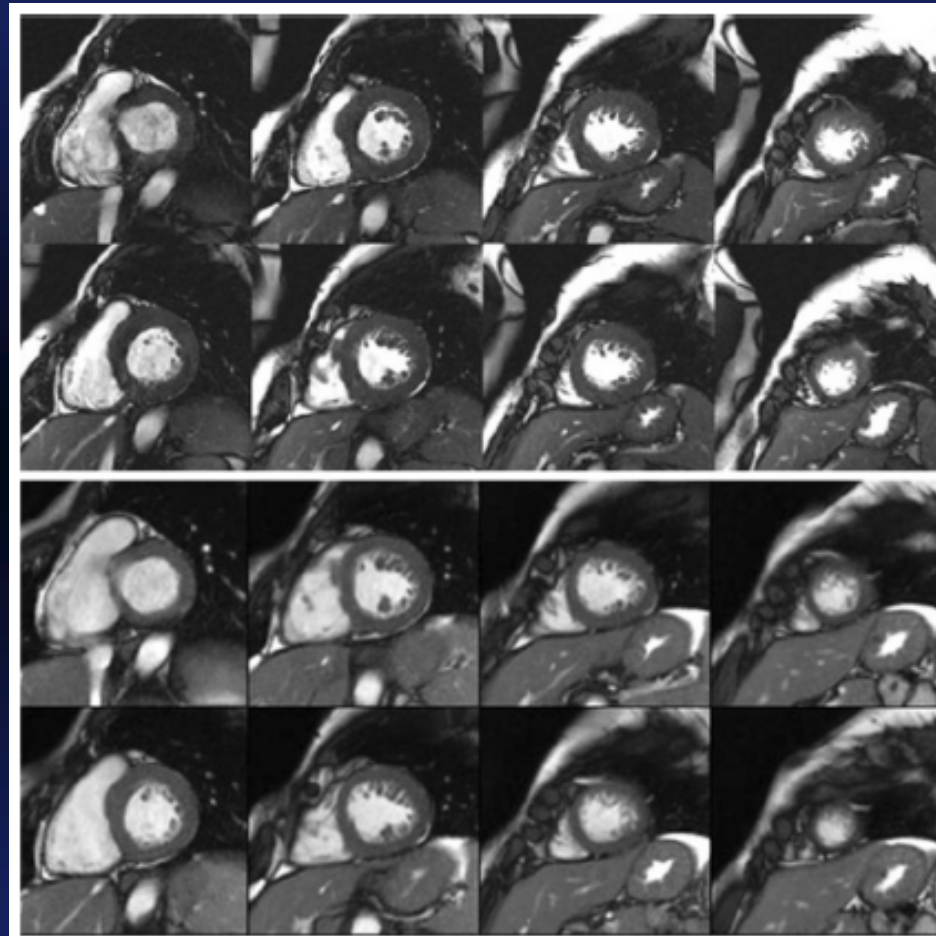
CMR in Hypertension

5 min	Cardiac and aortic anatomy
10 min	Ventricular function 2-chamber, 4-chamber, 3-chamber cines Short axis cines
5 min	Aorta Oblique saggital cine SSDP to exclude coarctation Flow mapping if necessary
5 min	Adrenal imaging Transaxial T1W, T2W, in-phase/out-phase Pre-contrast VIBE
10 min	Renal imaging 3D-CE-MRA (arterial and venous phase) Post-contrast VIBE
10 min	
5 min	Myocardial LGE Same views as cines
50 min	

- Indications
 - Assess target organ damage
 - Detect identifiable causes
- Not in the guidelines
- Cardiac MR
 - LVH
 - LA dilatation
 - Myocardial Fibrosis
 - Diastolic dysfunction
 - Higher risk for CAD

Maceira and Mohiaddin JCMR 2012, 14:28

LVH Regression



Maceira and Mohiaddin JCMR 2012, 14:28

LV Dimension, Geometry and Function

- Accurate and Precise for LV mass
- Gold-Standard for Volumes, Mass and Function
- Lower Intraobserver and Interobserver variability
 - 2.0-7.4% and 3.3 – 7.7%
- LVH differential diagnosis
 - HCM, infiltrative disease, Fabry's, sarcoidosis, aortic stenosis, exercise-induced, athlete's heart

RESEARCH

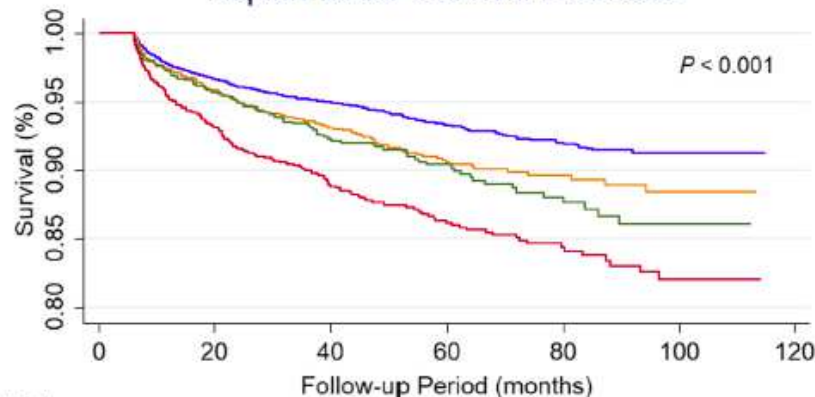
Open Access



Association of left atrial volume index and all-cause mortality in patients referred for routine cardiovascular magnetic resonance: a multicenter study

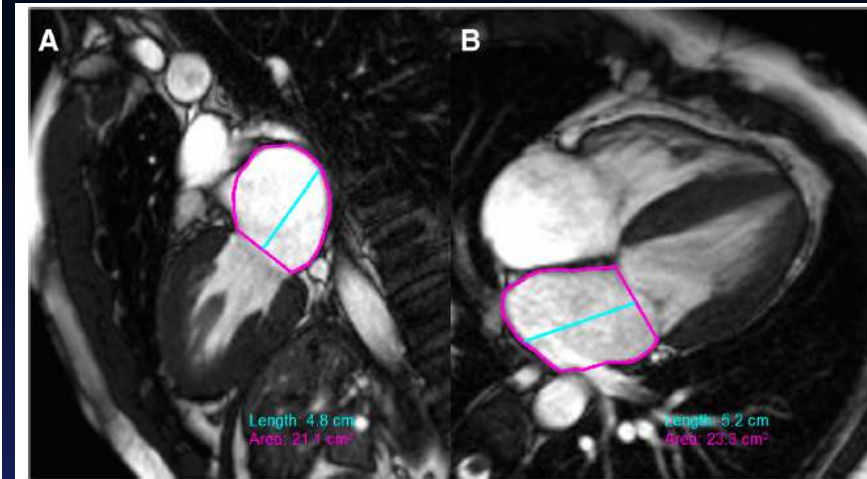
Mohammad A. Khan^{1,5}, Eric Y. Yang¹, Yang Zhan¹, Robert M. Judd³, Wenyaw Chan⁴, Faisal Nabi¹, John F. Heitner², Raymond J. Kim³, Igor Klem³, Sherif F. Nagueh¹ and Dipan J. Shah^{1*}

Kaplan-Meier Survival Estimates



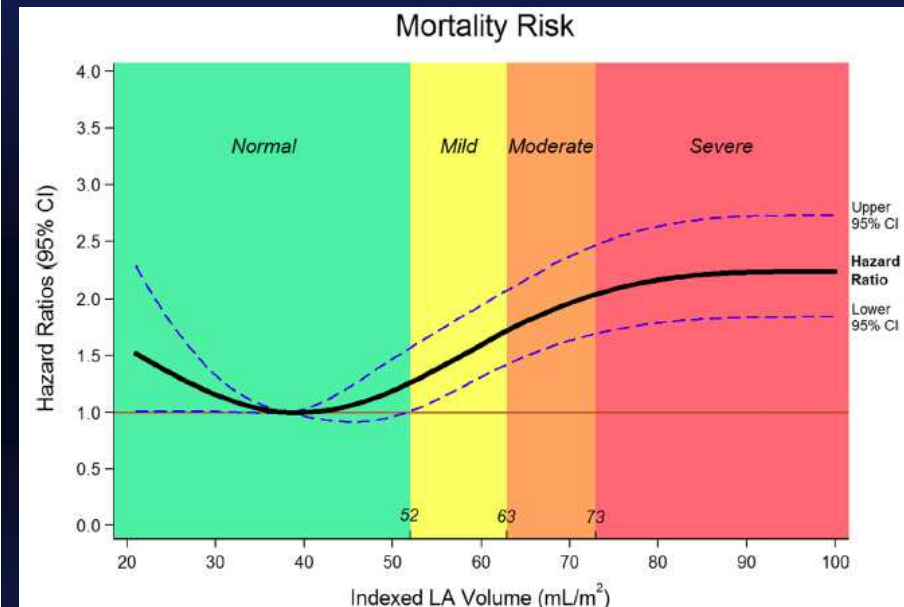
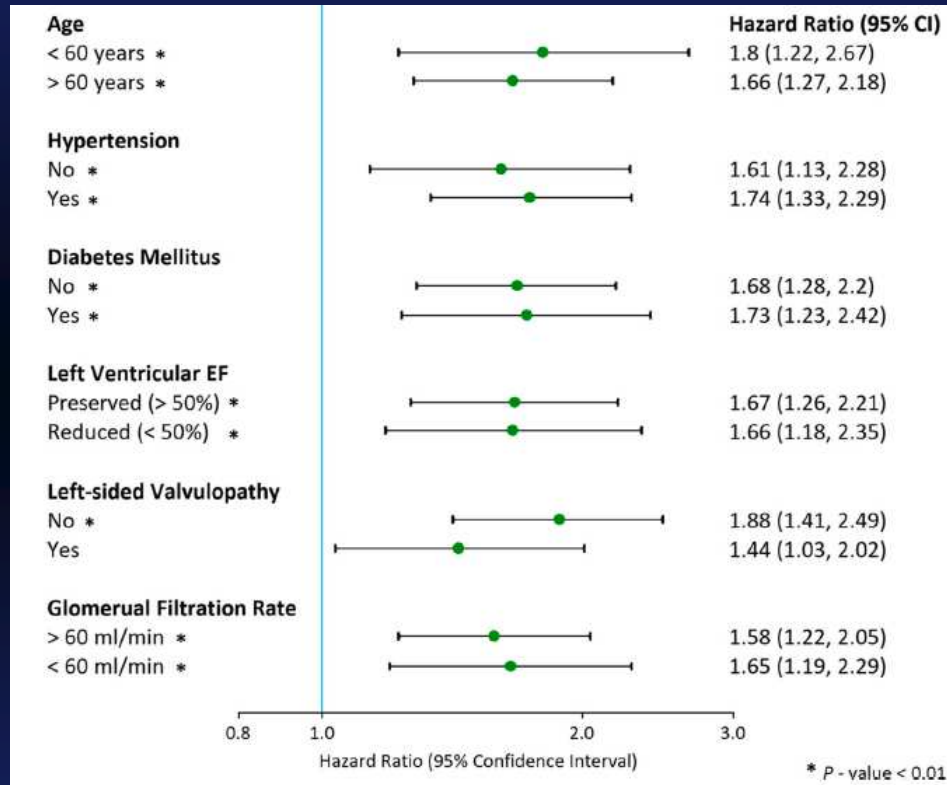
Number at risk	0	20	40	60	80	100	120
Normal	6471	5785	4222	2412	1115	274	
Mild	1617	1425	1024	609	309	108	
Moderate	1142	981	697	416	218	63	
Severe	1660	1403	952	539	312	108	

- Normal Sized LA
- Mildly Enlarged LA
- Moderately Enlarged LA
- Severely Enlarged LA



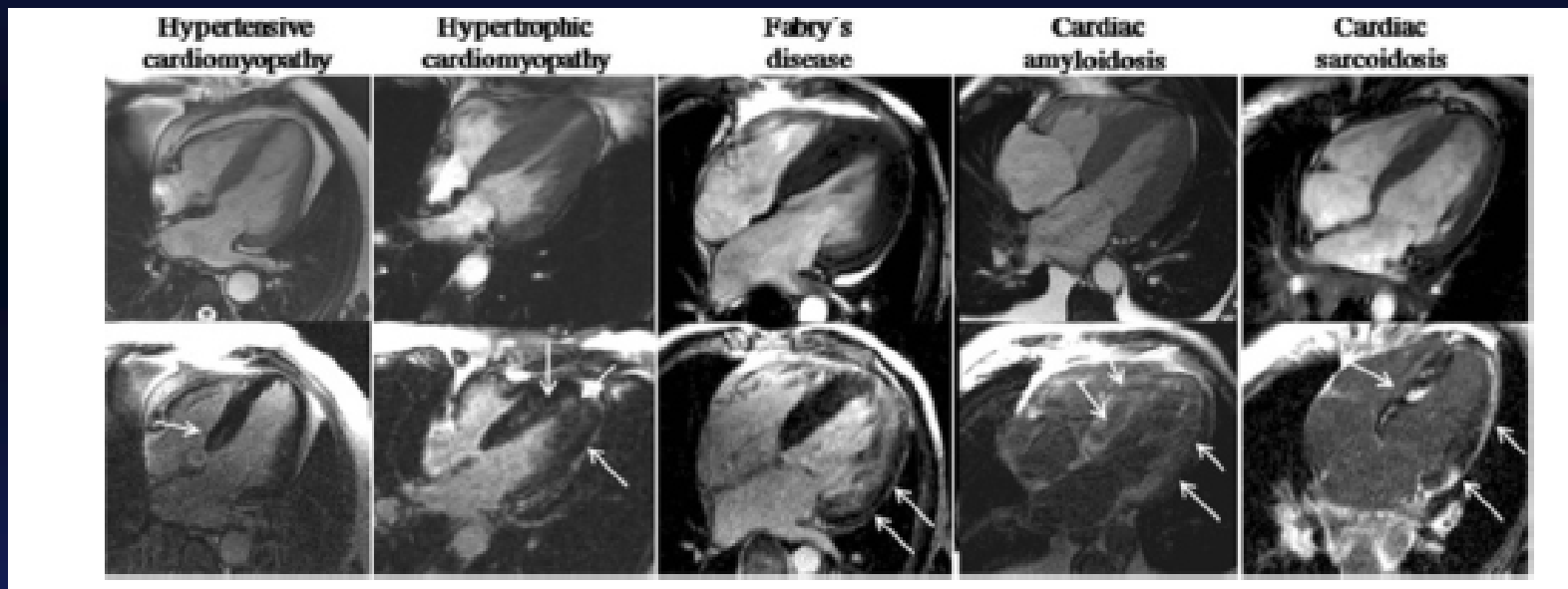
Khan et al. *Journal of Cardiovascular Magnetic Resonance* (2019) 21:4

LA Volume Mortality



Khan et al. Journal of Cardiovascular Magnetic Resonance (2019) 21:4

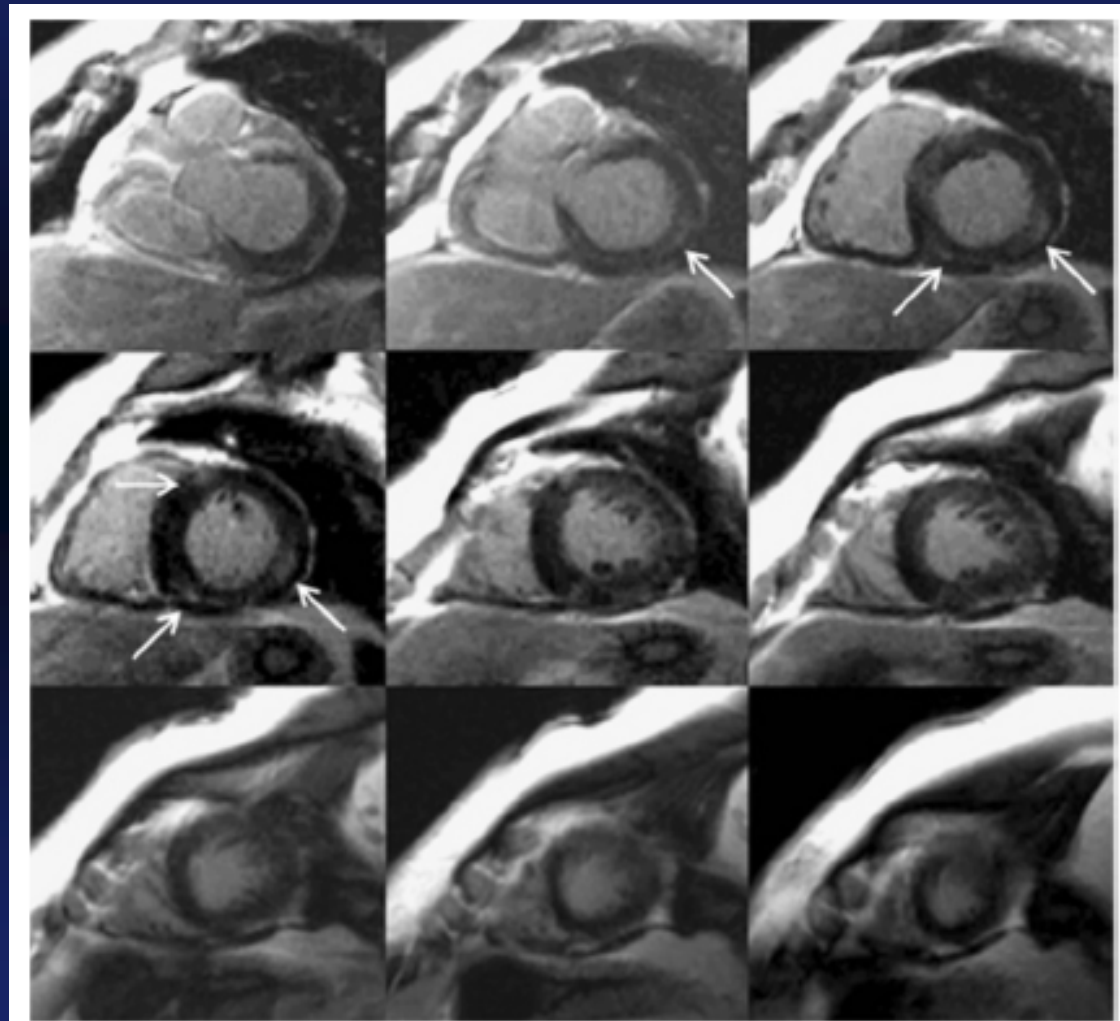
LVH Differential Diagnosis



Maceira and Mohiaddin JCMR 2012, 14:28

Detection of Myocardial Fibrosis

- Serum markers of fibrosis
 - carboxyterminal propeptide of procollagen type I (PIP), a marker of collagen synthesis



Hemochromatosis-related hypertension

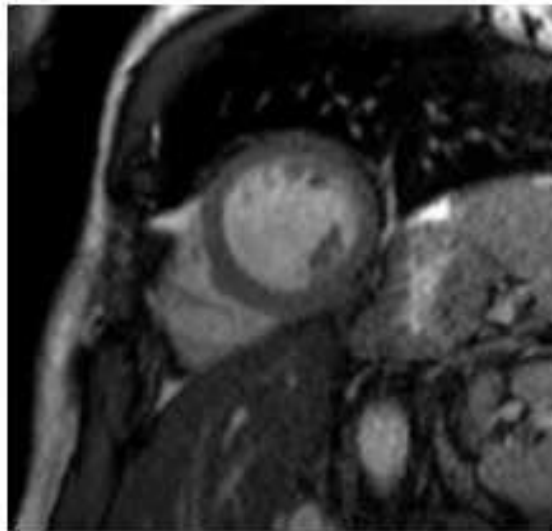


Figure 1.



Figure 2.

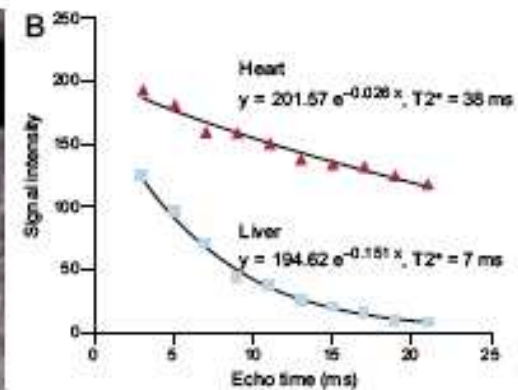
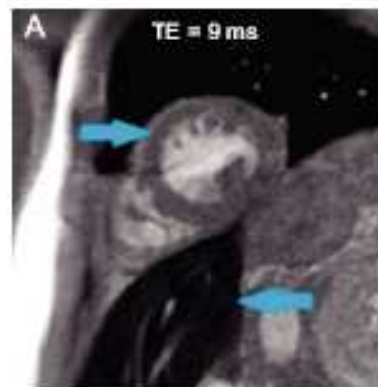
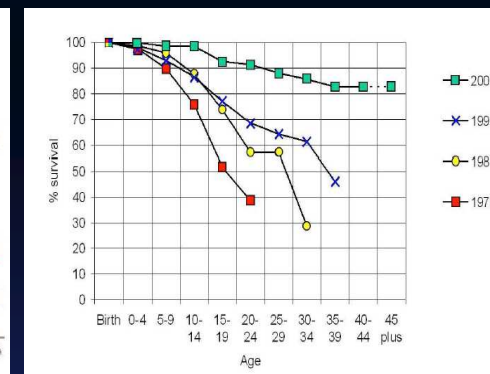
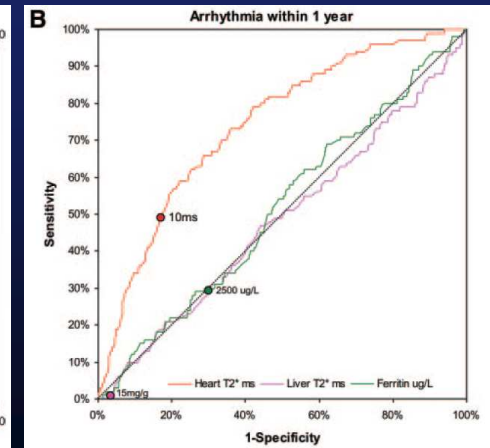
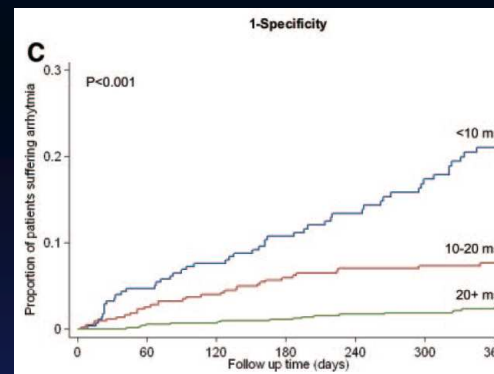
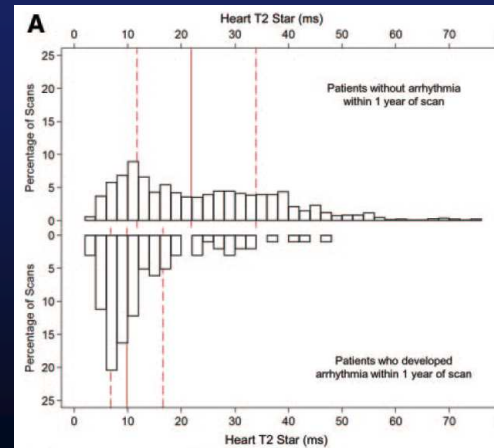
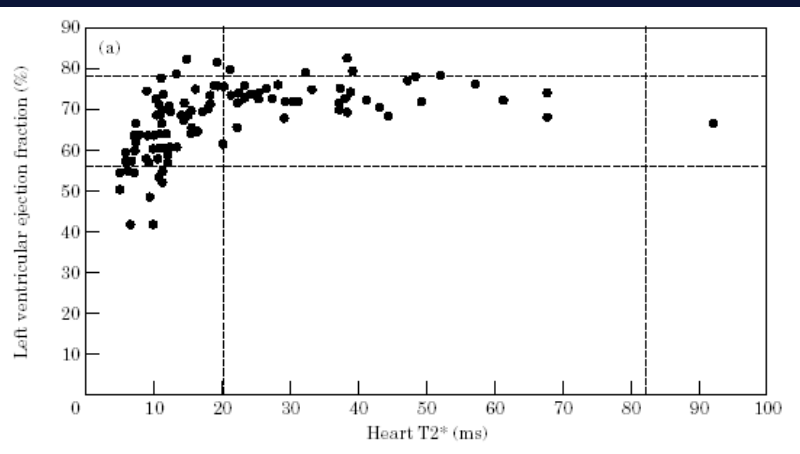


Figure 3.

Cardiovascular T2-star (T2*) magnetic resonance for the early diagnosis of myocardial iron overload

L. J. Anderson¹, S. Holden², B. Davis², E. Prescott³, C. C. Charrier¹, N. H. Bunce¹, D. N. Firmin¹, B. Wonke³, J. Porter², J. M. Walker² and D. J. Pennell¹

¹Cardiovascular MR Unit, Royal Brompton Hospital, London; ²University College Hospital, London; ³Whitington Hospital, London, U.K.



Cardiac T2* CMR identifies patients at high risk of heart failure and arrhythmia from myocardial siderosis in thalassemia major and is superior to serum ferritin and liver iron.

Kirk P et al. *Circulation*. 2009;120:1961-1968

Modell B et al. *JCMR* 2008, 10:42

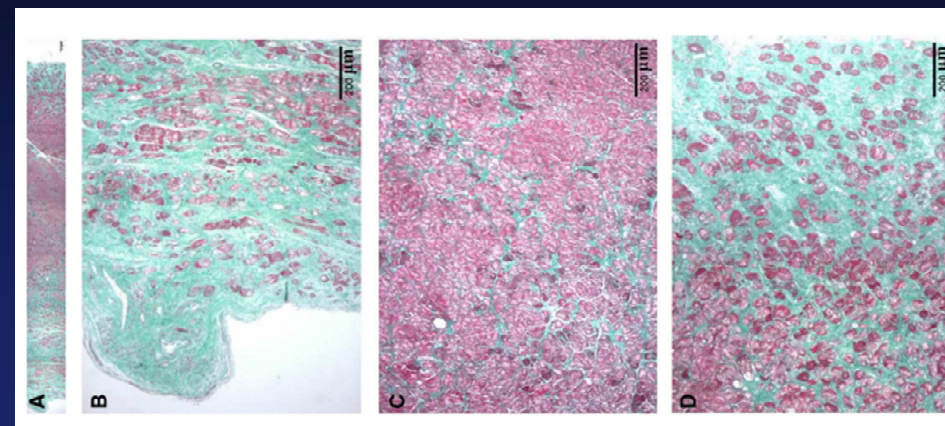
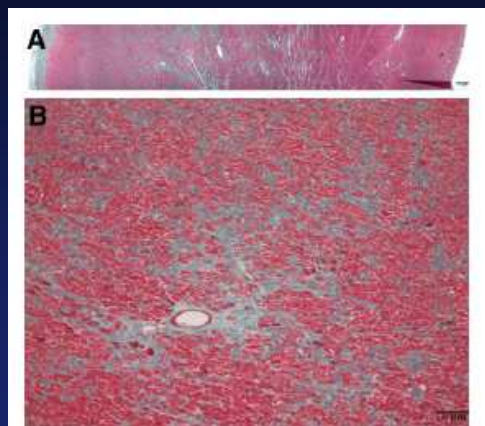
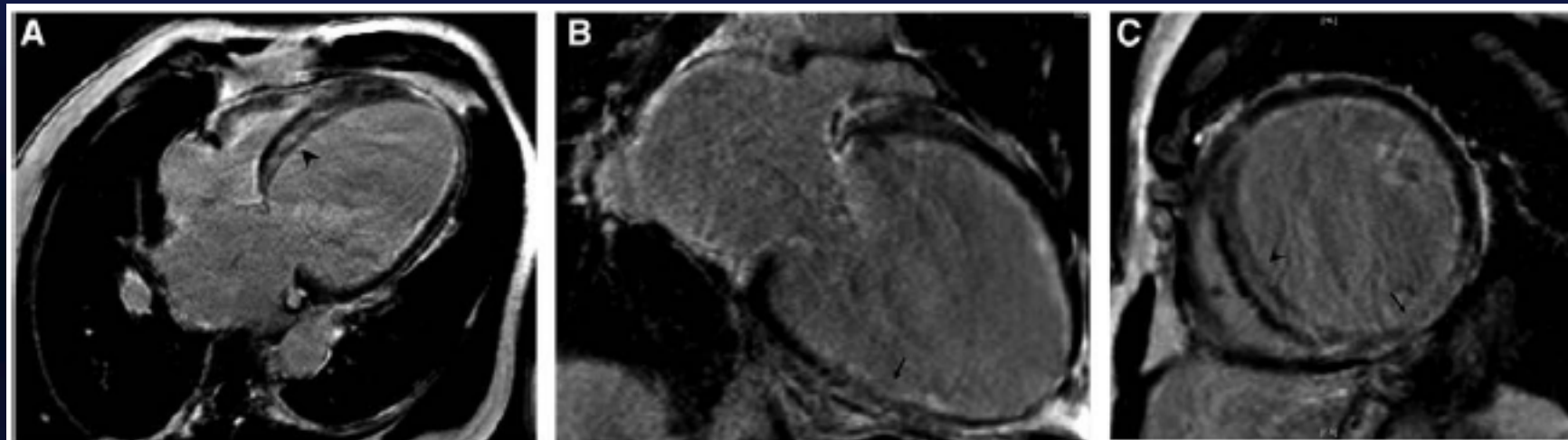
<http://www.rochitte.med.br>

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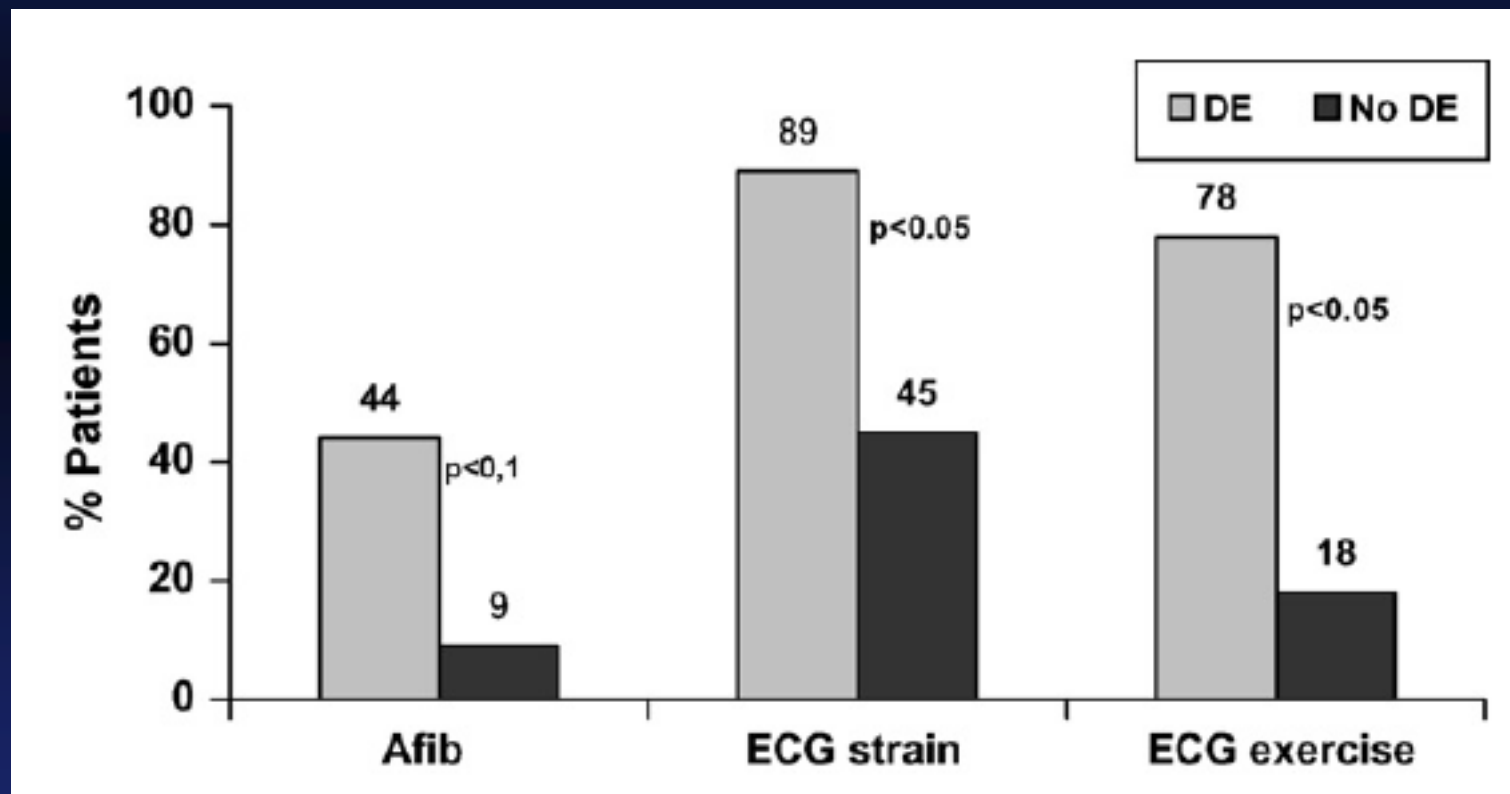
Anderson LJ et al. 2001 *Eur Heart J*; 22: 2171-2179

MF Histopathology

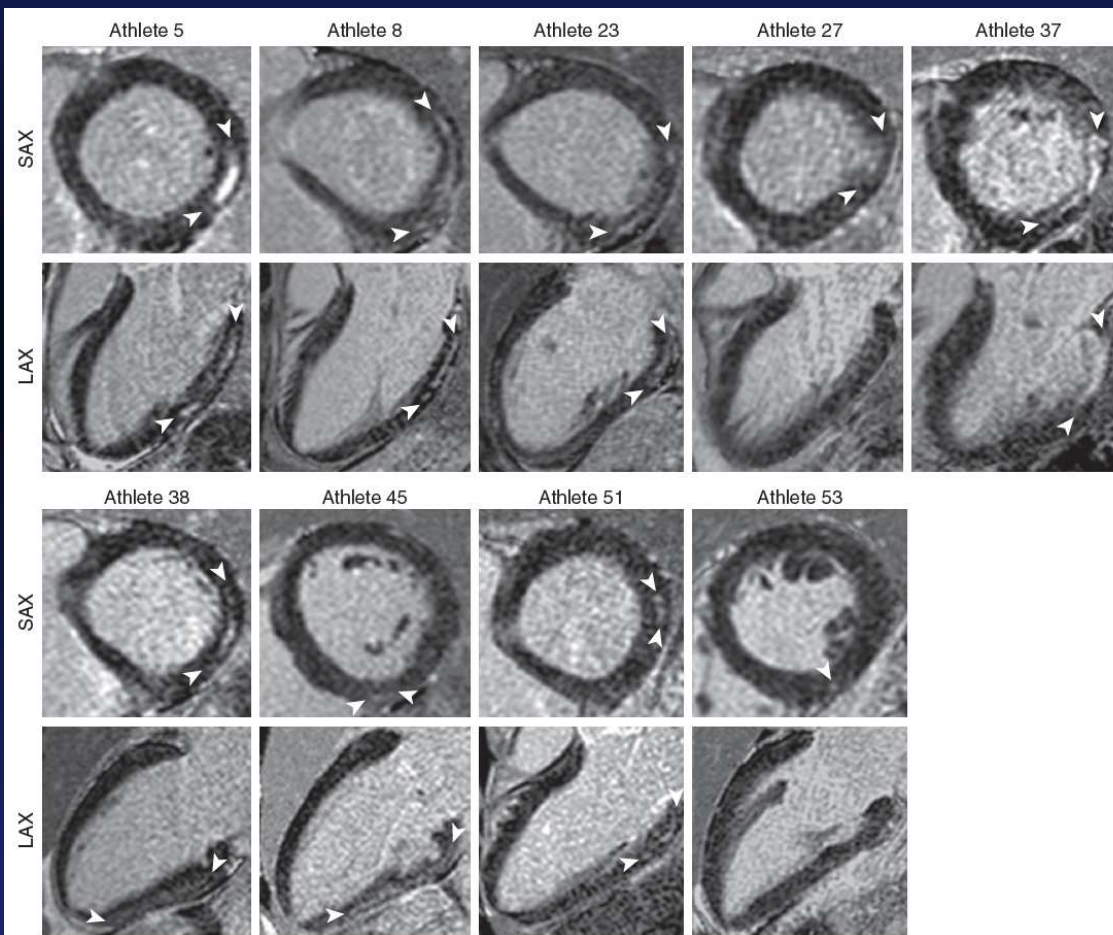
- Histological basis of myocardial LGE in patients with systemic hypertension: localized myocardial interstitial fibrosis in the midwall (or outer myocardium) and replacement fibrosis in the subendocardium.



- 45% of patients with arterial hypertension showed DE on cardiac MRI

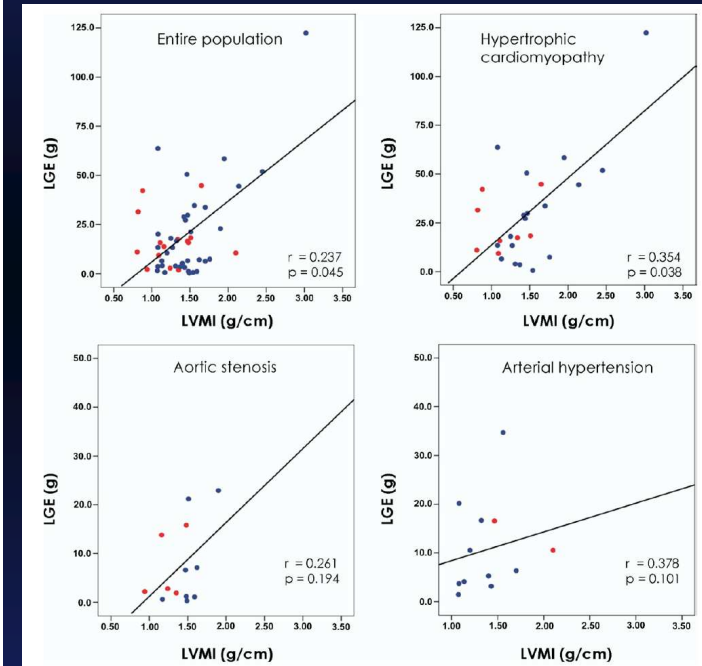
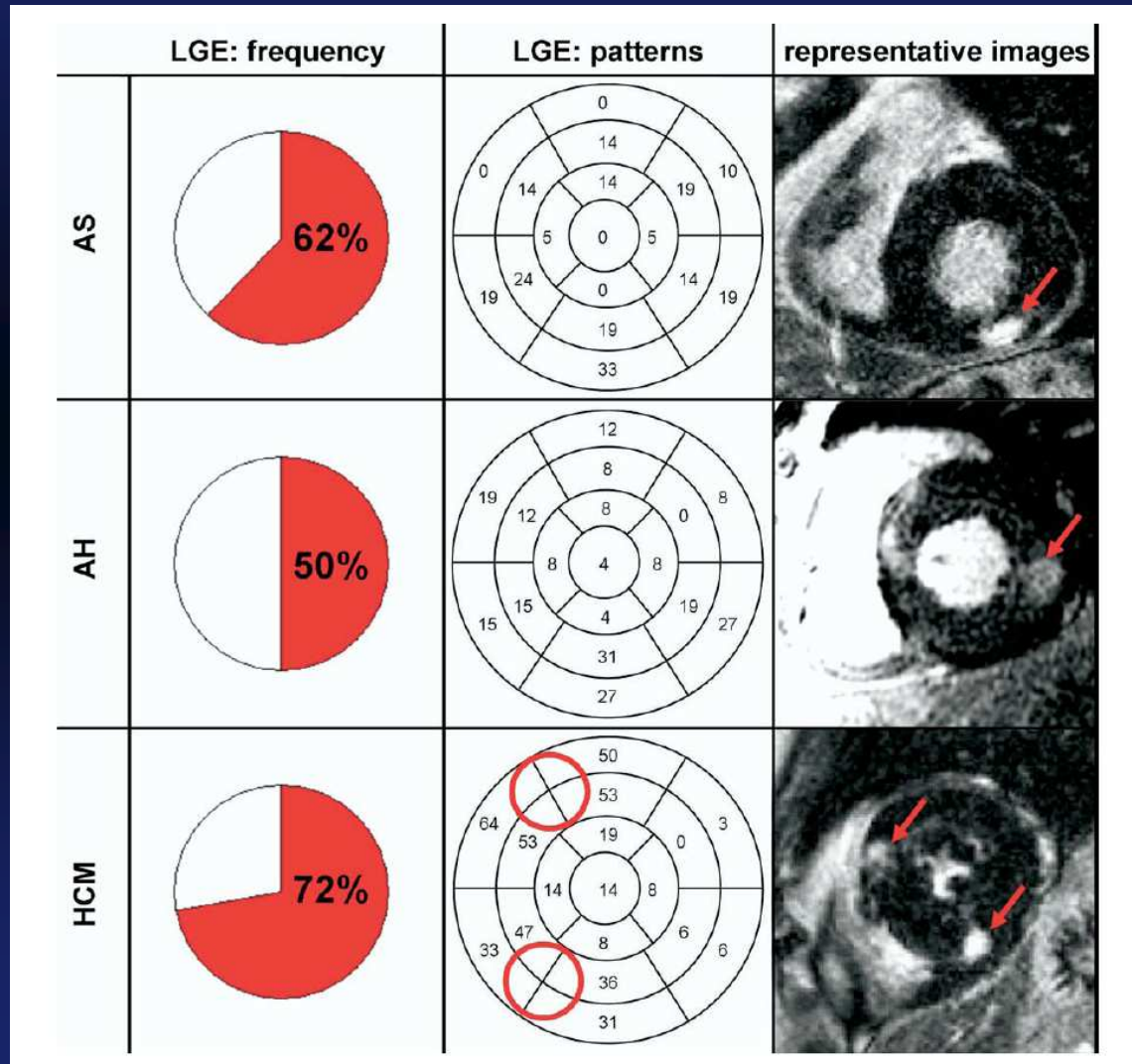


Myocardial Fibrosis in Competitive Triathletes Detected by Contrast-Enhanced CMR Correlates With Exercise-Induced Hypertension and Competition History



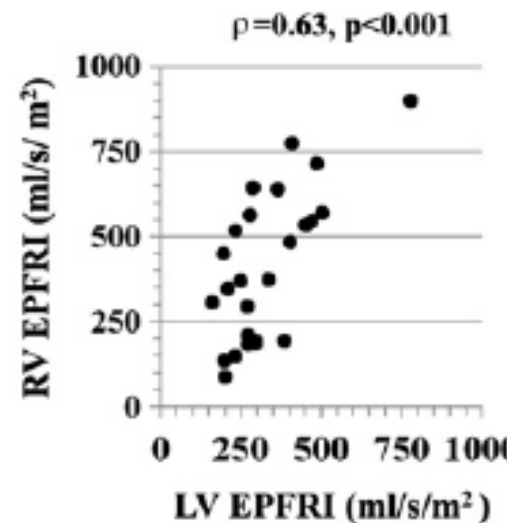
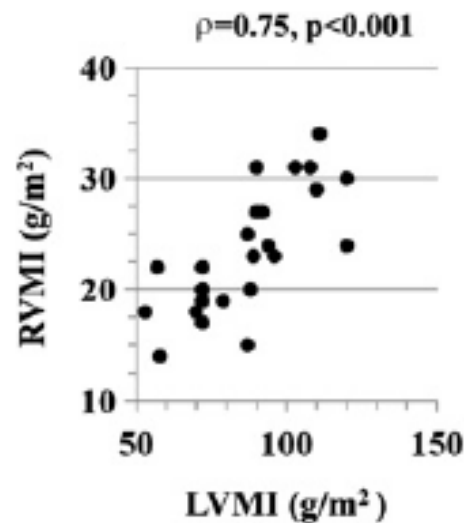
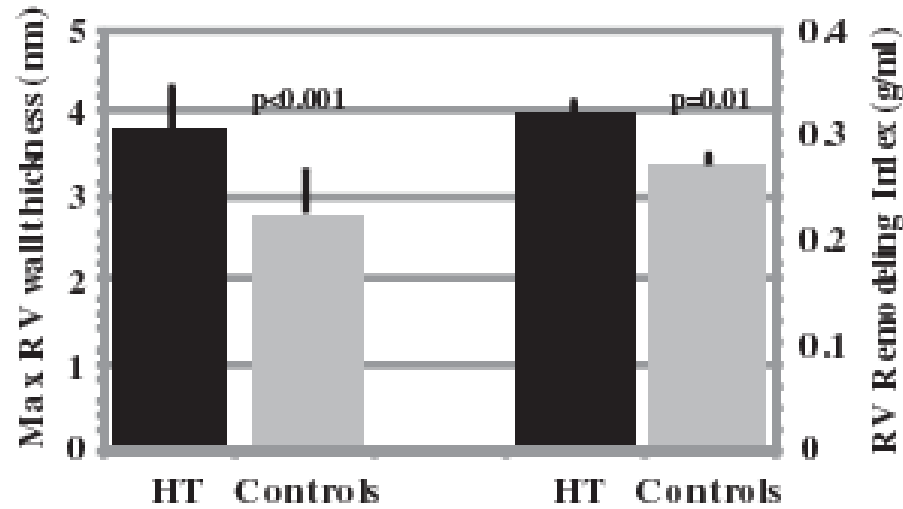
Noninvasive Detection of Fibrosis Applying Contrast-Enhanced Cardiac Magnetic Resonance in Different Forms of Left Ventricular Hypertrophy

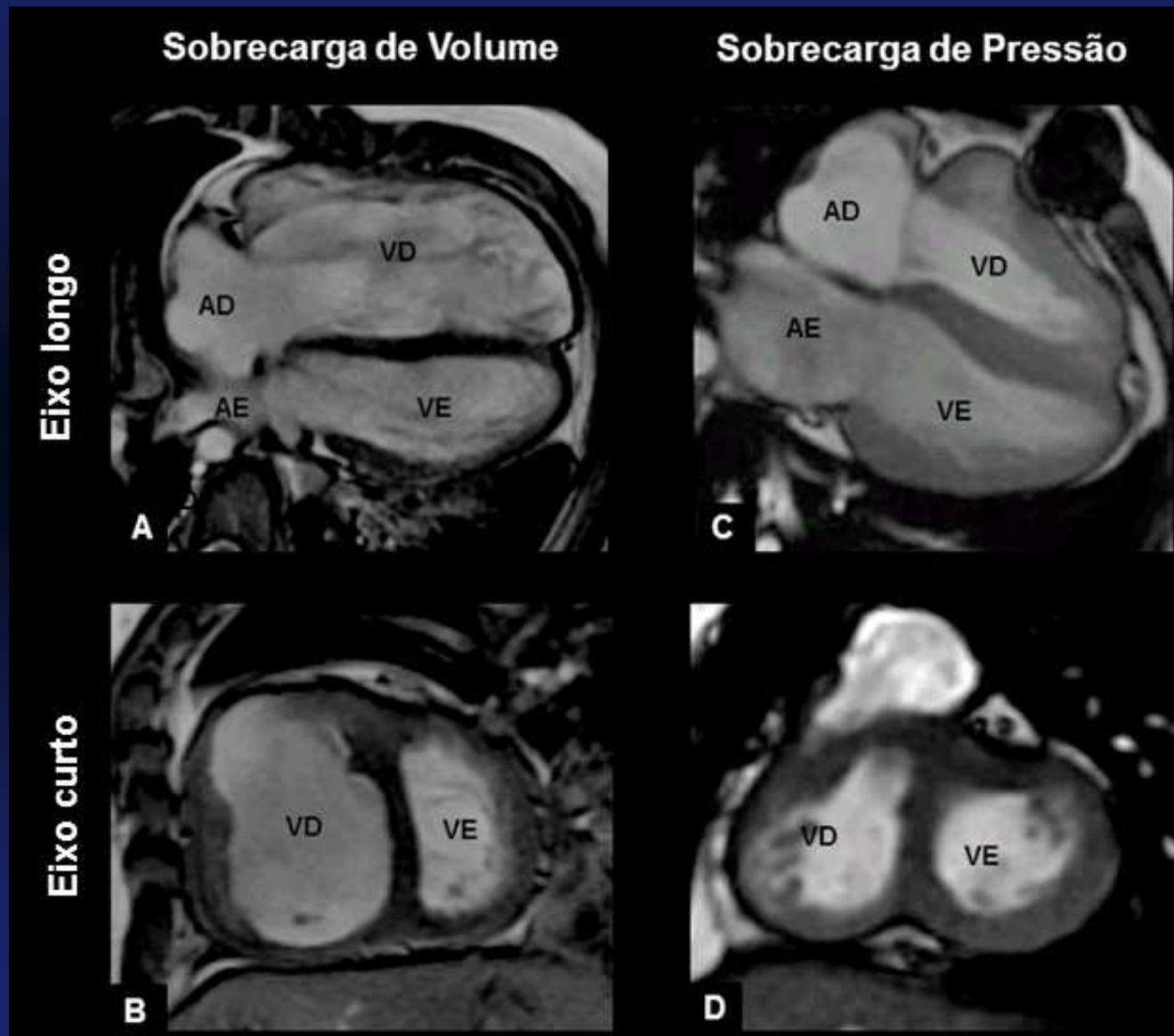
Relation to Remodeling



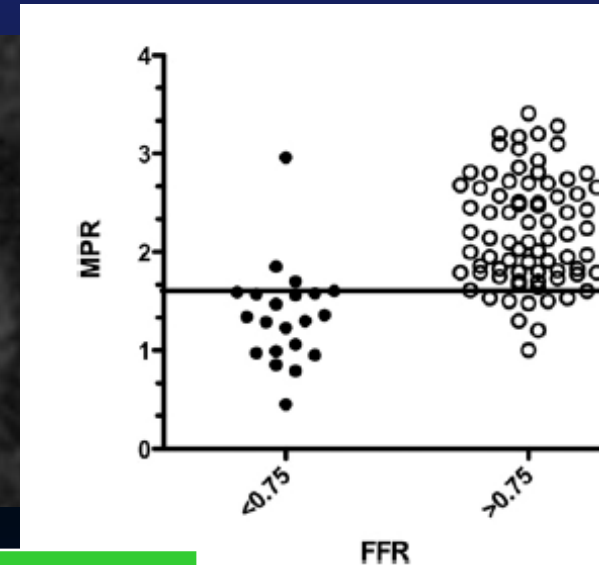
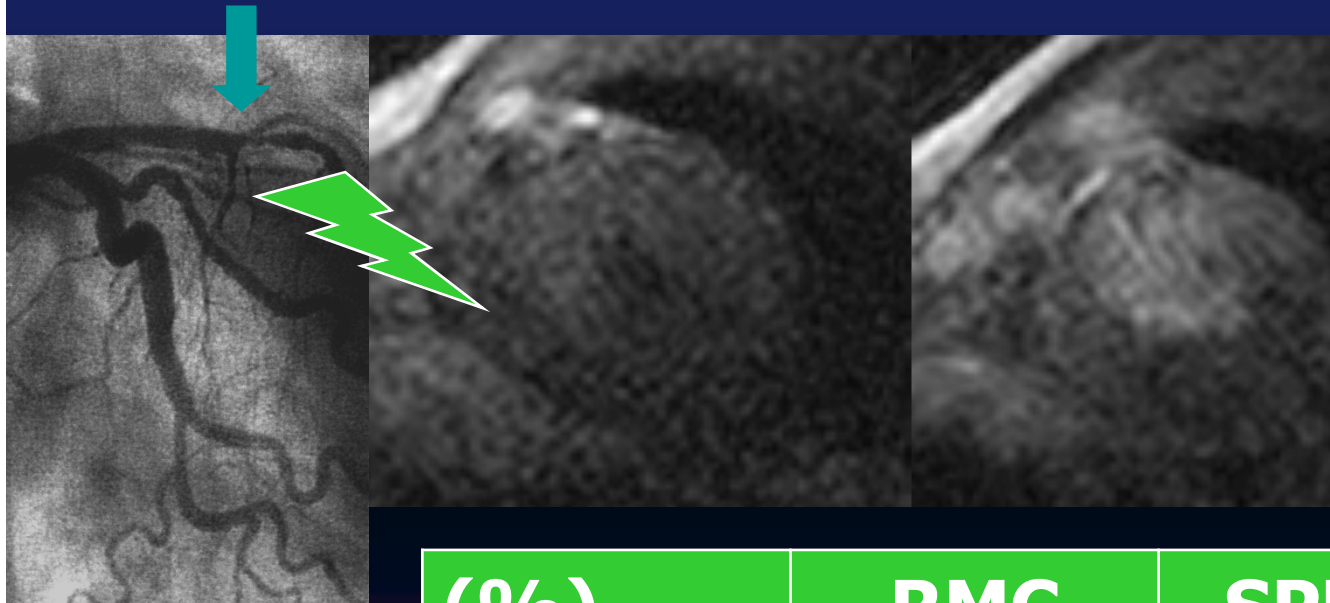
Rudolph A. et al.
J Am Coll Cardiol 2009;53:284-91

Right ventricular remodelling in systemic hypertension: a cardiac MRI study





DAC - Isquemia Miocárdica



(%)	RMC	SPECT
Sens	86.5	66.5
Espec	83.4	82.6
VPP	77.2	71.4
VPN	90.5	79.1

Lockie T et al. J Am Coll Cardiol 2011;57:70–5

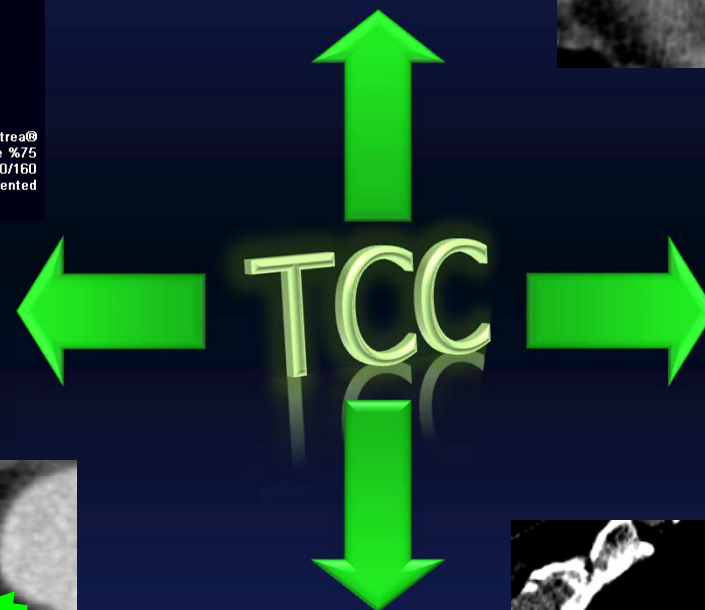
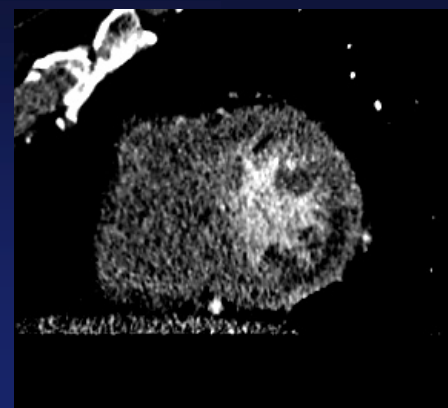
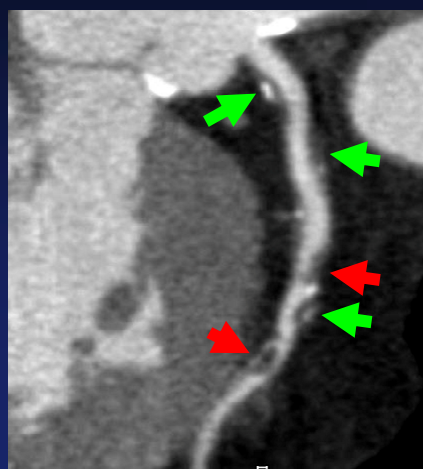
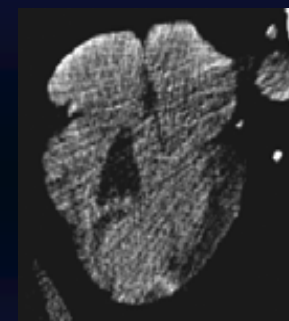
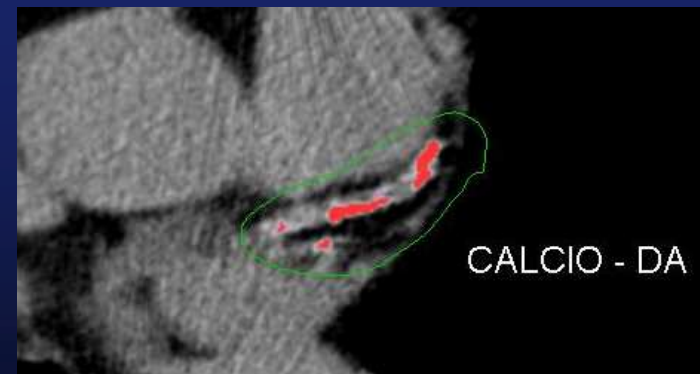
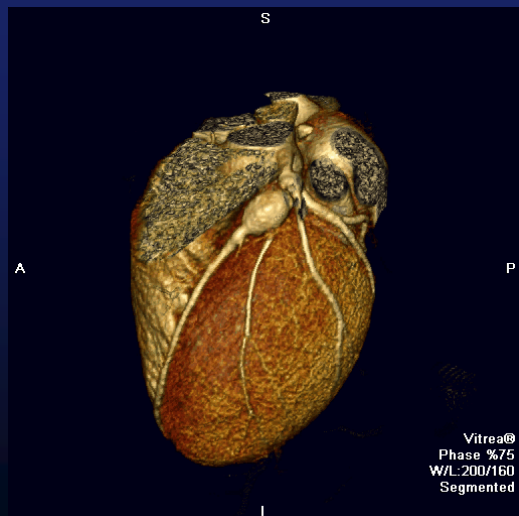
Greenwood JP et. al. Lancet. 2012;379:453-60

<http://www.rochitte.med.br>

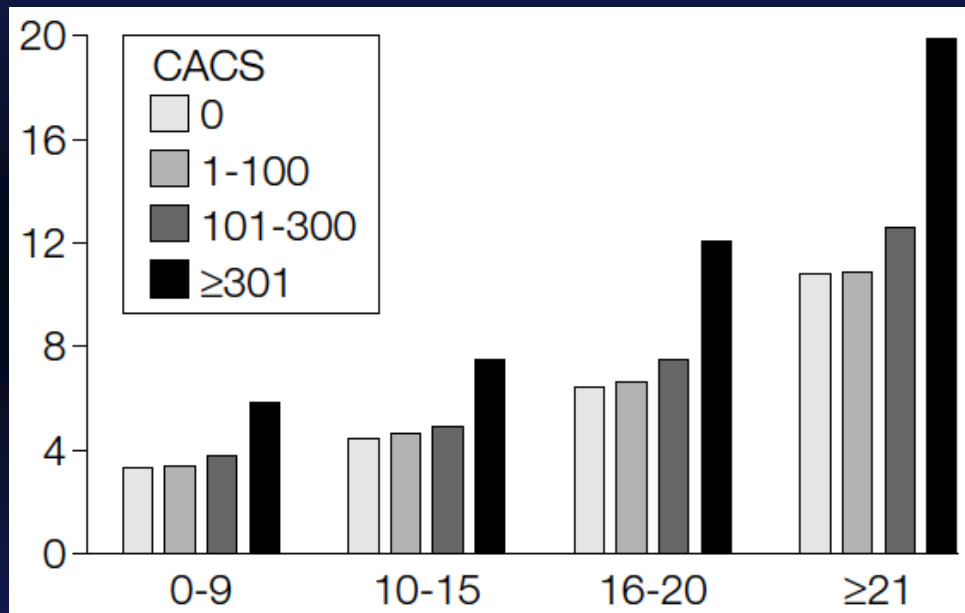
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Aorta torácica e abdominal



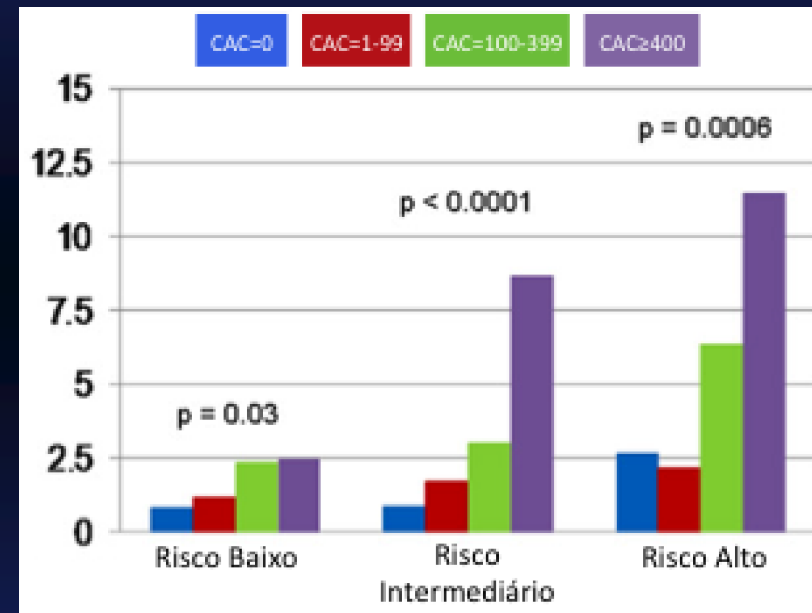


Preditor de Eventos Coronários



Score de Risco de Framingham

Greenland et al. JAMA 2004; 291:210-5

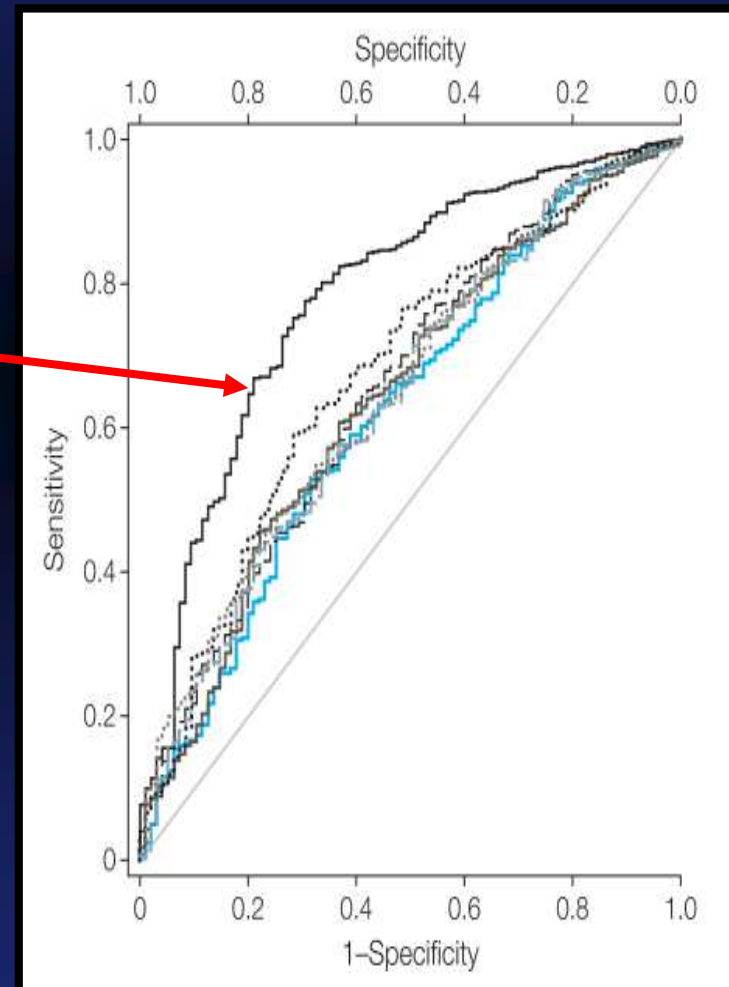
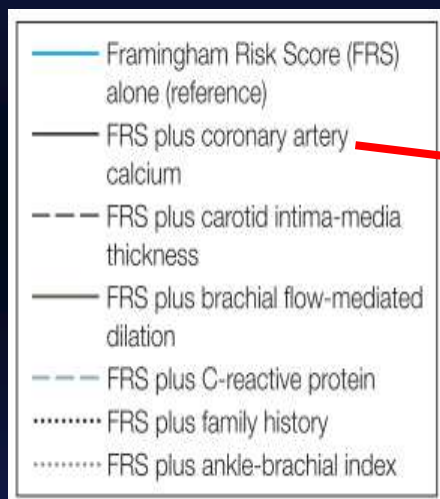


Score de Risco de Framingham

Mohlenkamp et al. JACC 2011; 57:1455-64

Risk Markers Accuracy

■ Intermediate risk:

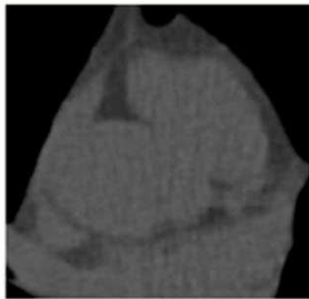
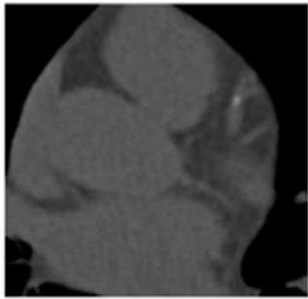
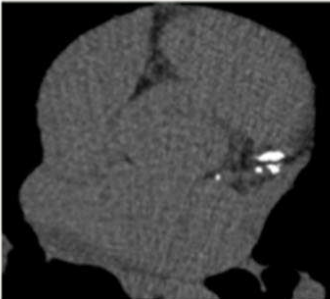


AUC FRS + CAC = **0,784**
 AUC FRS + HF = 0,675

YEBOAH, J. et al. JAMA, 2012.



O Que Fazer Depois

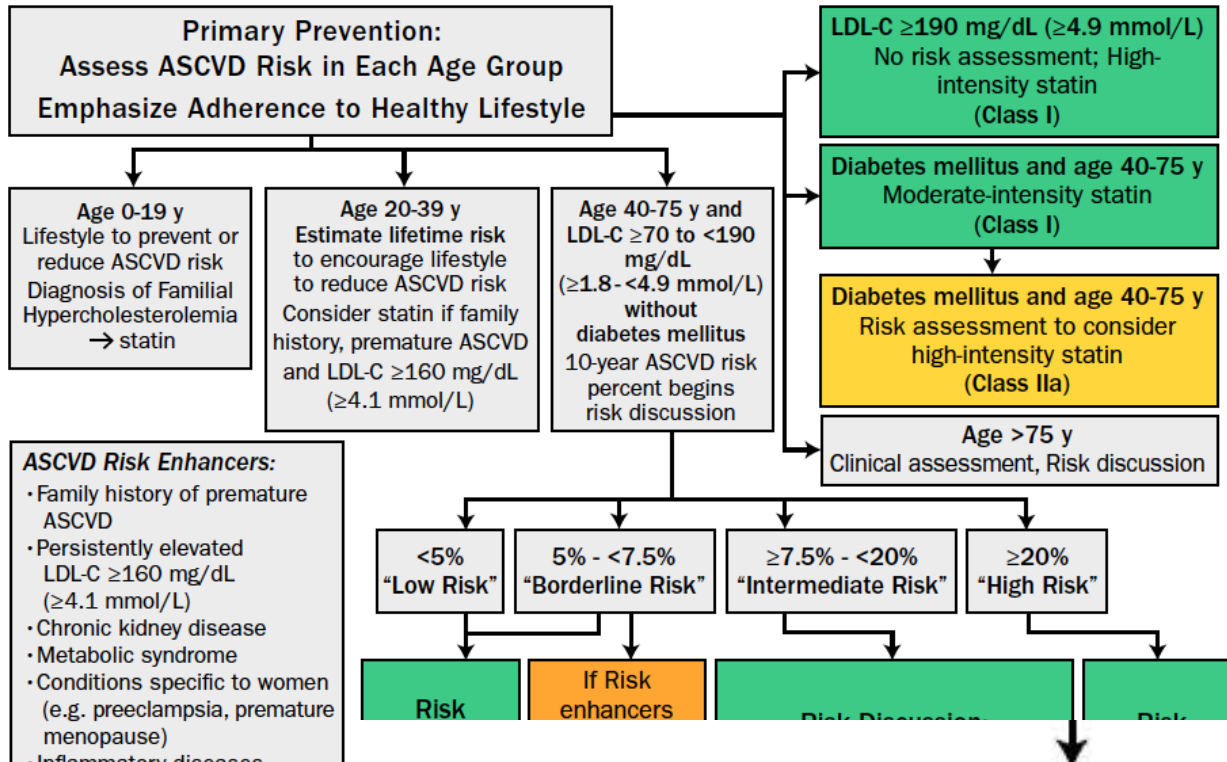
		 CAC = 0	 CAC 1-100	 CAC > 100
Population (% patients) ³²		56%	26%	18%
Annual CHD Event Rate ³³		0.1%	0.5%	1.9%
Annual CVD Event Rate ³²		0.4%	0.8%	2.4%
Number Needed to Treat (NNT) to Prevent One CHD Event Over 5-Years				
NNT Aspirin ³²	FRS <10%	2036	571 [^]	173
	FRS ≥10%	808	146 [^]	92
NNT Statin ³³		549	94	24
		↓	↓	↓
		Reassure	Individualize Statin + Aspirin	Treat with Statin + Aspirin
All Patients: Lifestyle Management + Control CVD Risk Factors				

Thomas DM et al. Curr Cardiovasc Imaging Rep. 2015;8(6):18

Primary Prevention Over The Life Span

Fourth Statin Benefit Group

Primary Prevention



- ASCVD Risk Enhancers:**
- Family history of premature ASCVD
 - Persistently elevated LDL-C ≥160 mg/dL (≥4.1 mmol/L)
 - Chronic kidney disease
 - Metabolic syndrome
 - Conditions specific to women (e.g. preeclampsia, premature menopause)
 - Inflammatory diseases (especially rheumatoid arthritis, psoriasis, HIV)
 - Ethnicity factors (e.g. South Asian ancestry)
- Lipid/Biomarkers:**
- Persistently elevated triglycerides (≥175 mg/mL)
- In selected individuals if measured:**
- hs-CRP ≥2.0 mg/L
 - Lp(a) levels >50 mg/dL or >125 nmol/L
 - apoB ≥130 mg/dL
 - Ankle-brachial index (ABI) <0.9

**If risk decision is uncertain:
Consider measuring CAC in selected adults:**

CAC = zero (lowers risk; consider no statin, unless diabetes, family history of premature CHD, or cigarette smoking are present)

CAC = 1-99 favors statin (especially after age 55)

CAC = 100+ and/or ≥75th percentile, initiate statin therapy

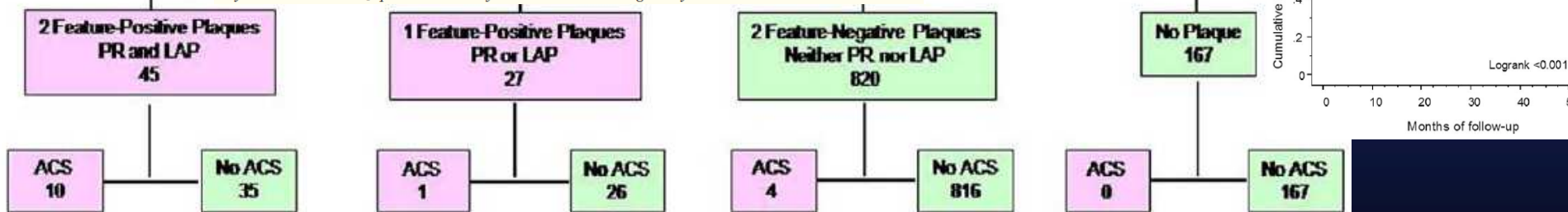


Grundy SM, et al.
2018 Cholesterol Clinical Practice Guidelines
<https://doi.org/10.1016/j.jacc.2018.11.003>

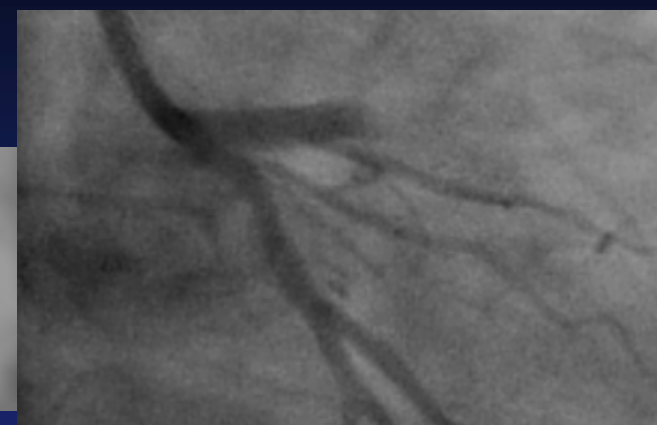
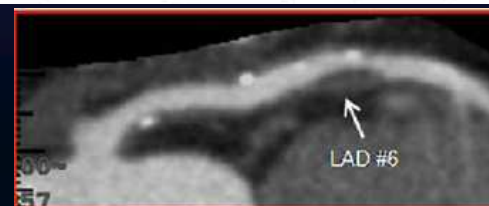
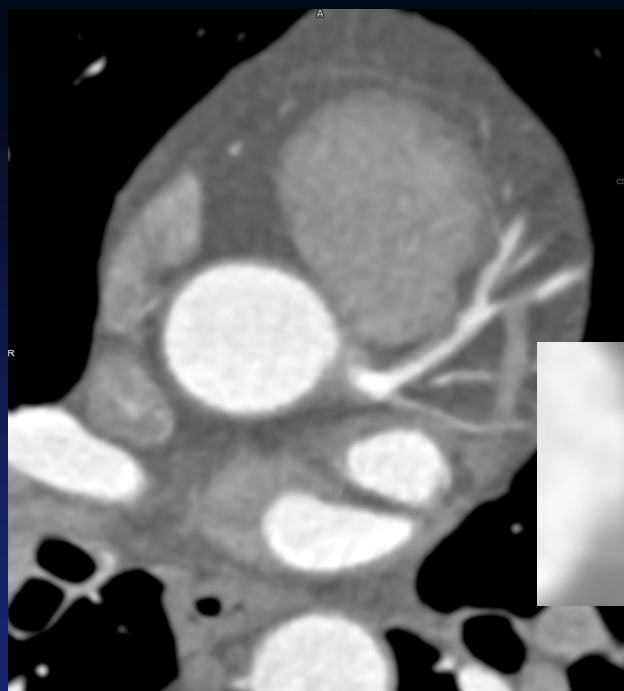
Computed Tomographic Angiography Characteristics of Atherosclerotic Plaques Subsequently Resulting in Acute Coronary Syndrome

Sadako Motoyama, MD, PhD,*‡ Masayoshi Sarai, MD, PhD,* Hiroto Harigaya, MD,*
Hirofumi Anno, MD, PhD,† Kaori Inoue, MD,* Tomonori Hara, MD,* Hiroyuki Naruse, MD, PhD,*
Junichi Ishii, MD, PhD,* Hitoshi Hishida, MD, PhD,* Nathan D. Wong, PhD,‡ Renu Virmani, MD,§
Takeshi Kondo, MD, PhD,|| Yukio Ozaki, MD, PhD,* Jagat Narula, MD, PhD‡

Toyake and Takasaki, Japan; Irvine, California; and Gaithersburg, Maryland

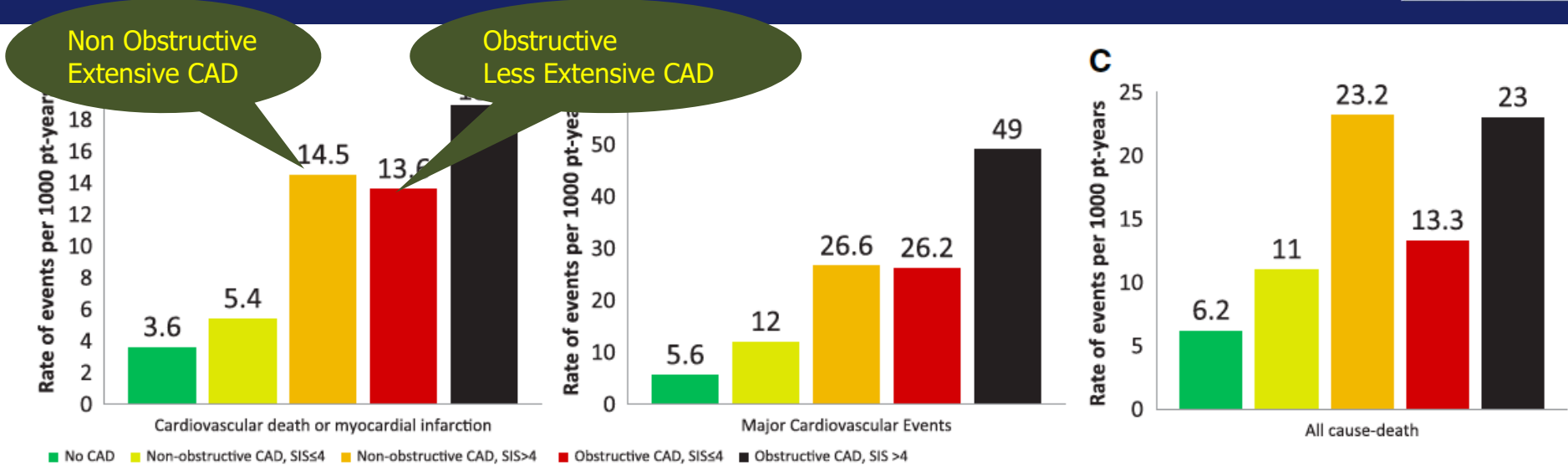


J Am Coll Cardiol 2009;54:49–57

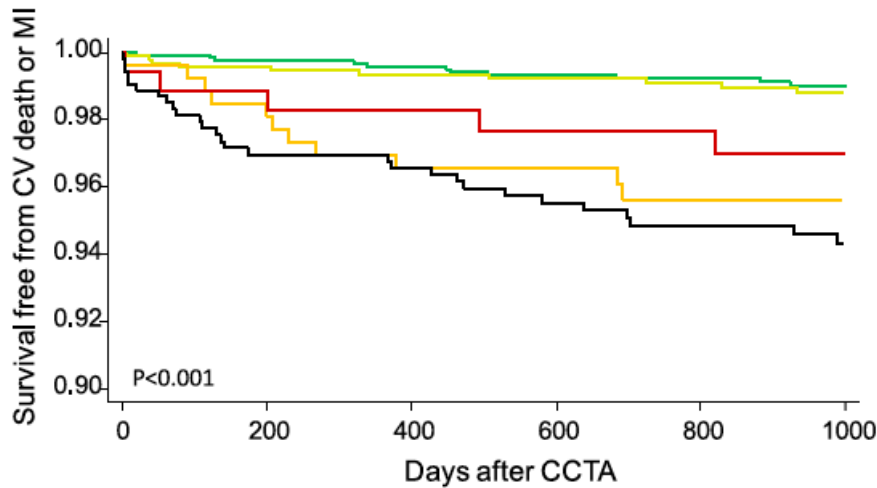


15/02/2013

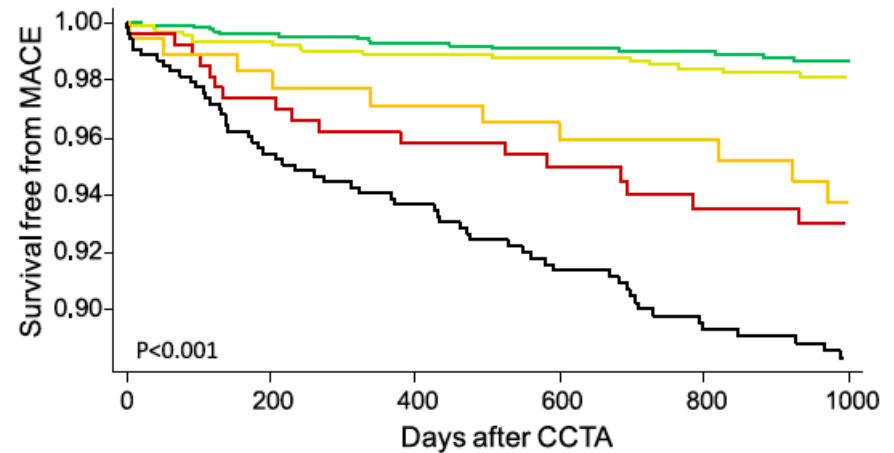
25/03/2014



A Survival free from CV death or Myocardial Infarction



B Survival free from major cardiovascular events

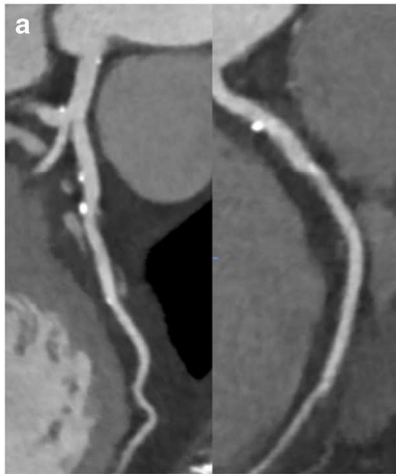


— No CAD — Non-obstructive CAD SIS<4 — Non-obstructive CAD with SIS>4 — Obstructive CAD with SIS<4 — Obstructive CAD with SIS>4

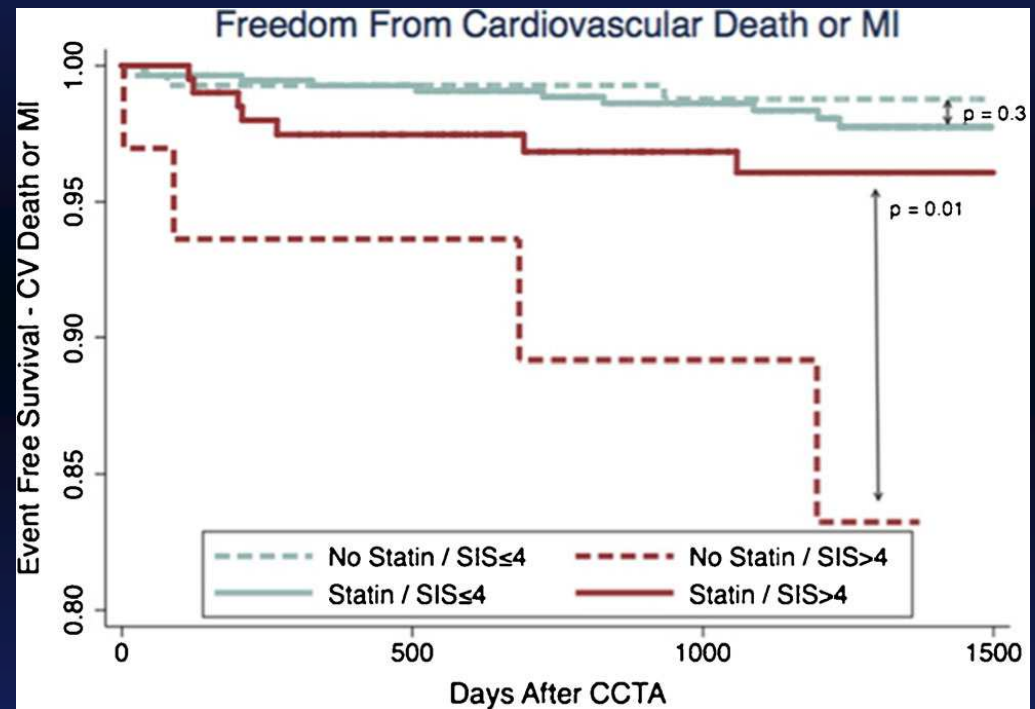
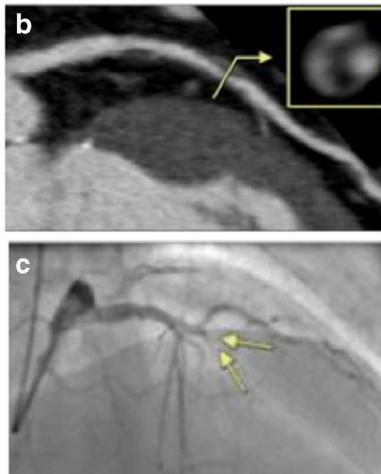
O Que Fazer Depois

Revise risk upwards if:

Extensive disease
(>4 segments involved)



CTA-identified
high-risk plaque features*

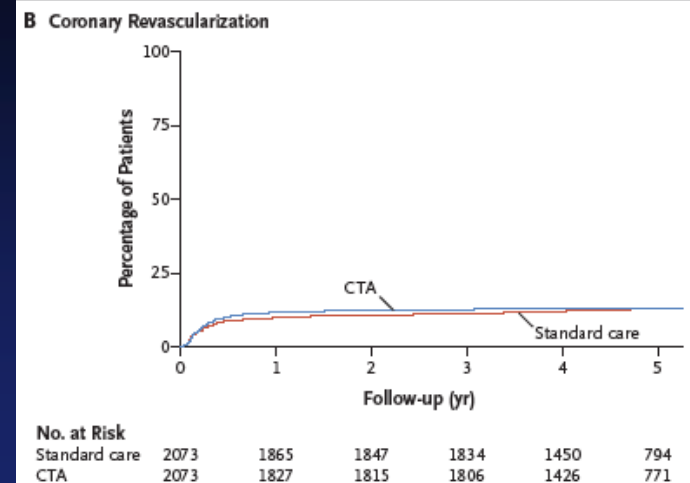
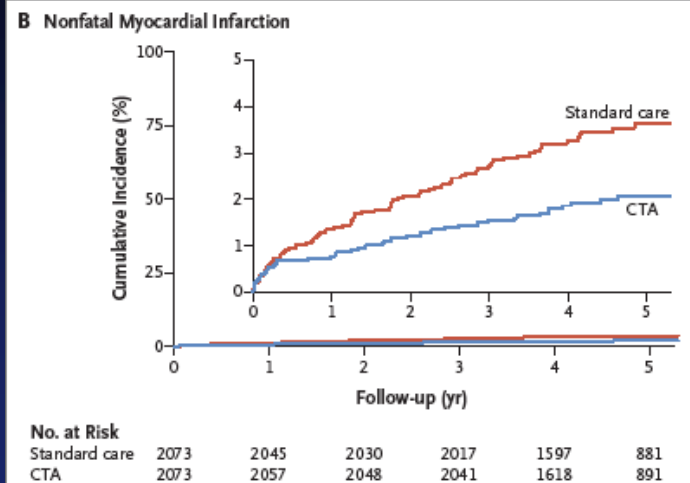
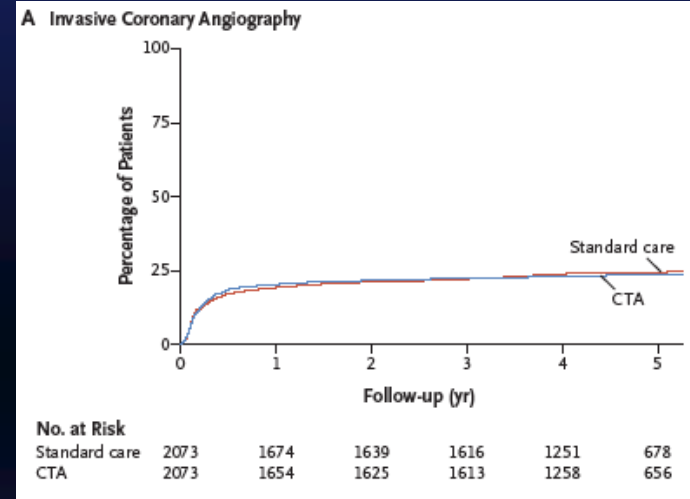
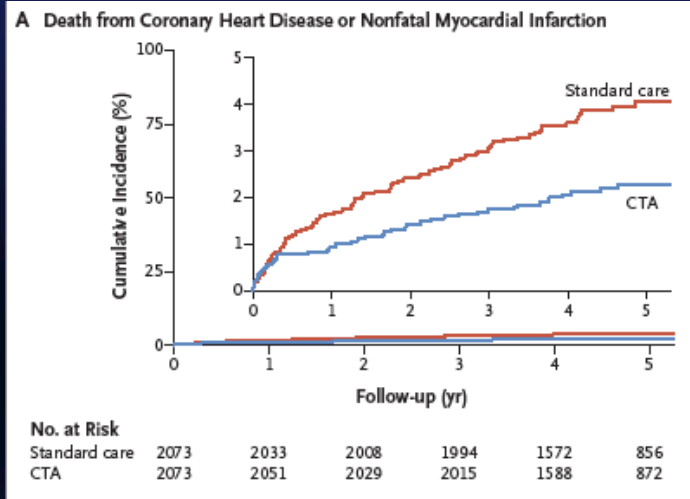


Thomas DM et al. Curr Cardiovasc Imaging Rep. 2015;8(6):18

ORIGINAL ARTICLE

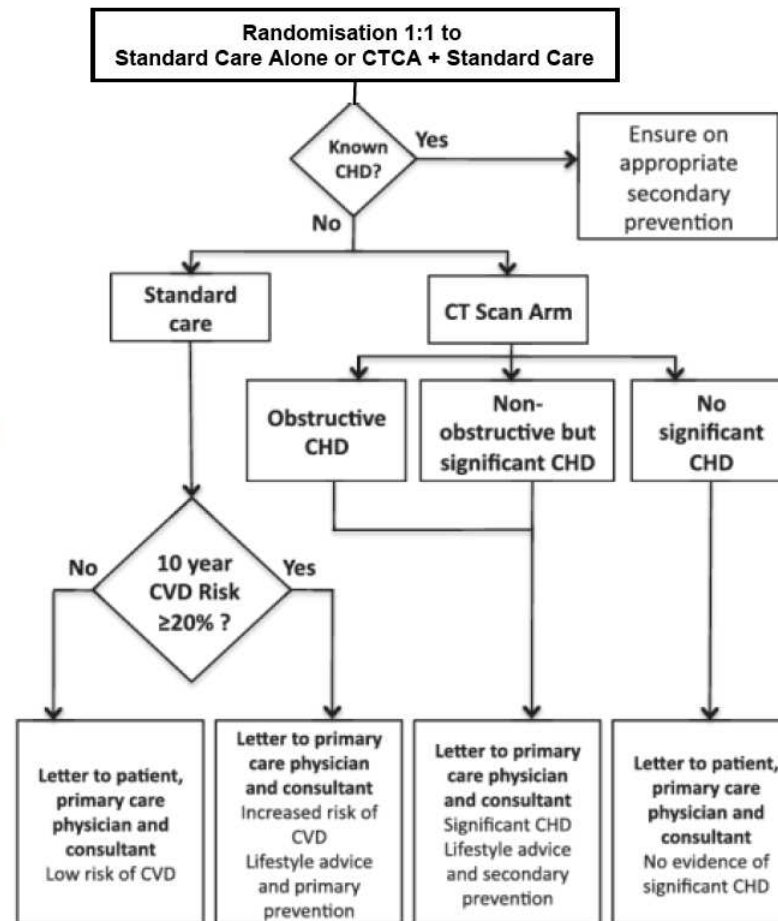
Coronary CT Angiography and 5-Year Risk of Myocardial Infarction

The SCOT-HEART Investigators*

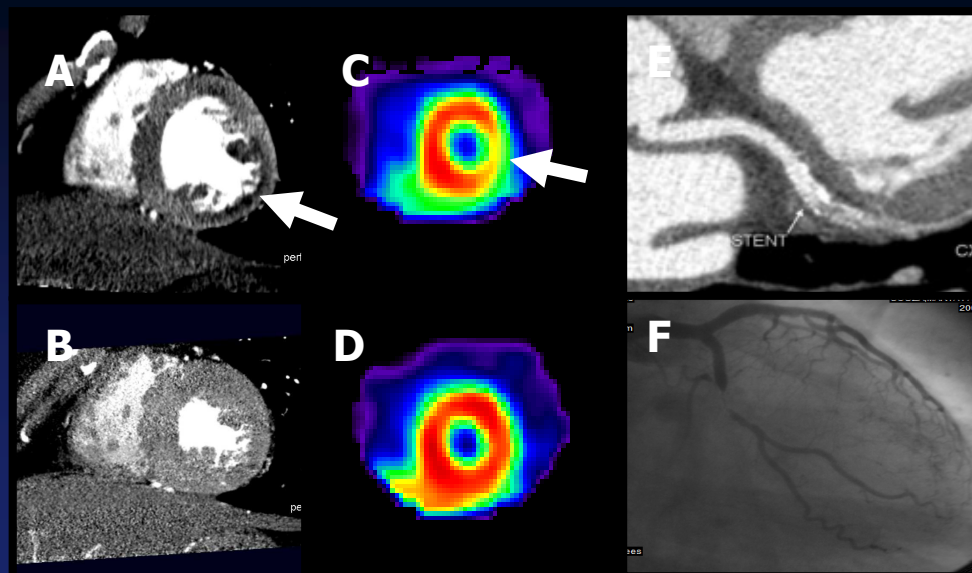
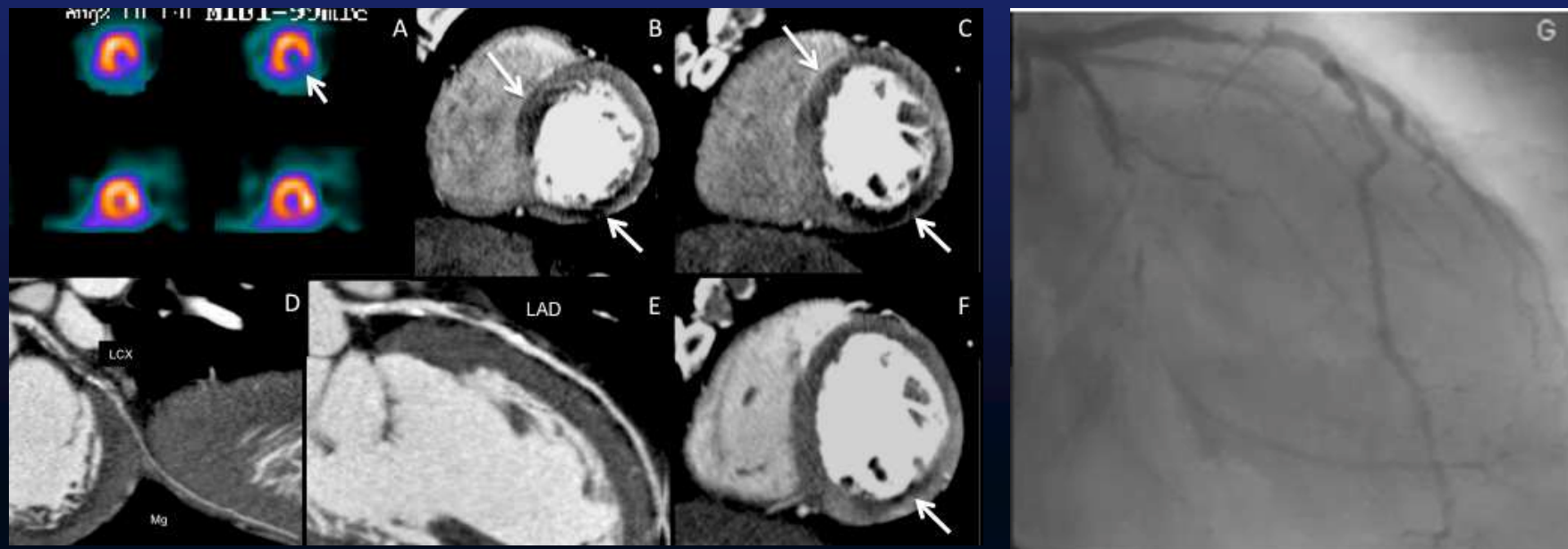




Healthy
Living



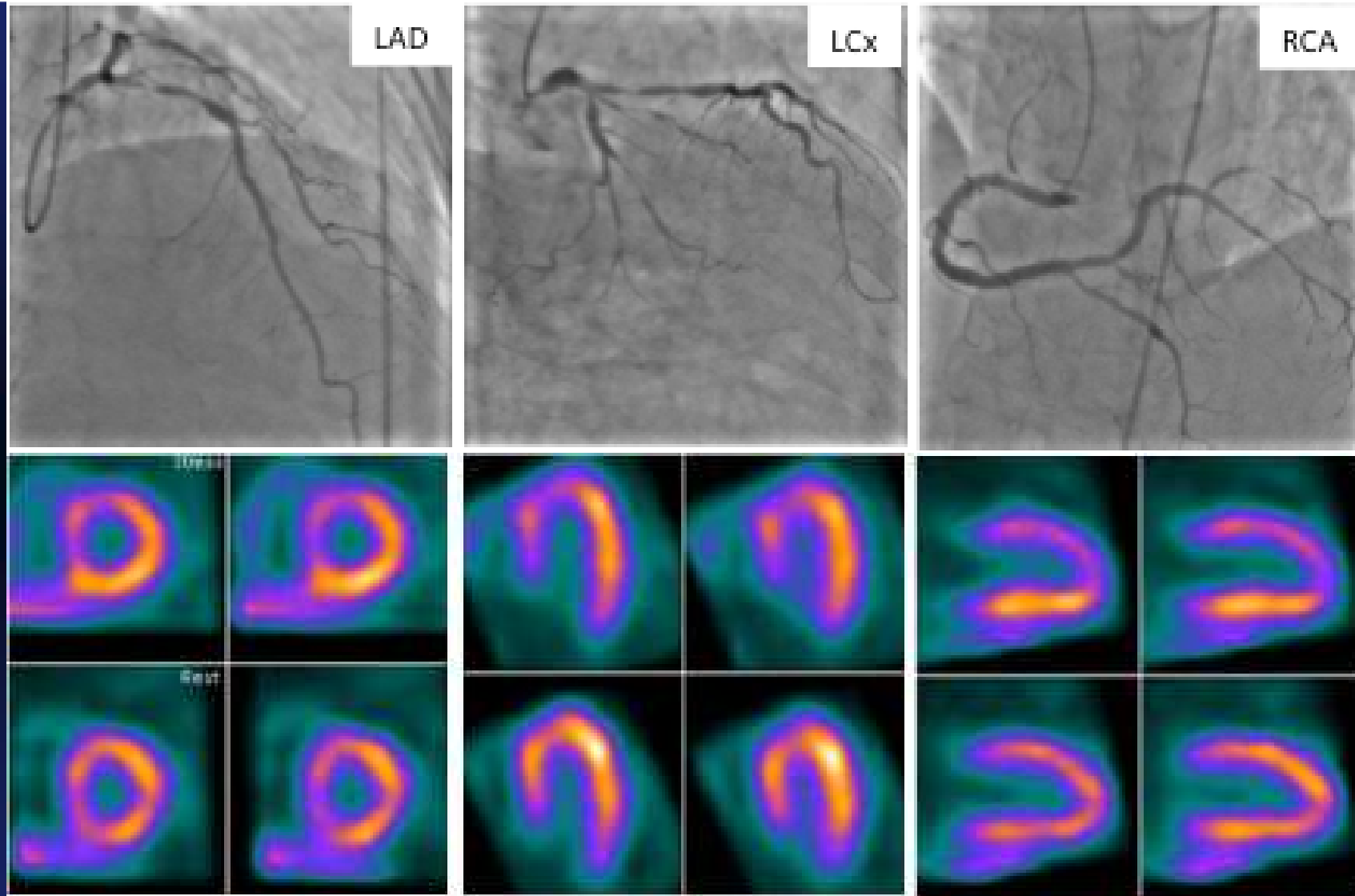
Single Center Study





Computed tomography angiography and perfusion to assess coronary artery stenosis causing perfusion defects by single photon emission computed tomography: the CORE320 study

Carlos E. Rochitte^{4†}, Richard T. George^{1†}, Marcus Y. Chen⁵, Armin Arbab-Zadeh¹, Marc Dewey⁶, Julie M. Miller¹, Hiroyuki Niinuma^{7,8}, Kunihiro Yoshioka⁷, Kakuya Kitagawa⁹, Shiro Nakamori⁹, Roger Laham¹⁰, Andrea L. Vavere¹, Rodrigo J. Cerci¹, Vishal C. Mehra¹, Cesar Nomura¹¹, Klaus F. Kofoed¹², Masahiro Jinzaki¹³, Sachio Kuribayashi¹³, Albert de Roos¹⁴, Michael Laule⁶, Swee Yaw Tan¹⁵, John Hoe¹⁶, Narinder Paul¹⁷, Frank J. Rybicki³, Jeffery A. Brinker¹, Andrew E. Arai⁵, Christopher Cox², Melvin E. Clouse¹⁰, Marcelo F. Di Carli³, and Joao A.C. Lima^{1*}

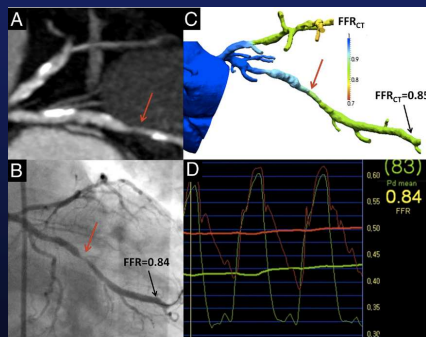


Rochitte et al. European Heart Journal (2014) 35, 1120–1130

<http://www.rochitte.med.br>

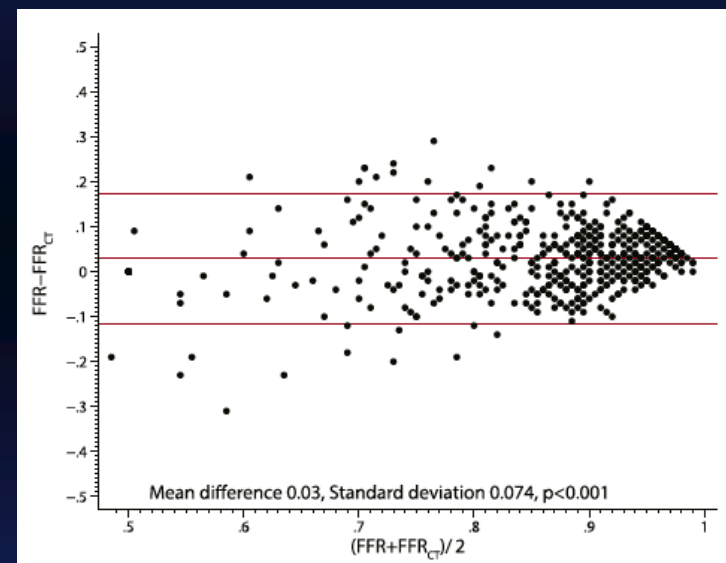
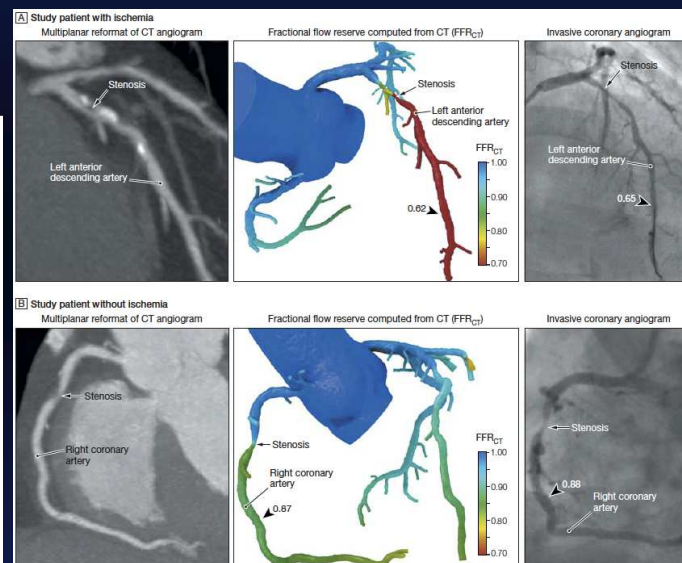
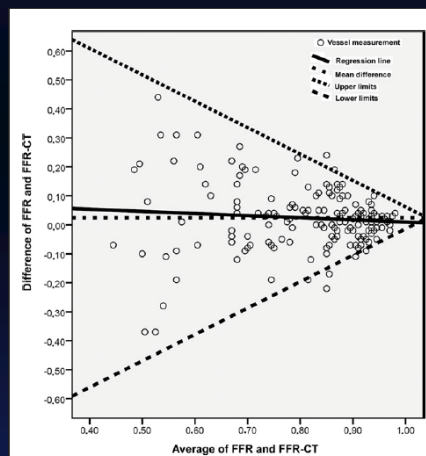
rochitte@incor.usp.br

FFR_{CT} vs. FFR



	FFR _{CT} ≤ 0.80		CT ≥ 50%	
	Estimate, % (95% CI)	No. of Patients in Group	Estimate, % (95% CI)	No. of Patients in Group
Accuracy	73 (67-78)	252	64 (58-70)	252
Sensitivity	90 (84-95)	129	84 (77-90)	129
Specificity	54 (46-63)	123	42 (34-51)	123
PPV	67 (60-74)	172	61 (53-67)	180
NPV	84 (74-90)	80	72 (61-81)	72

	FFR _{CT} ≤ 0.80	Coronary CTA Stenosis > 50%	p Value
Accuracy	80 (75-85)	51 (44-57)	< 0.0001
Sensitivity	85 (74-91)	93 (85-97)	0.058
Specificity	79 (72-84)	32 (26-40)	< 0.0001
PPV	63 (53-72)	37 (31-44)	< 0.0001
NPV	92 (87-96)	91 (81-96)	0.42



Discovery-Flow

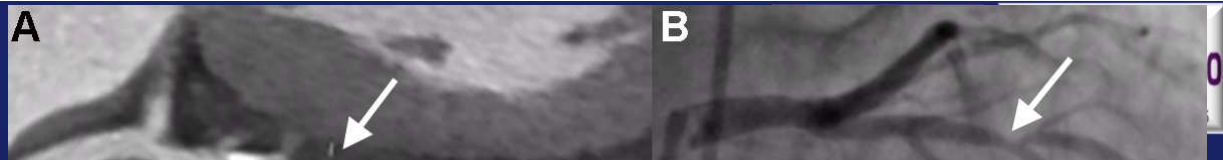
J Am Coll Cardiol. 2011 Nov 1;58(19):1989-97.

DeFacto

Min JK et al. JAMA. 2012;308(12):1237-1245

NXT

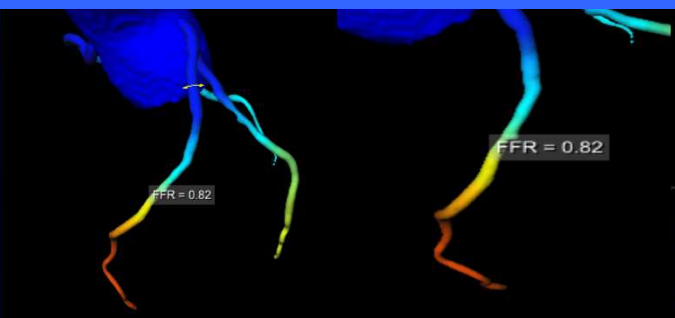
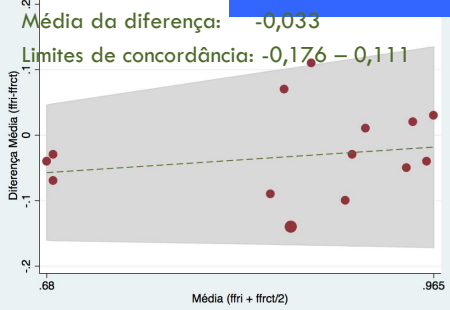
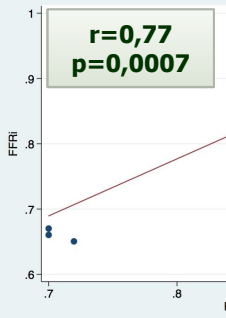
Norgaard B, et al. J Am Coll Cardiol. 2014 Apr 1;63(12):1145-55



$P=0,003$

Acurácia
TCCor 53%

Acurácia
FFRct 80%



Conclusões

- HAS → Lesão de Órgão Alvo
 - Coração e Vasos (CoAo, Renovasc, Adrenais)
- RMC
 - Fibrose miocárdica
 - focal – RT
 - difusa – Mapa T1 e ECV
 - Infarto e isquemia
- TCC
 - Estratificação de Risco Cardiovascular
 - Escore de Cálcio
 - DAC não obstrutiva → Placa Vulnerável
 - DAC obstrutiva
 - Avaliação anatômica – angioTC de Coronárias
 - Avaliação funcional → Perfusão, CTP e FFRct

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