Imaging in HFpEF : role of CMR

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- Consulting and lecture fees:
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  - Bayer
  - Bristol-Myers Squibb (BMS) – Pfizer
  - Vifor Pharma
  - Novartis
  - Boehringer Ingelheim
  - Amarin corporation
  - Siemens Healthineers (France, Global)
  - GE Healthcare (France)
  - MEDIS imaging
  - Hexacath

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  - Servier
  - Bayer

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ESC European Society of Cardiology
European Heart Journal (2021) **00**, 1–128
doi:10.1093/eurheartj/ehab368

2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

Developed by the Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC)

With the special contribution of the Heart Failure Association (HFA) of the ESC

Investigati… …onsider in selected patients		
CMR imaging is recommended to evaluate cardiac structure and function, to measure LVEF, and to characterize cardiac tissue, especially in subjects with inadequate echocardiographic images or where the echocardiographic findings are inconclusive or incomplete (but taking account of cautions/contraindications to CMR).	I	C
Coronary angiography is …coronary revascularization, to evaluate the coronary anatomy.	I	C
Myocardial perfusion/ischaemia imaging (echocardiography, CMR, SPECT, or PET) should be considered in patients thought to have CAD, and who are considered suitable for coronary revascularization, to determine whether there is reversible myocardial ischaemia and viable myocardium.	IIa	C

"… CMR is recommended to evaluate cardiac structure and function."

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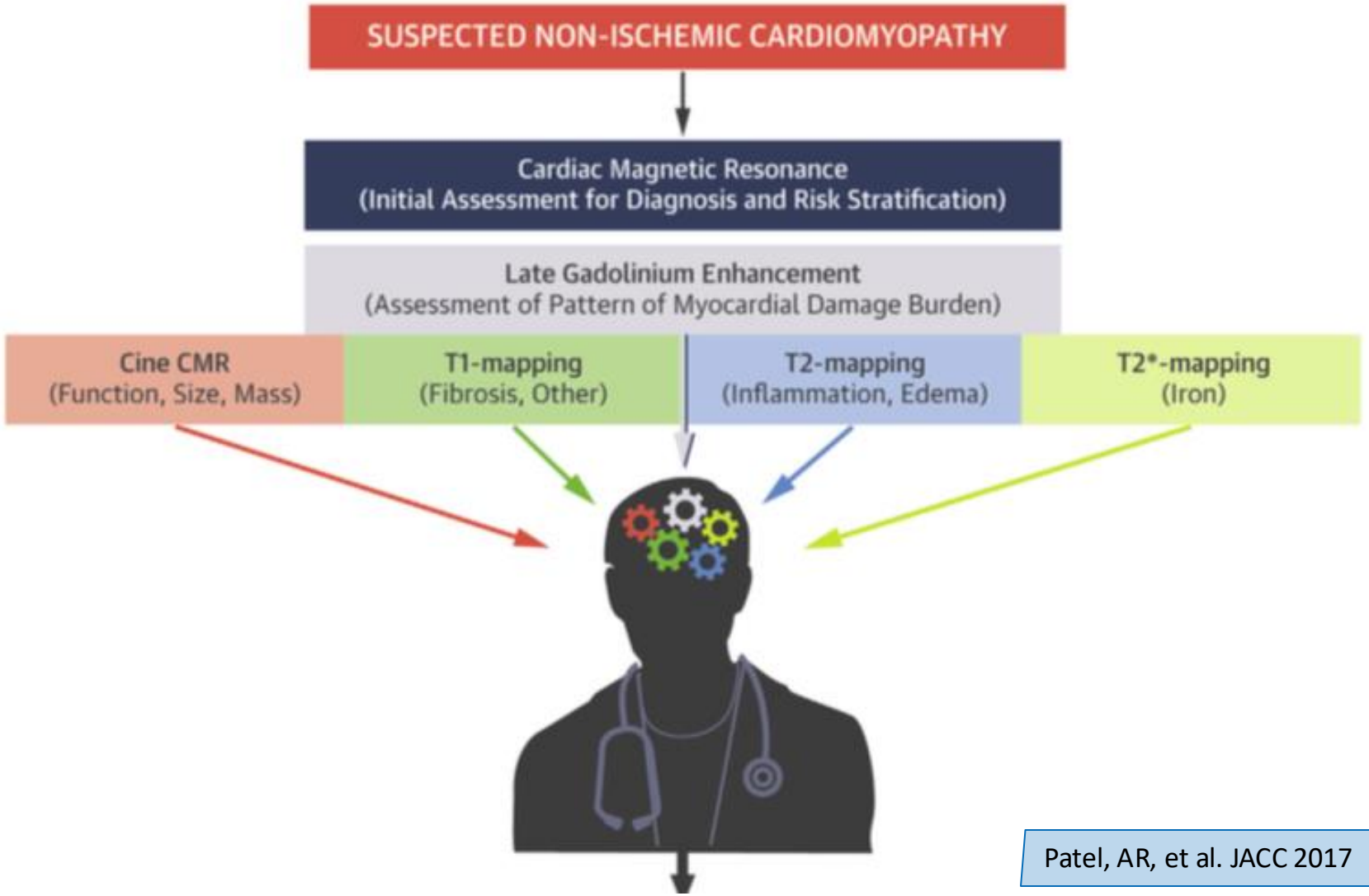
Role of CMR

Heart failure and cardiomyopathy



Patel, AR, et al. JACC 2017

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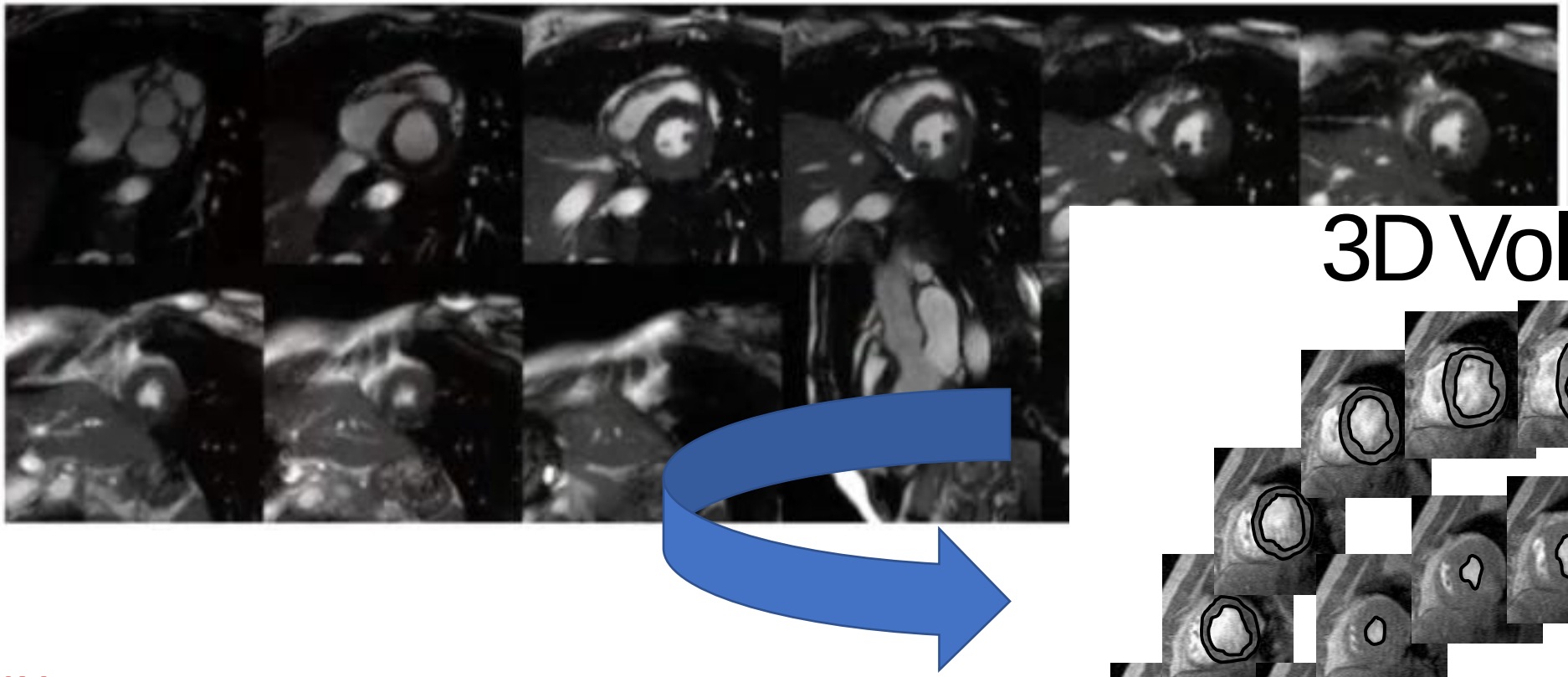
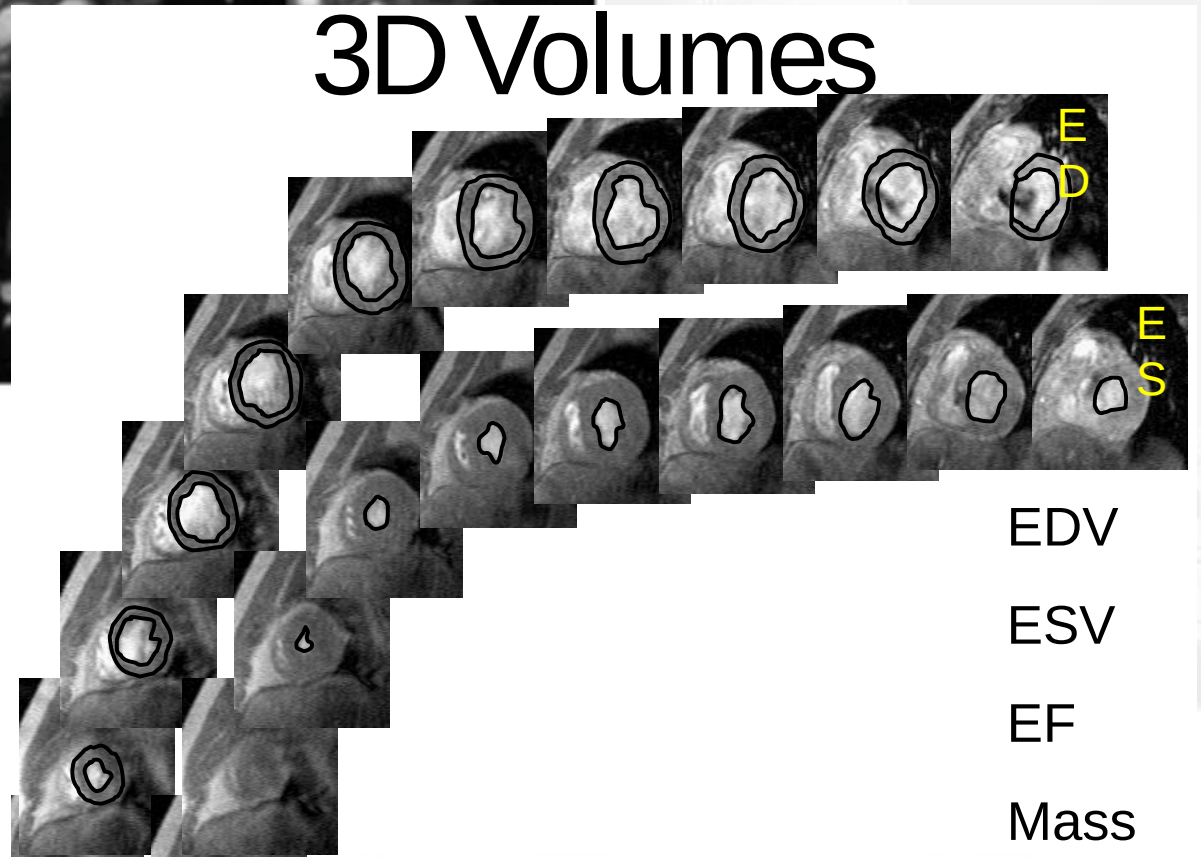
Cine-CMR

Left ventricle parameters



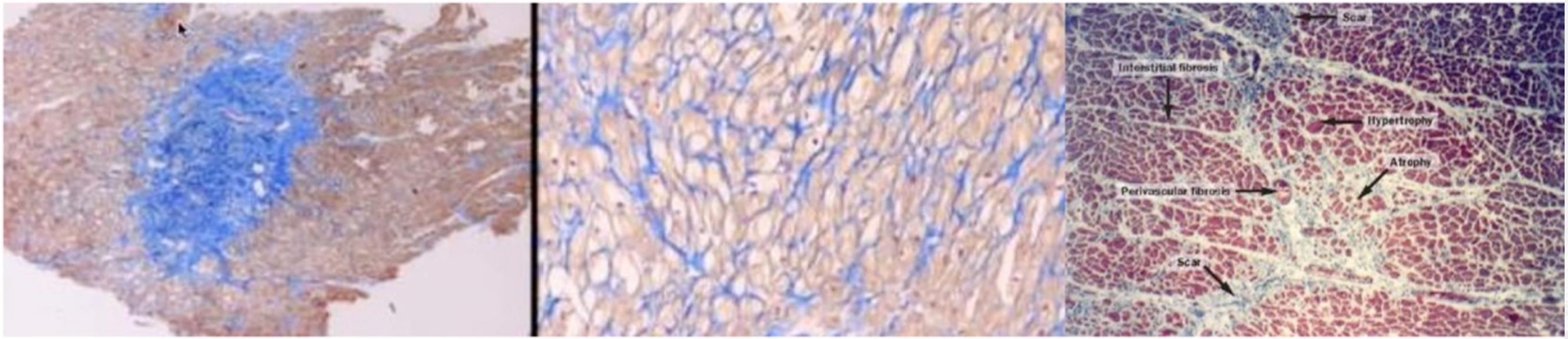


LV parameters

- **HFpEF → LVEF ≥ 50%**
- **LV ED volume** (LV dilation if **>100 ml/m²**)

Myocardial fibrosis

Two types of myocardial fibrosis



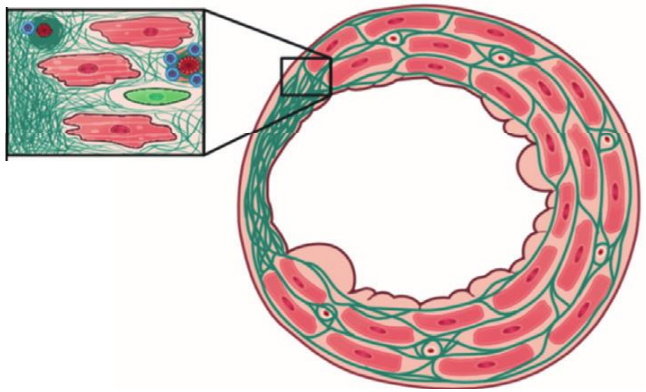
Replacement fibrosis | Interstitial fibrosis | Mixture

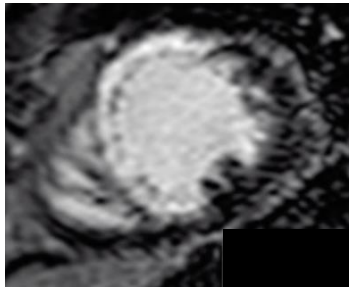
Braunwald's Heart Disease textbook, 11TH Edition. 2018

Myocardial fibrosis

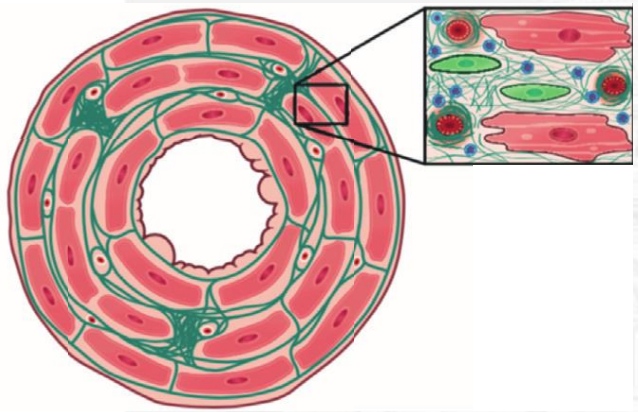
Two types of myocardial fibrosis

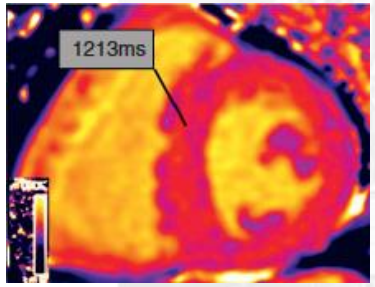
Replacement fibrosis
(focal myocardial scar)



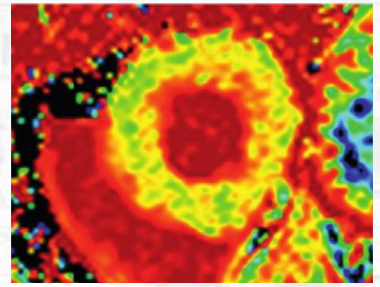


Diffuse interstitial fibrosis





Native T1 mapping



ECV mapping

Adapted from Pezel T., et al. JACC Cardiovasc Imaging. 2021

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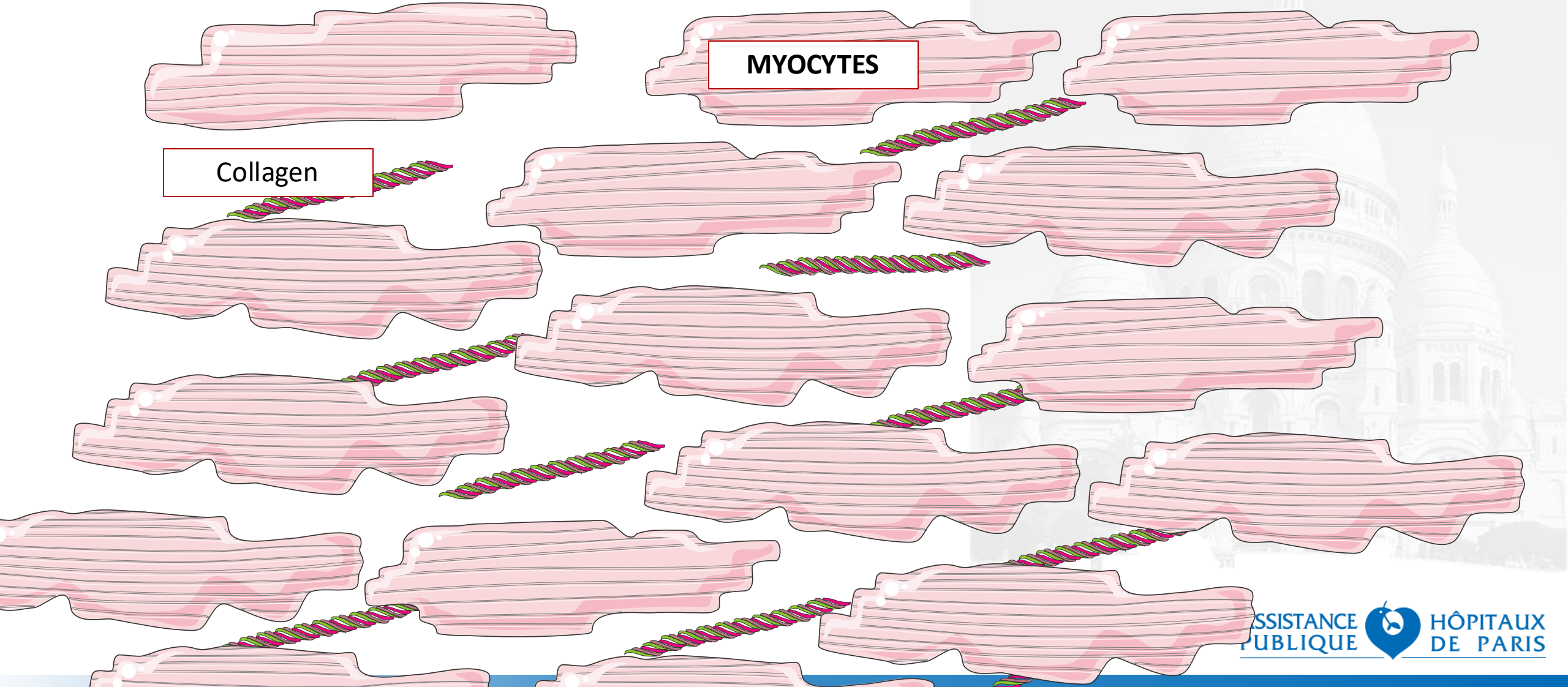
Replacement fibrosis in CMR

What is the Late gadolinium enhancement (LGE)?



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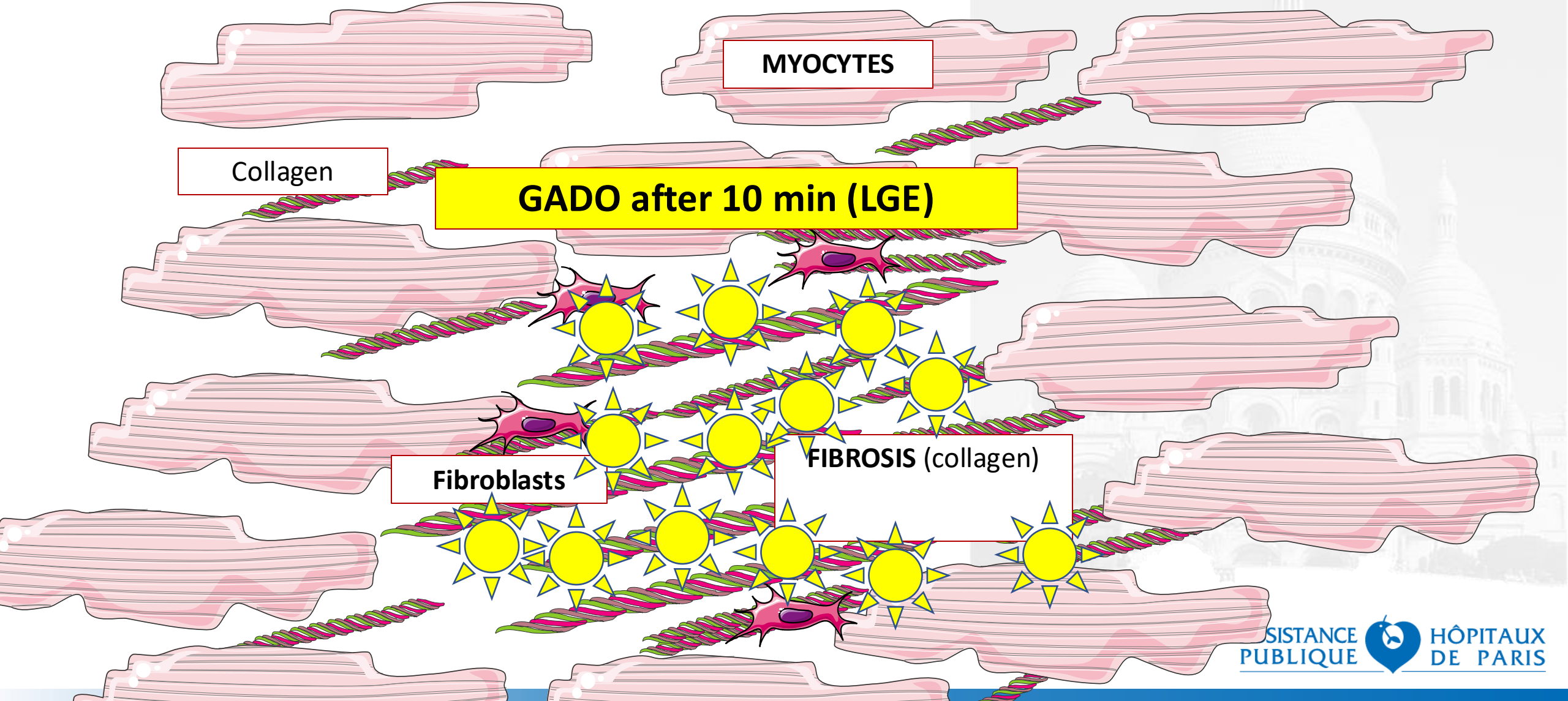
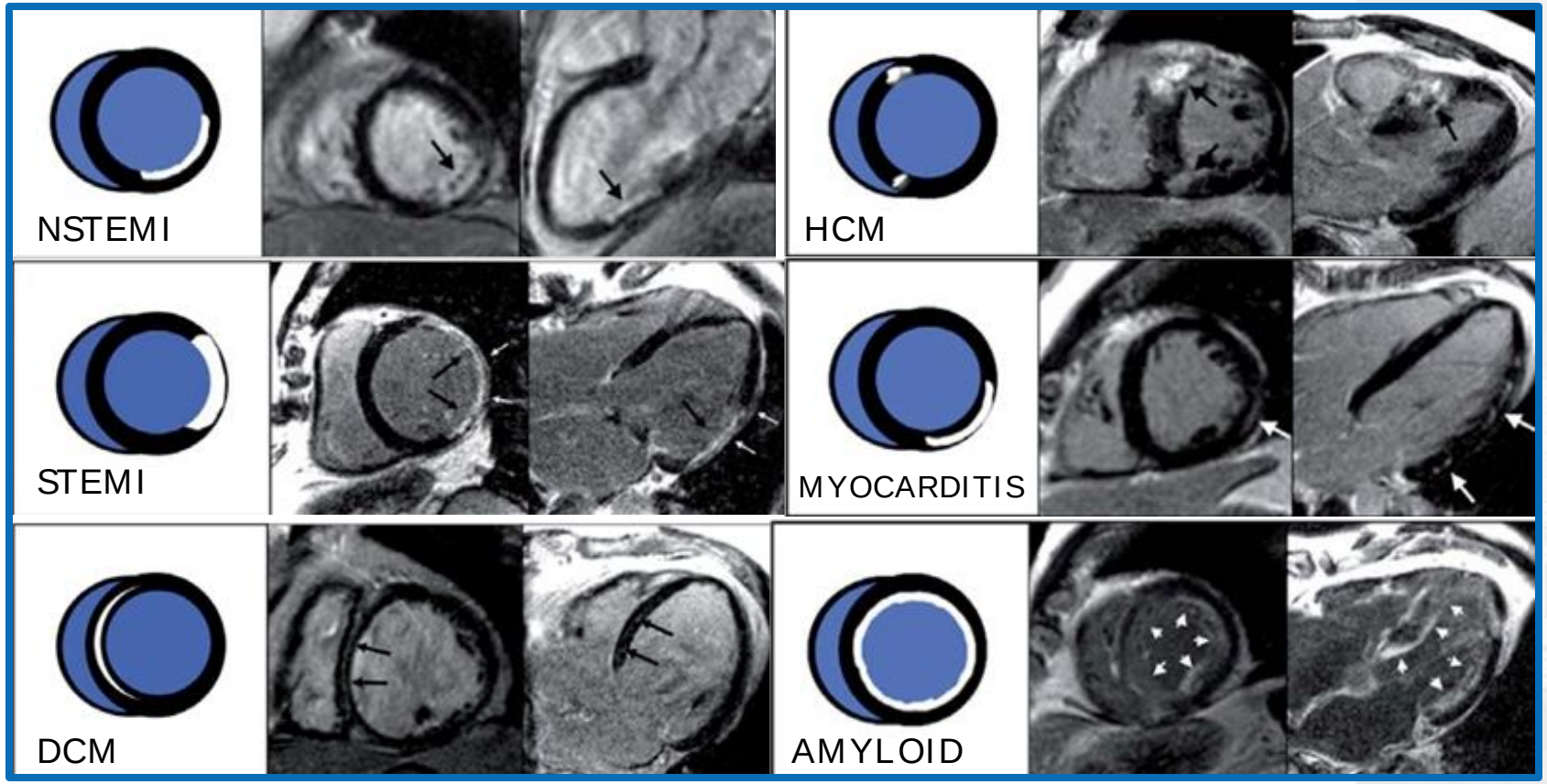
Replacement fibrosis in CMR

What is the Late gadolinium enhancement (LGE)?



Replacement fibrosis in CMR

What is the Late gadolinium enhancement (LGE)?



"LGE = focal increase of the extracellular volume"

i.e. myocardial necrosis, fibrosis, myocardial edema, amyloid deposits...

Mahrholdt H et al , EHJ 2005

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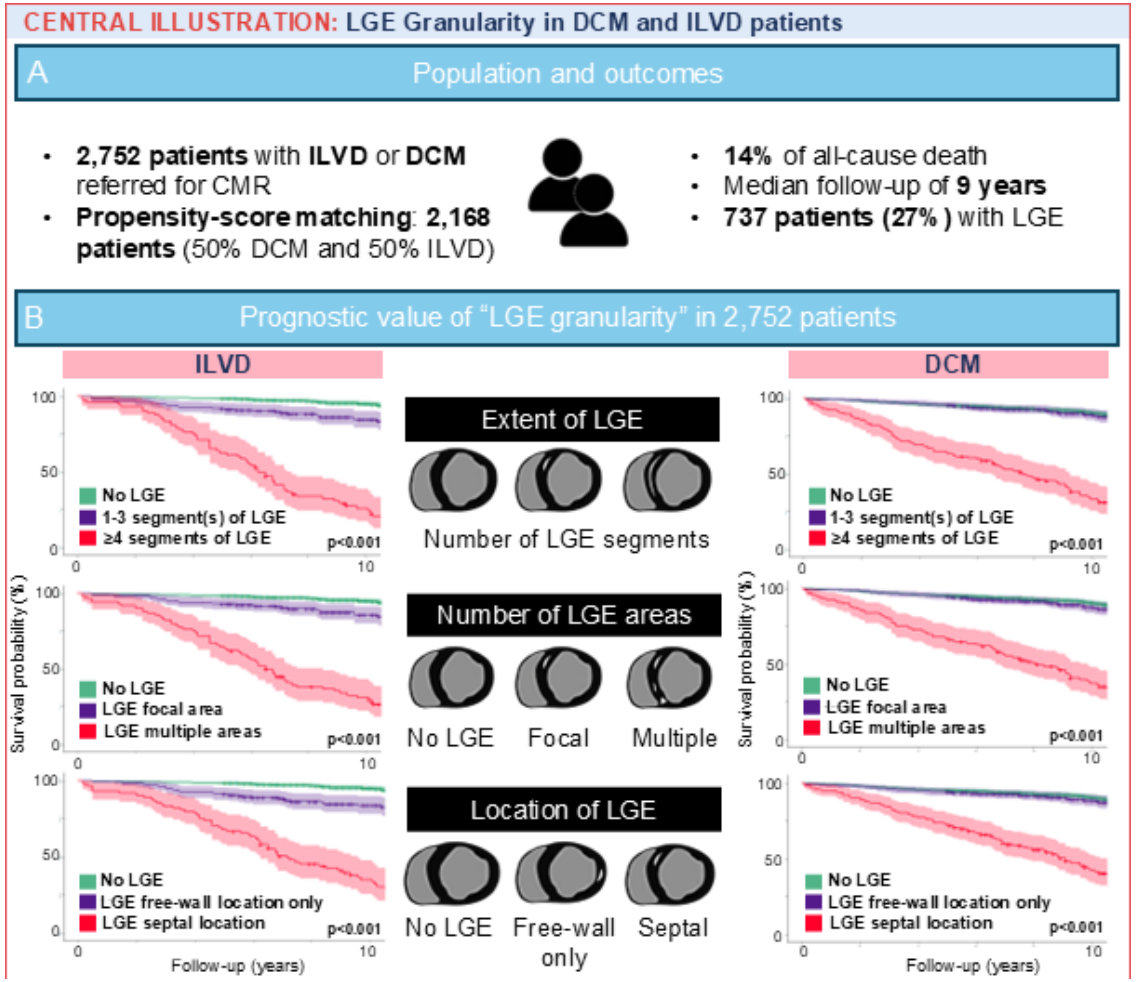
Replacement fibrosis in CMR

Interest of LGE in HFpEF patients with LV dilation



Gonçalves T et al. JACC CV imaging, major revision

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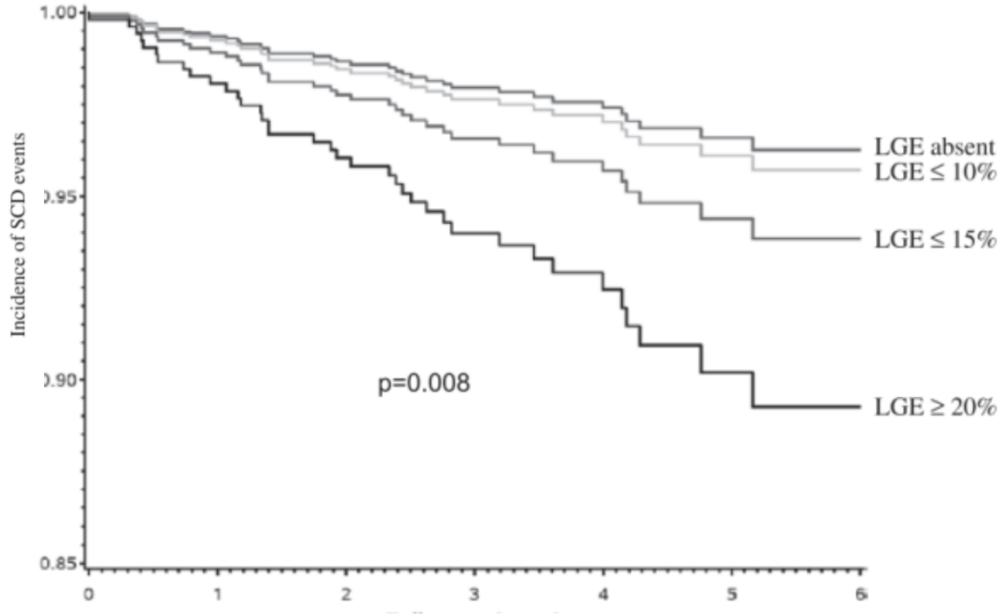
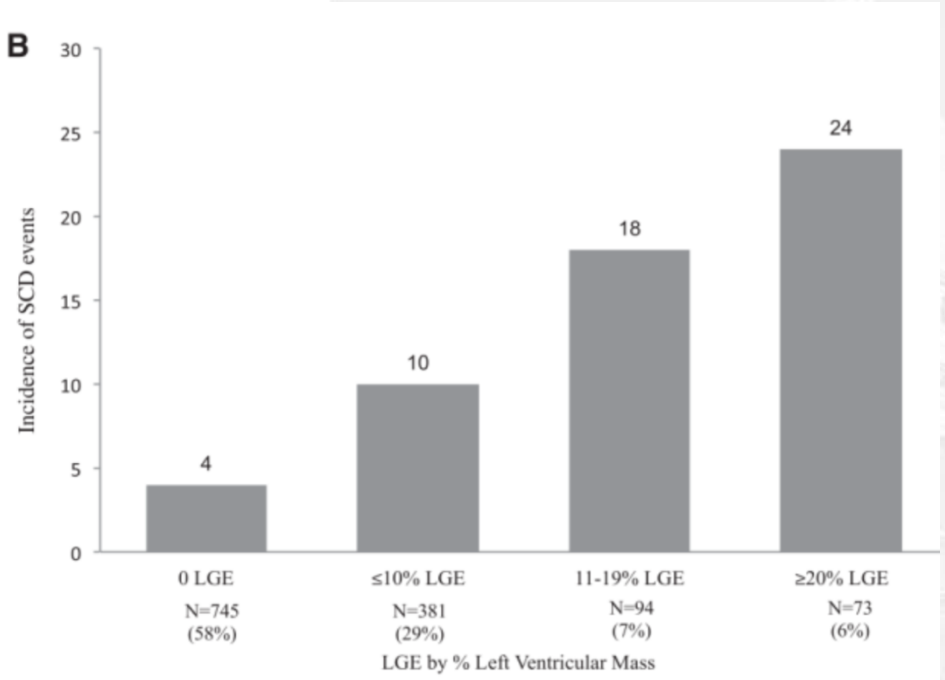
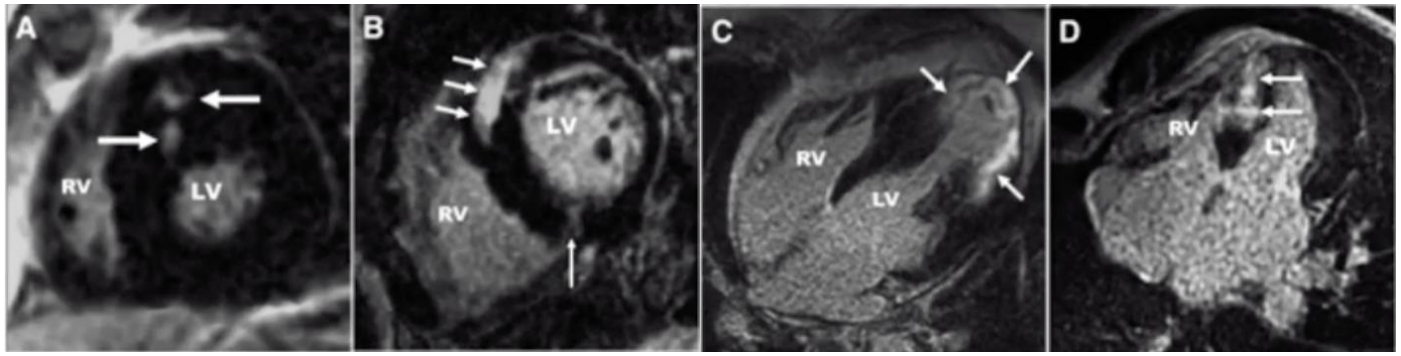
Prognostic value of LGE

HFpEF patients with LV hypertrophy / HCM







Chan et al. Circulation 2014

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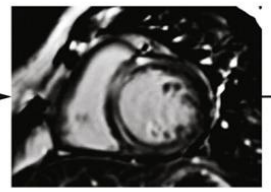
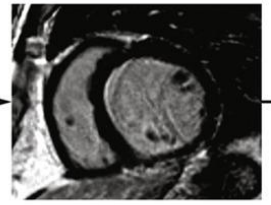
Prognostic value of diffuse interstitial fibrosis

T1/ECV mapping

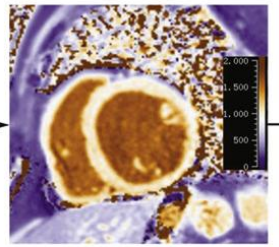
777 patients



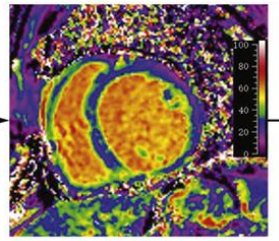
LGE positive



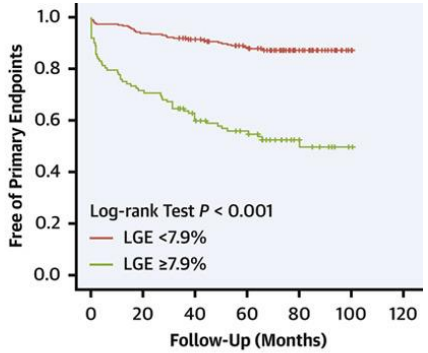
LGE negative

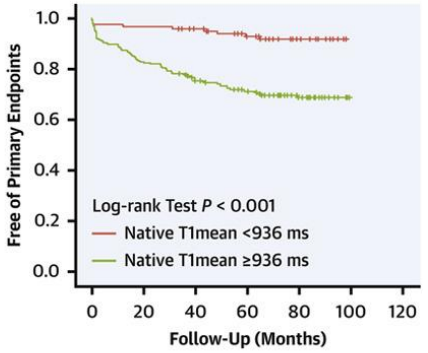


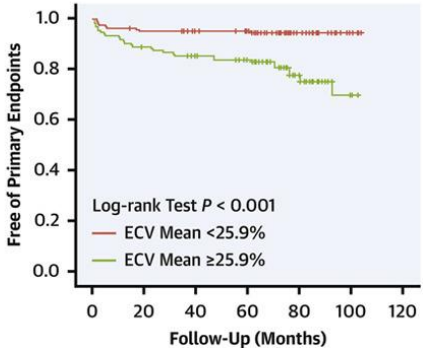
NativeT1



ECV







Shuang L, et al. JACC CV Imaging 2021

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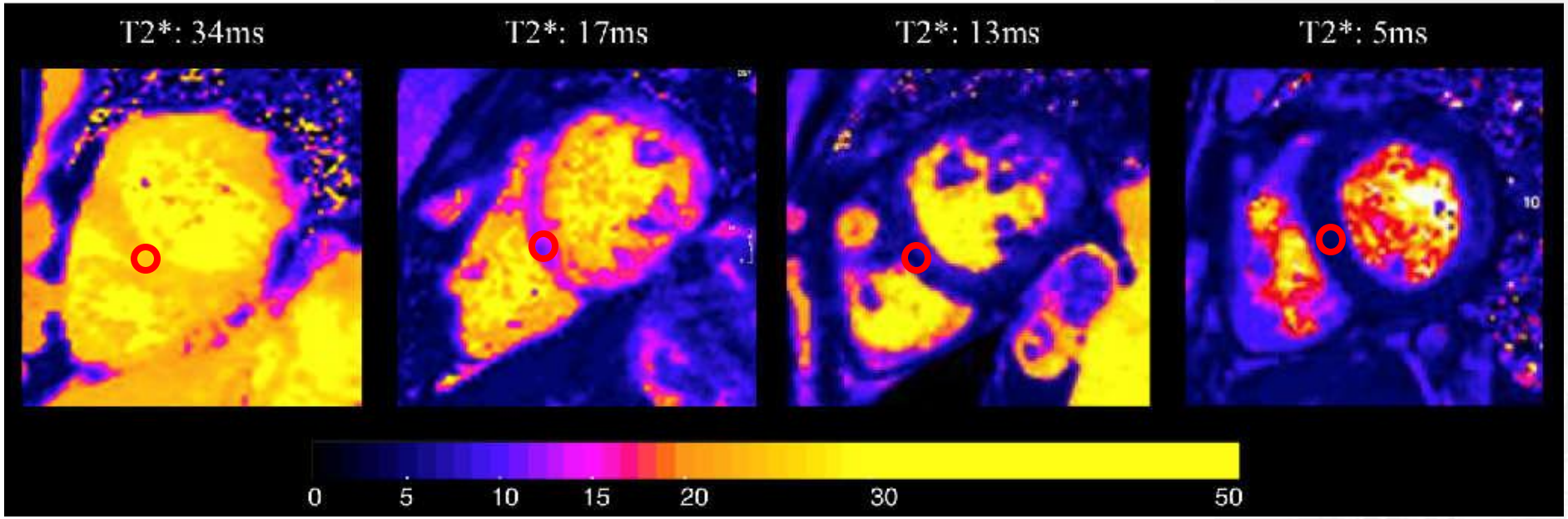
T2* mapping
Hemochromatosis



T2*mapping mid-septal (ROI) :

- norme **≥ 20 ms**
- Hemochromatosis **< 20 ms**

Torlasco et al. PLoS ONE 2018

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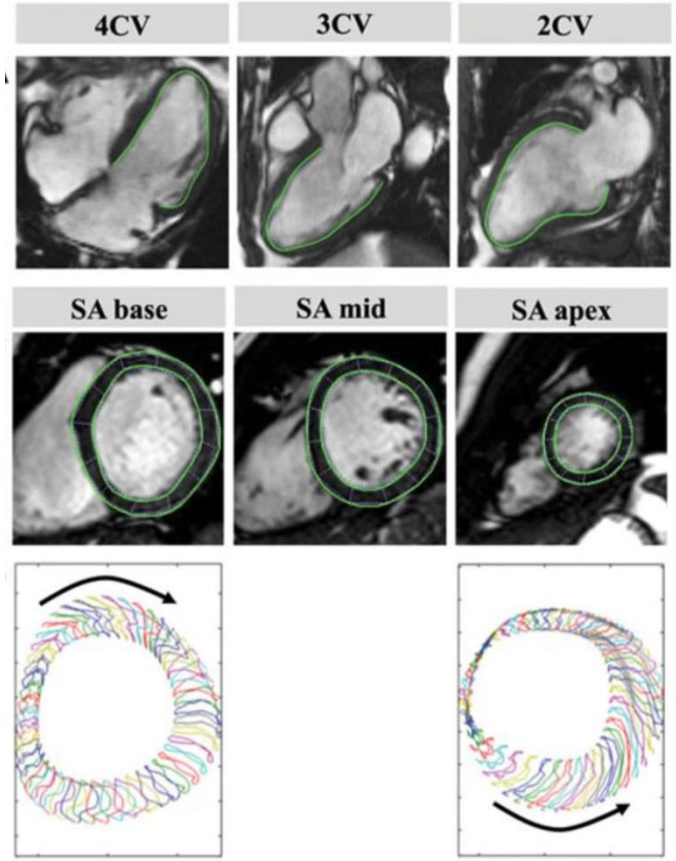
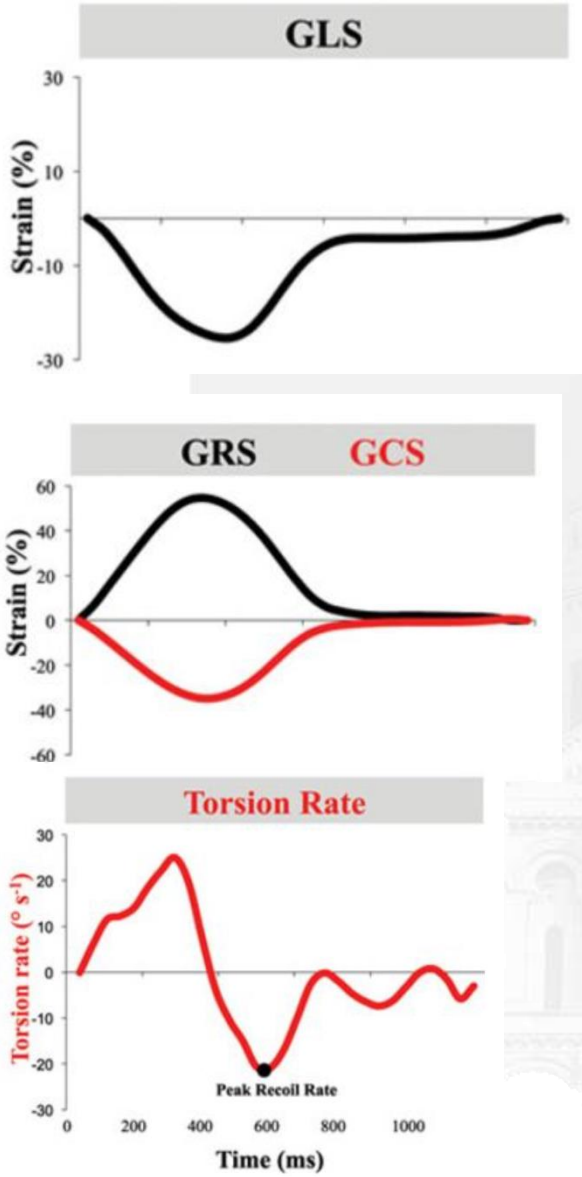
Imaging Biomarkers in HF

LV Strain





Strain longitudinal

Strain radiaire
Strain circonférentiel

Torsion

Schuster A et al. Circ CVI 2016

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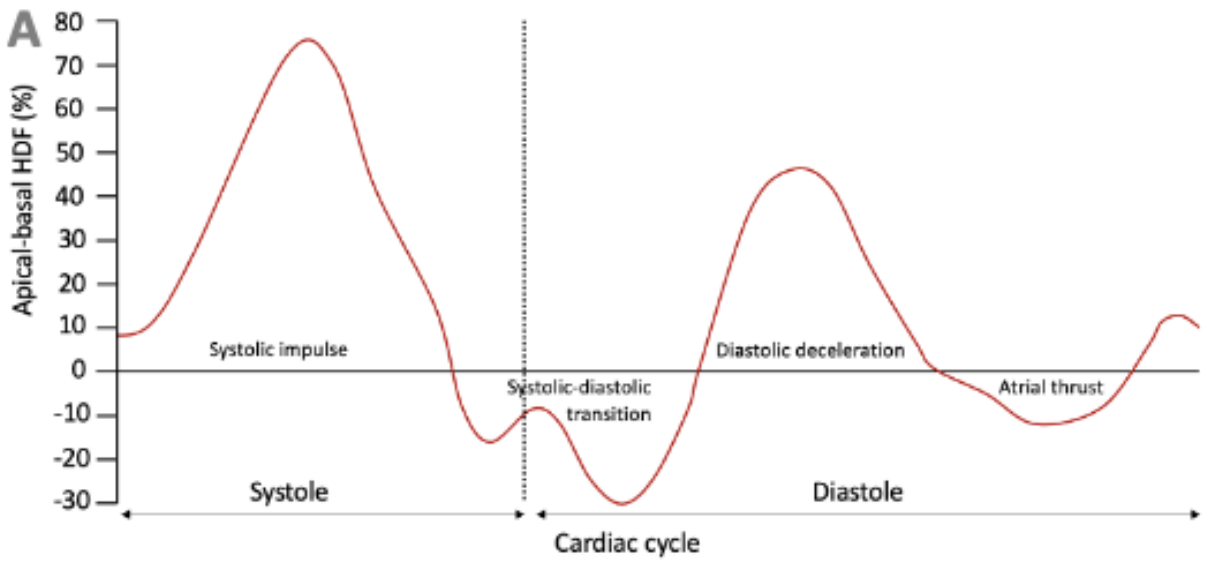
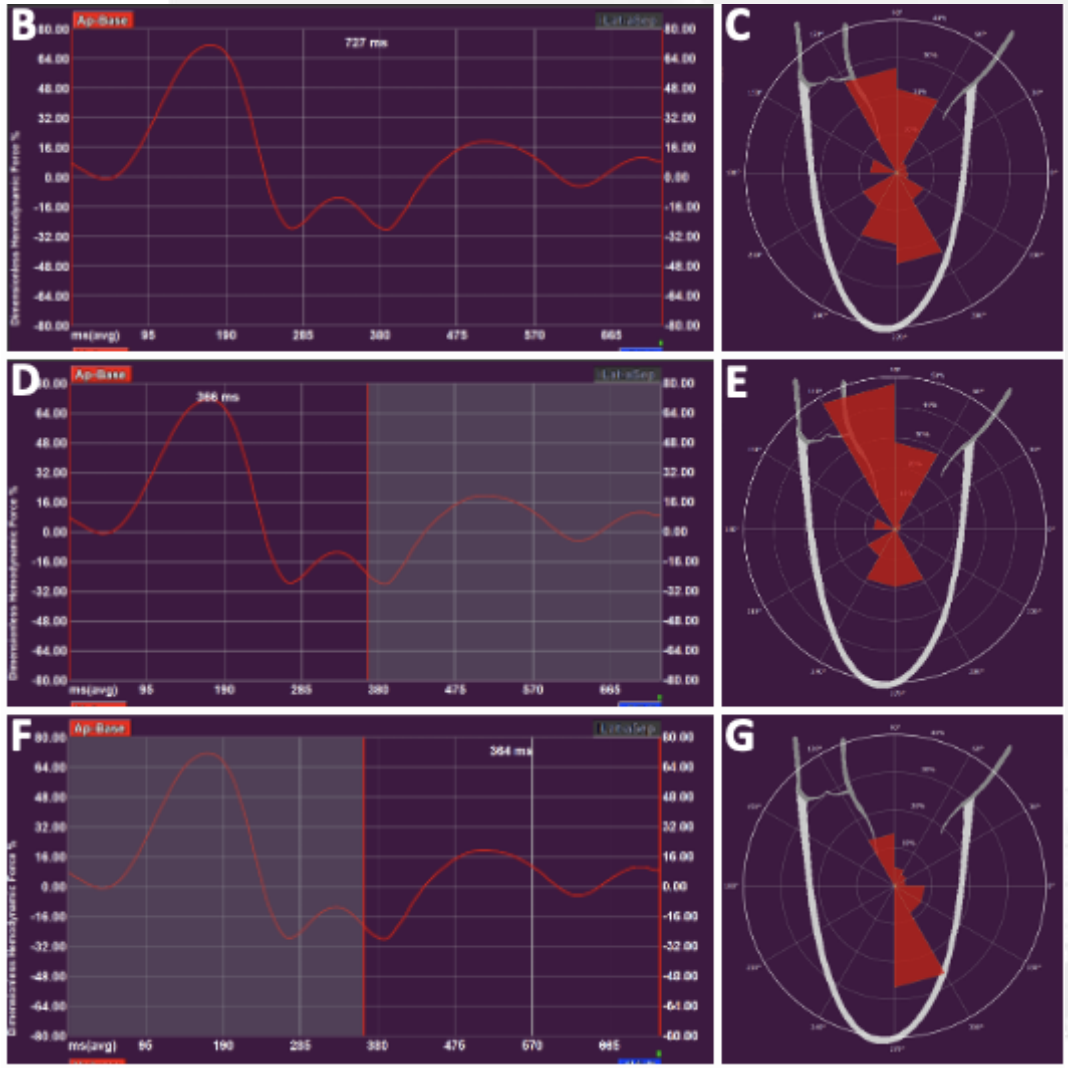
Imaging Biomarkers in HF

Hemodynamic forces (Medis imaging)





Afana Andreea et al. LV hemodynamic forces in Systemic Sclerosis patients, in preparation
Kante A et al. LV hemodynamic forces in Cardiac sarcoidosis patients, in preparation

Medis MEDICAL IMAGING

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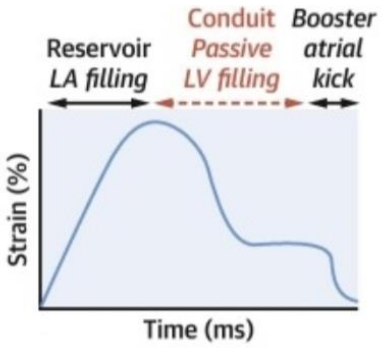
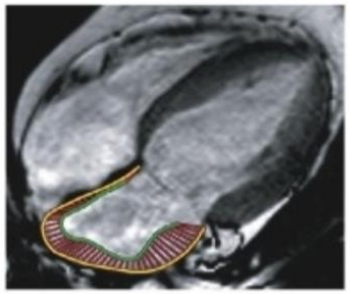
Imaging Biomarkers in HF

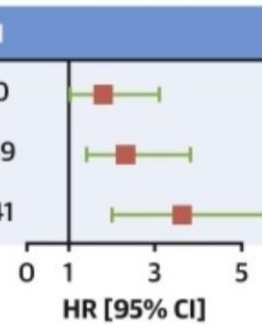
LA Strain



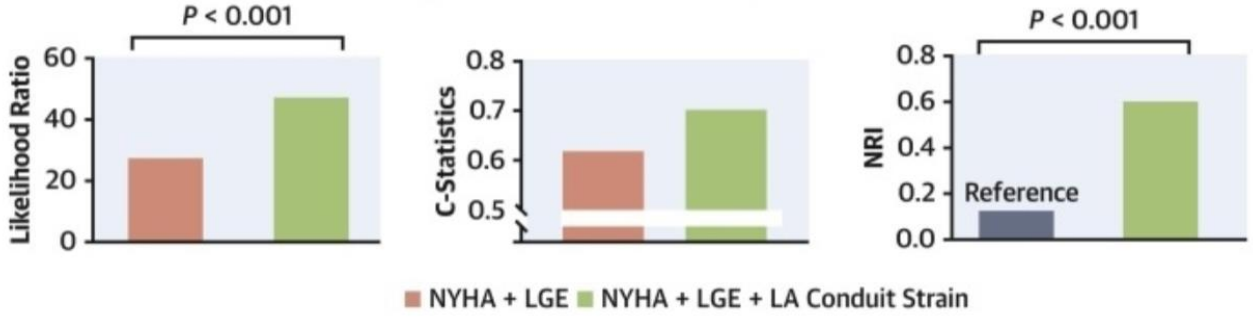


Multivariable Adjusted Analysis
Outcome: sudden/cardiac death, HF hospitalization and life-threatening arrhythmias

	N	HR [95% CI]	*P* Value
NYHA functional class >II	70	1.81 [1.05-3.12]	0.033
LGE presence	189	2.33 [1.42-3.85]	< 0.001
LA-strain (conduit) <12%	241	3.65 [2.01-6.64]	< 0.001



LA Conduit Strain is a Strong Independent Prognostic Predictor, **Superior** to **Left Ventricular Strain, LVEF and LA Volume Index,** and **Incremental** to **LGE**



Raafs AL, et al. JACC Cardiovascular Imaging. 2022;15(6):1015-1026

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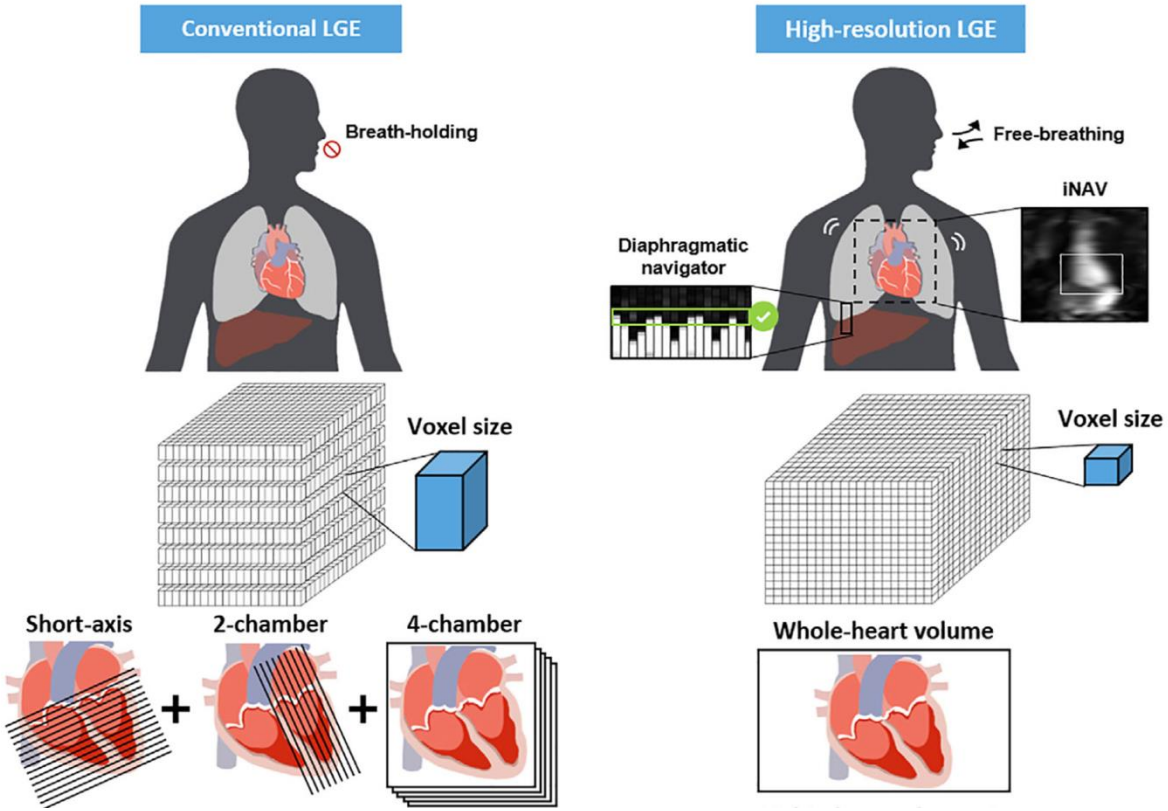
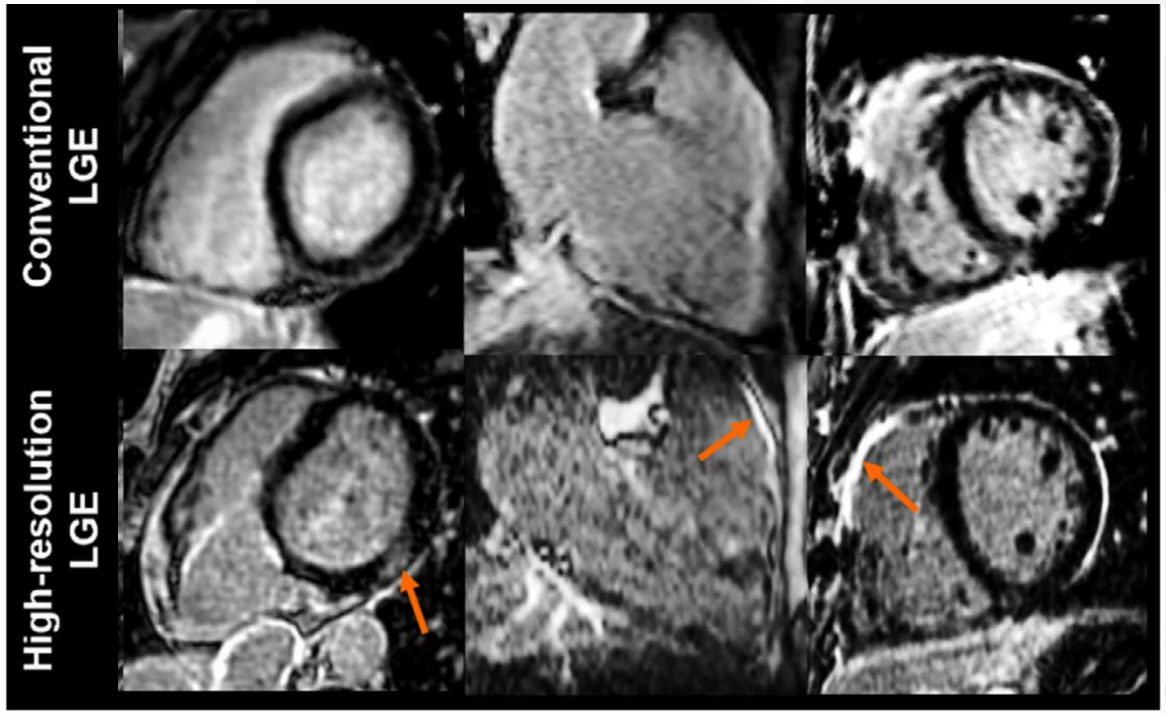
Innovations in CMR

3D High-Resolution LGE sequence





3D-HR LGE: voxel size 1.25 × 1.25 × 2.5 mm

Toupin S, Pezel T, Bustin A, Cochet H. JMRI. 2021

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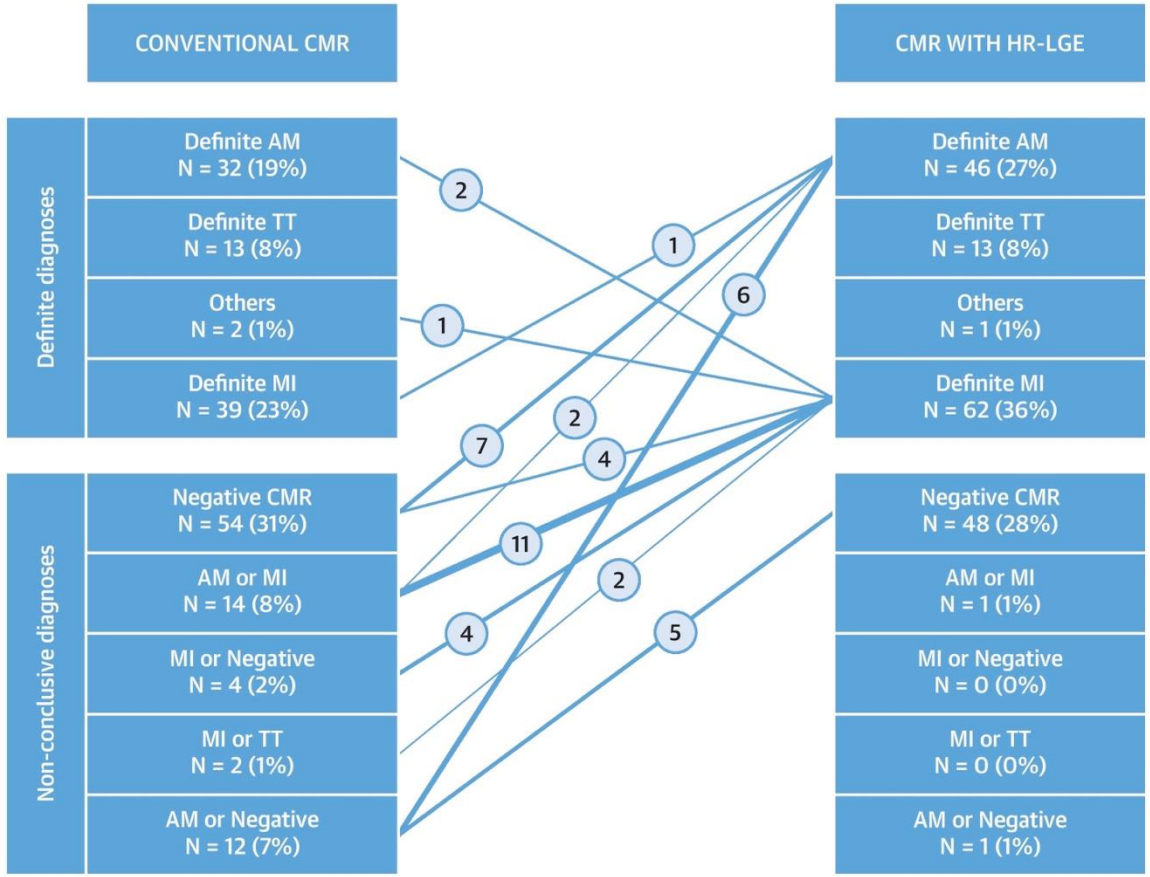
Innovations in CMR

3D High-Resolution LGE sequence

CENTRAL ILLUSTRATION: Diagnostic Changes Introduced by HR LGE Imaging (172 Patients With Both Conventional CMR and HR LGE Imaging)



Lintingre, P.-F. et al. J Am Coll Cardiol Img. 2020;13(5):1135-48.

- 172 patients with MINOCA
- and negative or inconclusive conventional LGE

Changes in final diagnosis for 26% of patients with MINOCA!

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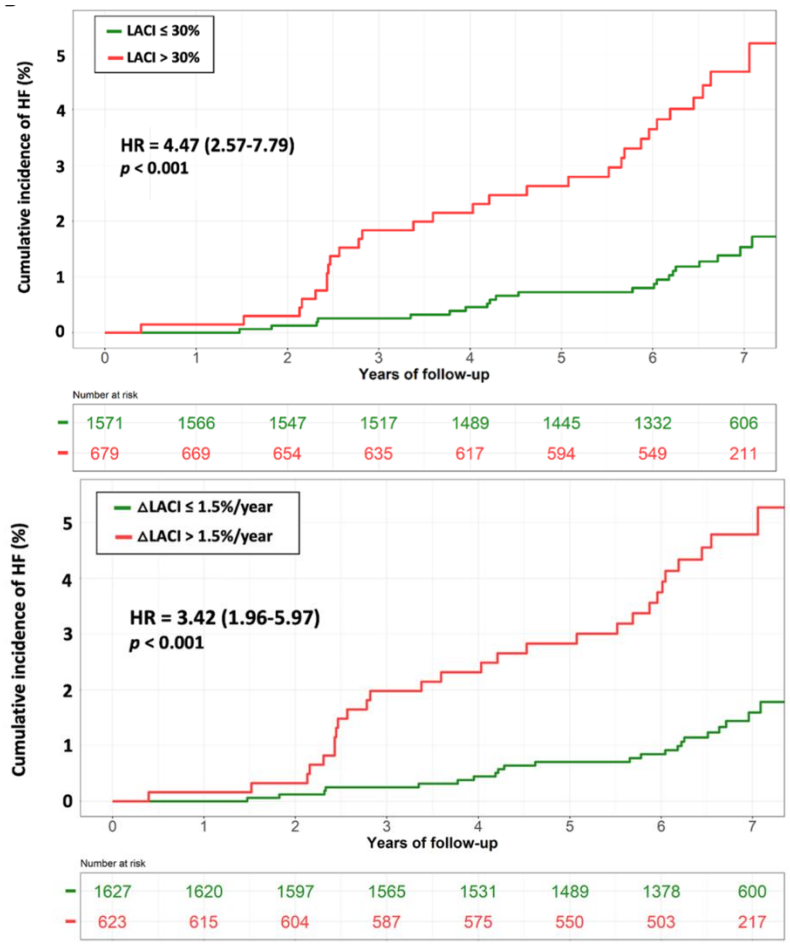
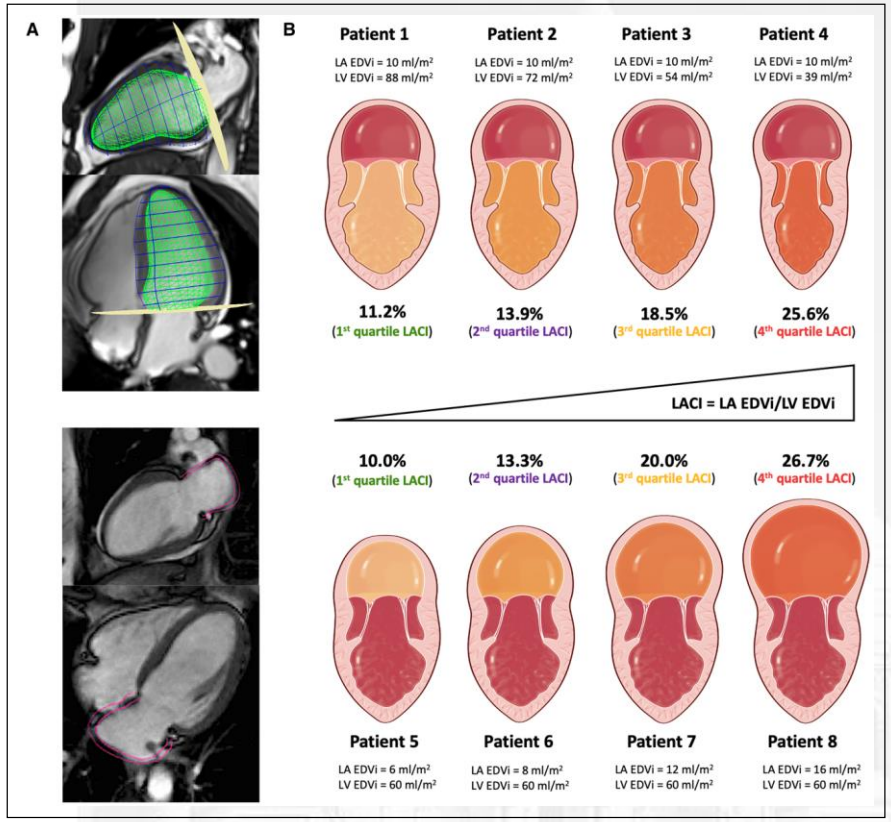
New left atrioventricular coupling index (LACI)

$$\text{LACI} = \frac{\text{Volume TD OG (ml)}}{\text{Volume TD VG (ml)}}$$

Most **powerful prognostic imaging biomarker** to predict the risk of HFpEF

LACI > any LA or LV imaging biomarkers





Pezel T, et al. Hypertension. 2021;78(3):661-671.
Pezel T, et al. Front Cardiovasc Med. 2021;8:704611.
Pezel T, et al. Radiology. 2022;303(2):317–26.
Pezel T, et al. Arch Cardiovasc Dis. 2022;115(8–9):414–25.
Pezel T, et al. Front Cardiovasc Med. 2022 21;9:1066849.
Pezel T, et al. JACC Cardiovasc Imaging. 2023; S1936-878X(23)00112-2.
Pezel T, et al. Diagn Interv Imaging. 2023:S2211-5684(23)00146-8
Pezel T, et al. EHJ CV imaging, 2024, accepted

Thank you

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