KHRS 2021 The 13th Annual Scientific Session of the Korean Heart Rhythm Society

Atrial Imaging Using Cardiac MRI

Name

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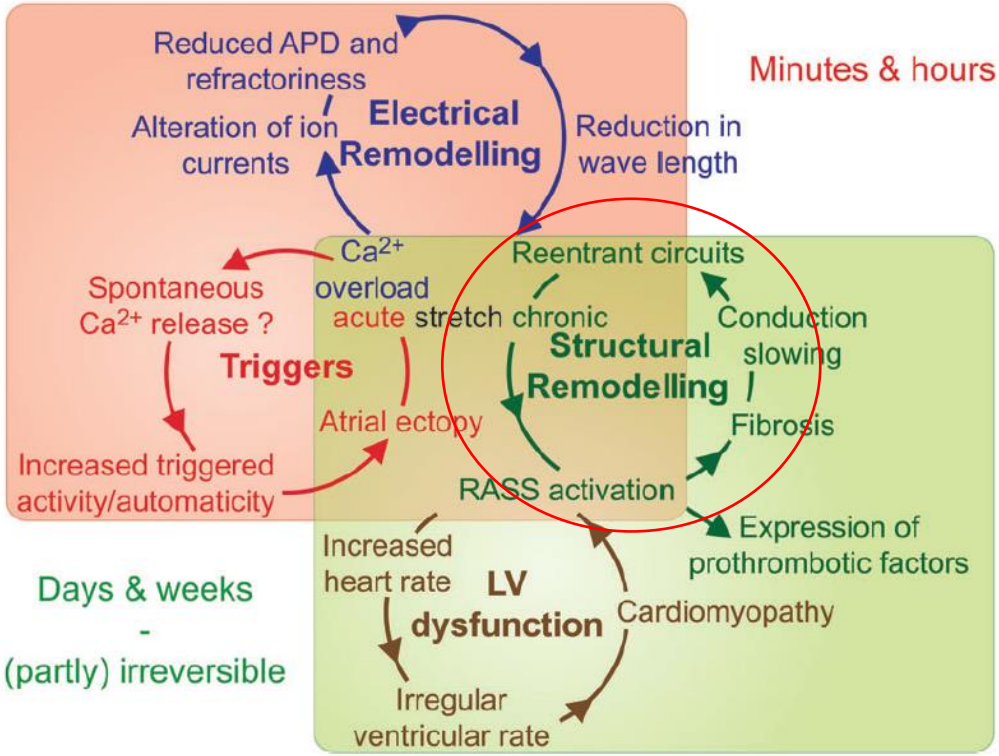
Korean Heart Rhythm Society
COI Disclosure

Name of First Author: Jung Myung Lee

The authors have no financial conflicts of interest to disclose concerning the presentation

LA remodeling accompanied with AF



→ **Functional remodeling**

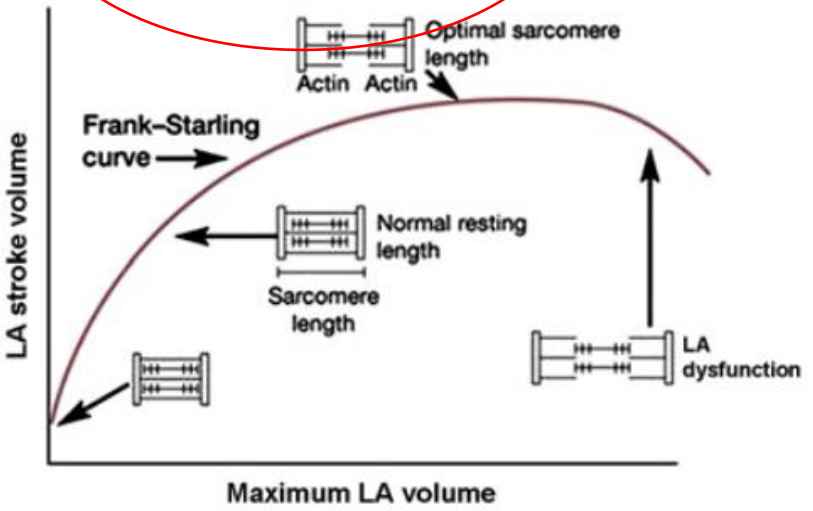
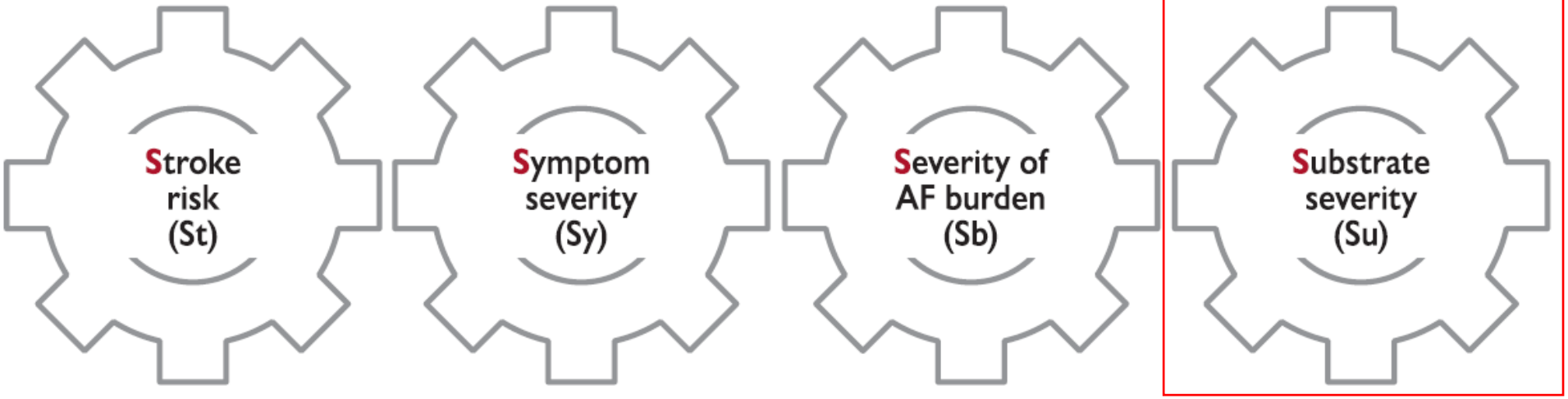


Figure 1 Frank–Starling law applied to the left atrium (LA).

European Heart Journal (2014) 35, 1439–1447

Heart 2011;97:1982e1989.

Structured characterization of AF



Stroke risk (St)	Symptom severity (Sy)	Severity of AF burden (Sb)	Substrate severity (Su)
Truly low risk of stroke • Yes • No	• Asymptomatic/mildly symptomatic • Moderate • Severe or disabling	• Spontaneously terminating • AF duration and density of episodes per unit of time	• Comorbidities/ cardiovascular risk factors • Atrial cardiomyopathy (atrial enlargement / dysfunction / fibrosis)
CHA_2DS_2-VASc score	EHRA symptom score QoL questionnaires	• **Temporal pattern of AF** (Paroxysmal, Persistent, Long-standing persistent, Permanent) • **Total AF burden** (total time in AF per monitoring period, the longest episode, number of episodes, etc.)	• **Clinical assessment** Incident AF risk scores, AF progression risk scores • **Imaging** (TTE, TOE, CT, cardiac MRI), biomarkers

Substrate status in guiding AF treatment

Substrate
(+1 if >75 years old)
Comorbidity/CV risk factors
0 = No
1 = Single
2 = Multiple (2 or more)
LA enlargement/dysfunction
0 = No
1 = Mild-moderate
2 = Severe
LA fibrosis
0 = No
1 = Mild
2 = Moderate-severe
0-2
3-4
5 or more

Anatomy, size

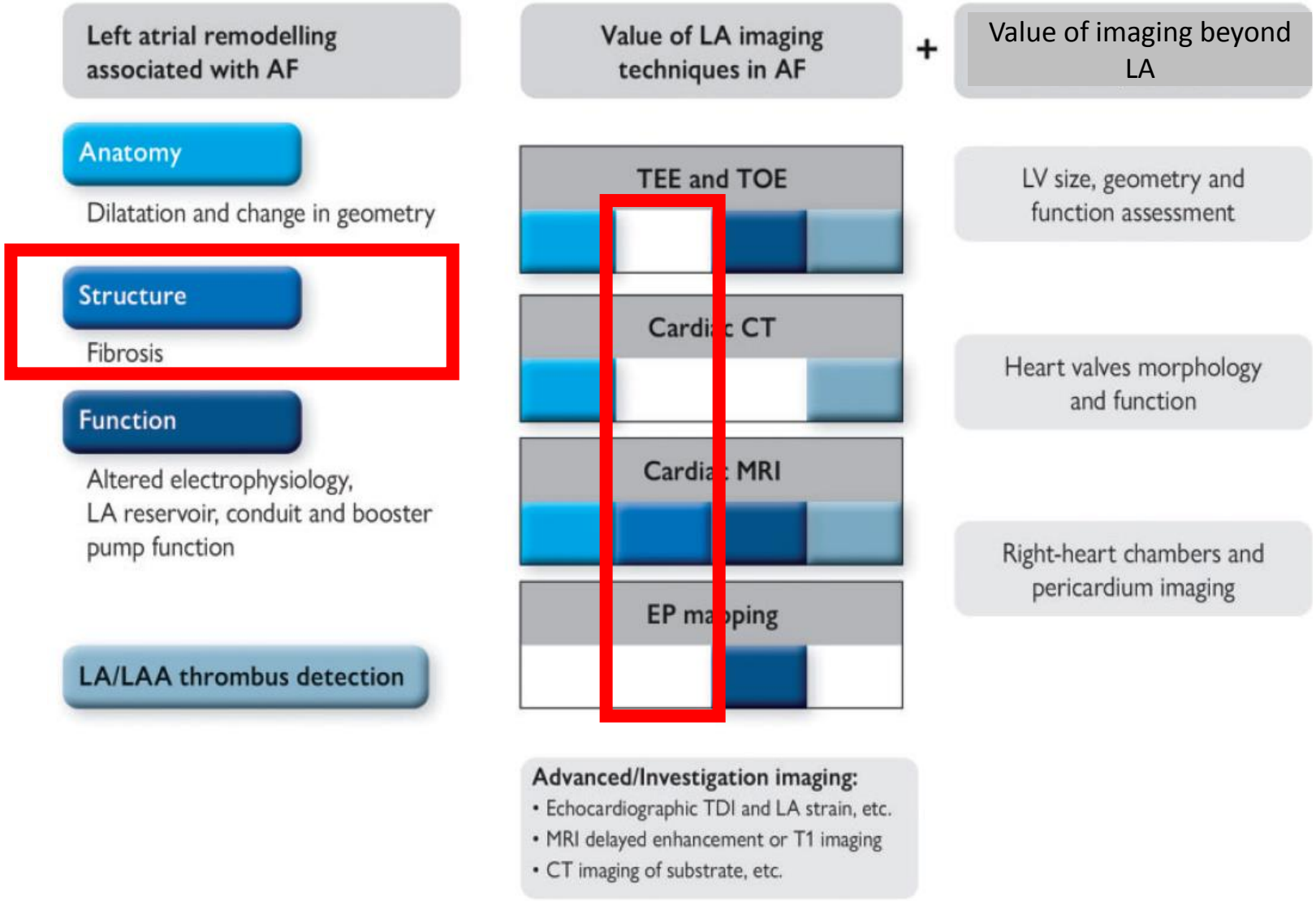
Structure, fibrosis

Functions

All green => Rhythm control
1 Yellow, 2 Green => Rhythm control can be attempted
Red => Consider rate control

Thromb Haemost *2020 Aug 24. doi: 10.1055/s-0040-1716408.* .

LA imaging modalities in AF



2020 ESC

Late gadolinium enhancement

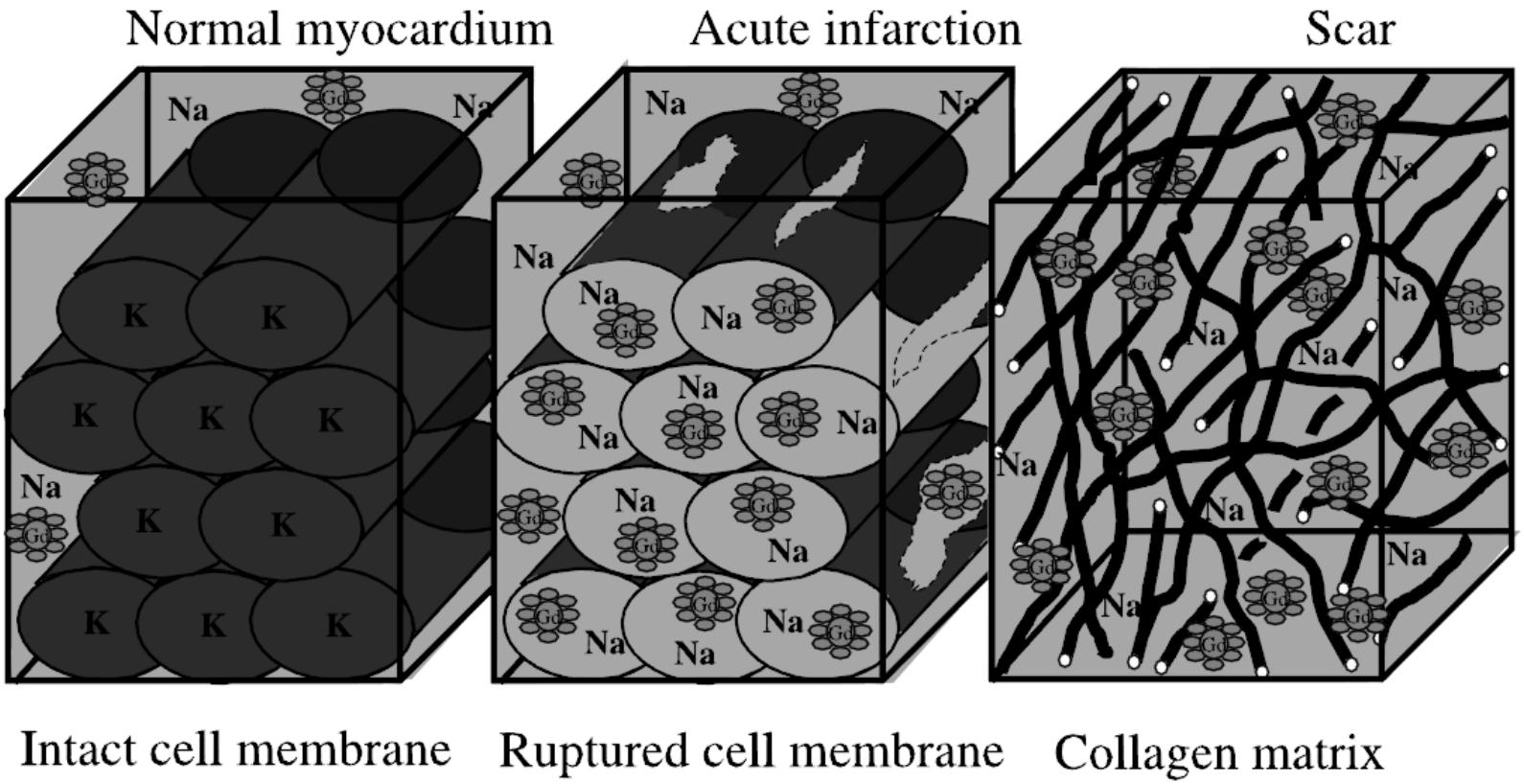
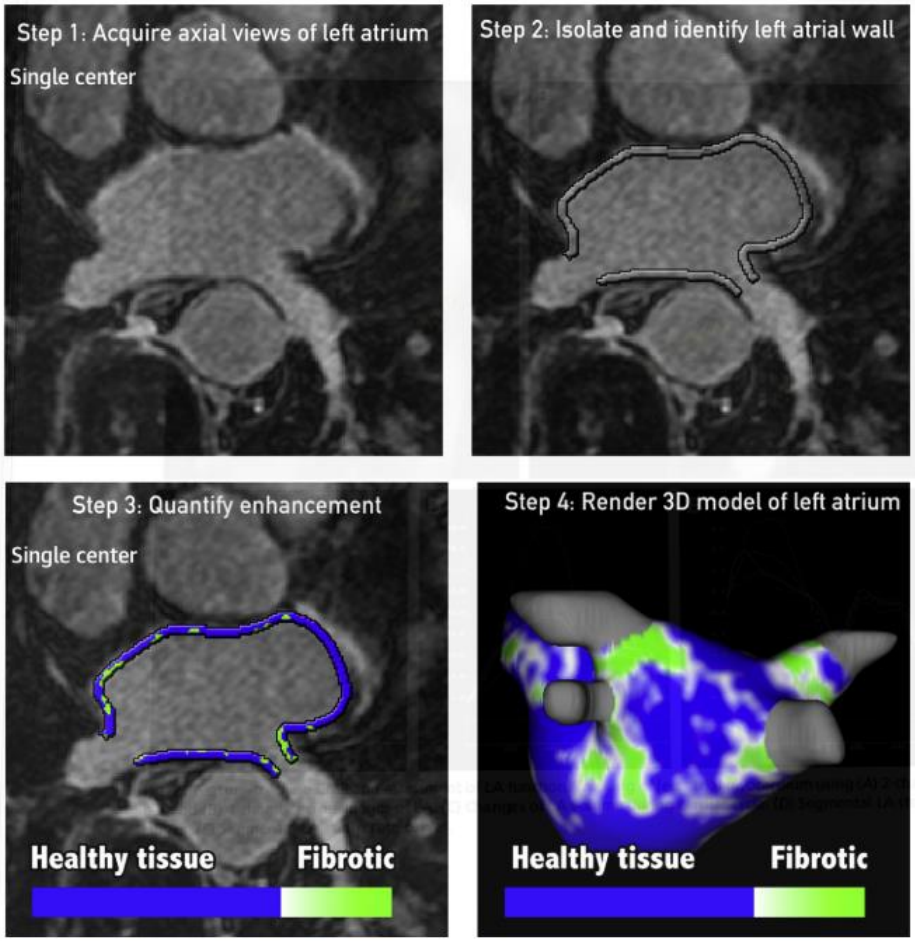


Figure 2. **Potential mechanisms of hyper-enhancement in acute and chronic myocardial infarcts.**

European Heart Journal (2002) **23,** 602–619

Acquiring atrial LGE



Following acquisition of high-resolution LGE-MRI scans, the endocardial borders of the left atrium (LA) are defined, including an extent of pulmonary vein (PV) sleeves, by manually tracing the PV–LA blood pool in each slice of the LGE-MRI volume. Next, the endocardial border is morphologically dilated (by 4 pixel layers, 2.5 mm) with manual adjustment to create a shell of the epicardial LA surface (step 2). The endocardial segmentation is subtracted from the epicardial layer to define the wall segmentation, with manual exclusion of the mitral valve and extension of the left ventricle. The next step is the quantification of fibrosis based on the relative intensity (signal intensity) of LGE. Finally, a 3-dimensional model of the LA is rendered with the maximum enhancement intensities being projected on the model surface

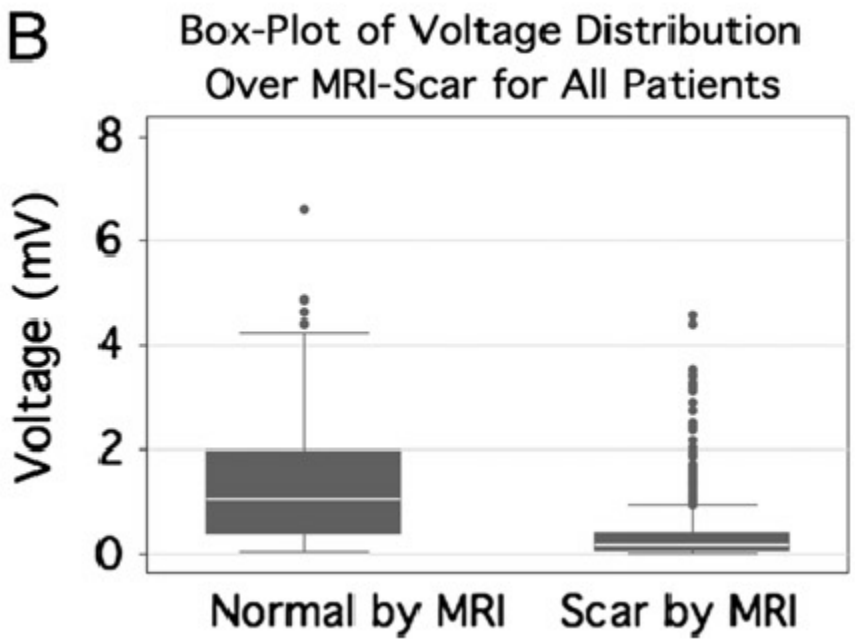
Challenges:
Thin atrial wall
Irregular HB
Respiration
No uniform protocol

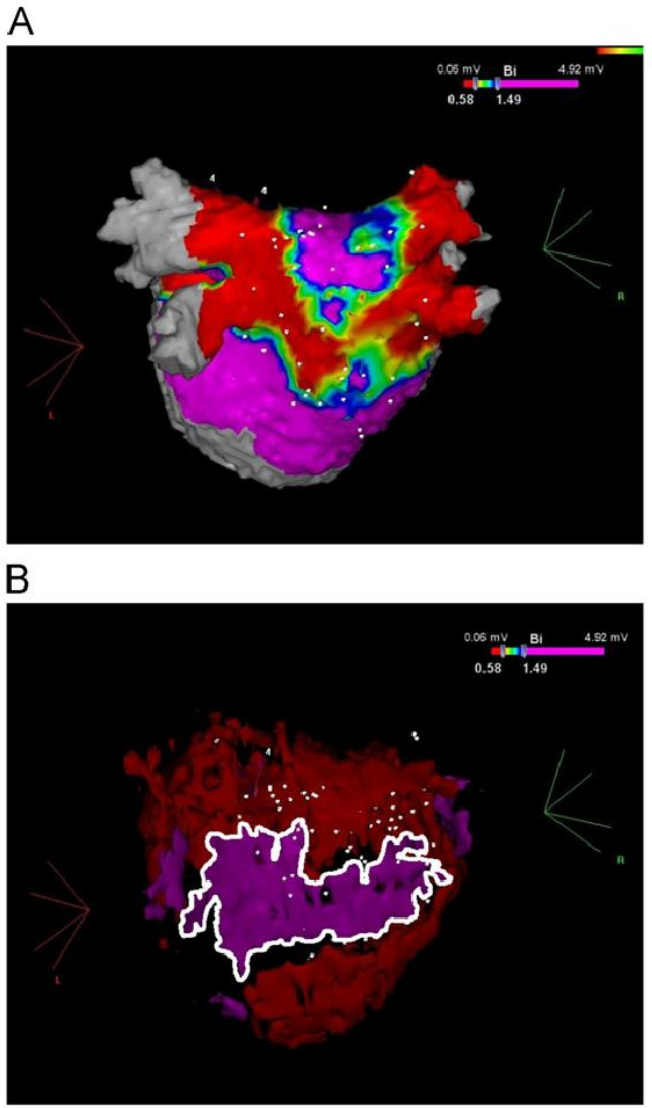
(J Am Coll Cardiol EP 2017;3:791–802)

LGE and low voltage area

a significant association between LGE and areas of low voltage

- Significant association between scar identified by DE- MRI and low-voltage regions of the LA

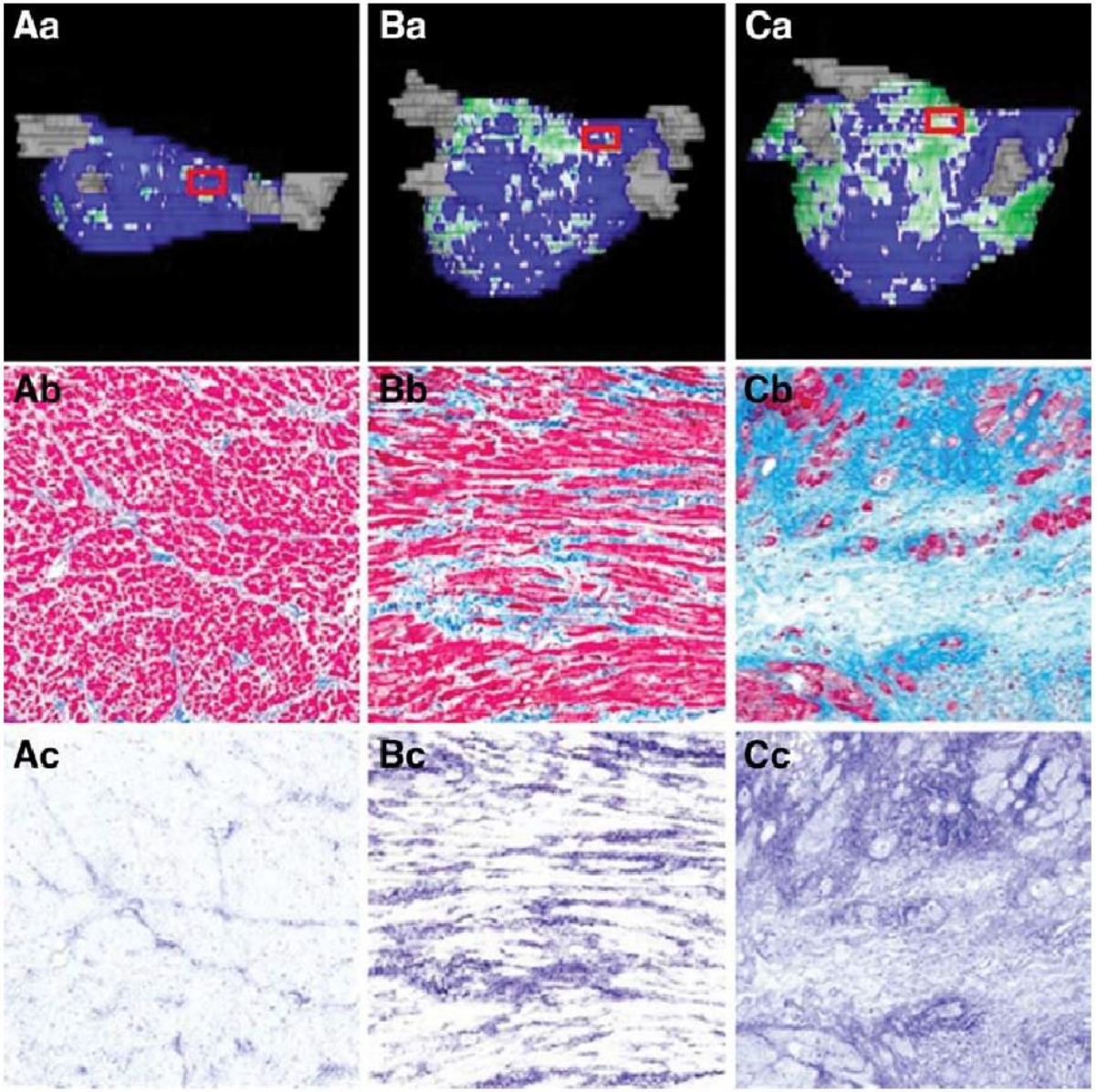




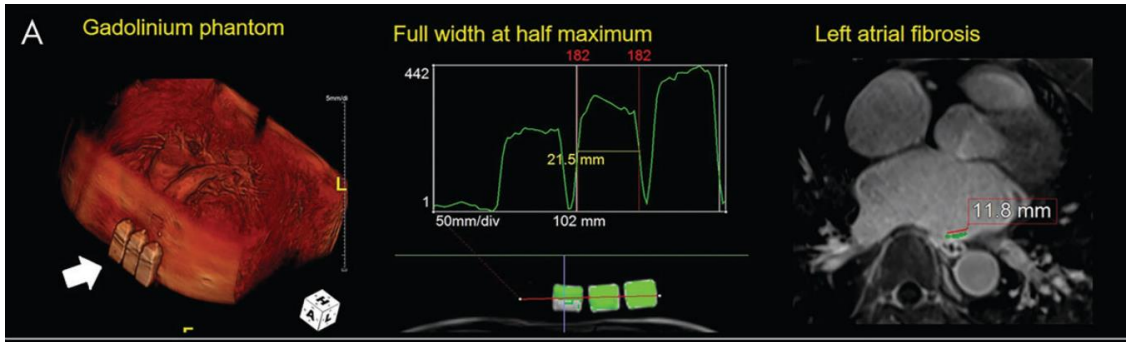
Heart Rhythm 2012;9:2003–2009

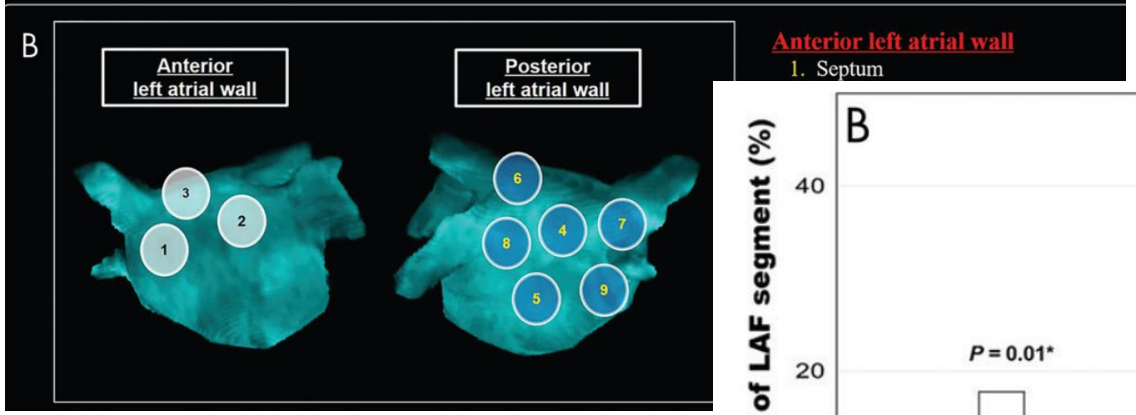
LGE and fibrosis on biopsies

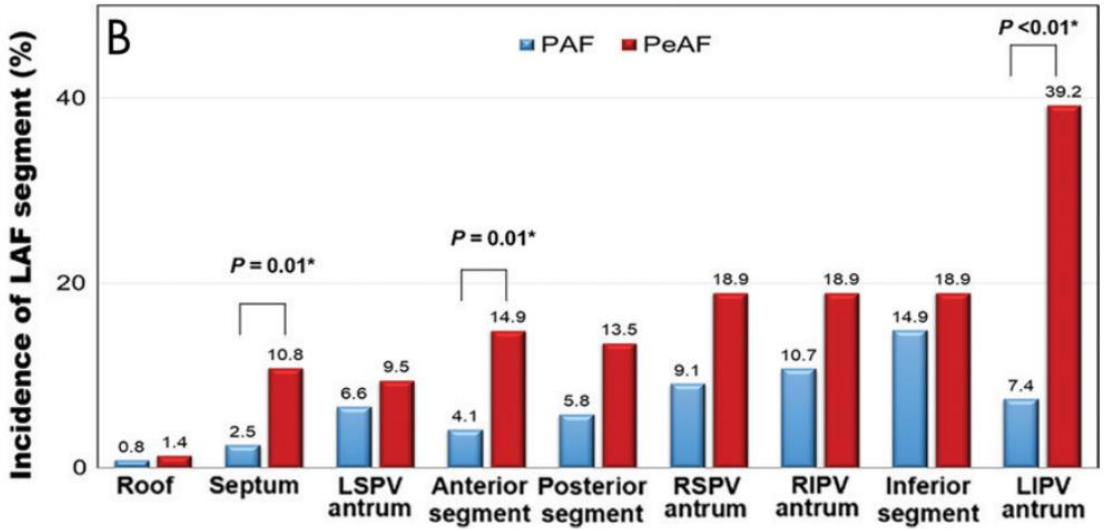
LA LGE is found to be matched with corresponding LA wall areas demonstrating fibrosis on surgical biopsies.



LGE pattern and AF type





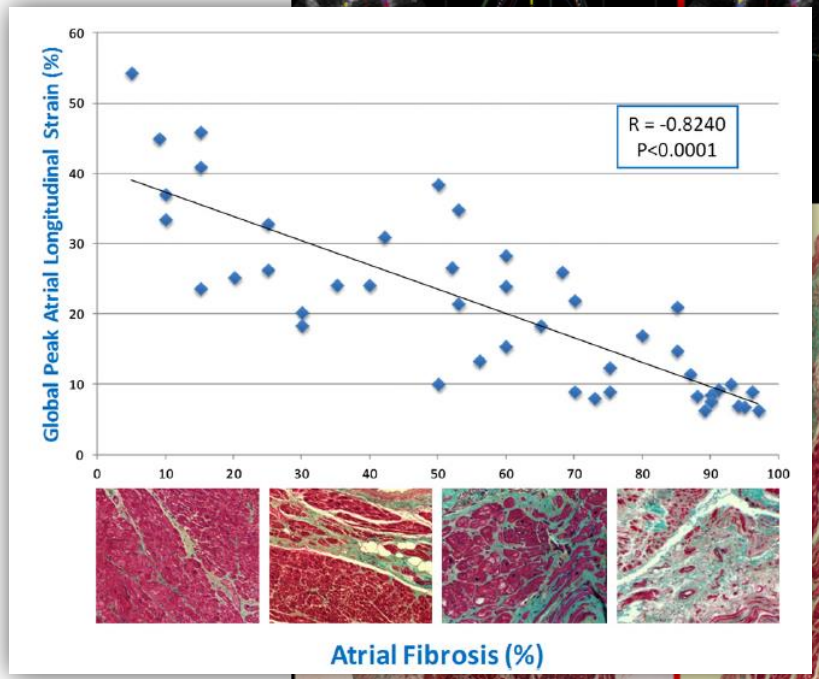


Korea University
195 patients
114 (58.4%) had at least one left atrial LGE segment.
The mean number of LGE segments was higher in the PeAF group than in the PAF group. The incidence of LGE at the LIPV antrum was higher in the PeAF group than in the PAF group

Radiology 2019; 292:575–582

Atrial fibrosis associated to function

Global PALS showed the best diagnostic accuracy to detect LA fibrosis (area under the curve 0.89) than LAVI, LAEF, E/E' (46 pts, OP for MR)

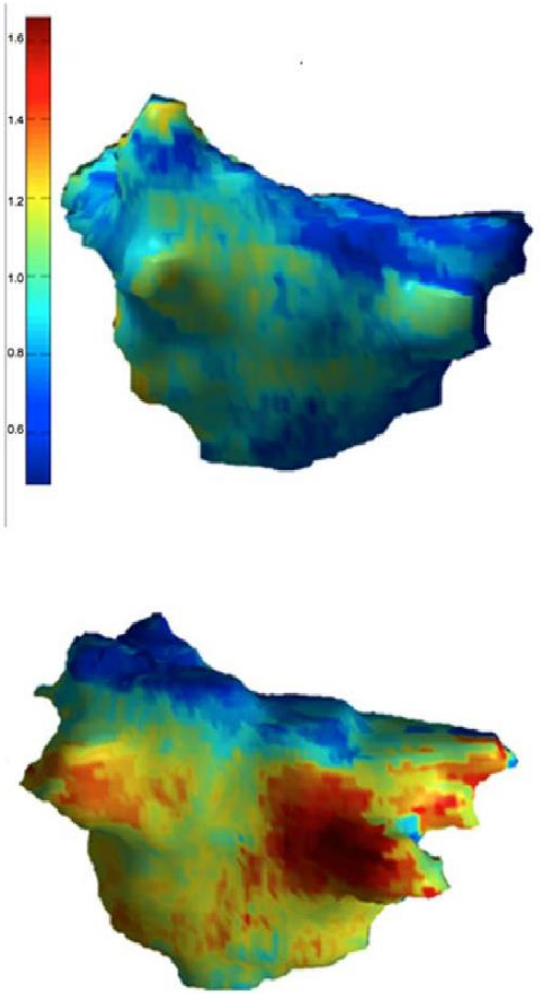


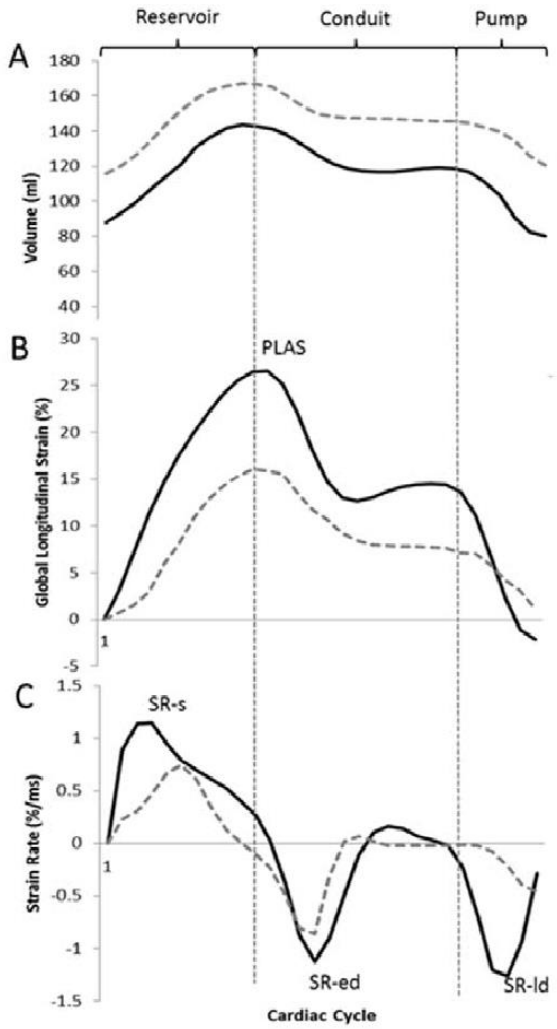
Am J Cardiol 2013;111:595e601

LGE and LA function

Increased LA enhancement is associated with decreased LA reservoir, conduit, and booster pump functions.

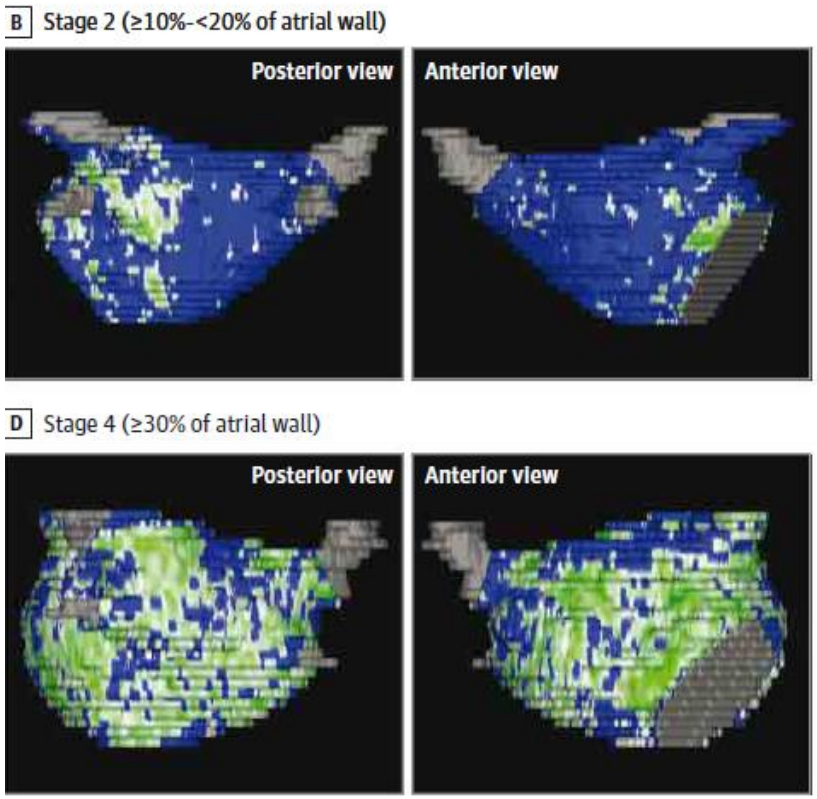
Phasic measurement of LA function using feature-tracking cardiac magnetic resonance may add important information about the physiological importance of LA fibrosis





Circ Cardiovasc Imaging. 2015;8:e002769

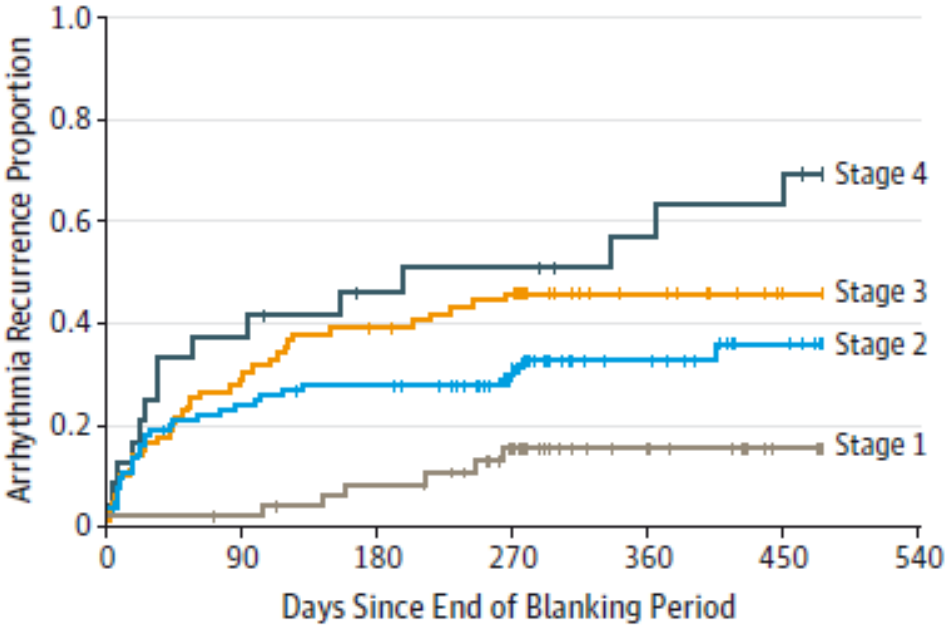
LGE and prognosis of AF:
Prediction of RFCA outcome by atrial fibrosis



272 of 329 pts

(57 pts (17%) excluded d/t poor MRI quality)

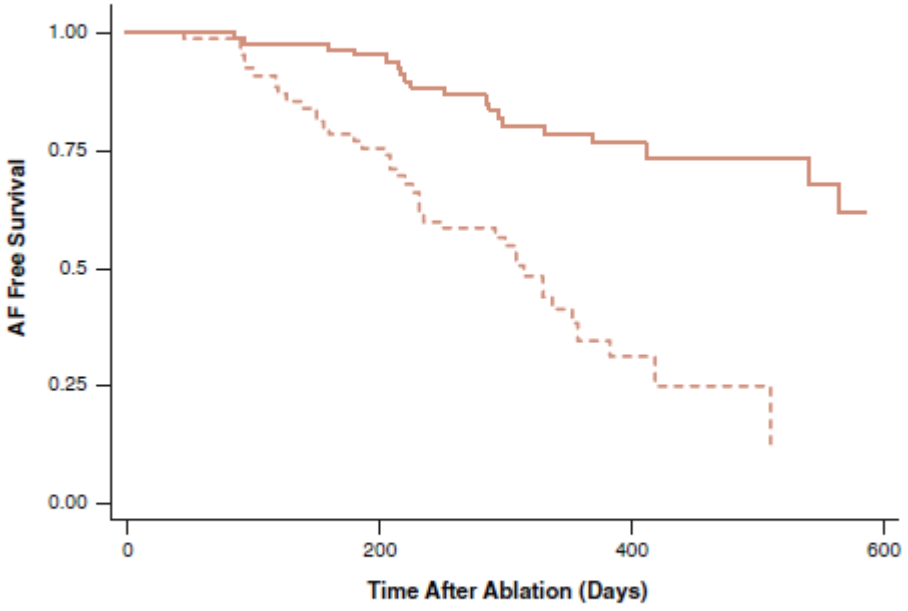
The addition of fibrosis to a recurrence prediction model → C statistic increasing from 0.65 to 0.69



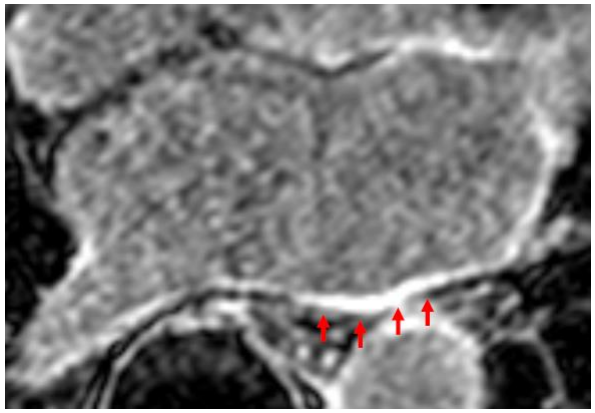
DECAAF . 2014 JAMA

Prediction of RFCA outcome by MRI

FIGURE 2 Kaplan-Meier Atrial Fibrillation-Free Survival Curves After Pulmonary Vein Isolation in Participants Stratified by Median Left Atrial Late Gadolinium Enhancement Extent



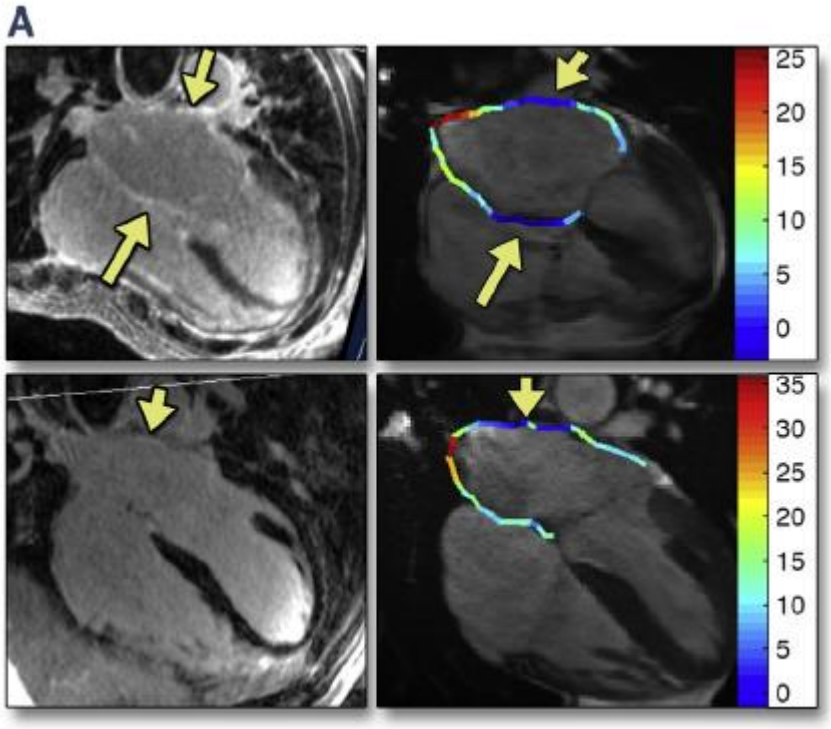
Time to first atrial fibrillation (AF) recurrence in 86 participants (52%) with late gadolinium enhancement (LGE) extent ≤35% **(solid line)** and 79 participants (48%) with LGE extent >35% of left atrial myocardium **(dashed line)** ($p < 0.001$).



Regardless of AF persistence at baseline, participants with LGE <35% have favorable outcomes, whereas those with LGE >35% have a higher rate of AF recurrence in the first year after ablation

Khurram et al. J Am Coll Cardiol Img 2016;9:142–8

LA function measured by MRI. Strain



Low strain region = LA fibrosis region

JACC 2017′ letter. http://dx.doi.org/10.1016/j.jcmg.2016.01.015

169 PAF pts.

LA strain measured by MRI had additive value in stroke prediction.

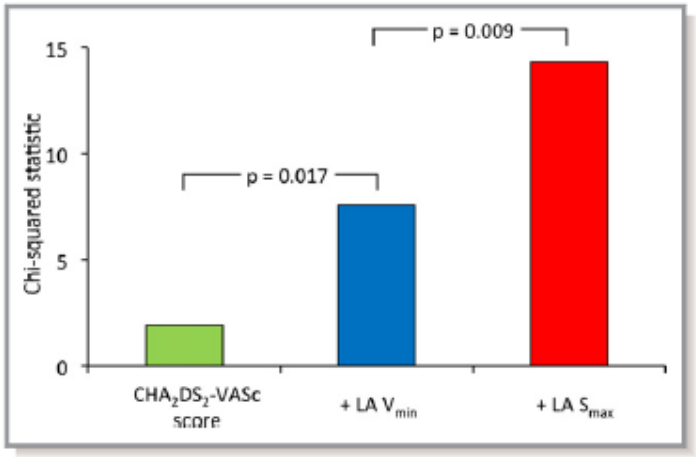


Figure 4. Incremental value of left atrial (LA) strain for diagnosis of stroke. The addition of the LA minimum volume (V_{min}) to the model on the basis of the CHA_2DS_2-VASc score resulted in significant improvement in the diagnostic value for stroke. The value was further increased by adding the LA global longitudinal maximum strain (S_{max}).

J Am Heart Assoc. 2015;4:e001844

Intra-atrial dyssynchrony during sinus rhythm is an independent predictor of recurrence after RFCA

FIGURE 2 Quantification of LA Regional Function Using Cine CMR

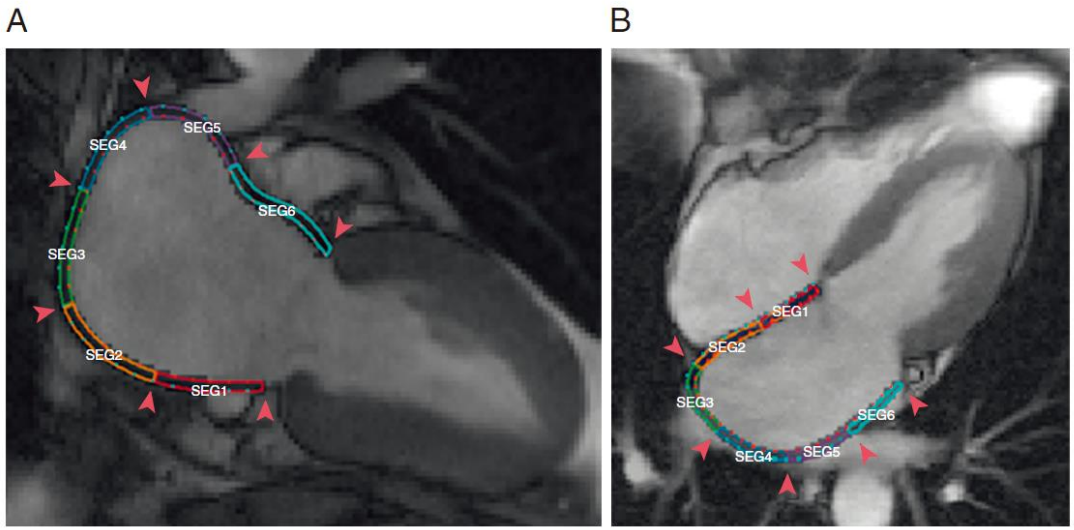


FIGURE 5 Time to Atrial Fibrillation Recurrence in the Test Group

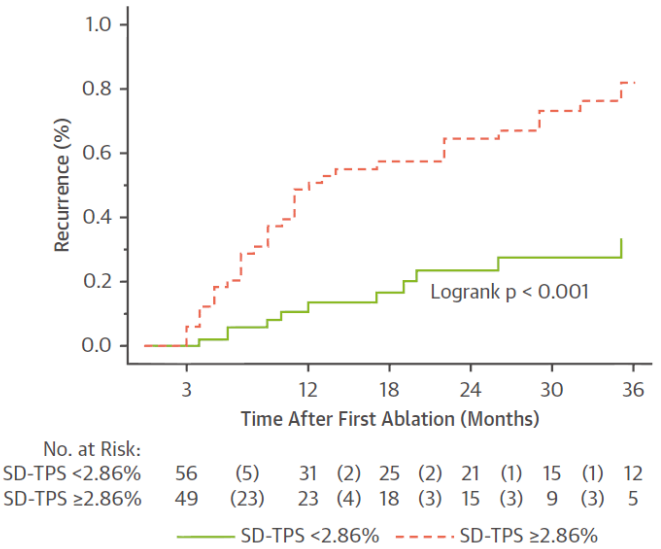
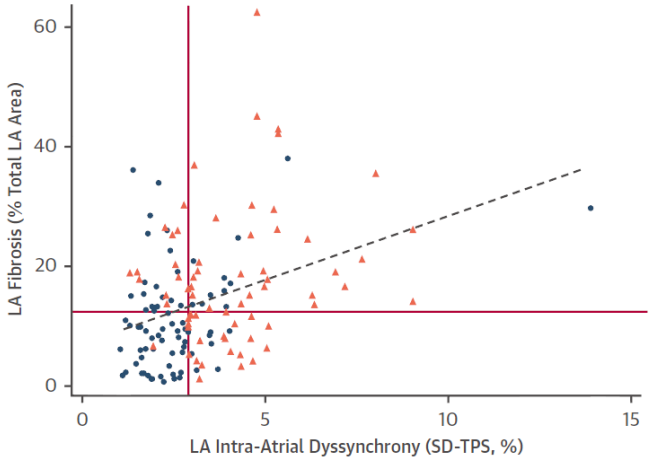


FIGURE 4 Correlation Between Intra-Atrial Dyssynchrony and LA Fibrosis

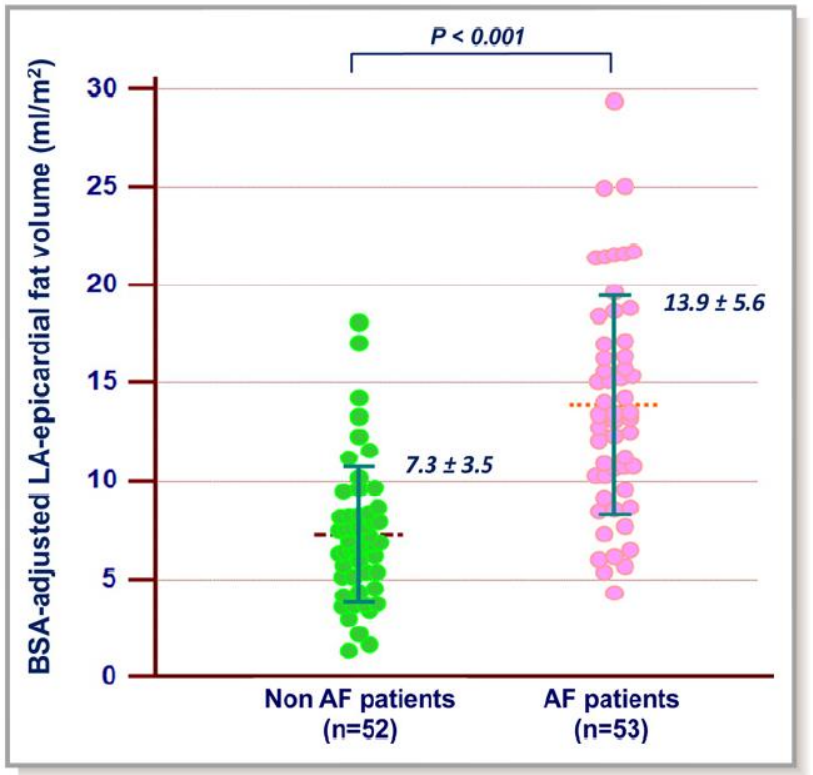


Patients with AF recurrence after ablation (n ¼ 101) had significantly higher SD-TPS than those without (n ¼ 107; 3.9% vs. 2.2%; p < 0.001).
Multivariable cox analysis showed that SD-TPS was associated with recurrence after adjusting for clinical risk factors, AF type, LA structure and function, and fibrosis (p < 0.001).
Furthermore, ROC analysis showed SD-TPS improved prediction of recurrence better than clinical risk factors, LA structure and function, and fibrosis.

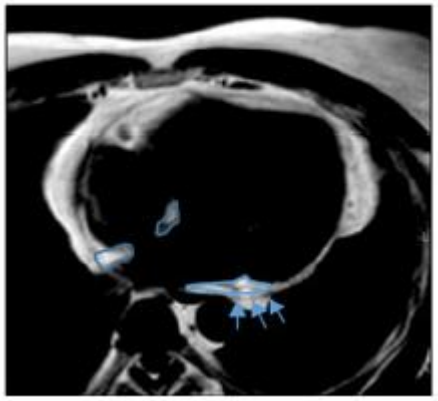
J AmColl Cardiol Img 2019;12:310–9

LA epicardial fat volume by MRI

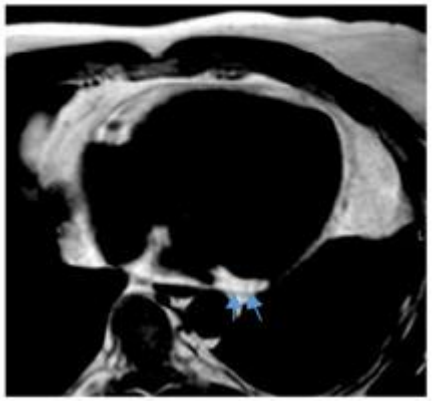
53 Hx of AF
52 control



Fat only image



Fat only image



J Am Heart Assoc. 2018;7:e008232

Sphericity index

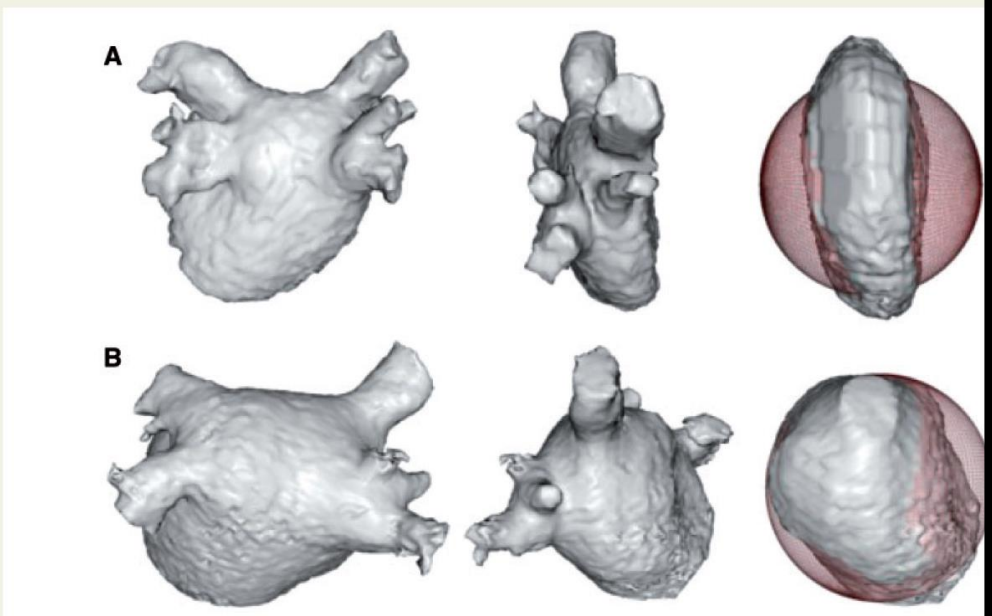
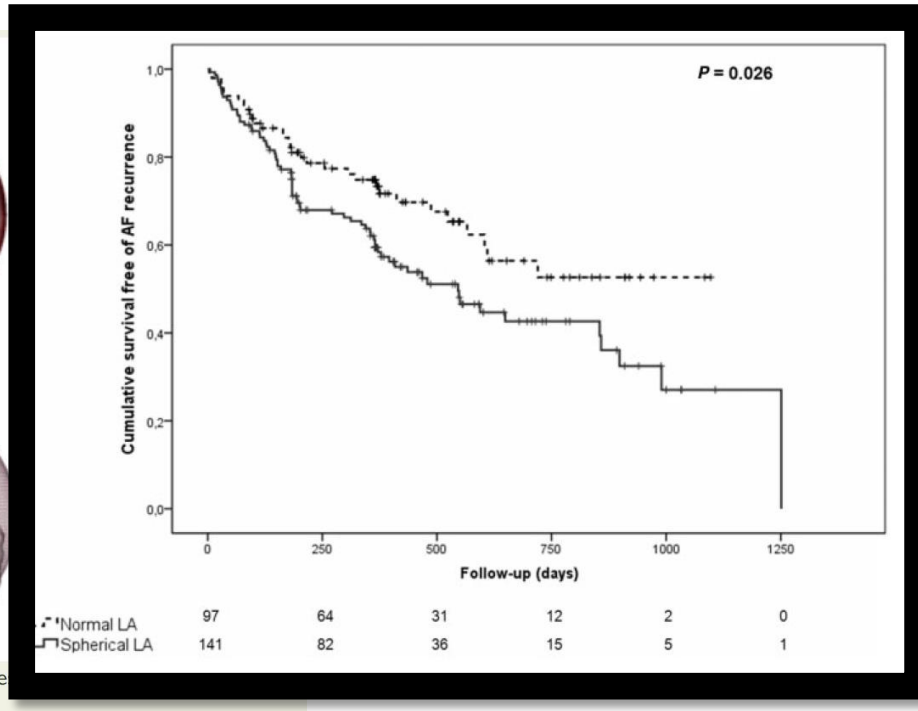


Figure 1 Left atrial sphericity (LASP) categories: examples of discoid (*A*) and spherical-shaped LA (*B*) corre
respectively. Posterior and right lateral views of 3D model are displayed. LAV, LA volume.



LA sphericity (HR 1.87, P = 0.035) was an independent predictors for AF recurrence.
A combined clinical-imaging score [Left Atrial Geometry and Outcome (LAGO)] including five items (AF phenotype, structural heart disease, CHA2DS2-VASc ≤ 1, LAD, and LA sphericity) classified patients at low (≤2 points) and high risk (≥3 points) of procedural
failure (35% vs. 82% recurrence at 3-year follow-up, respectively; HR 3.10, P < 0.001).

European Heart Journal – Cardiovascular Imaging (2018) 19, 1002–1009

Can CMR guide ablation?

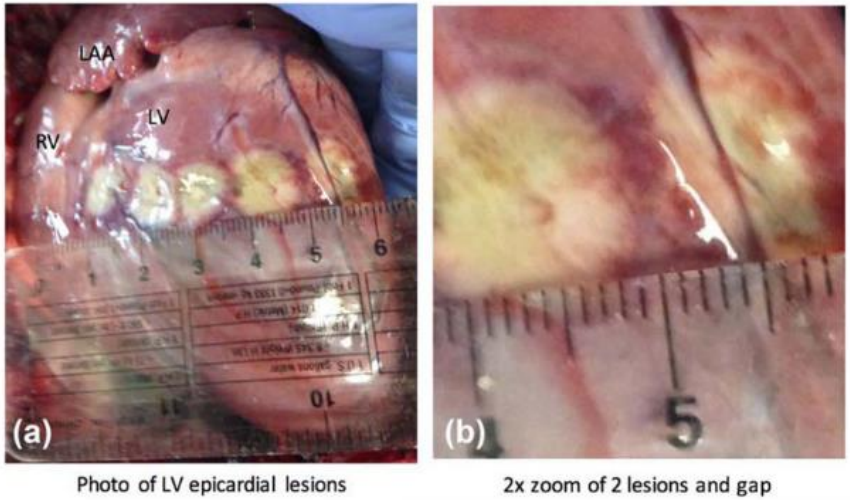
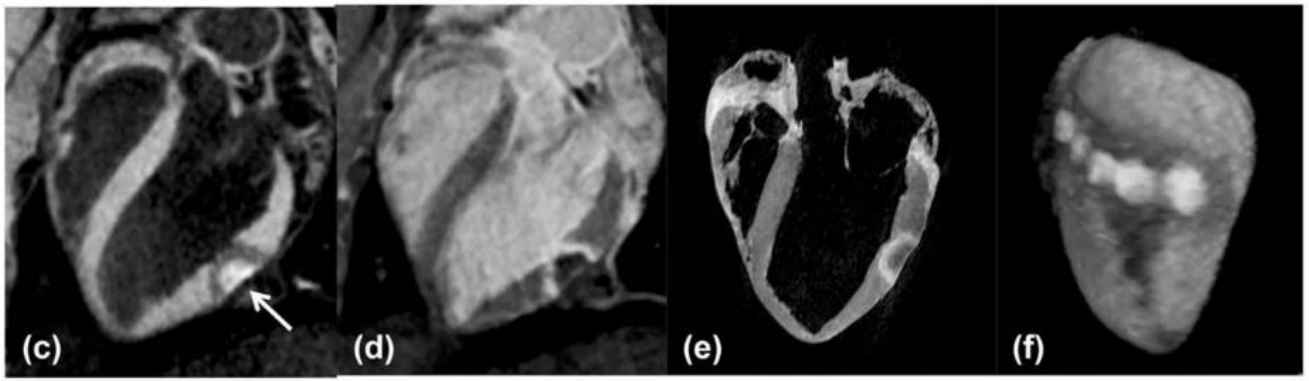


Photo of LV epicardial lesions

2x zoom of 2 lesions and gap



T1w

Early CE

Ex vivo (w/contrast)

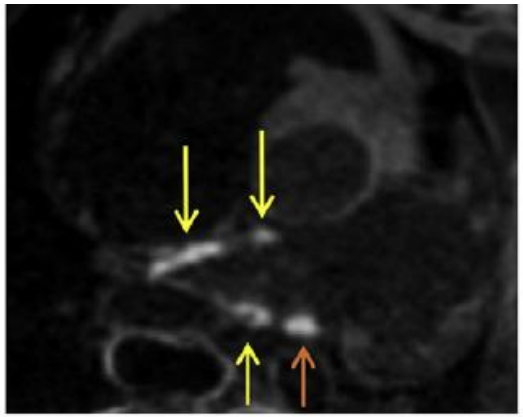
Volume rendering

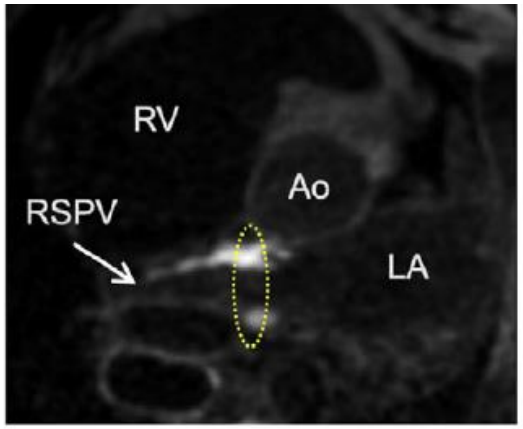
All ablations were visibly enhanced in non-contrast-enhanced T1w imaging using TI =700 ms. T1w enhancement agreed with regions of necrosis in gross pathology and histology.

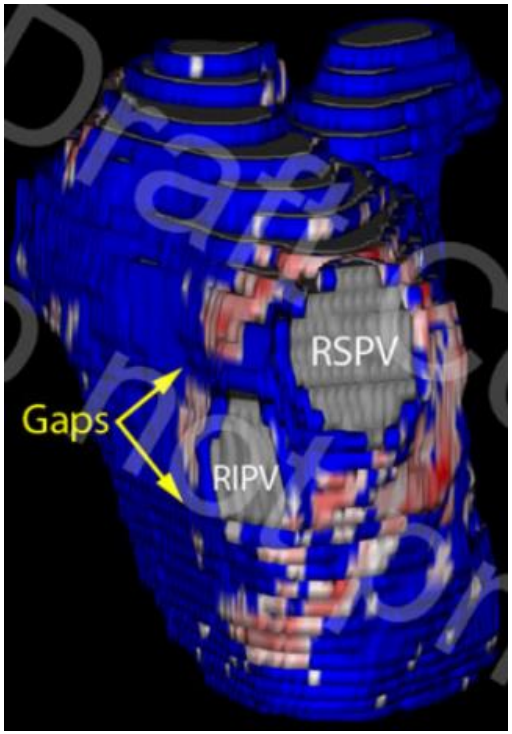
Magn Reson Med. 2018 February ; 79(2): 879–889

Can CMR guide AF ablation?

Non-contrast-enhanced T1-weighted (TWILITE) imaging acutely post radiofrequency ablation.







incomplete encirclement with gaps

Controversial results reported on the ability of LGE-CMR in identification of ablation gaps in patients undergoing a repeat ablation. In a study on 10 patients undergoing repeat ablation, no association was found between scar gaps in CMR and PV reconnection sites during electroanatomic mapping. However, in another study in 15 patients undergoing repeat AF ablation, the sites of electrical PV reconnection matched with a CMR gap in 79% of PVs.

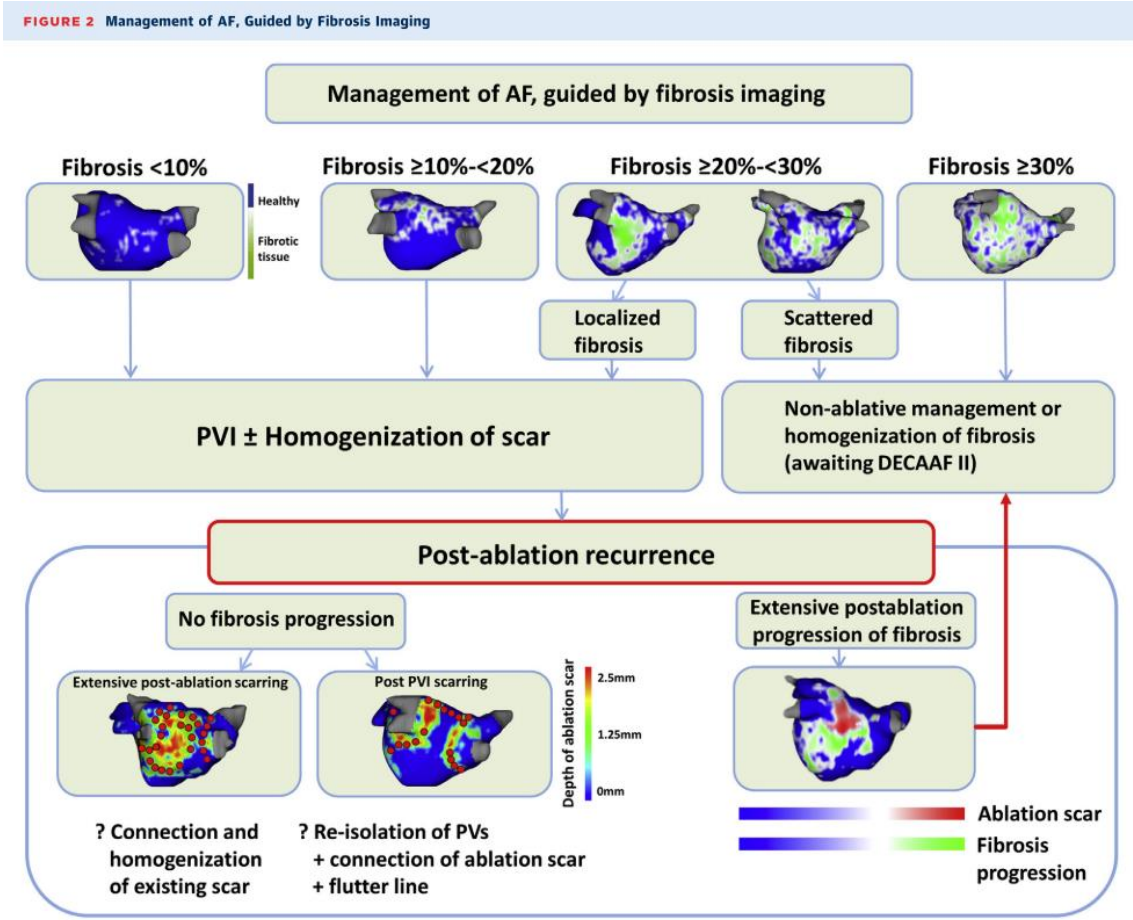
Card Electrophysiol Clin 12 (2020) 131-139
Heart Rhythm 2012;9:2003-9.
JACC Cardiovasc Imaging 2014;7:653-63.
J Cardiovasc Electrophysiol, Vol. 26, pp. 473-480, May 2015

Can CMR guide AF ablation?

Analysis of CMR images of patients from the DECAAF study reveals that in addition to preablation LGE, residual nonablated atrial fibrosis is also associated with poor outcomes.

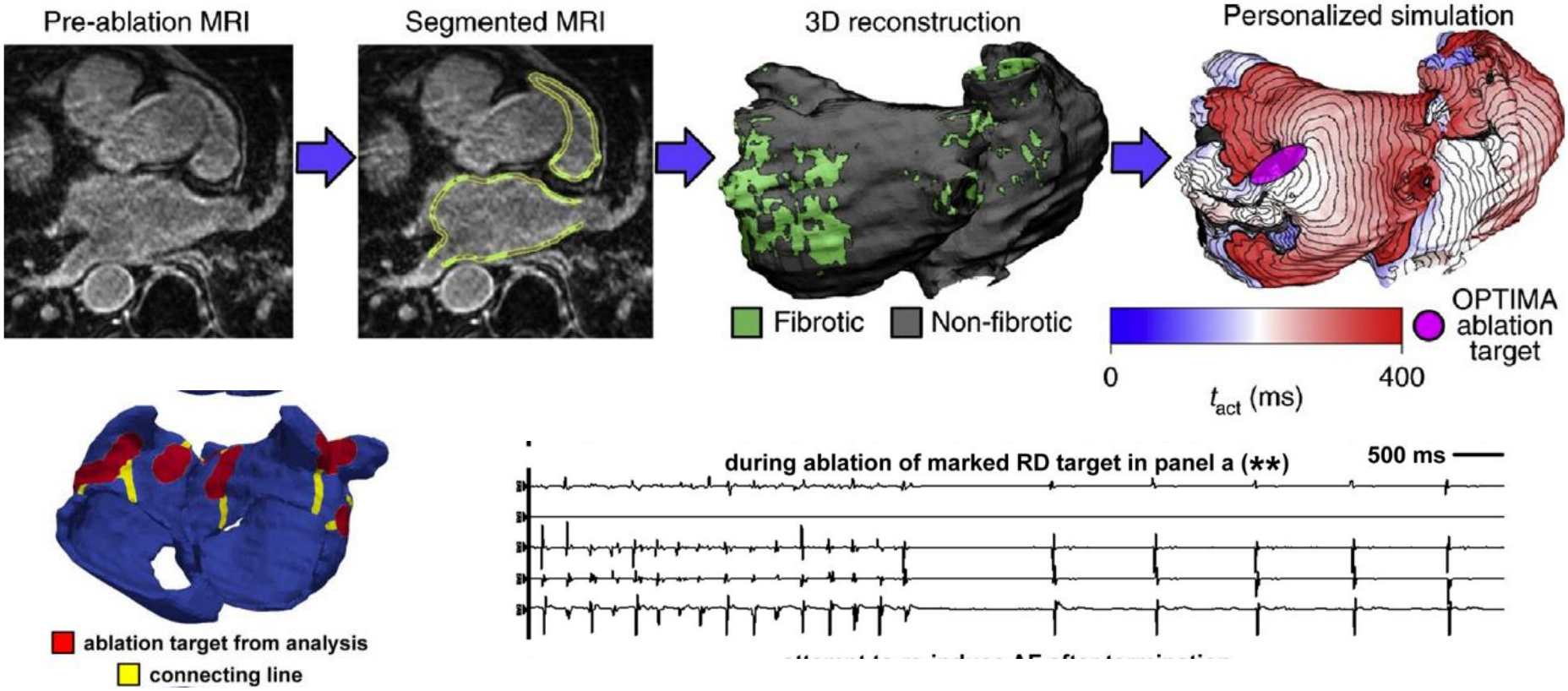
Therefore, an approach of ablating areas of LGE detected by preablation CMR in addition to PVI may potentially eliminate the substrate and triggers.

Ongoing DECAAF II trial (NCT02529319).



J Am Coll Cardiol EP 2017;3:791–802
J Cardiovasc Electrophysiol, Vol. 26, pp. 473-480, May 2015

Can CMR guide AF ablation?

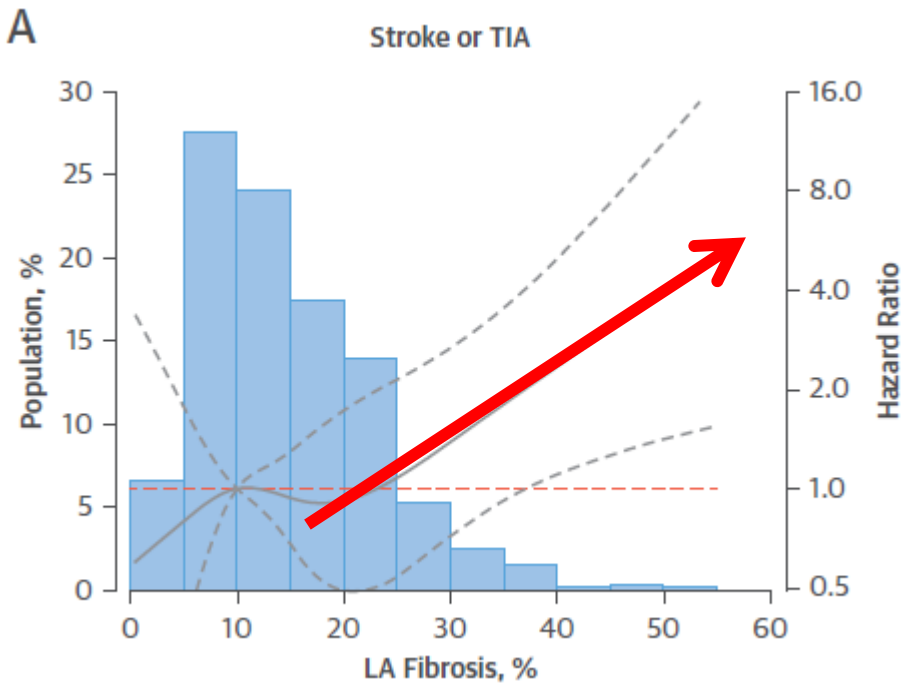


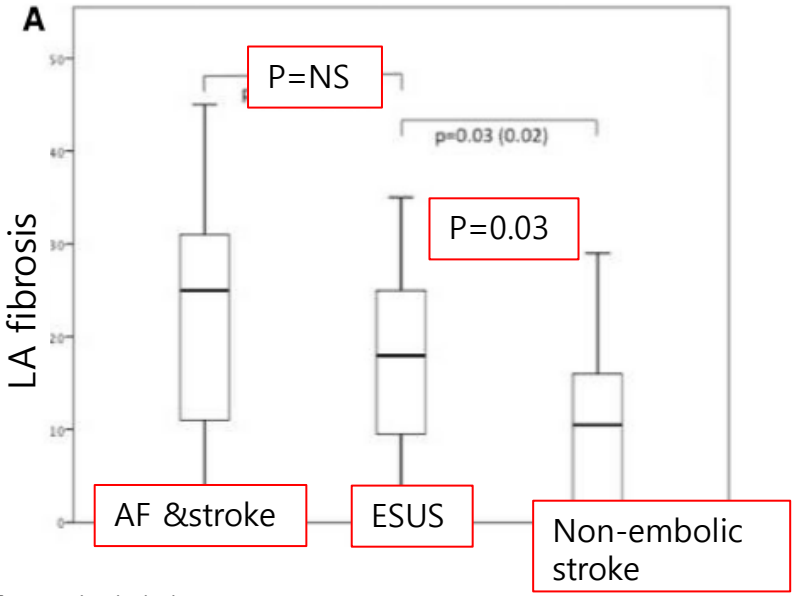
computational model of the atria of patients identifies fibrotic tissue that if ablated will not sustain AF. integrated the target-ablation sites in a clinical-mapping system, and tested its feasibility in 10 patients with persistent AF.

Nat Biomed Eng. 2019 November ; 3(11): 870–879

Can MRI guide stroke prevention in AF?
CARDIAC MAGNETIC RESONANCE AND ASSESSMENT FOR RISK OF STROKE

1,228 pts with AF.
62 stroke or TIA
Retrospective.
LA fibrosis well correlated with stroke



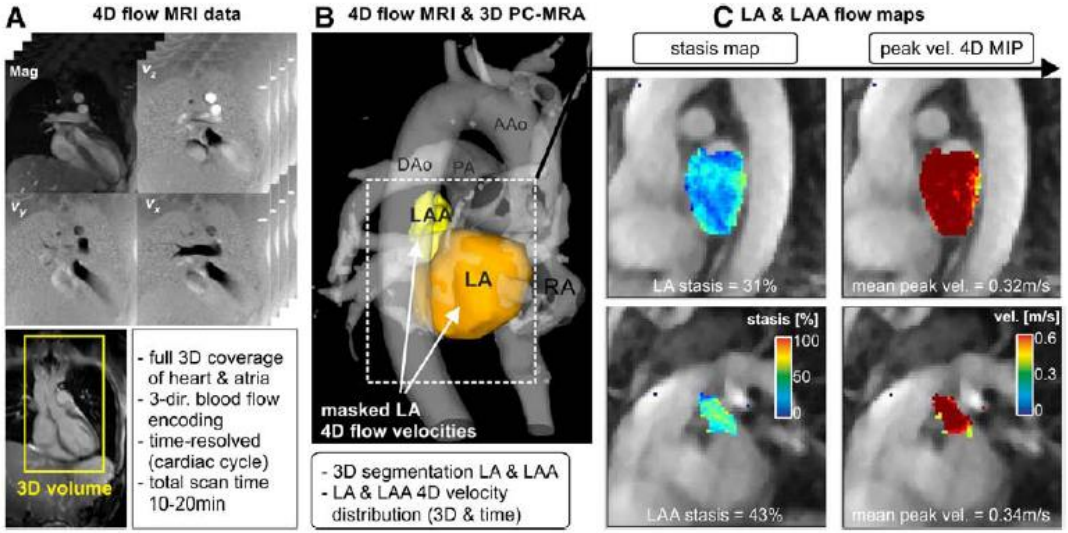


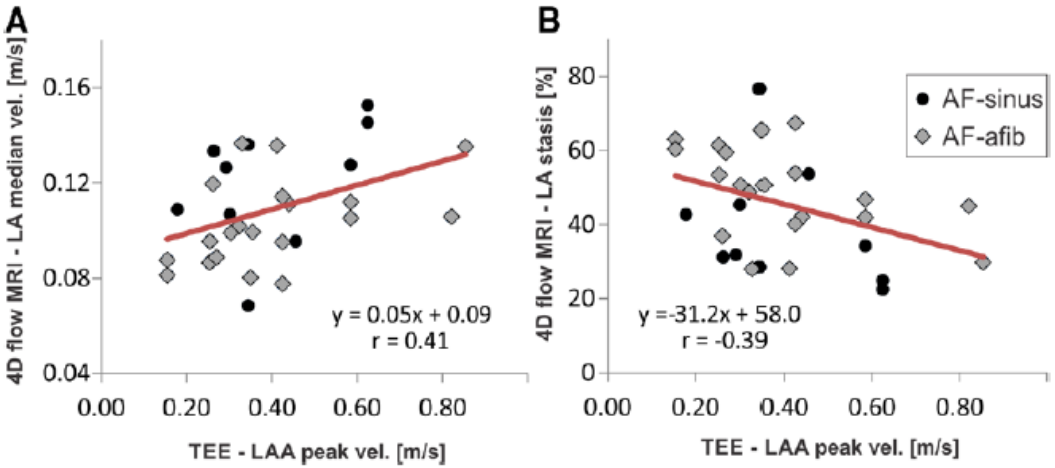
- Total 111 pts.
- ESUS a higher LA fibrosis (p=0.03)
- AF and ESUS showed a similar value of atrial fibrosis.
- an atrial disease may be associated with stroke.

J Am Coll Cardiol 2017;70:1311–21

Stroke. 2018;49:734–737

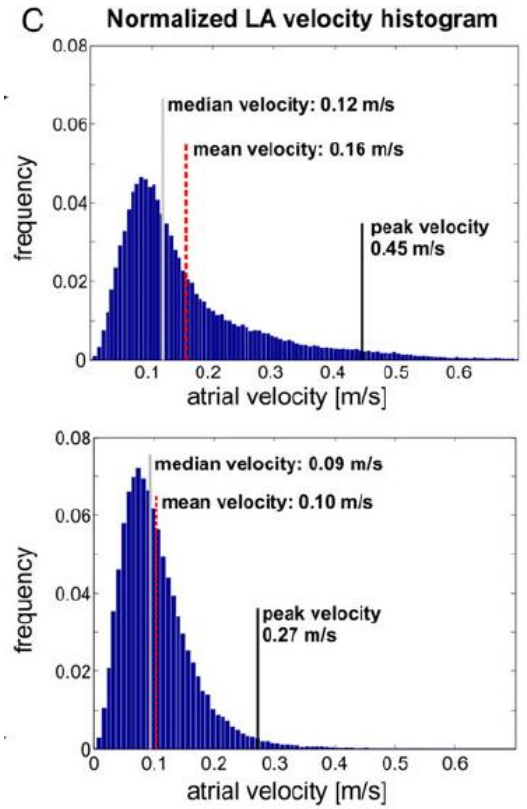
Can MRI guide stroke prevention in AF?
LAA flow by 4D MRI





MRI-measured LAA flow velocity
Correlated with TEE-measured velocity

Flow velocity was lower in AF than NSR



M Markl et al.
Circ Cardiovasc Imaging. 2016 Sep;9(9):e004984
EHJ – Cardiovascular Imaging (2016) 17, 1259–1268

Summary

- CMR can give information on atrial structure, function, tissue characteristics, and blood flow
- Recent studies suggests AF as a part of LA myopathy. CMR has the potential of changing AF management by assessment of LA myopathy.
- It also can be used in management of patients with AF in preablation prognostication, and planning of ablation strategies.
- CMR can be used in assessment of stroke risk and, therefore, potentially can be incorporated in decision making about anticoagulation