Ruolo della Risonanza magnetica nell'infarto: perfusione e funzione one shot

G.D.Aquaro

ondazione G.Monasterio Regione Toscana/
CNR - Pisa

MRI in ACS

CMR provides useful information in selected patients with ACS

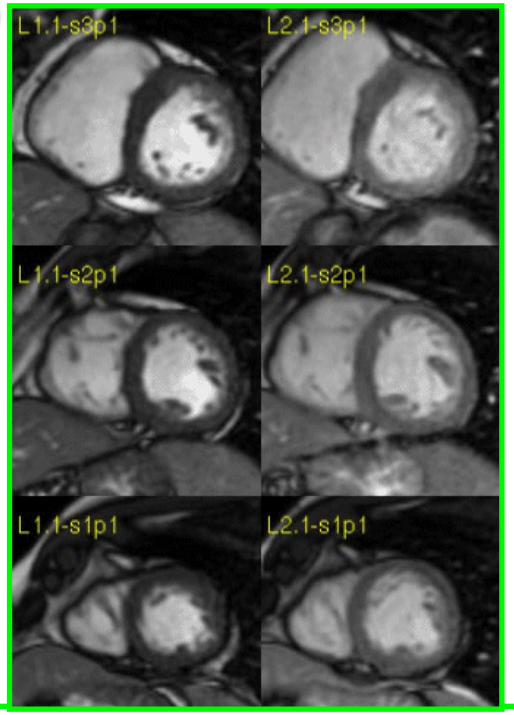
Exclude:
1) Absolute contraindication
2) Obese >tunnel diameter (55-70 cm)
3) True claustrophobic (2:10000 gen pop)
4) Severe renal insufficiency (CrCl <20 ml/min)
5) Atrial fibrillation

Try to:
1) Minimize BEV
2) Treat allergy (rare Gd allergy)
3) Treat false claustrop.

MRI in ACS

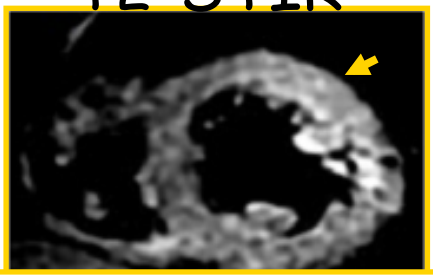
Clinical setting

Perfusion defect



Wall motion abnormalities

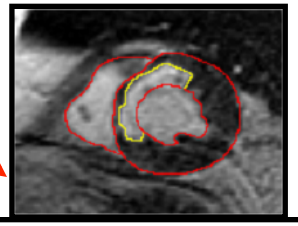
T2-STIR



Myocardial edema

Reversible damage

Irreversible damage



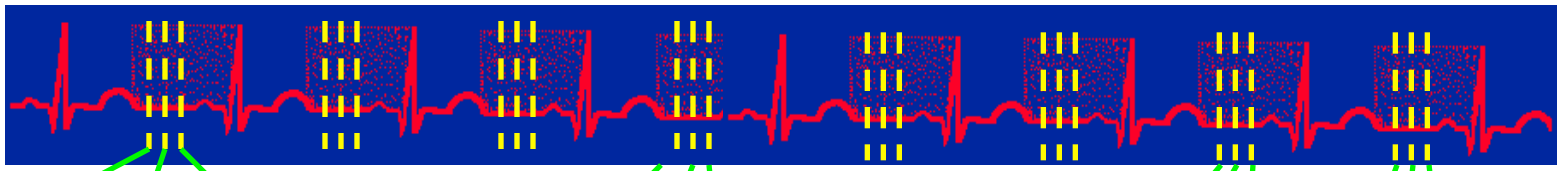
Myocardial Necrosis

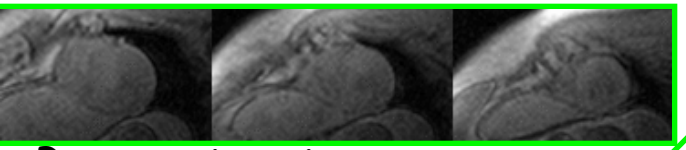
MRI in ACS

First Pass MRI
Injection of Gd-based c.m. (0.05 mmol/kg,4 mL/s)

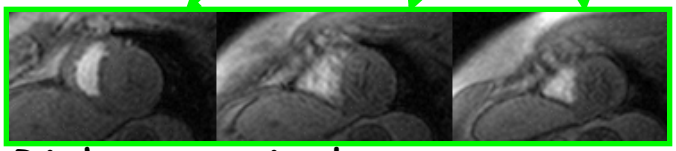
GRE EPI ET:
fill K-space in 1 beat
3 short axis views (now 5-6)

60-80 beats

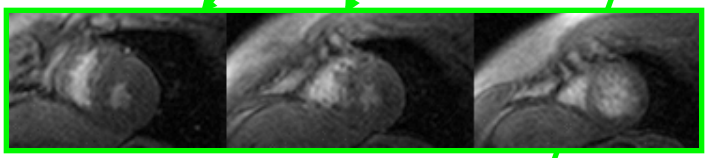




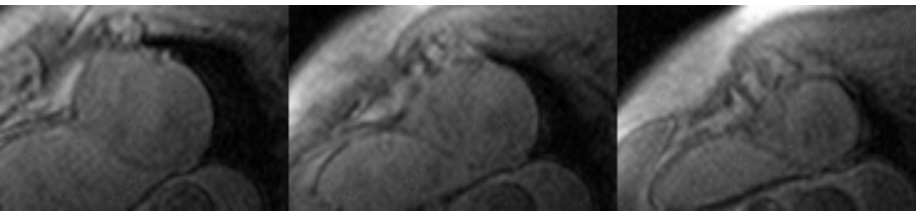
Pre-contrast



Right ventricular



Left ventricular

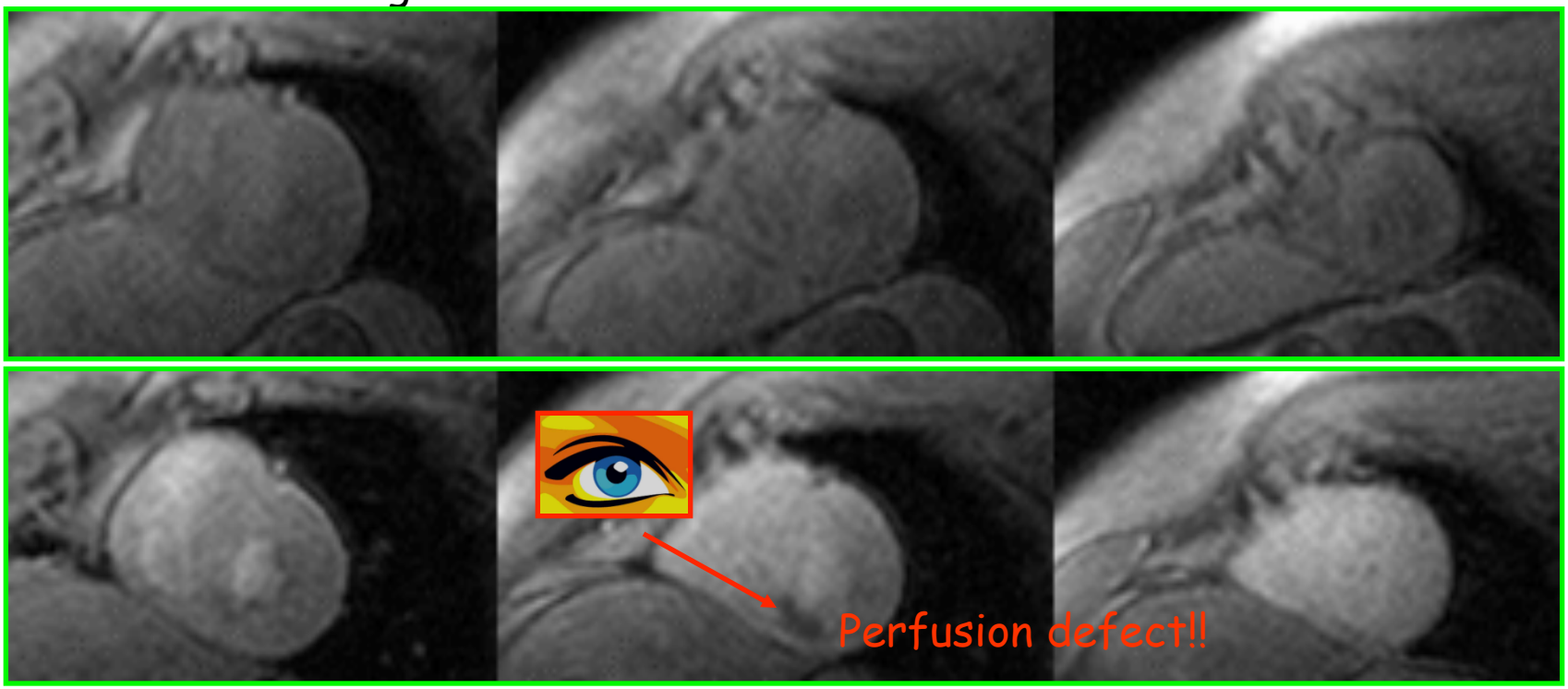


Myographic

MRI in ACS

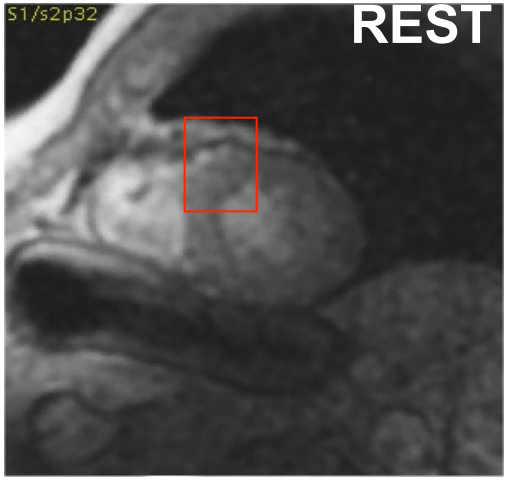
First Pass MRI
Image analysis

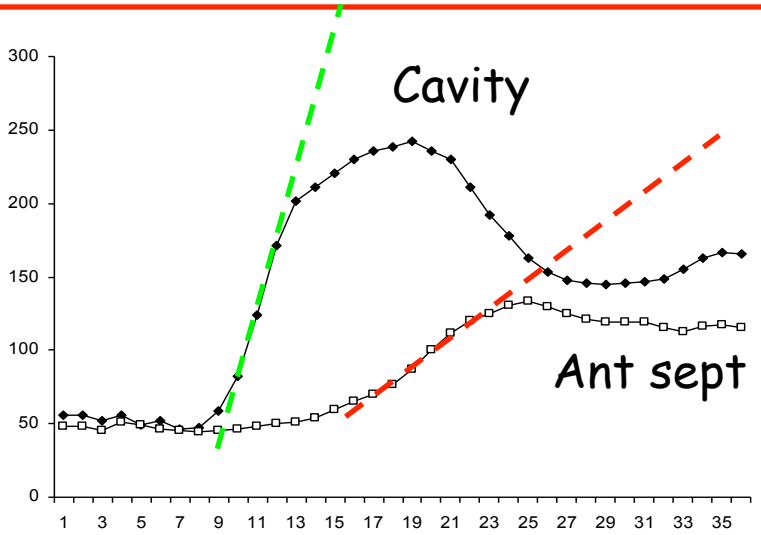
In the clinical settings: VISUAL ANALYSIS

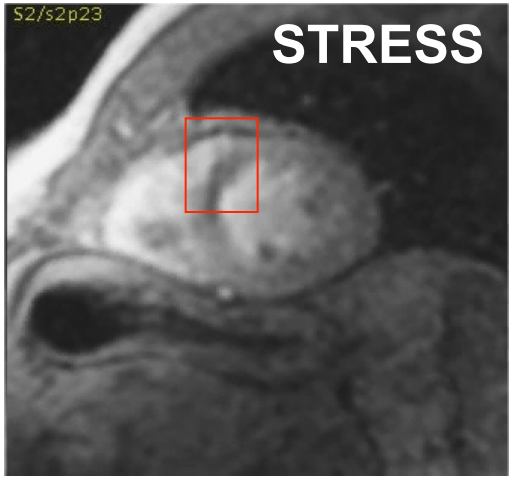


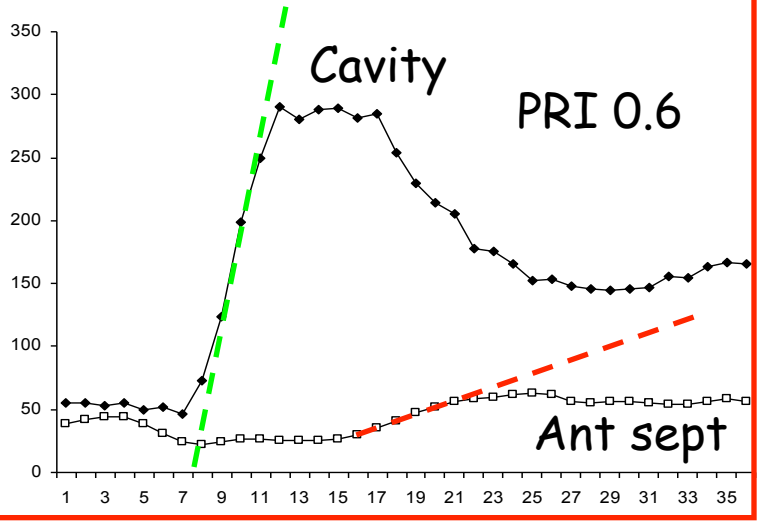
Susceptibility artefacts and dark rime
PVC ==> images acquired in systole==> hypoperfusion in subendocardial layer
Scar post-contrast enhancement ==> compare with DE

MRI in ACS









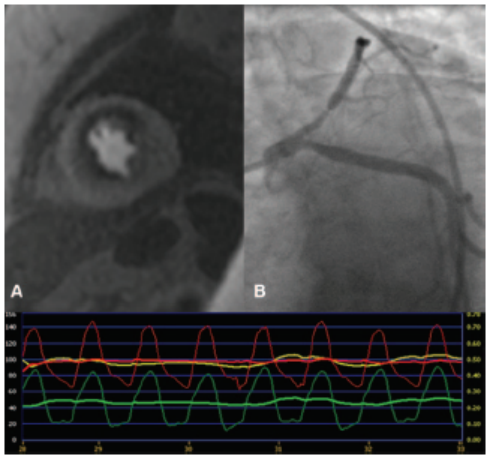
PRI:
Perfusion
Reserve index

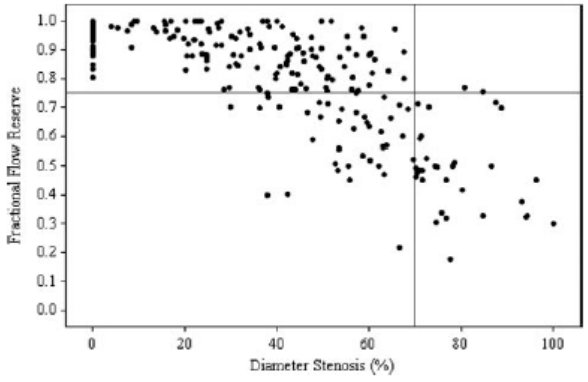
Upslope Stress
(rel. cavity)

Upslope Rest
(rel. cavity)

PRI normal: 2+
PRI ischemic <1.5

MRI in ACS





Validation of Magnetic Resonance Myocardial Perfusion Imaging With Fractional Flow Reserve for the Detection of Significant Coronary Heart Disease

Background—Magnetic resonance myocardial perfusion imaging (MRMPI) has a number of advantages over the other noninvasive tests used to detect reversible myocardial ischemia. The majority of previous studies have generally used quantitative coronary angiography as the gold standard to assess the accuracy of MRMPI; however, only an approximate relationship exists between stenosis severity and functional significance. Pressure wire–derived fractional flow reserve (FFR) values <0.75 correlate closely with objective evidence of reversible ischemia. Accordingly, we have compared MRMPI with FFR.

Methods and Results—One hundred three patients referred for investigation of suspected angina underwent MRMPI with a 1.5-T scanner. The stress agent was intravenous adenosine (140 $\mu g \cdot kg^{-1} \cdot min^{-1}$), and the first-pass bolus contained 0.1 mmol/kg gadolinium. In the following week, coronary angiography with pressure wire studies was performed. FFR was recorded in all patent major epicardial coronary arteries, with a value <0.75 denoting significant stenosis. MRMPI scans, analyzed by 2 blinded observers, identified perfusion defects in 121 of 300 coronary artery segments (40%), of which 110 had an FFR <0.75. We also found that 168 of 179 normally perfused segments had an FFR ≥0.75. The sensitivity and specificity of MRMPI for the detection of functionally significant coronary heart disease were 91% and 94%, respectively, with positive and negative predictive values of 91% and 94%.

Conclusion—MRMPI can detect functionally significant coronary heart disease with excellent sensitivity, specificity, and positive and negative predictive values compared with FFR. (*Circulation*. 2009;120:2207-2213.)

Diagnostic Ability of MRMPI

	FFR <0.75	FFR ≤0.8	DS ≥70%
Sensitivity, %	90.9 (84.2–97.6)	81.9 (73.5–90.4)	97.3 (92.8–101.8)
Specificity, %	93.9 (88.9–98.8)	98.1 (95.0–101.2)	78.1 (70.5–85.6)
PPV, %	90.9 (84.3–97.5)	97.5 (94.0–101.0)	59.0 (47.5–70.6)
NPV, %	93.9 (88.9–98.9)	85.5 (78.2–92.8)	98.9 (96.9–100.9)

MRMPI Compared With FFR at 2 Cutoff Values (0.75 and 0.8) and Degree of Stenosis by QCA

	FFR <0.75	FFR ≥0.75	Total	FFR ≤0.8	FFR >0.8	Total	DS ≥70%	DS <70%	Total
Positive MRMPI	110	11	121	118	3	121	72	50	122
Negative MPMRI	11	168	179	26	153	179	2	178	180
Total	121	179	300	144	156	300	74	228	302

Results are expressed per coronary artery territory.

Visual assessment!!

Watkins S et al Circulation 2009

MRI in ACS

Cardiovascular magnetic resonance and single-photon emission computed tomography for diagnosis of coronary heart disease (CE-MARC): a prospective trial

John P Greenwood, Neil Maredia, John F Younger, Julia M Brown, Jane Nixon, Colin C Everett, Petra Bijsterveld, John P Ridgway, Aleksandra Radjenovic, Catherine J Dickinson, Stephen G Ball, Sven Plein

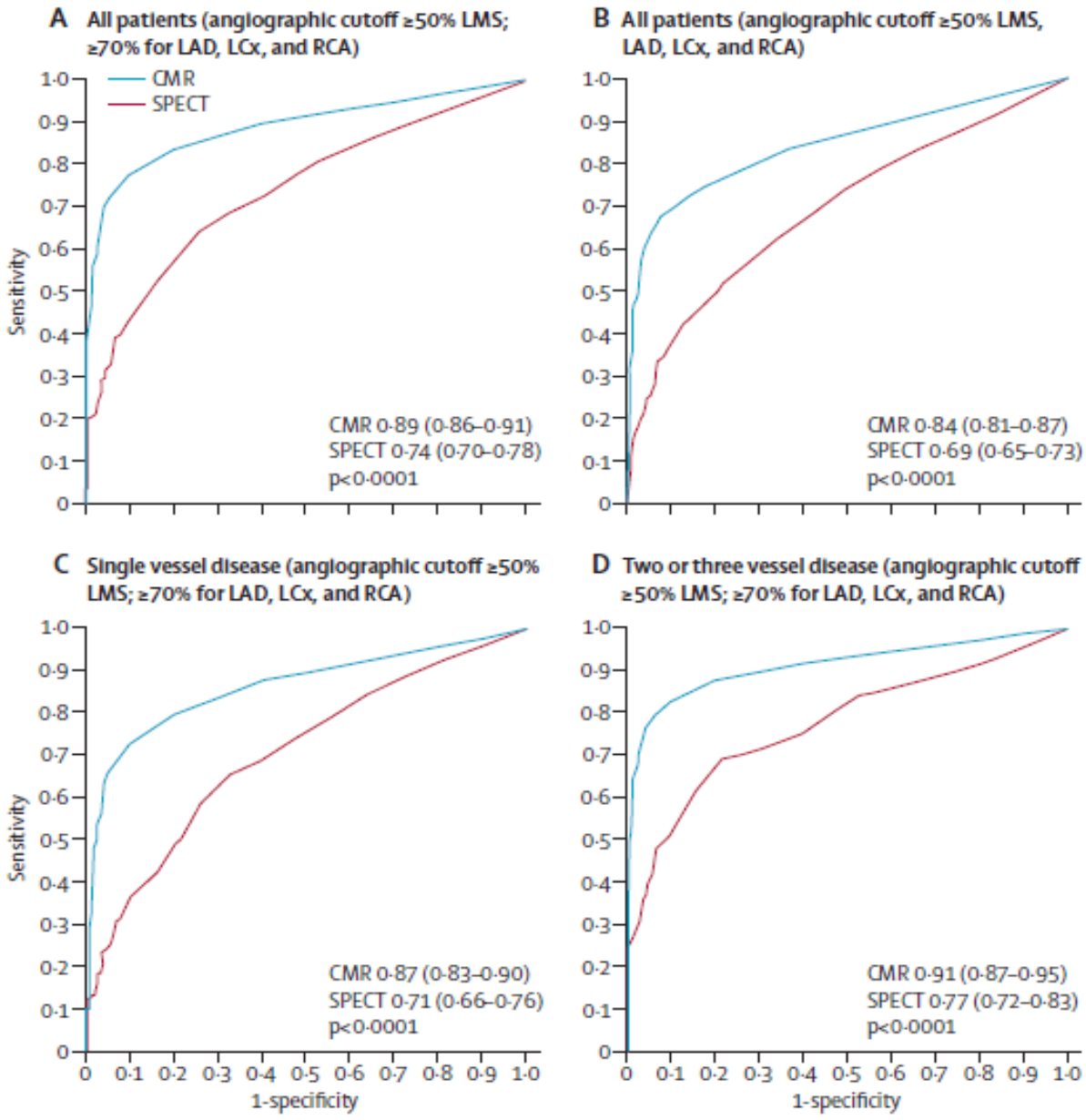
The largest, prospective, real world evaluation of CMR vs SPECT trial:

751 patients with
1) suspected angina pectoris, *and*
2) at least one cardiovascular risk factor

-adenosine stress-CMR + LGE-CMR + coronary angio-CMR
-adenosine G-SPECT
-coronary angiography as GOLD STANDARD

Lancet, 2012

MRI in ACS

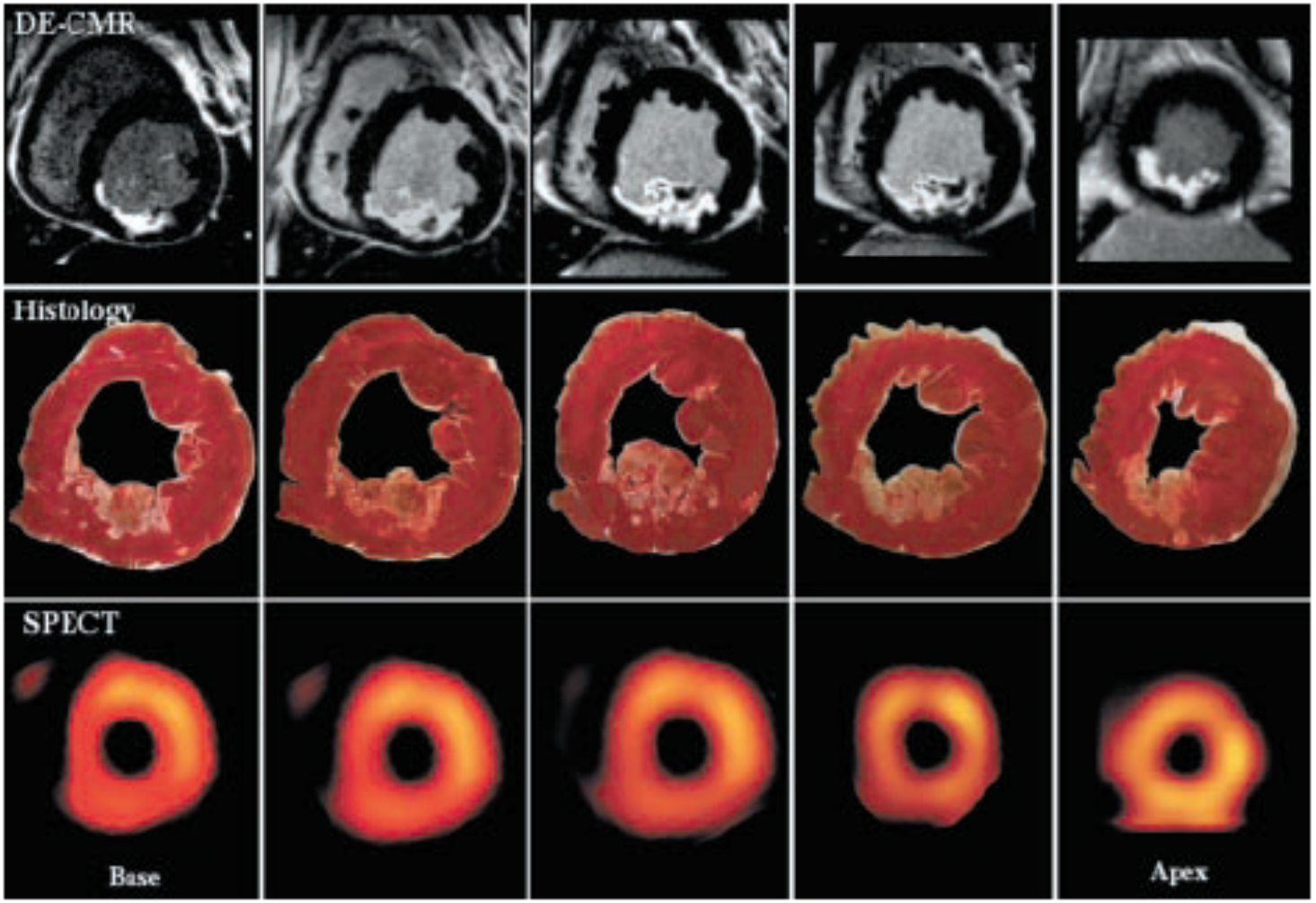


CE-MARC

"CE-MARC has established CMR's high diagnostic accuracy in coronary heart disease and CMR's superiority over SPECT. It should be adopted more widely than at present for the investigation of coronary heart disease…."

Lancet, 2012

MRI in ACS



Subendocardial necrosis

TTC staining

SPECT

High resolution of DE-MRI and subendocardial necrosis

Kim et al NEJM 99

MRI in ACS

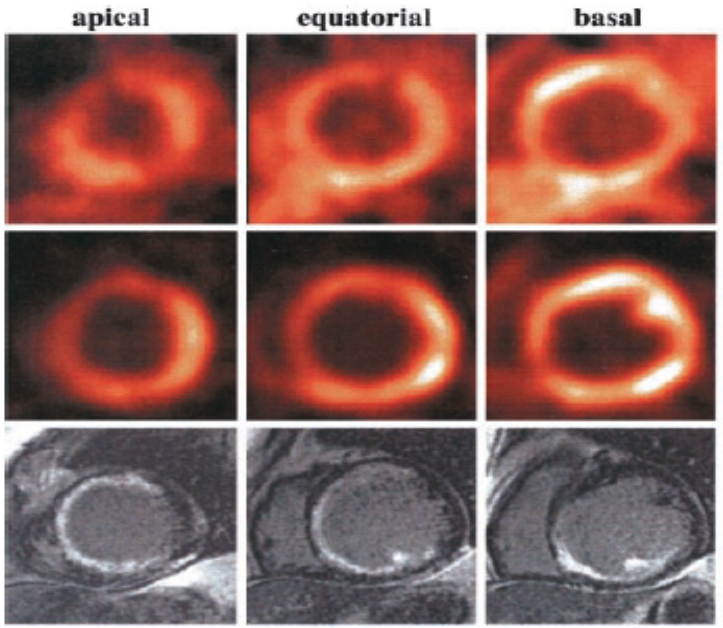
DE-CMR, PET and SPECT

DE in prediction of patients with PET defects:
Specificity 96%, Sensitivity 100%

DE in prediction of segment with PET defects:
Specifitiy 86%, Sensitivity 94%

11% of total segments were normal with PET but enhanced with DE

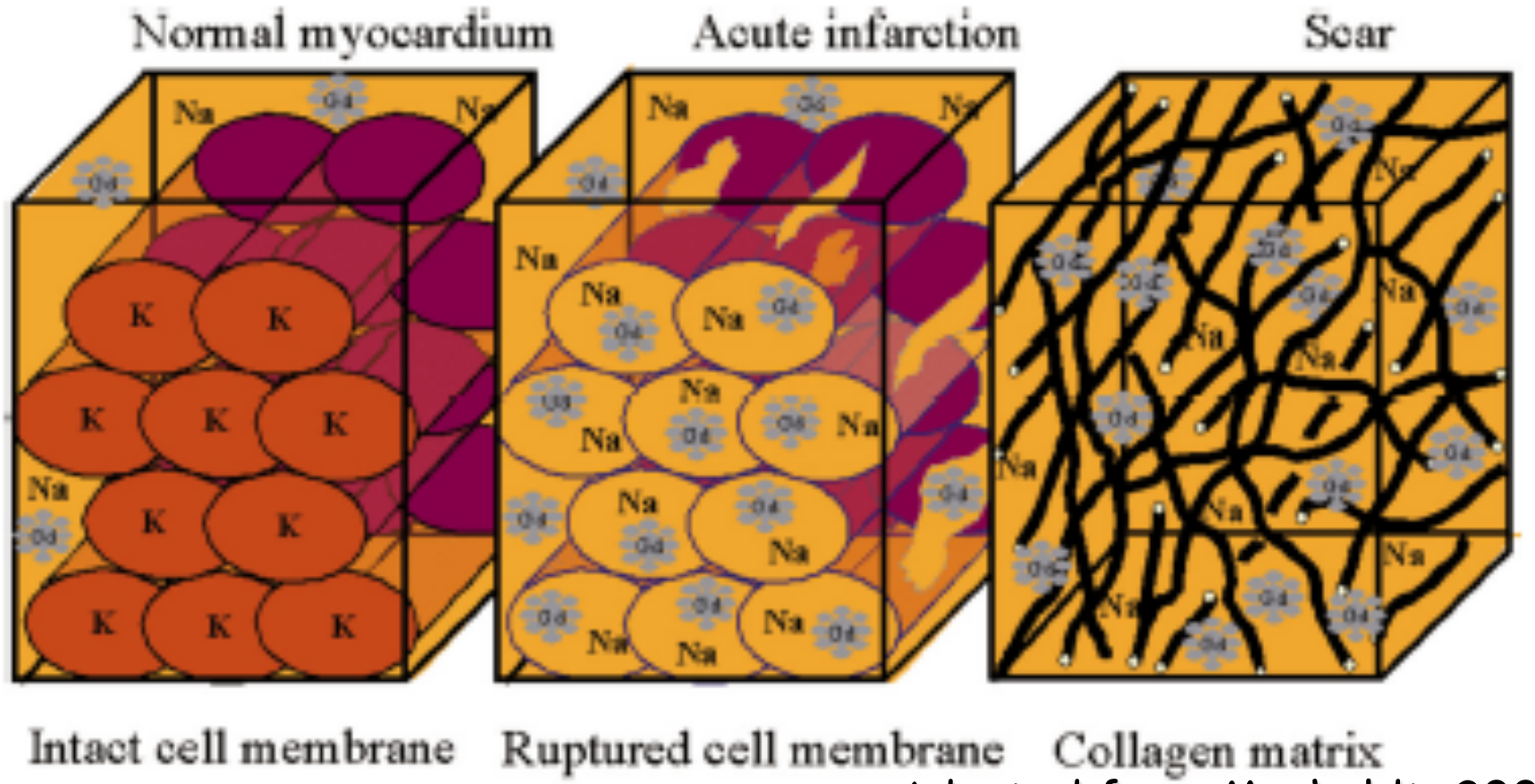
What technique is
the gold standard???



Klein et al,2002

MRI in ACS

LATE or DELAYED ENHANCEMENT



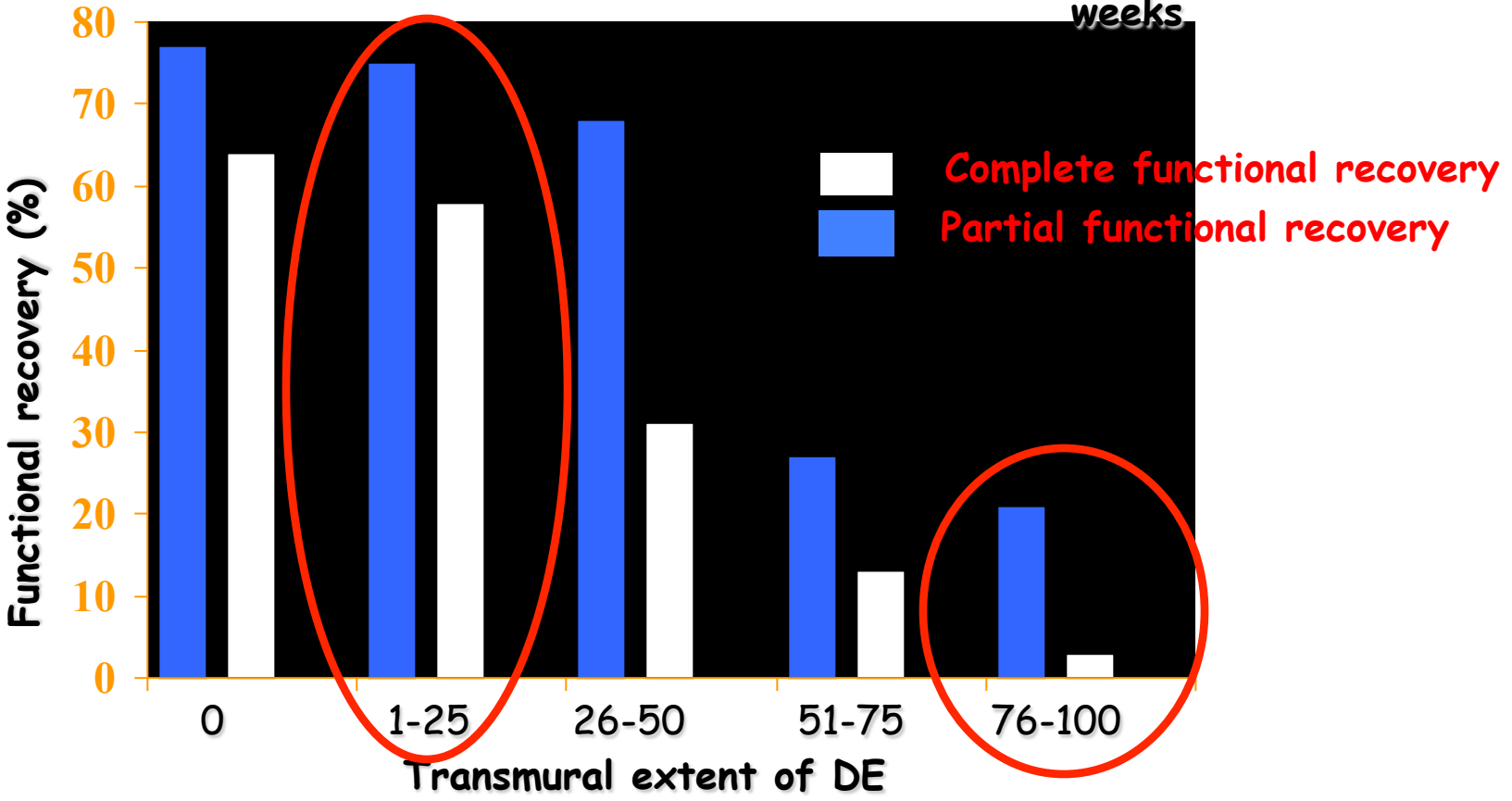
Adapted from Marholdt, 2009

MRI in ACS

DE and contractile reserve

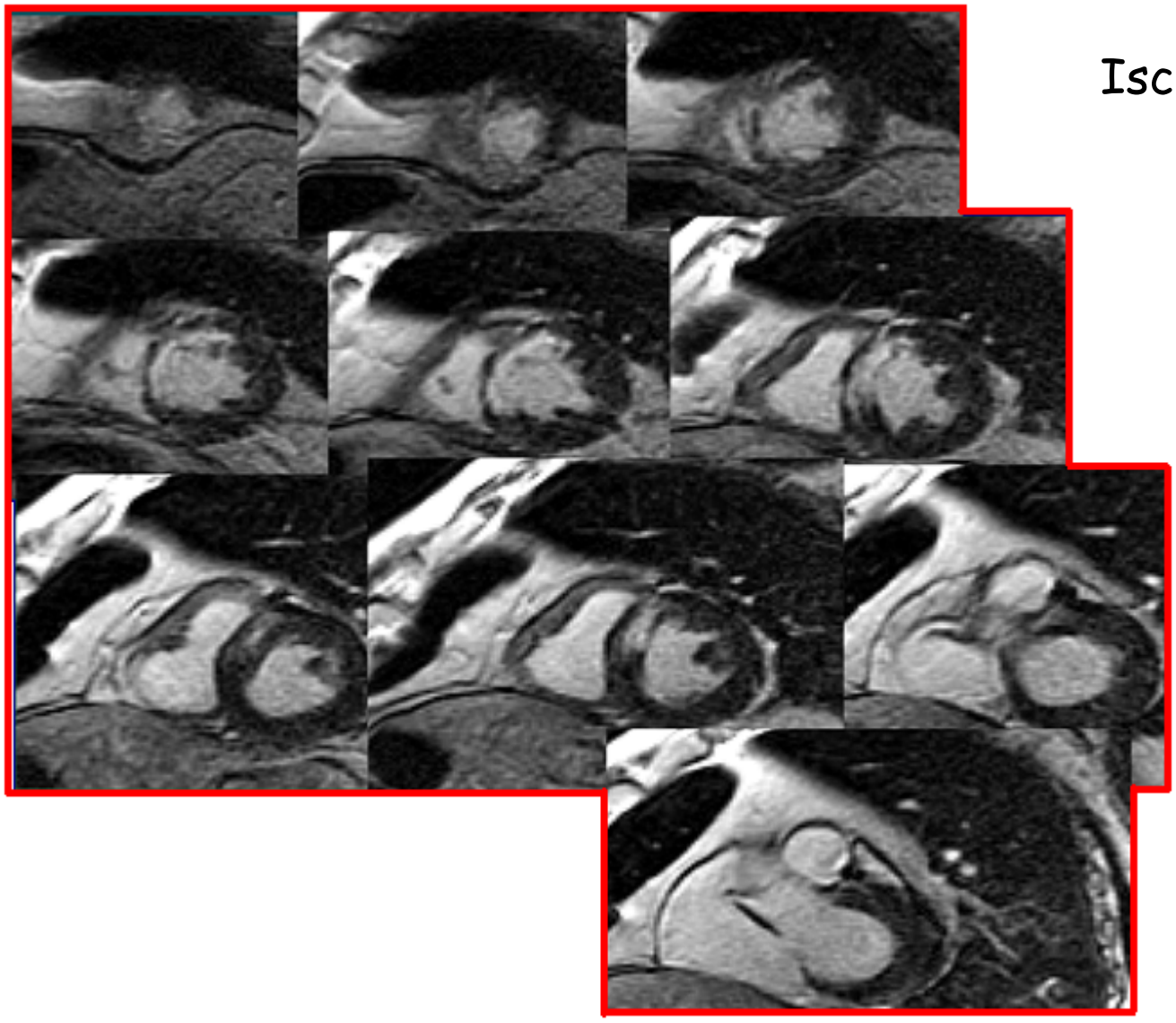
30 pts with AMI treated with PTCA

In Follow-up of 8-12 weeks



Beek AM et al. (2003) JACC

MRI in ACS



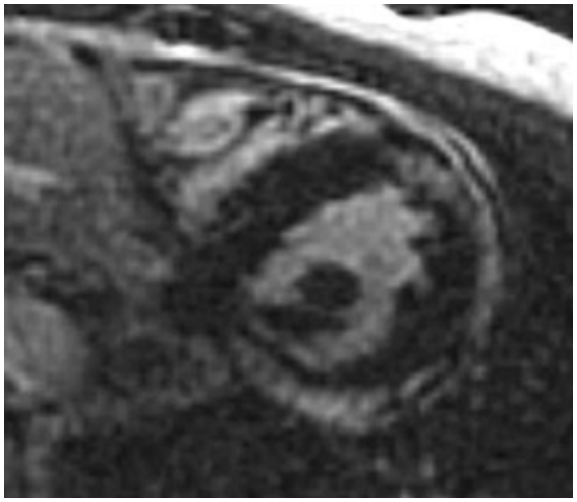
Ischemic pattern of DE

- subendocardial layer always involved
- +/- transmural extent
- confluent scar
- vascularization territory of one coronary artery

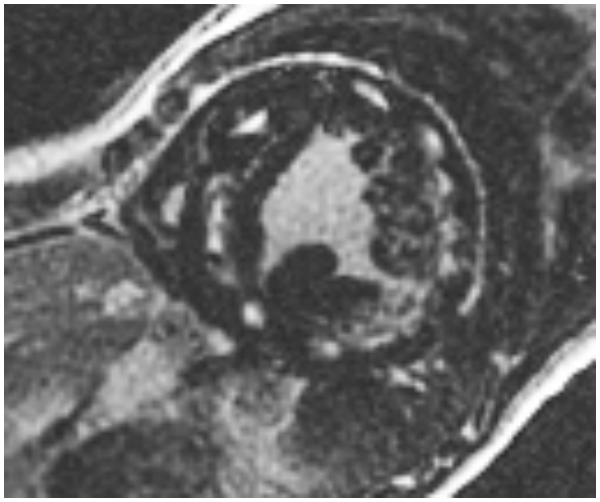
MRI in ACS

Non ischemic pattern of DE

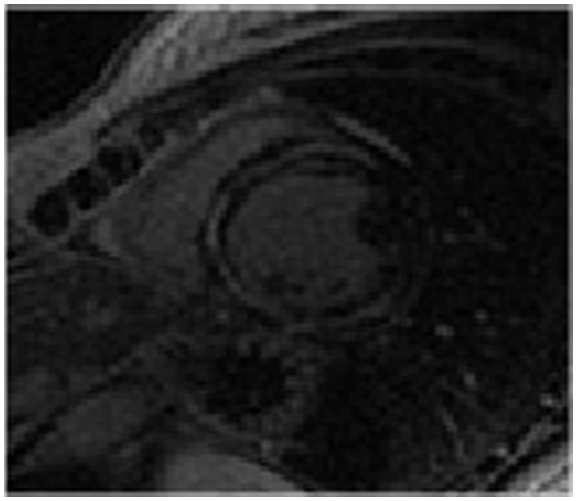
Epicardial involvement



Diffuse, patchy



Intramural



Not respected territory of vascularization of one coronary artery

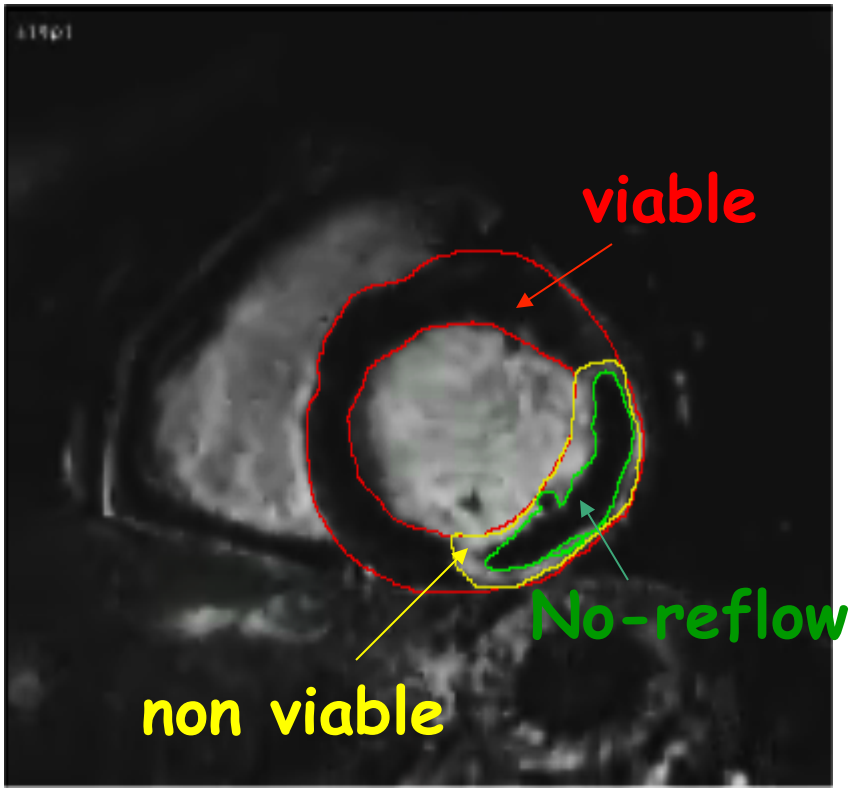
Role of Cardiovascular Magnetic Resonance as a Gatekeeper to Invasive Coronary Angiography in Patients Presenting With Heart Failure of Unknown Etiology

Ravi G. Assomull, MRCP; Carl Shakespeare, MD, FRCP; Paul R. Kalra, MA, FRCP; Guy Lloyd, MD, FRCP; Ankur Gulati, MRCP; Julian Strange, MRCP; William M. Bradlow, MD, MRCP; Jonathan Lyne, MRCP; Jennifer Keegan, PhD; Philip Poole-Wilson, FRCP, FESC; Martin R. Cowie, MD, FRCP; Dudley J. Pennell, MD, FRCP, FESC; Sanjay K. Prasad, MD, FRCP, FESC

Sensitivity 100%
Specificity 96%
To predict
ischemic-HF

MRI in ACS

No-reflow phenomenon (MVO)

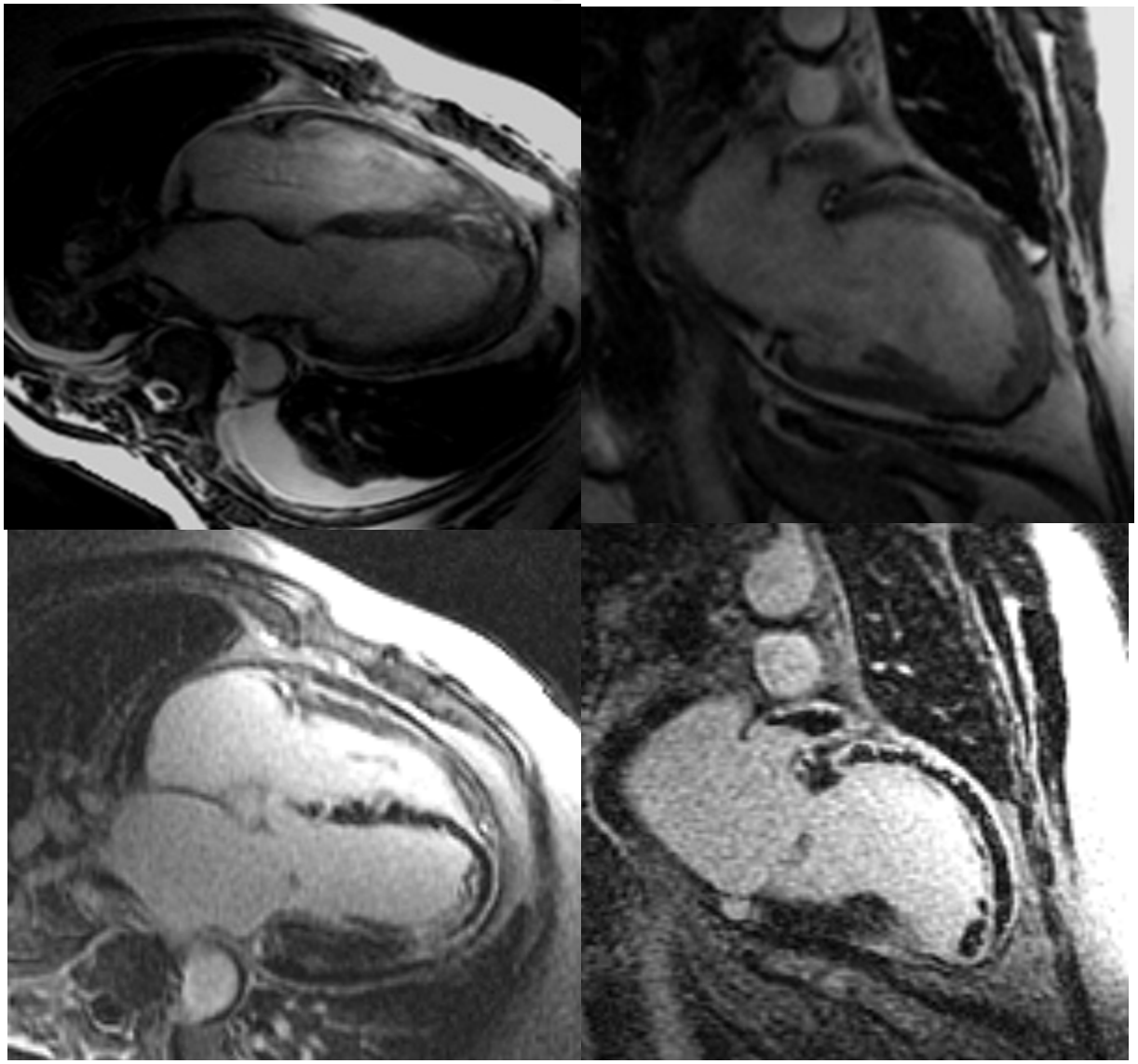


The NoReflow is defined as a hypoenhanced zone within the hyperenhanced region

NoReflow phenomenon is related to microvascular obstruction for endotelial swelling, interstitial edema, capillary plugging, embolization and thrombosis

MRI in ACS

No-reflow phenomenon



Male, 63 y.
Anteroseptal AMI
treated with
primary PTCA
and STENT on
anterior descending
artery 5 h
after pain

MRI:
DE in 47%
No-reflow in 27%

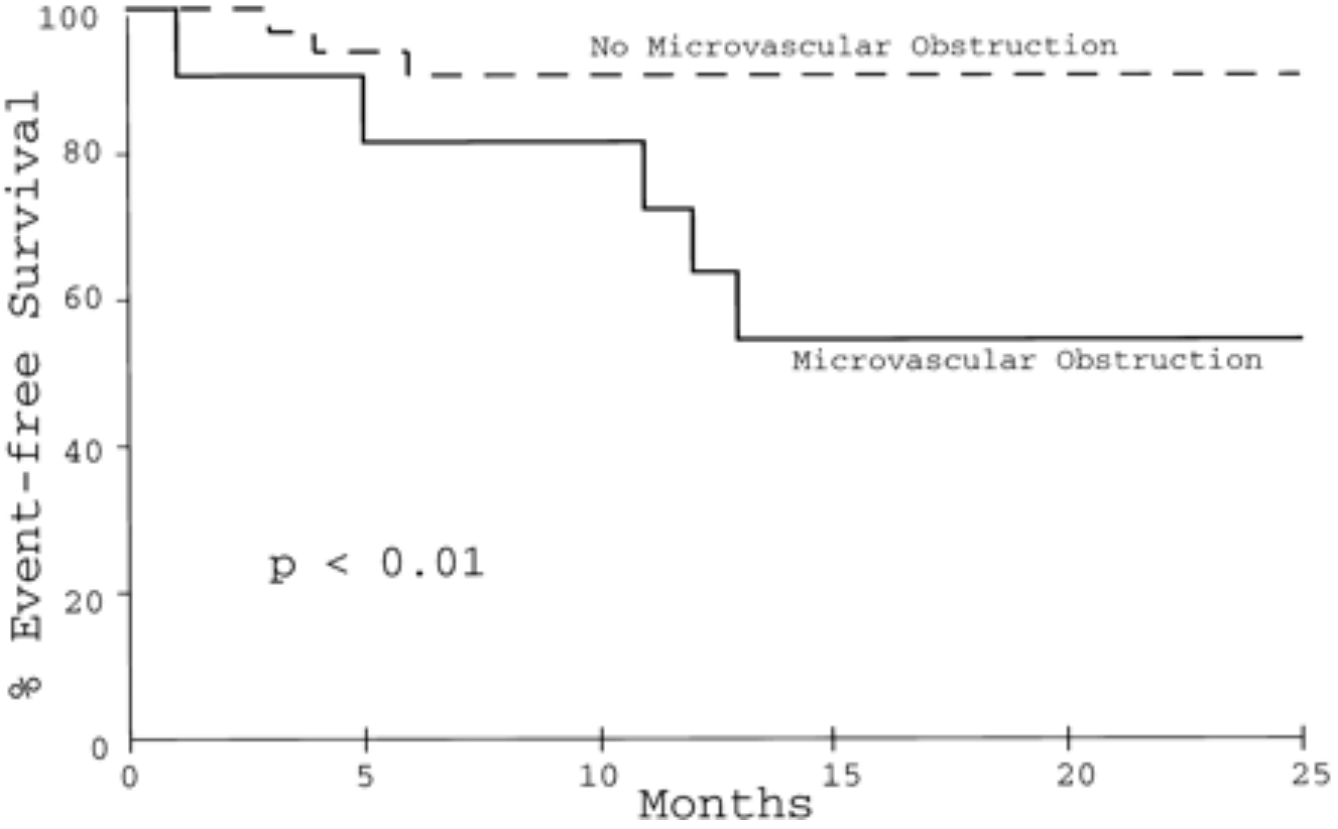
On day V
heart rupture
and death

MRI in ACS

No-reflow and prognosis

44 pts with AMI: 11 with no-reflow. Follow-up: 16+/-5 months

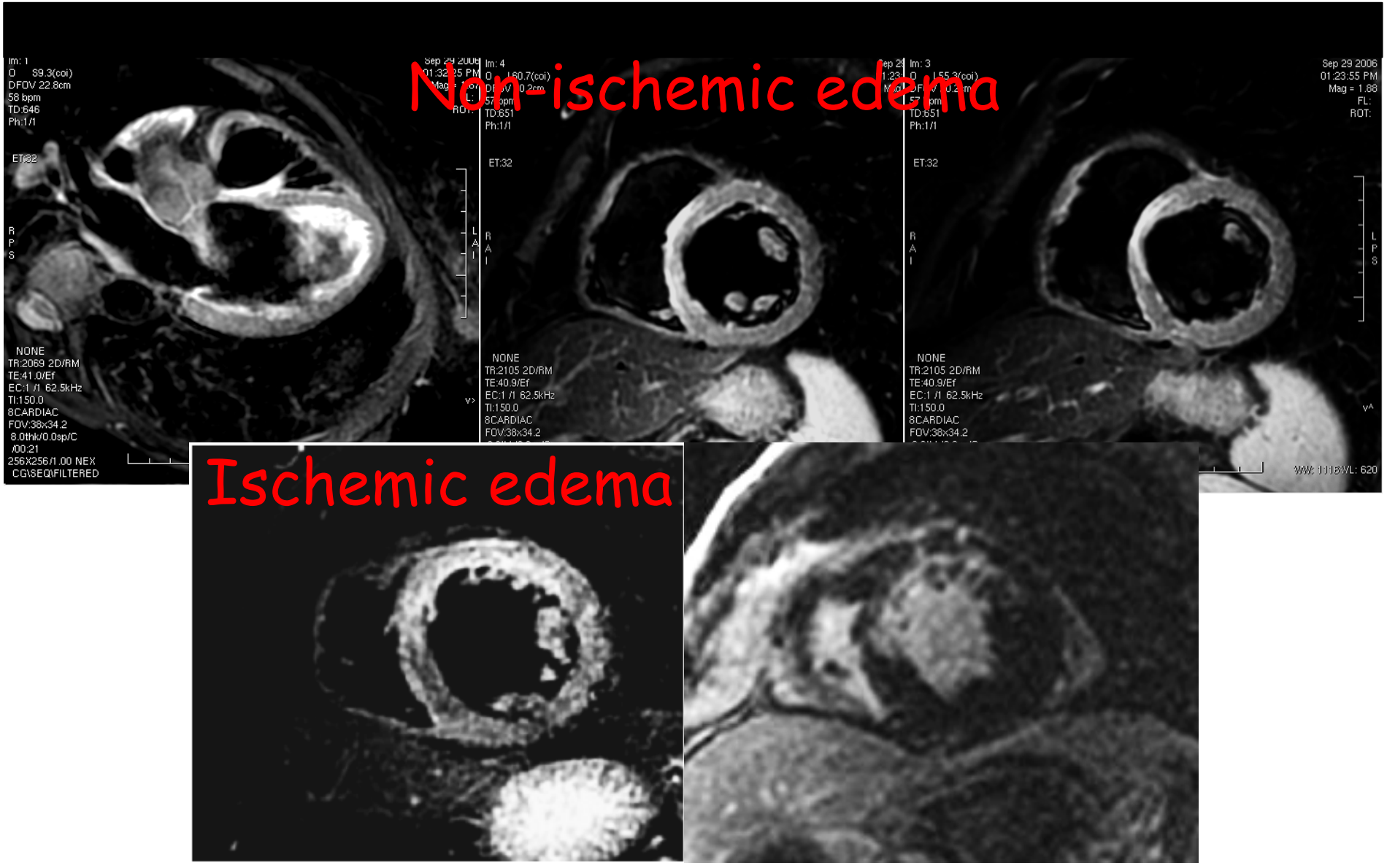
Events: cardiac death, reinfarction, heart failure, stroke



Wu KC et al. Circulation 1998

MRI in ACS

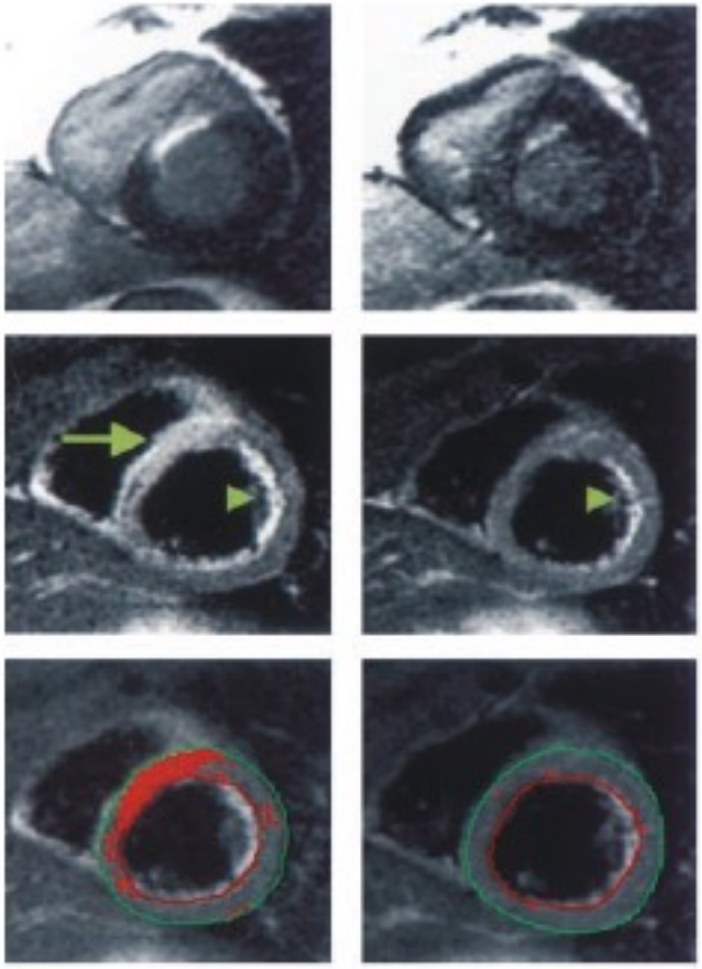
T2-STIR: MYOCARDIAL EDEMA



MRI in ACS

MRI and MI datation

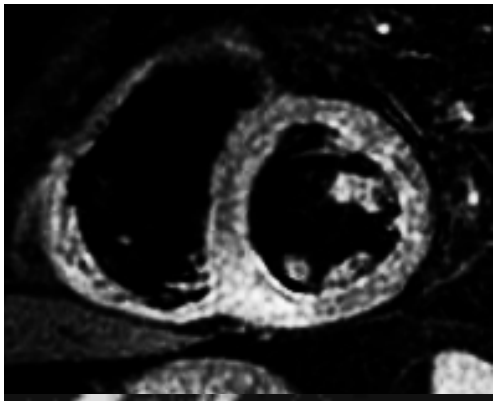
Acute/subacute/recent (<1 month) AMI



acute chronic

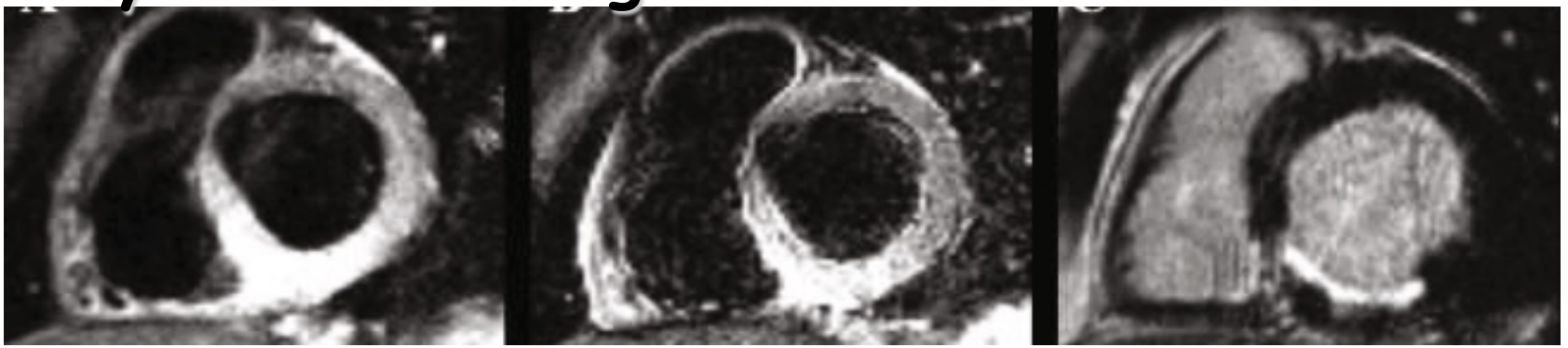
Abdel-Aty, Circulation 2004

Myocardial Edema and/ or No-reflow



MRI in ACS

Myocardial salvage index and Area at Risk



LGE extent/ Edema extent %
Edema 22% LGE 9% ➔ Myocardial salvage index : 41%

Lomborg JCMR 2011

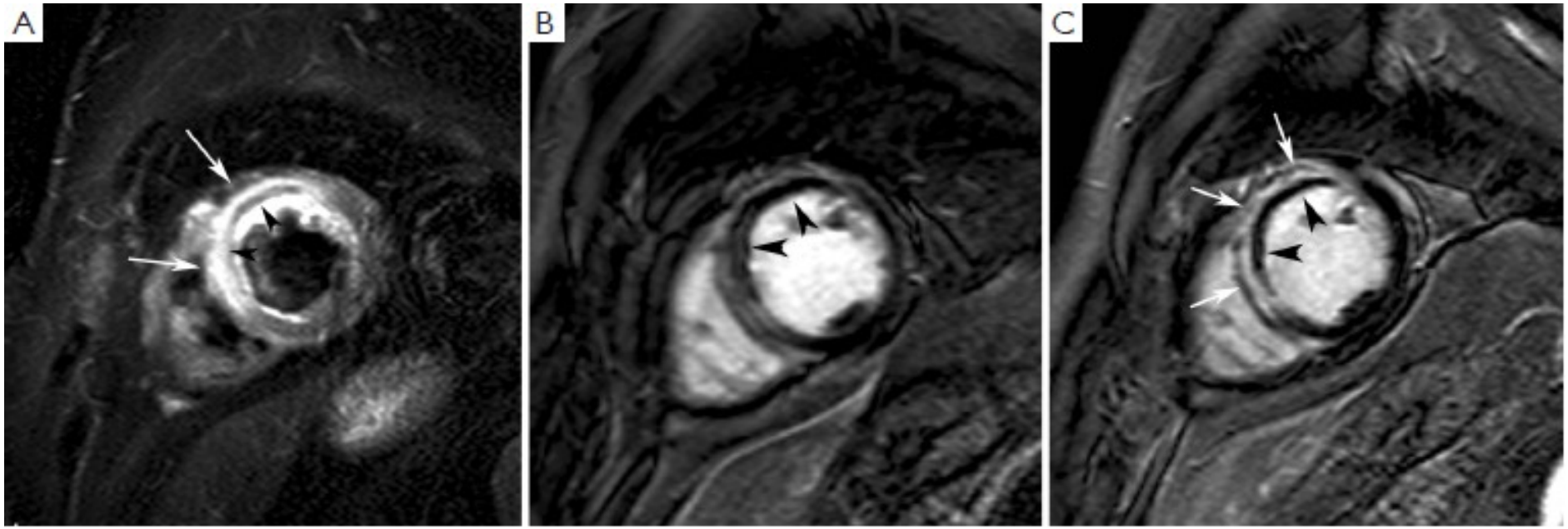
Area at Risk= Edema-LGE

	Adverse LV Remodeling			
	Univariate		Multivariate	
Baseline Variables	OR (95% CI)	p Value	OR (95% CI)	p Value
MI transmurally (%)	1.04 (1.01–1.07)	0.005	—	—
AAR (% of LV)	1.04 (1.01–1.07)	0.003	1.04 (1.01–1.08)	0.001
MSI (for 0.10 increment)	0.58 (0.46–9.75)	<0.0001	0.64 (0.49–0.84)	0.001
Presence of MO	6.79 (3.55–18.06)	<0.0001	—	—
Time to reperfusion (min)	1.00 (0.99–1.00)	0.588	—	—
Age (for 10-yr increment)	1.22 (0.87–1.72)	0.241	—	—
Anterior vs. nonanterior MI	2.27 (1.02–5.04)	0.044	—	—
LV ejection fraction	0.92 (0.87–0.97)	0.003	—	—

Masci, JACC Imaging 2010

MRI in ACS

Hemorrhagic Infarction: T2 STIR

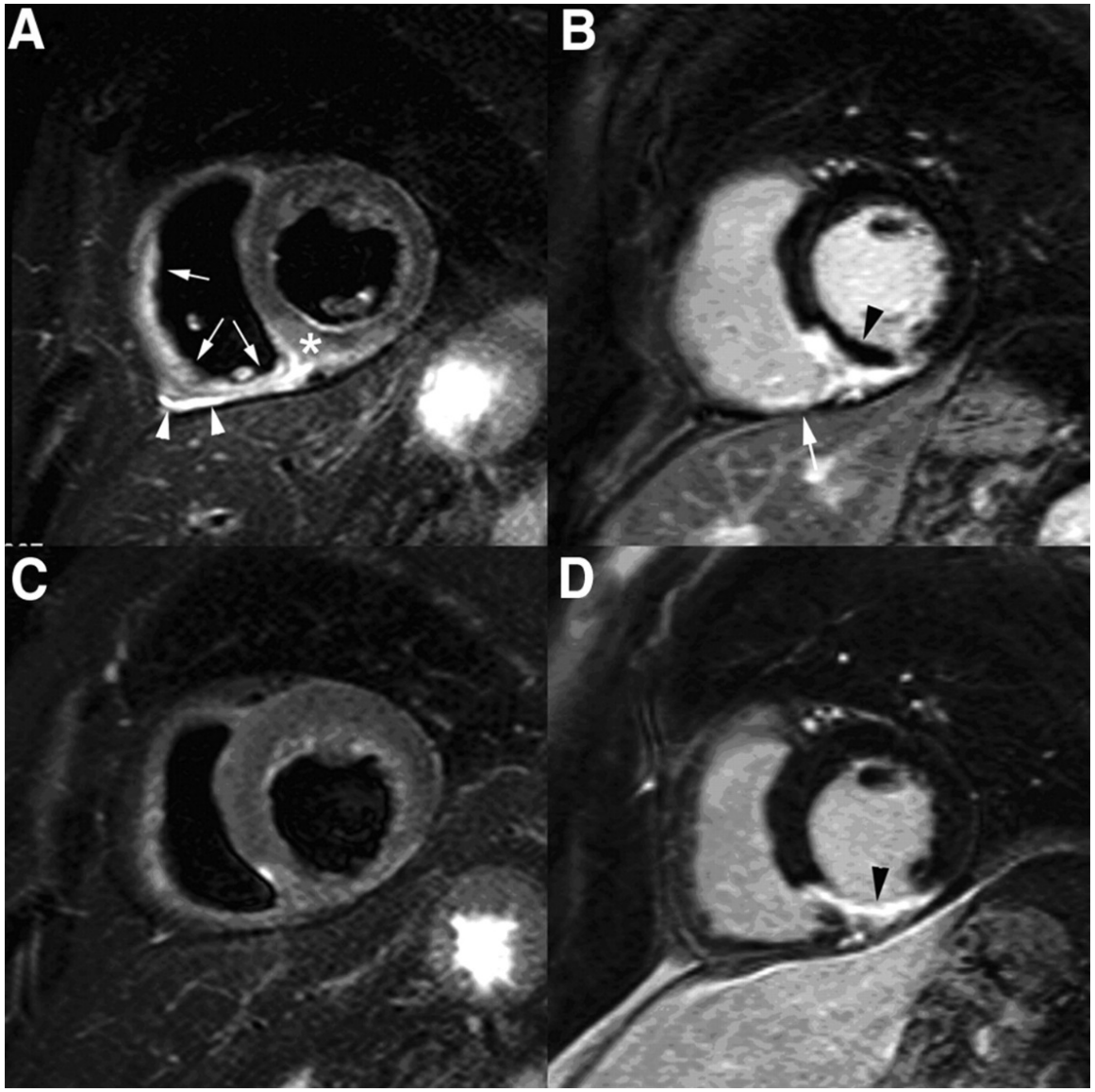


Hypointense area inside edema: T2* effect of Blood

Associated to adverse remodeling – heart rupture - SCD

Cardiovasc Diagn Ther 2012

MRI in ACS



RV infarction

Inferior LV infarction in a 56-year-old man with proximal right coronary artery occlusion.

Masci P G et al. Circulation. 2010;122:1405-1412

MRI in ACS

- Z.C., male, 55 years old
- Family history of CAD
- Hypertension

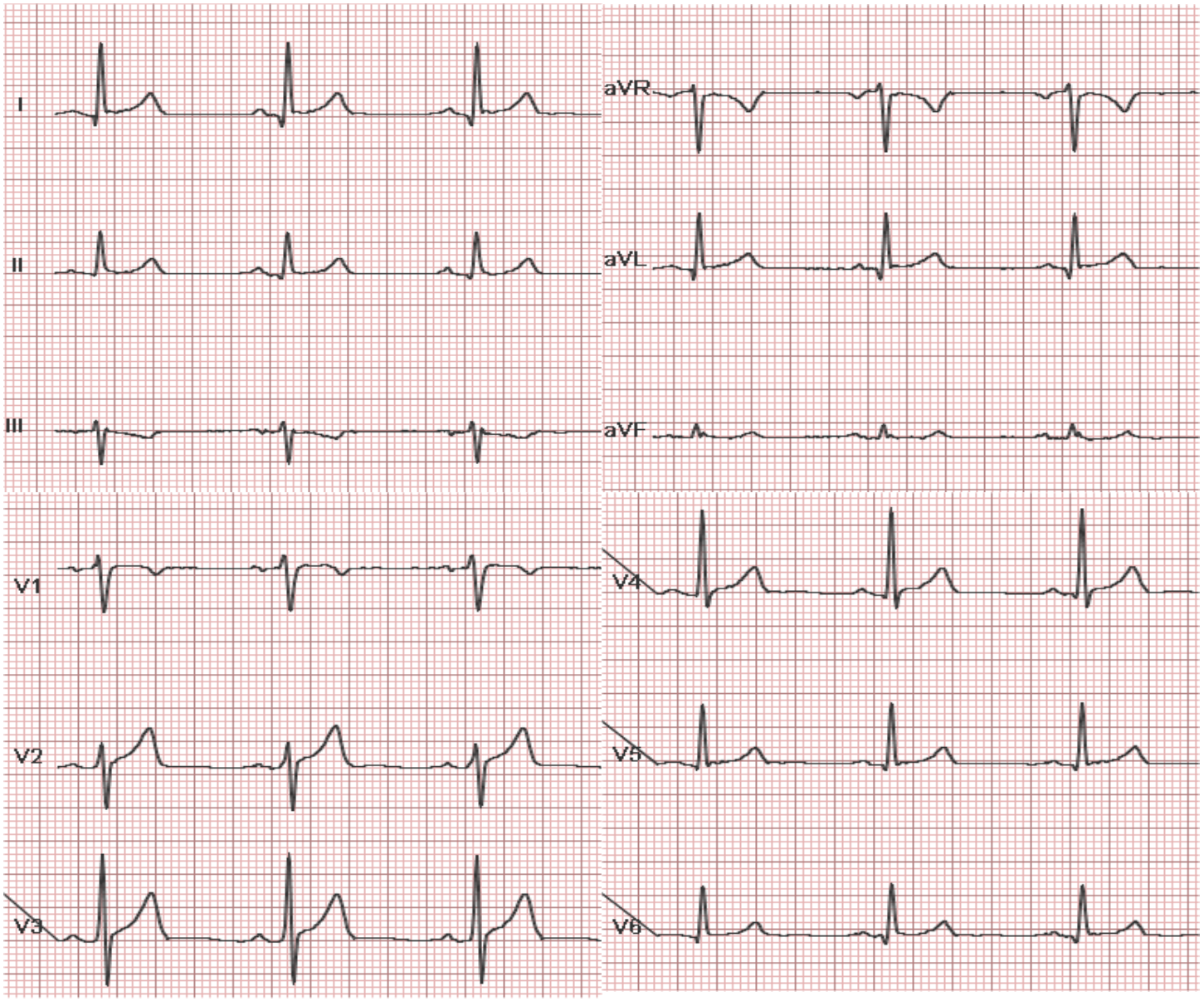
- 2006 episode of acute dyspnea

- presenting with chest pain

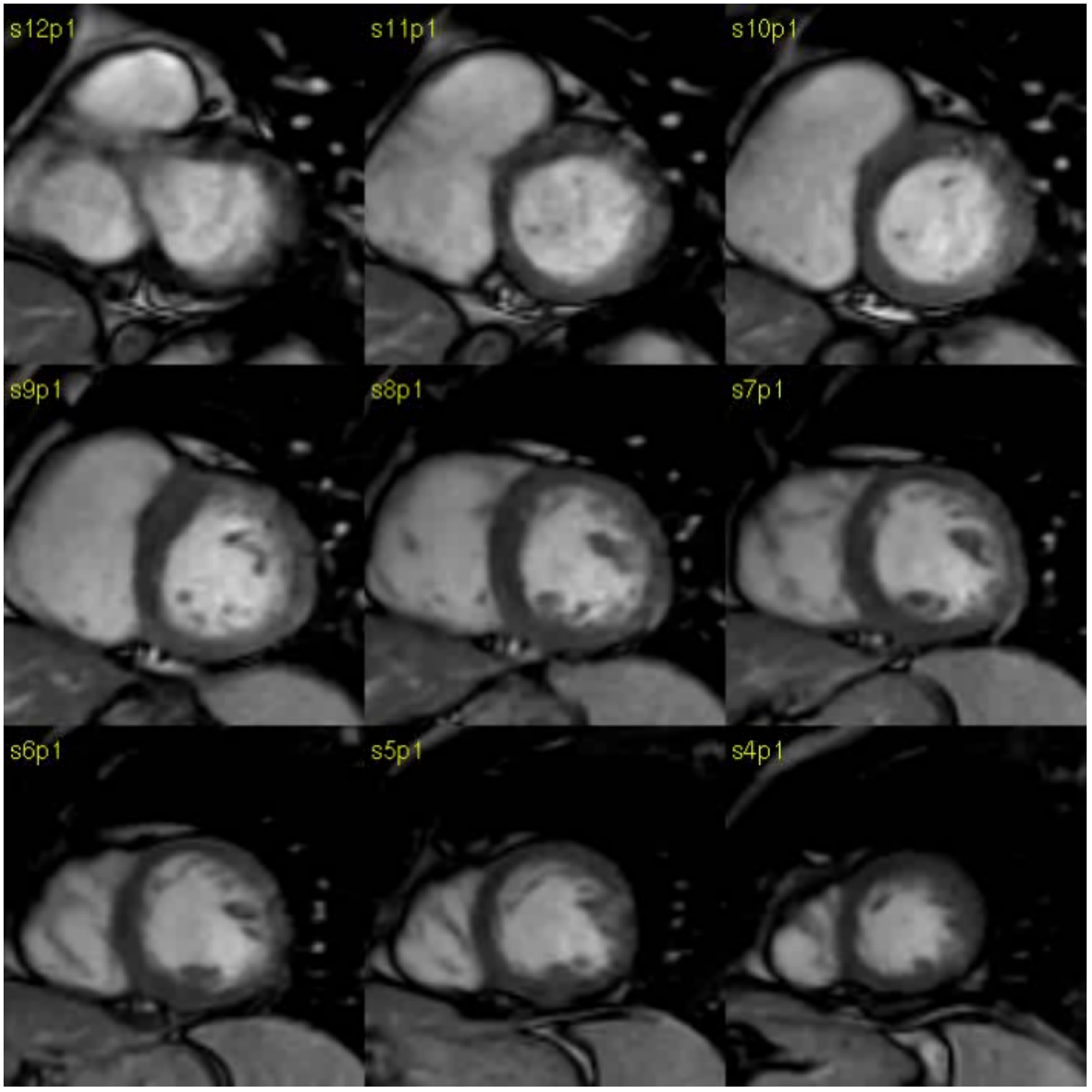
- negative enzyme

- echo: normal wall motion

MRI in ACS

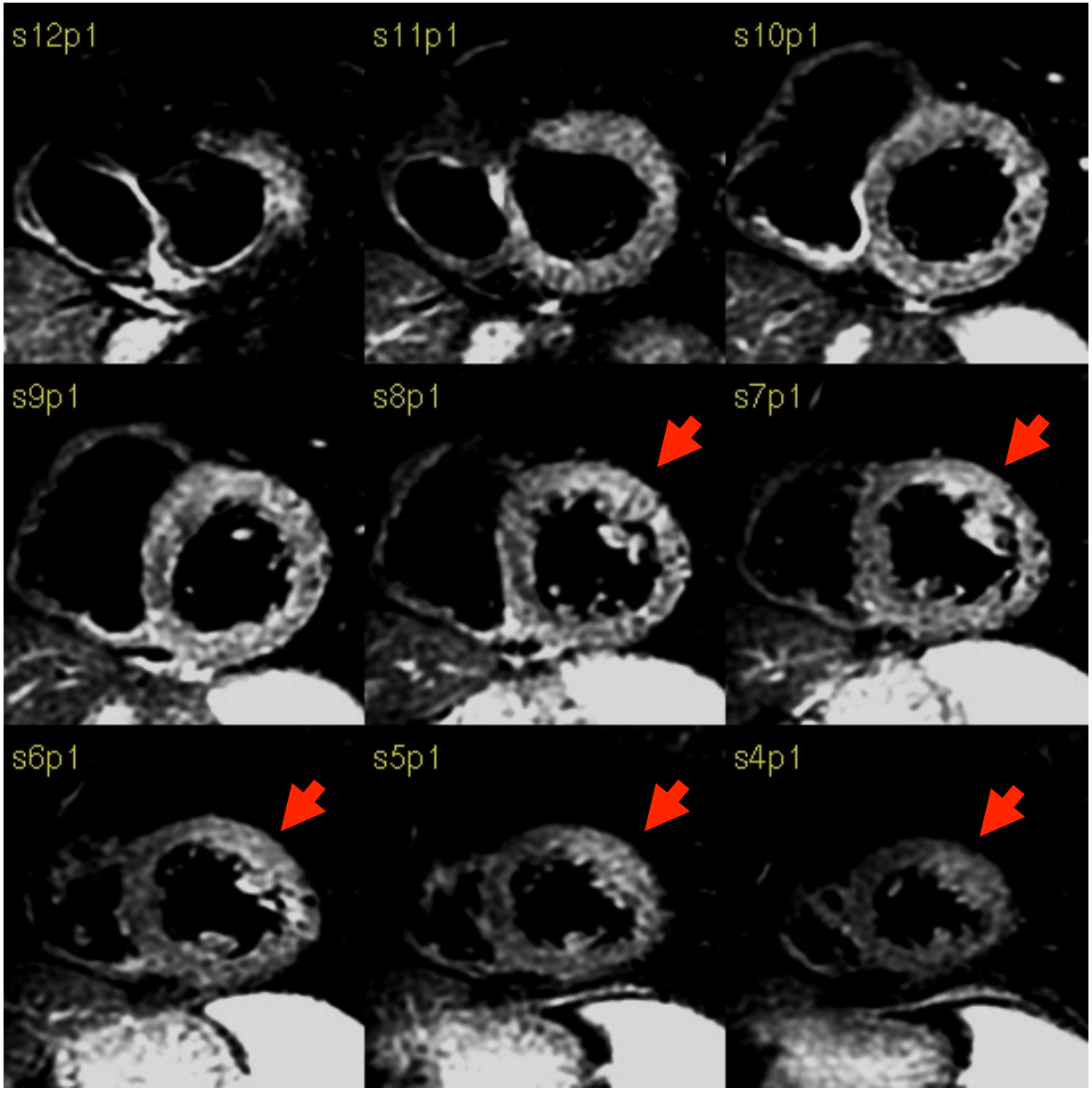


MRI in ACS



SSFP, function

MRI in ACS

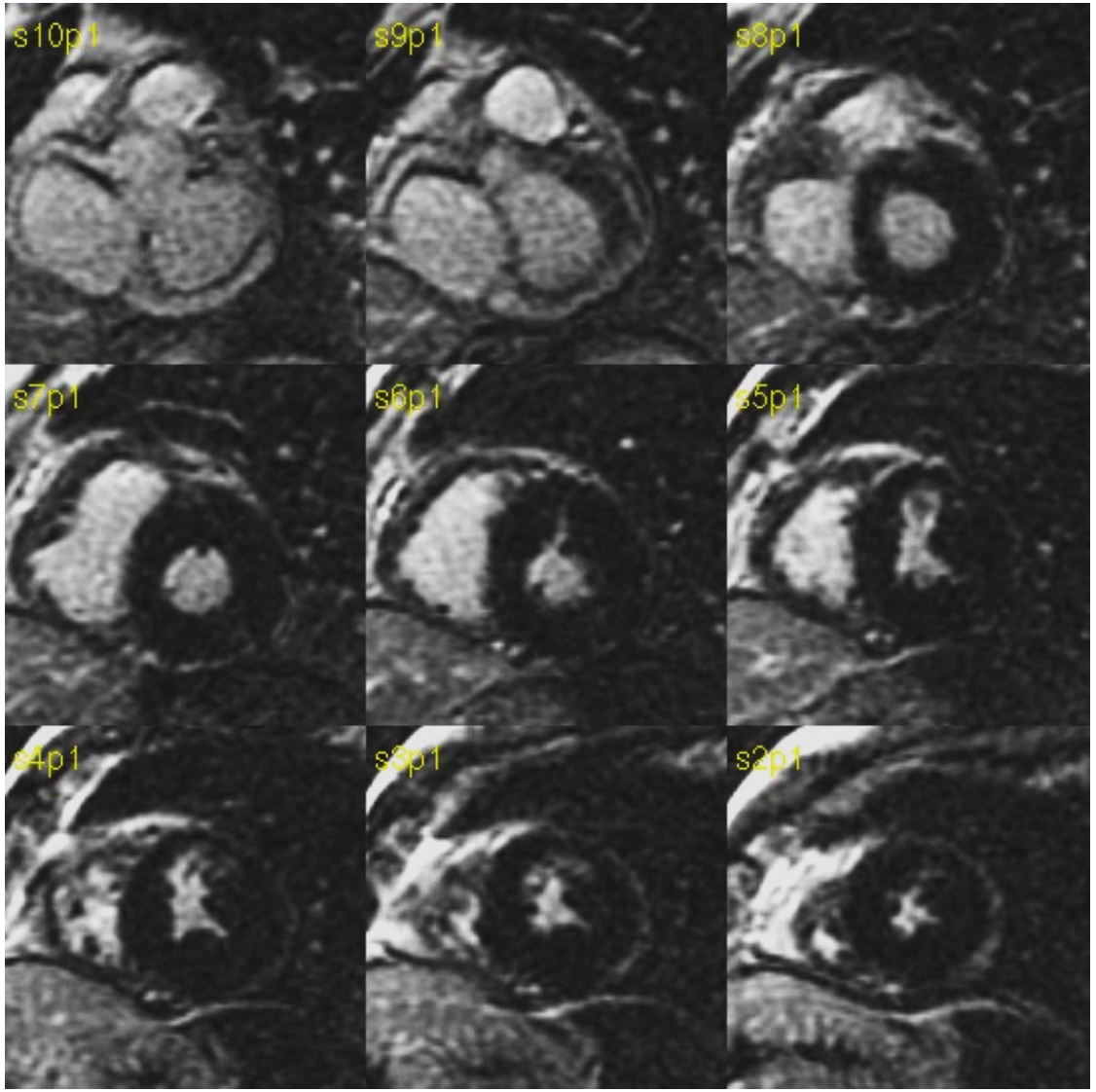


T2 STIR

Transmural edema

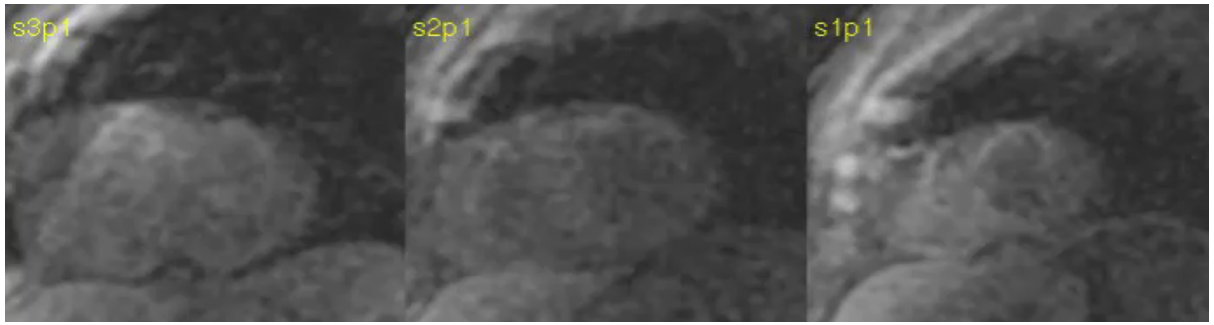
MRI in ACS

Late Enhancement

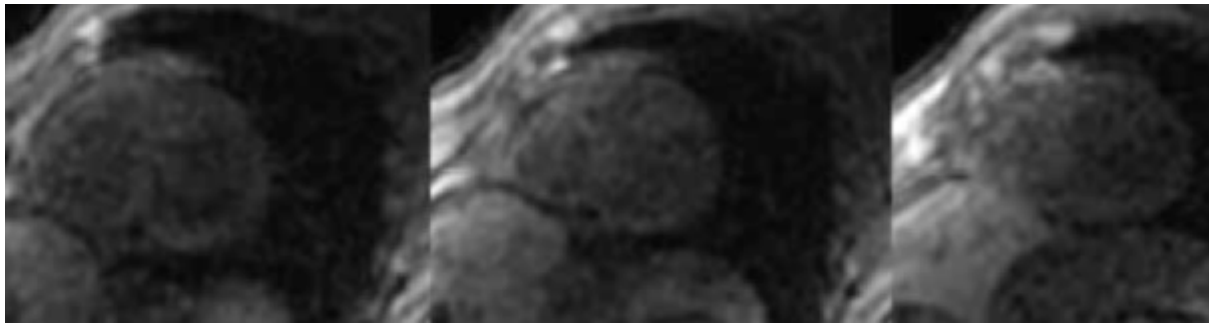


Small anterior scar
No troponine, no edema=> old infarction

MRI in ACS



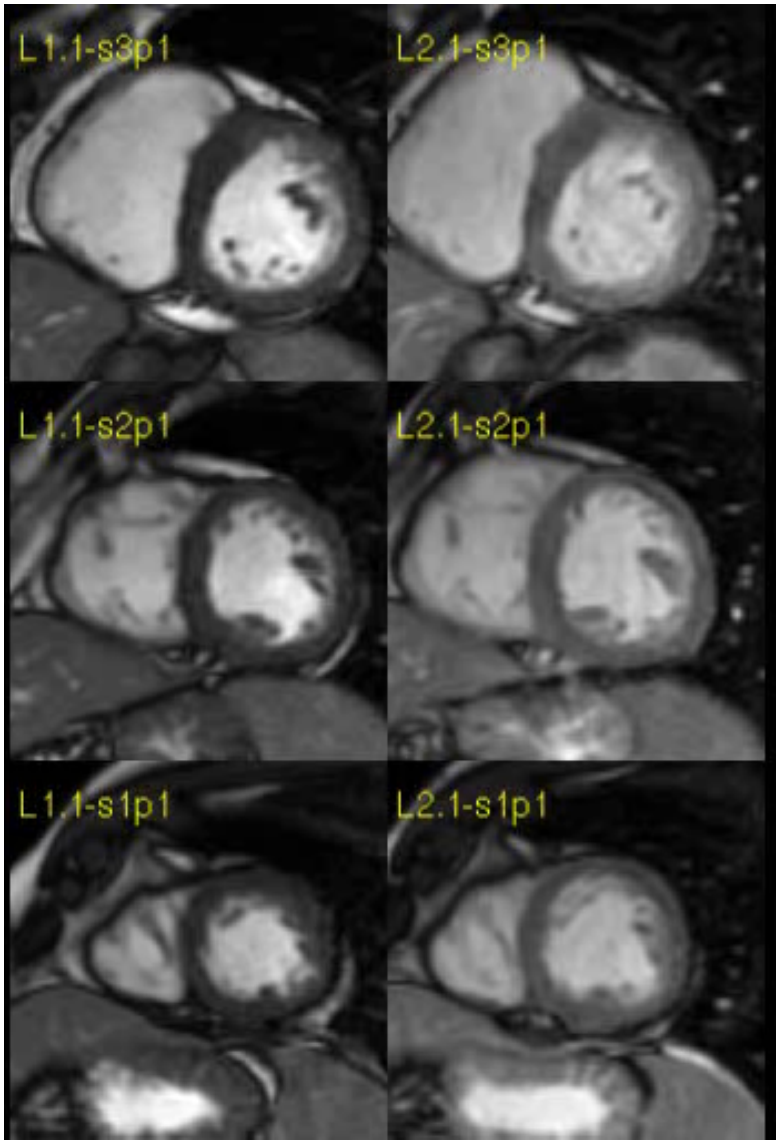
REST



STRESS

STRESS MRI with Dypiridamole

MRI in ACS



REST STRESS

WMA in the anterior and anterolateral segments
with Dypiridamole

MRI in ACS

Old anterior necrosis (2006?)

acute ischemia and inducible ischemia
in anterolateral wall

coronary angiography:
90% stenosis in LAD
90% stenosis in first diagonal branch

MRI in ACS

PATIENT A

N.R. 49 y male,
Hypertension, Smoker

Fever two weeks before

Angor, mild troponine increase,

Echo: no WMA, EF 60%

ECG: ST elevation in V5-V6

PATIENT B

M.L. 52 y male,
Smoker

Angor, mild troponine increase,

Fever ten days before

Echo: no WMA, EF 65%

ECG: ST elevation in V5-V6

MRI in ACS

PATIENT A

Coronary angiography:

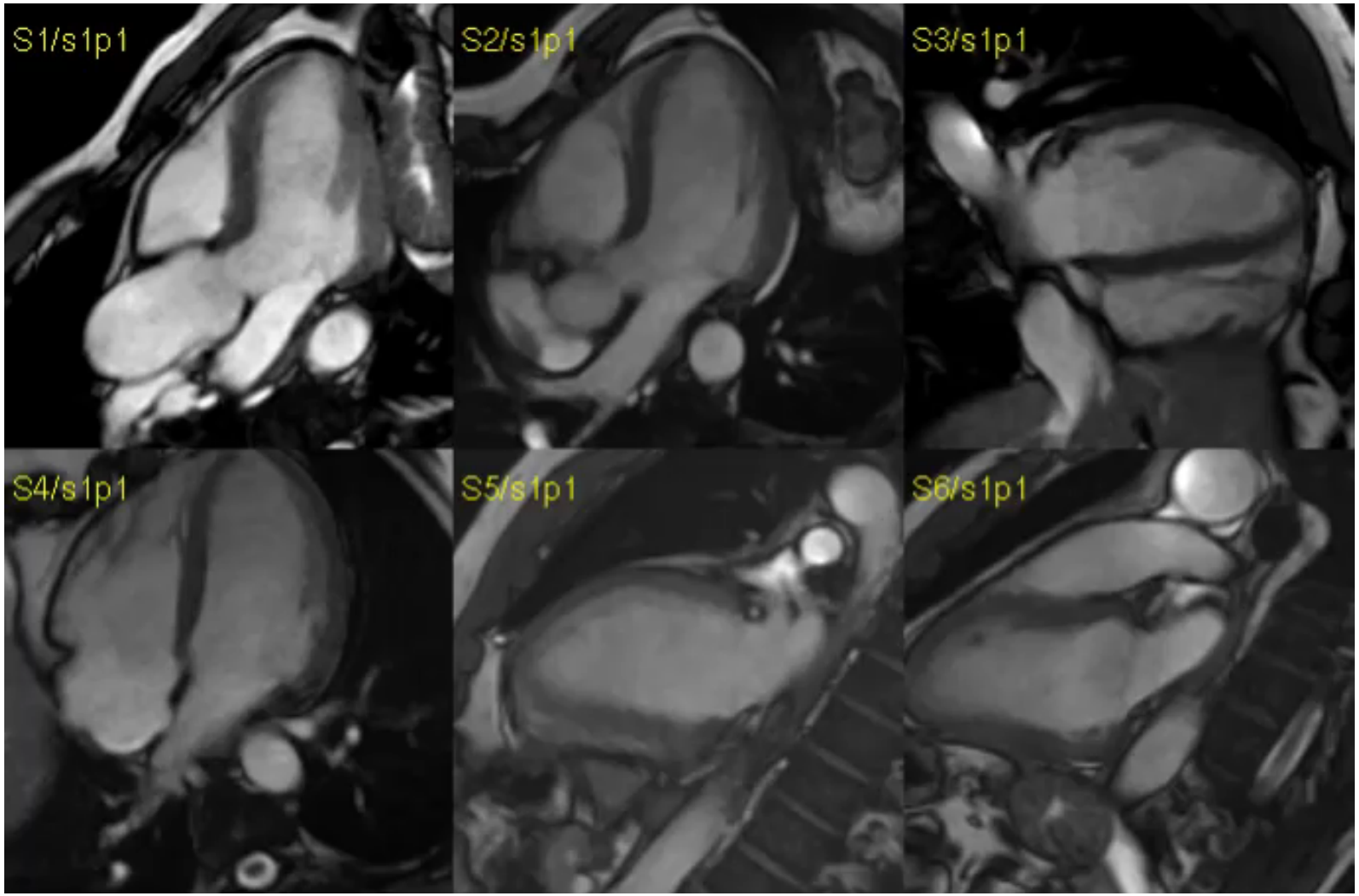
hypoplastic RCA

No-significant stenosis on LAD and CX

➔myocarditis?
➔MRI

MRI in ACS

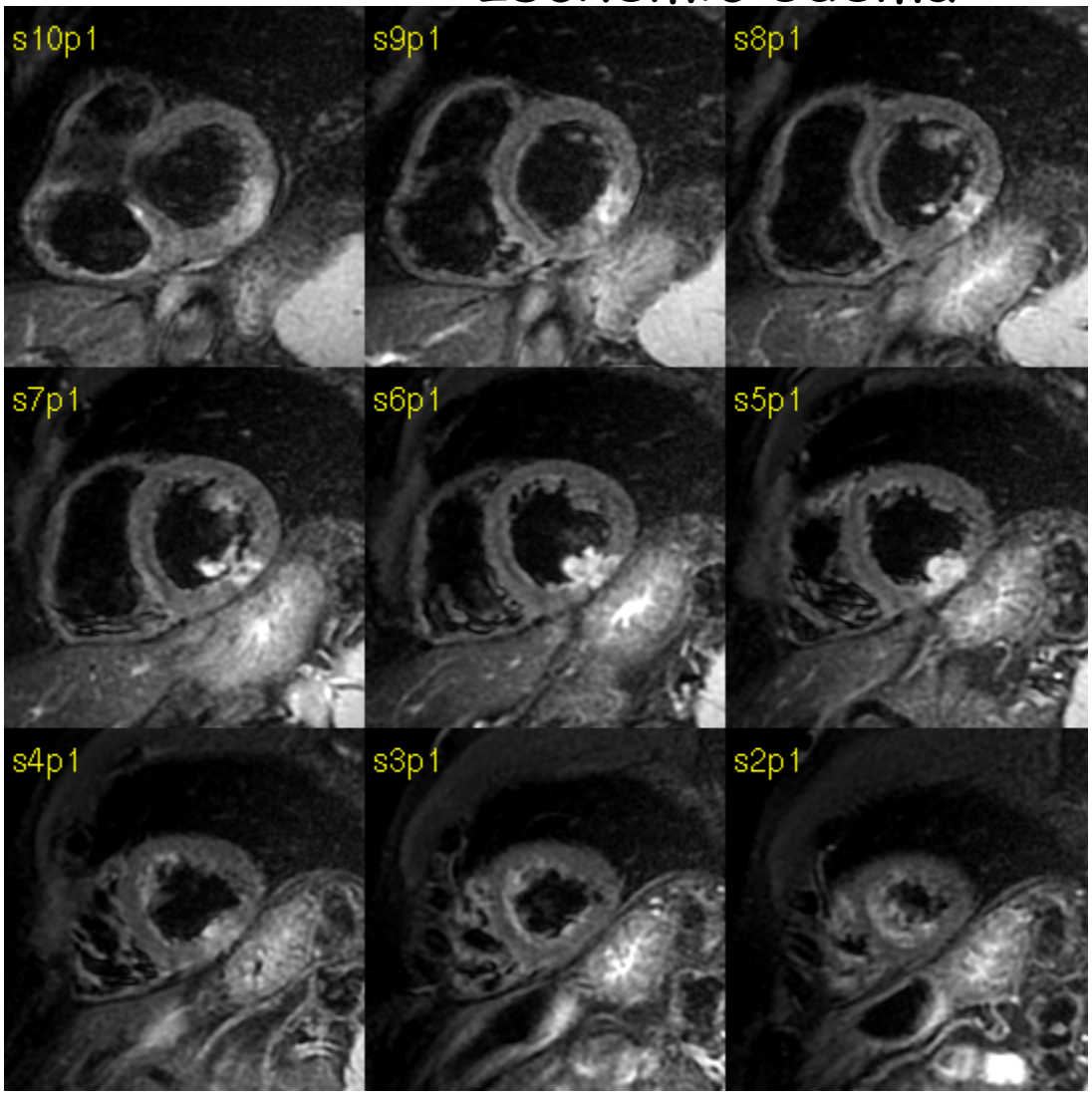
PATIENT A

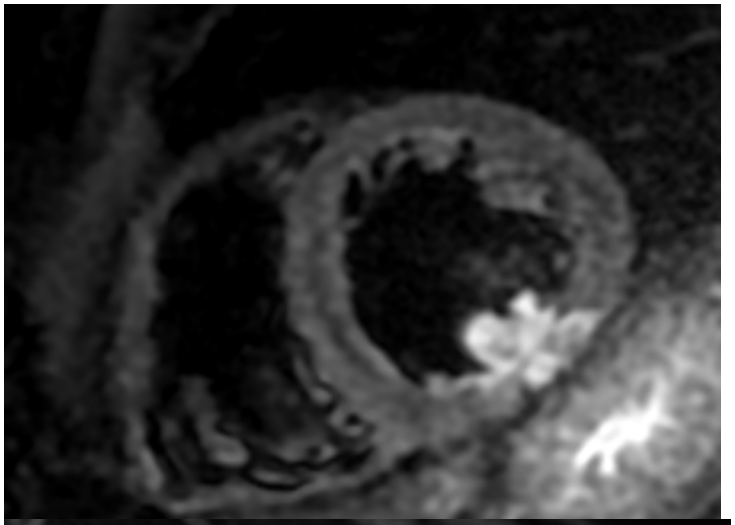


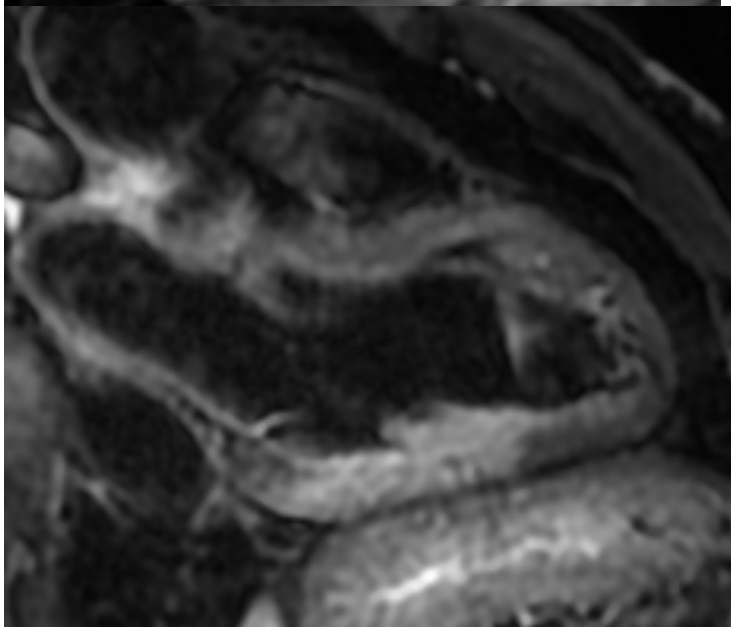
MRI in ACS

PATIENT A

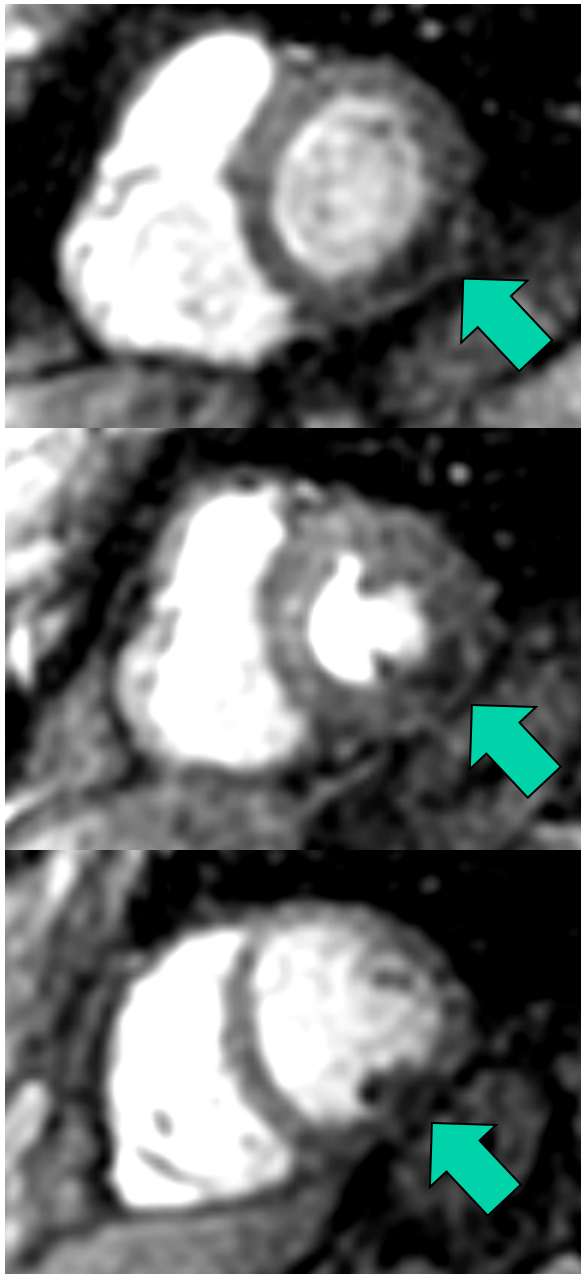
Ischemic edema







MRI in ACS

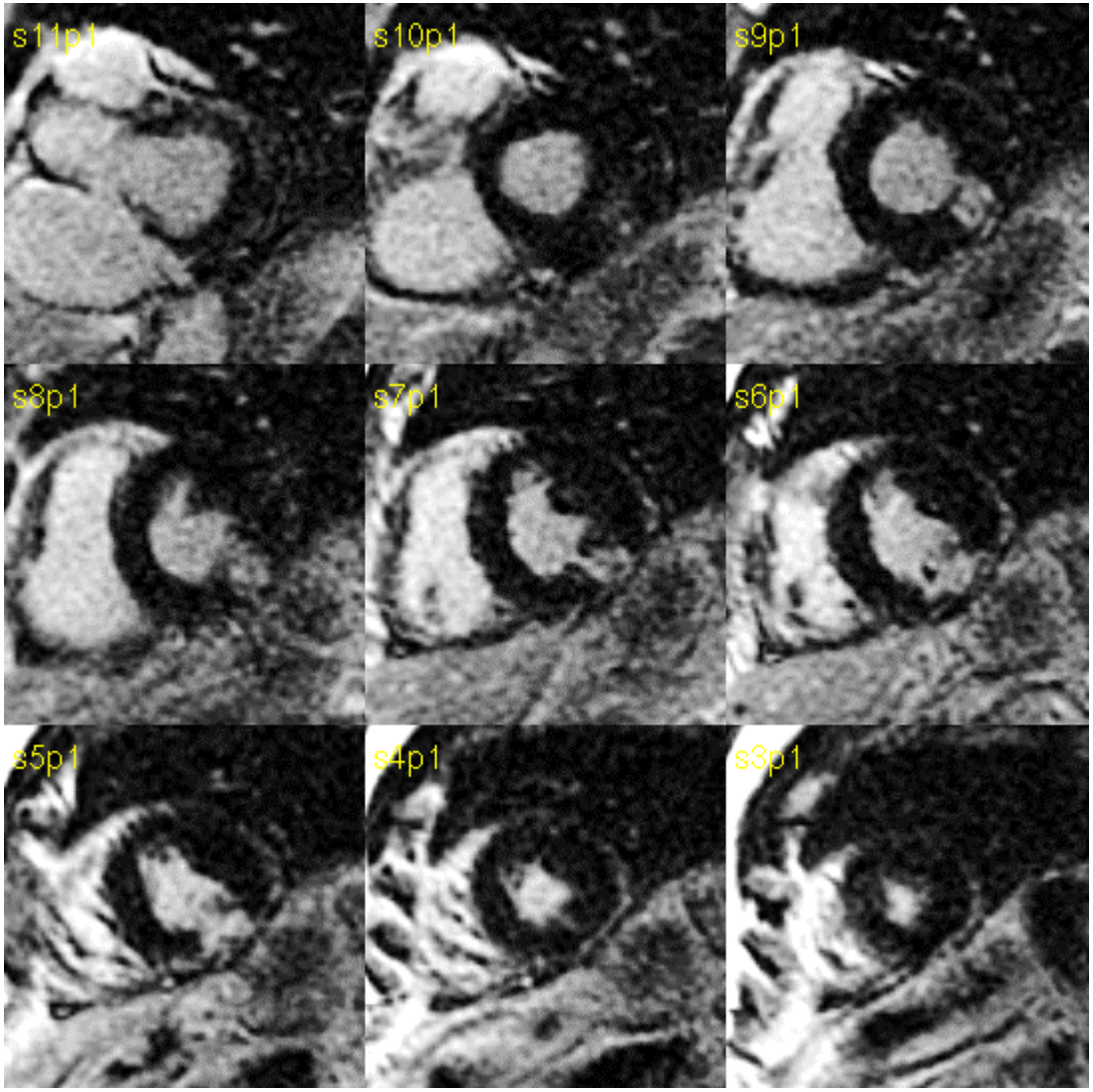


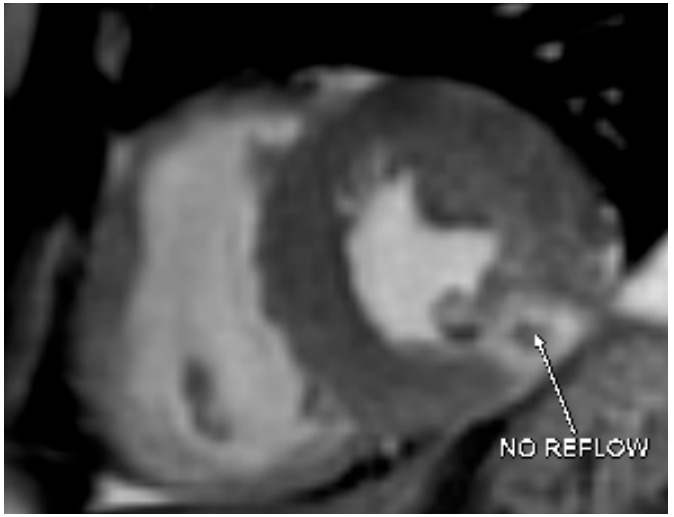
PATIENT A

First pass
Perfusion:
Rest perfusion defect
involving papillary muscle

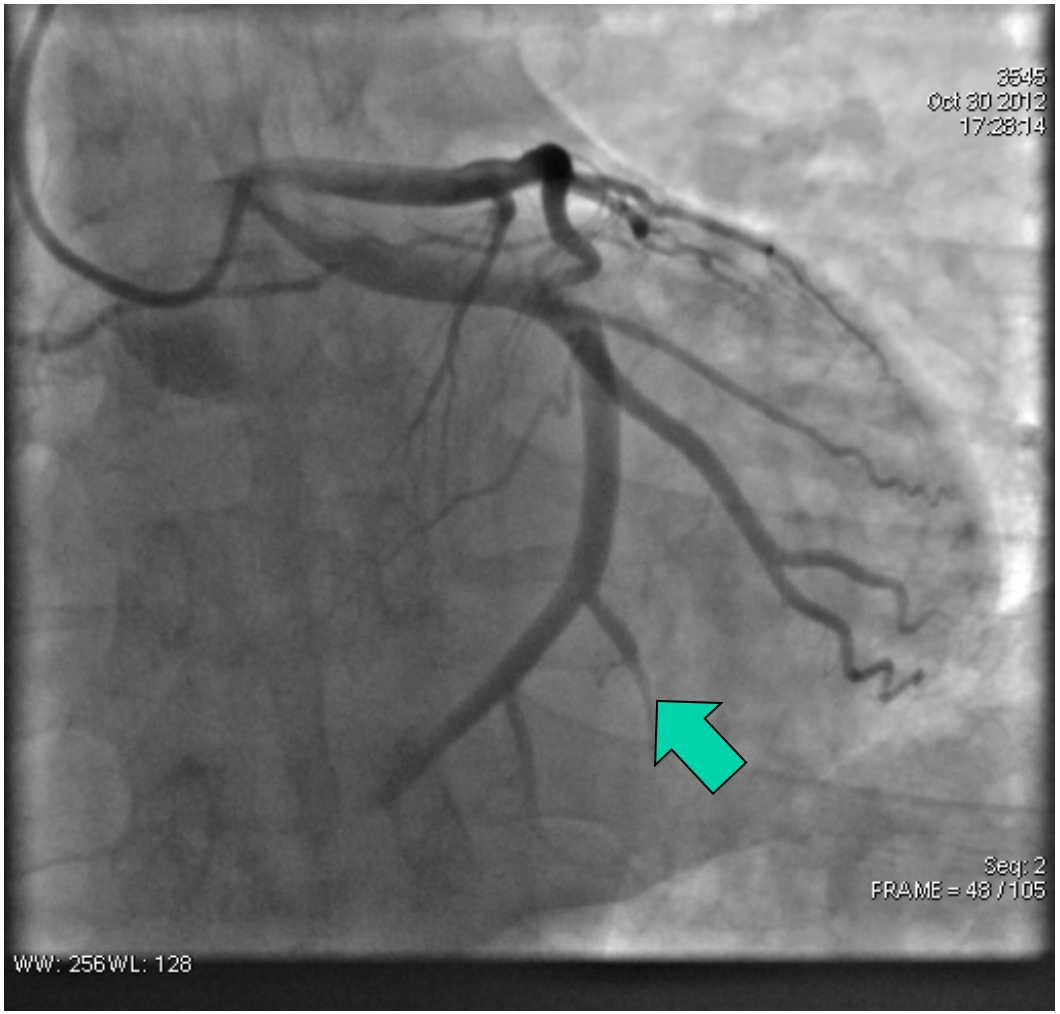
MRI in ACS

PATIENT A





MRI in ACS



Coronary angiography:

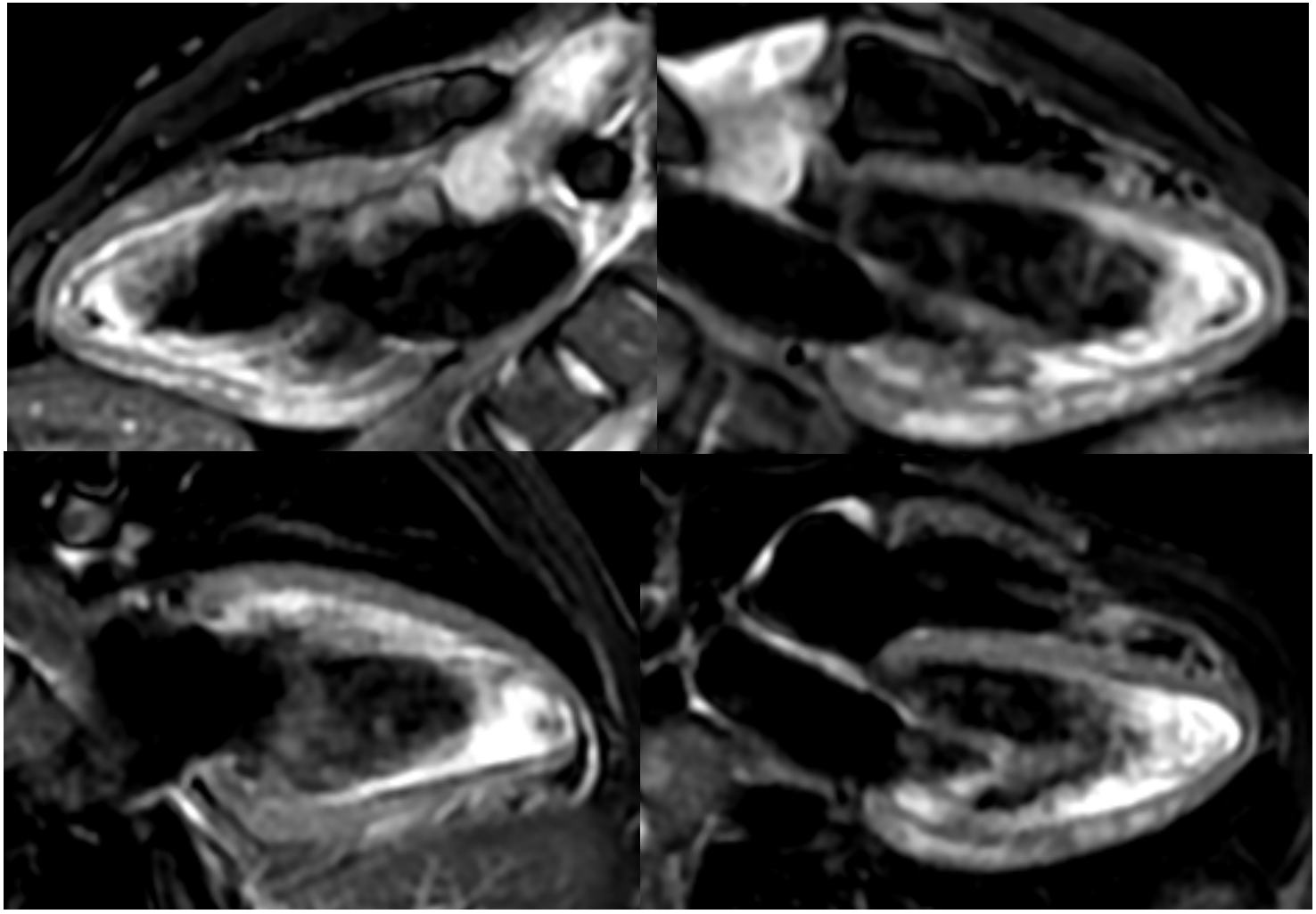
hypoplastic RCA

No-significant stenosis on LAD and CX

2° marginal branch…

MRI in ACS

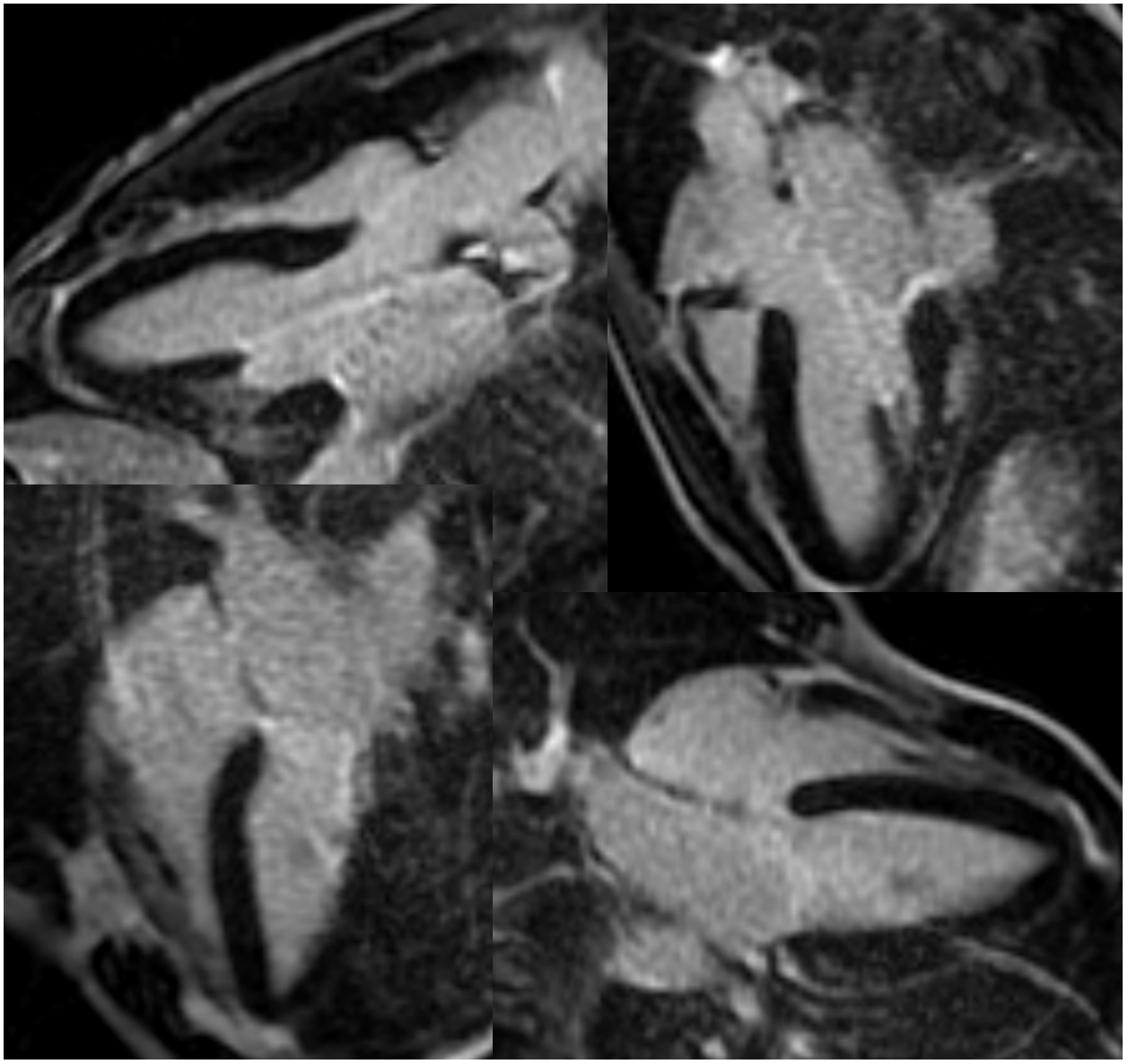
PATIENT B



CORO:
normal

Non
Ischemic
edema

MRI in ACS



PATIENT B

Non ischemic edema

+

Non ischemic LGE

➔ Acute myocarditis

MRI in ACS

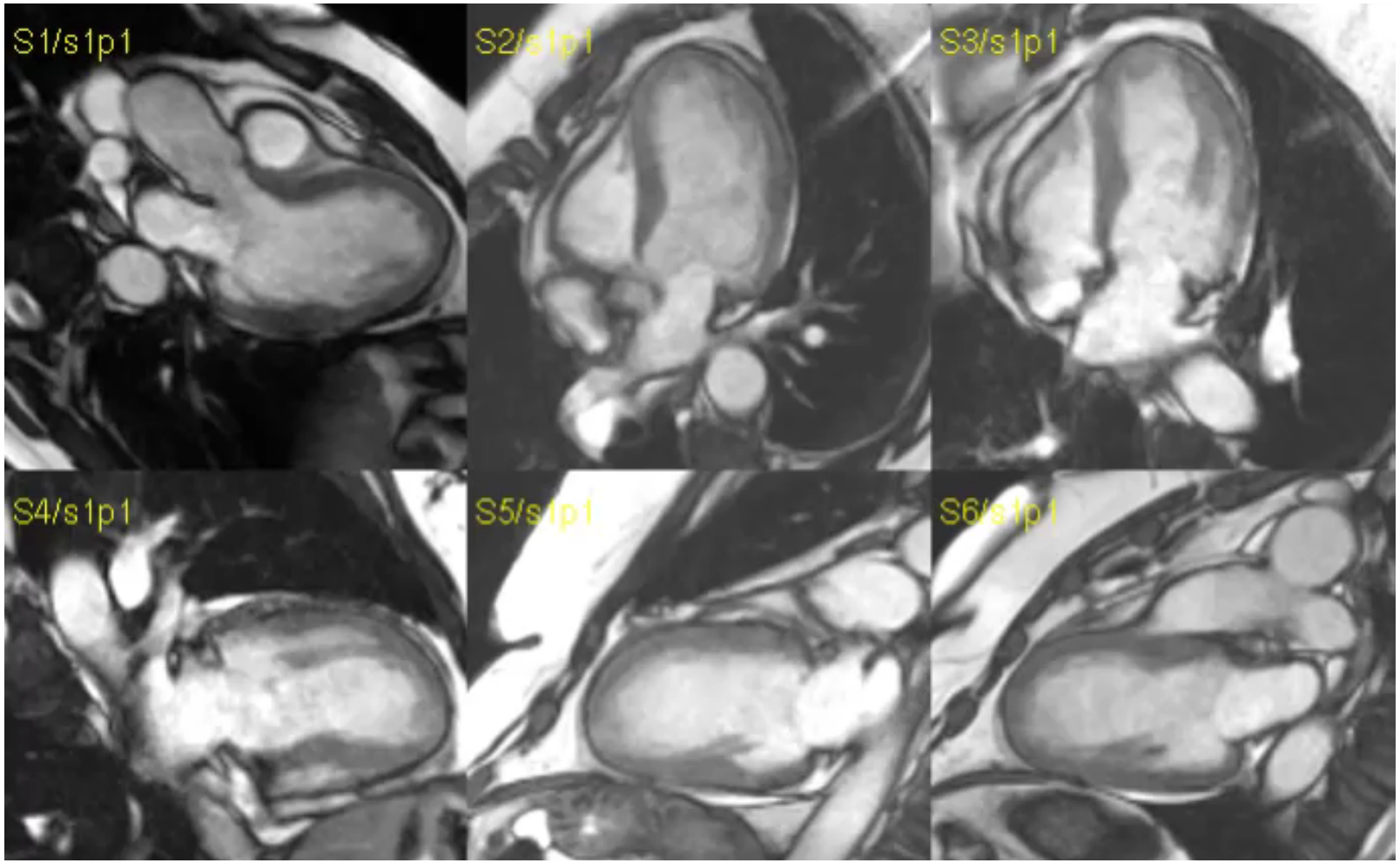
L.N. 56y female,
Emotional stress following fight

Chest pain

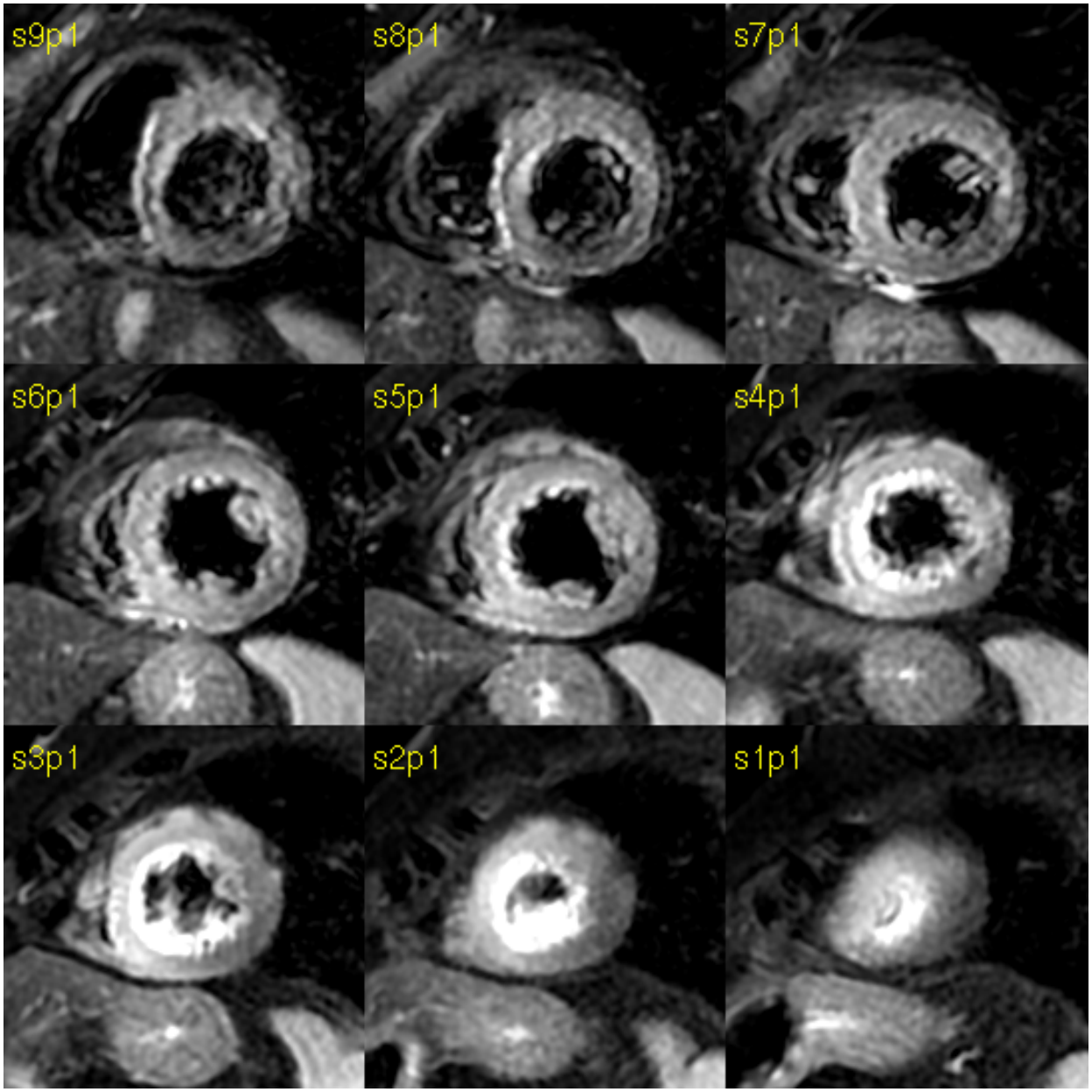
Echo: apical ballooning

Coro: negative

MRI in ACS



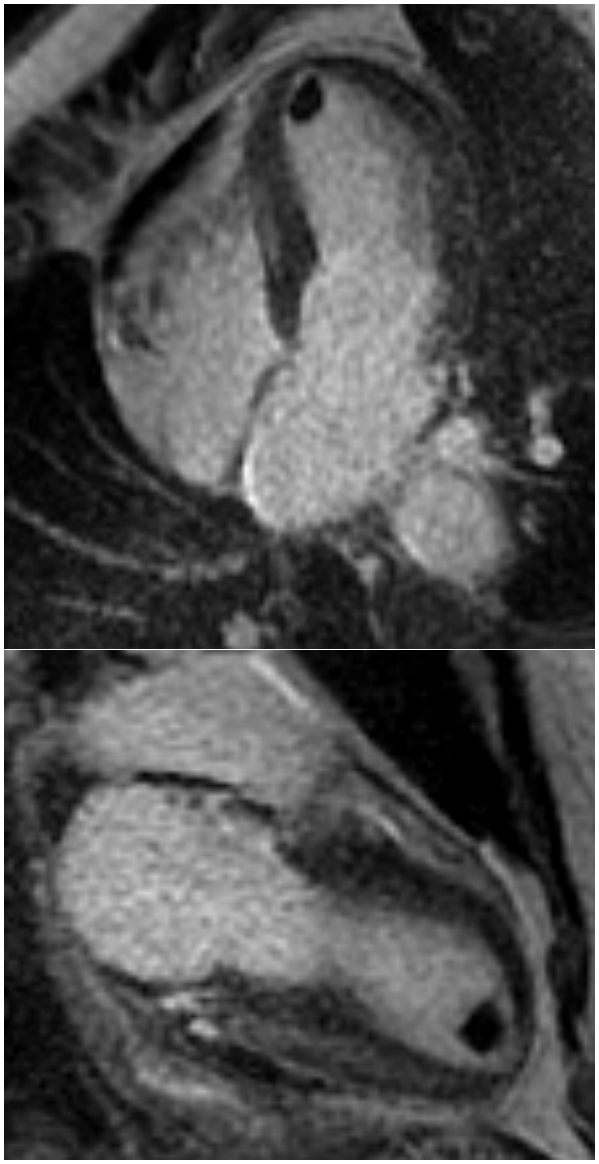
MRI in ACS

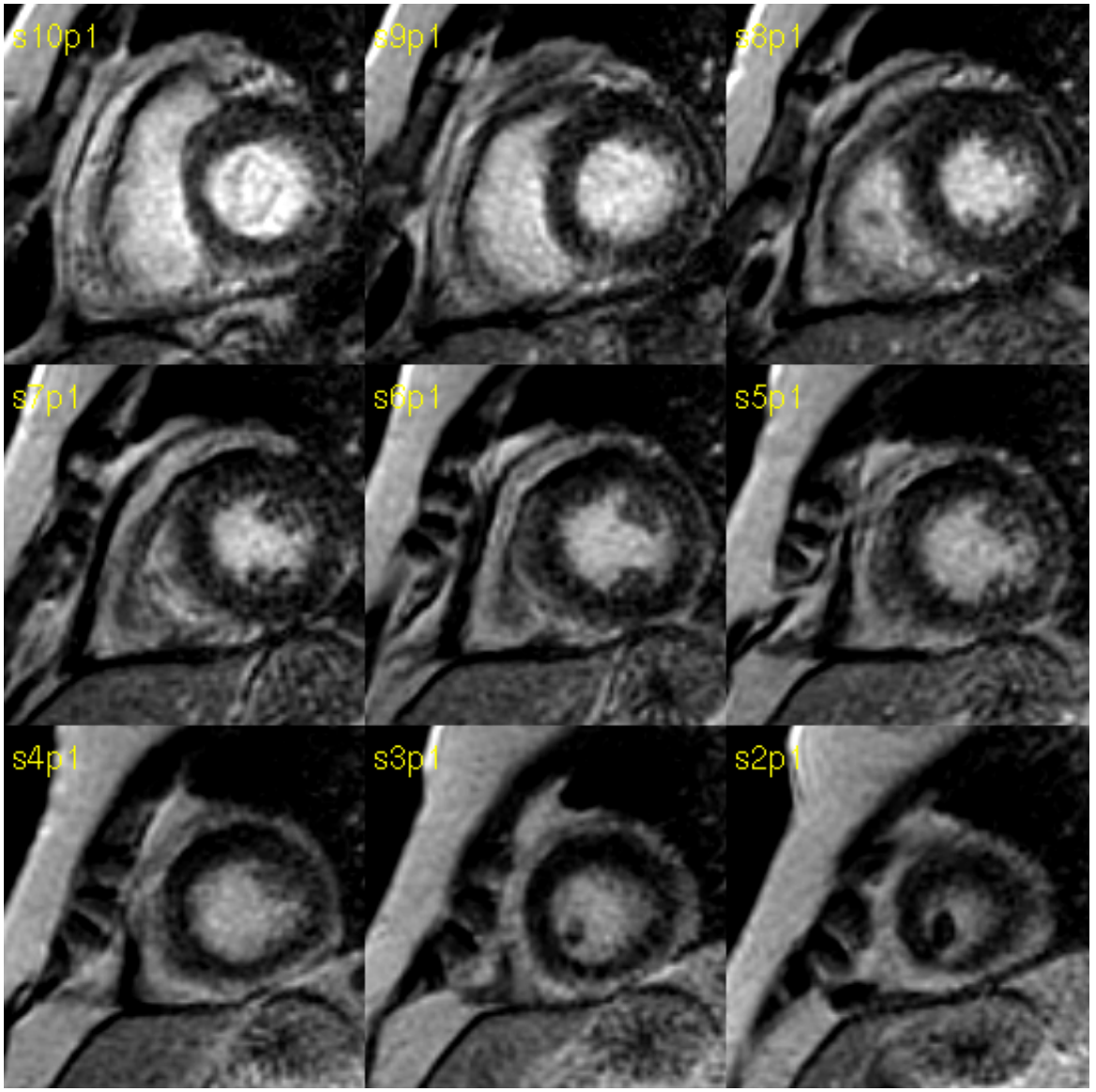


Apical Edema

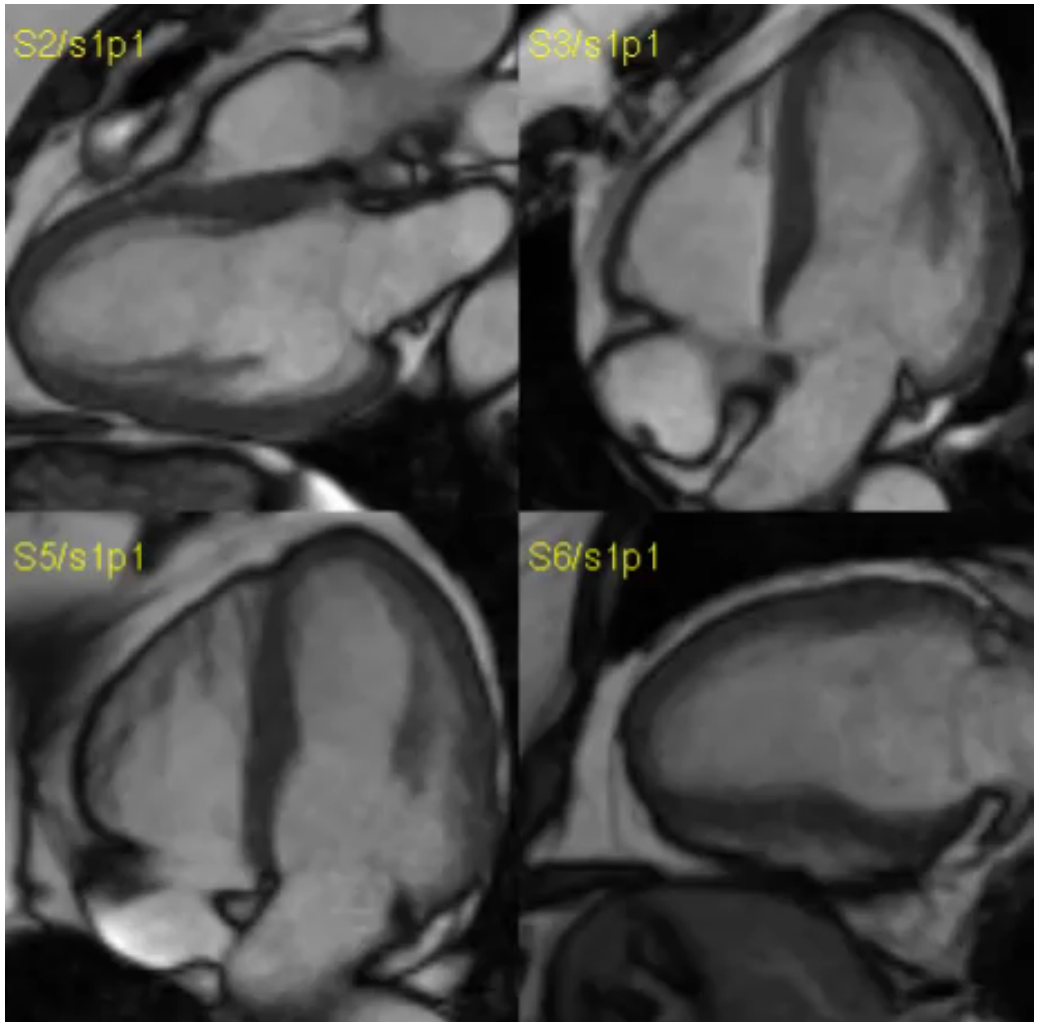
MRI in ACS

Tako-tsubo with LV thrombus: Heaven or Hell?





MRI in ACS

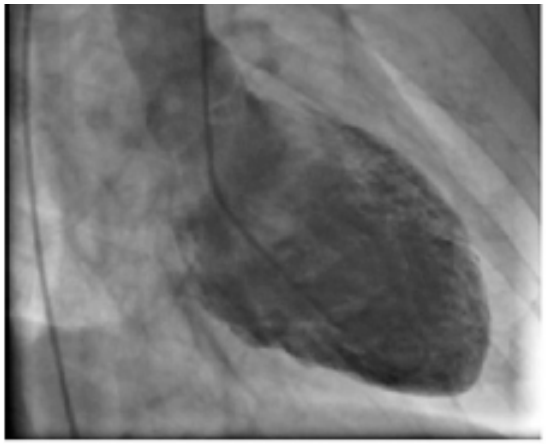


One month later.....

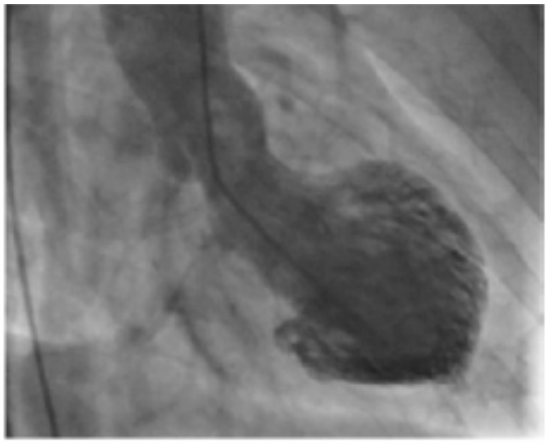
Heaven!!!

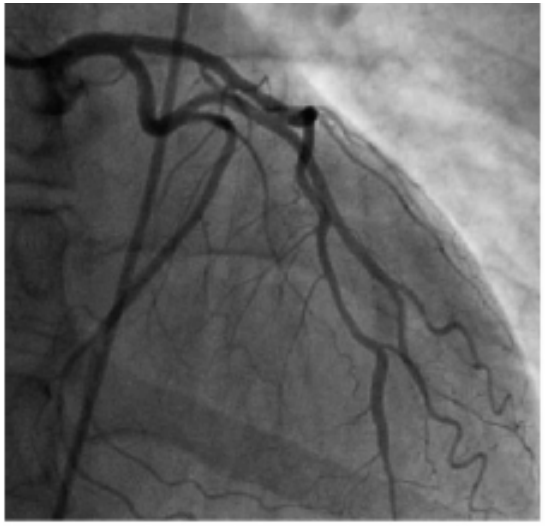
MRI in ACS

Diastole



Systole





TAKO-TSUBO!!

Female, 57y
Smoker
Systemic Hypertension

Chest pain after ES (30 min after conflict with her daughter)

ST elevation in V4-V6

first assay: 2.3 troponine I

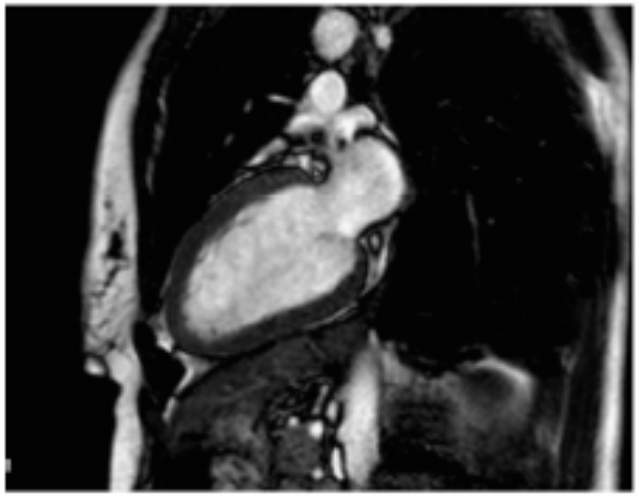
Non significant CAD

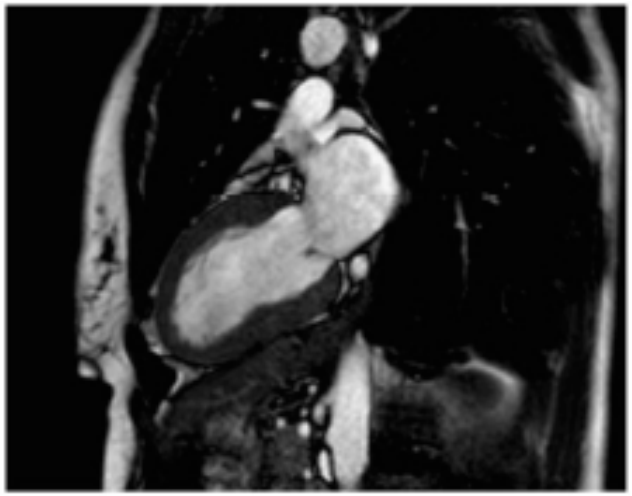
Eite, *int j Cardio* 2008

MRI in ACS

Diastole

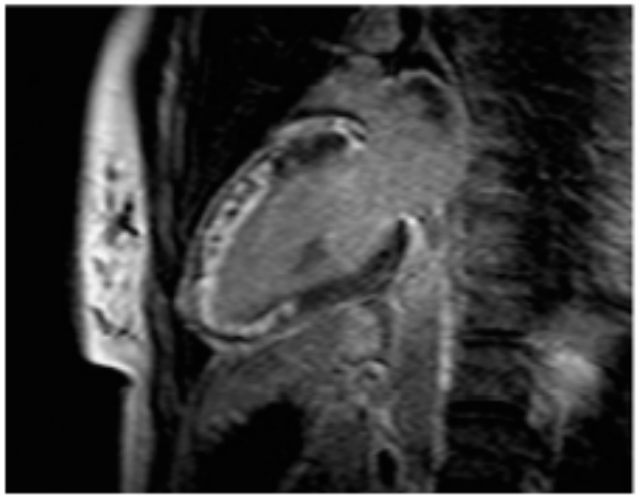
Systole

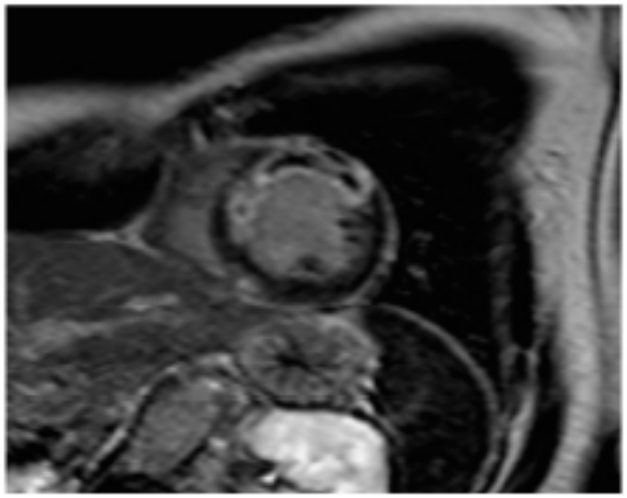




IR-GRE

IR-GRE





Progressive raise of troponine (peak 323 ng)

Typical WM abnormalities

transmural DE

No-Reflow

Myocardial infarction !!!!!!!!!!!!

Eite, *int j Cardio* 2008

MRI in ACS

Female, 21y
Allergic Asthma

1 month after partum,
following trauma of the son

Chest pain, dyspnea

Echocardiogram: EF 35-40%, akinesia in mid-distal segments and apex

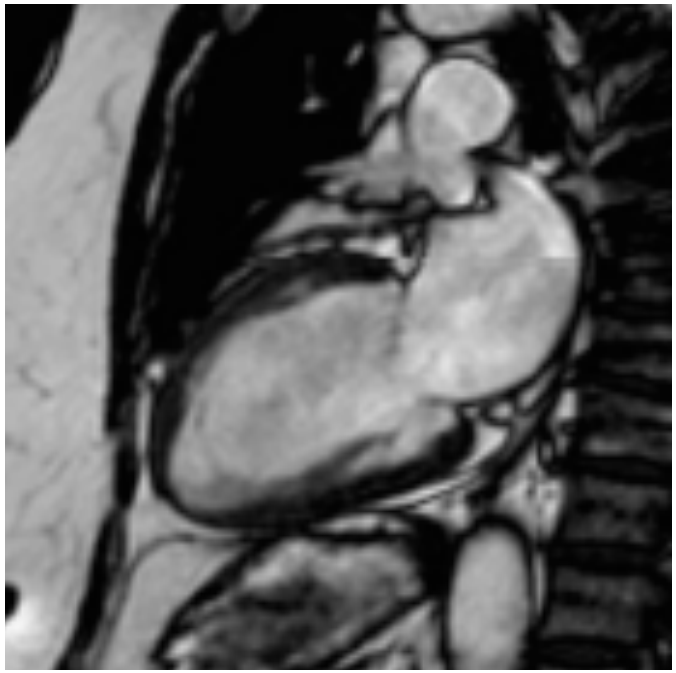
Mild raise of troponine (peak 3.2 ng/ml)
mild hyper-eosinophilia (Asthma?)

No coronary angiography

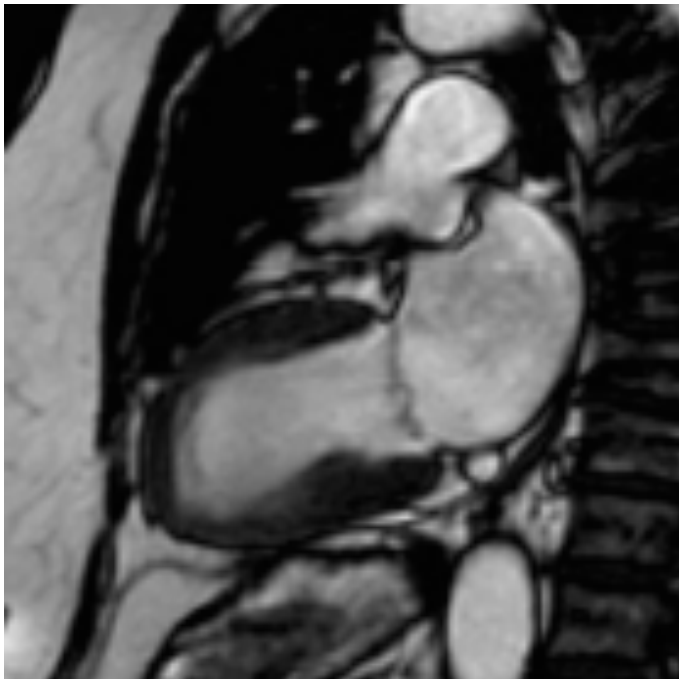
TAKO-TSUBO? MYOCARDITIS? PERIPARTUM?

MRI in ACS

Diastole



Systole



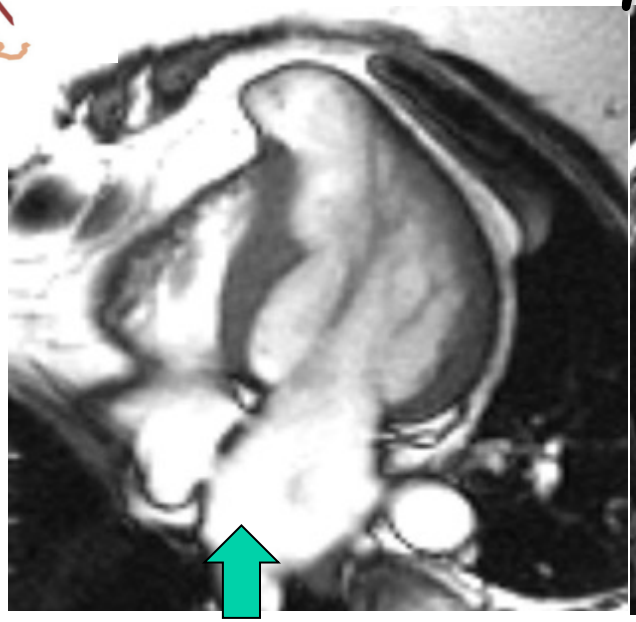
Typical WM abnormalities

MRI in ACS

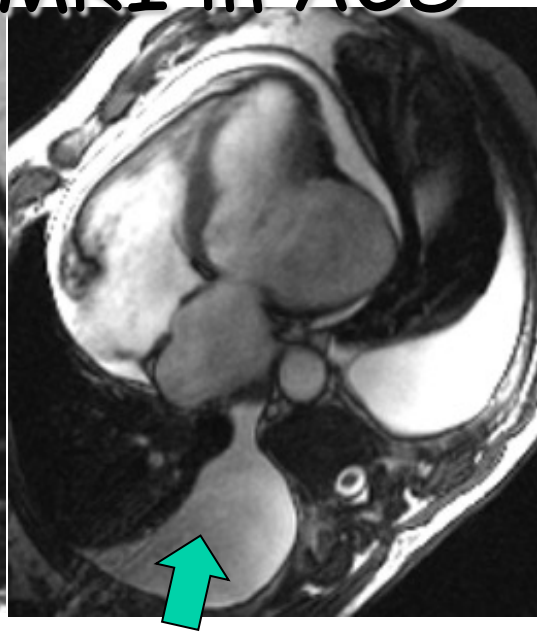
IR-GRE

diffuse subendocardial fibrosis➔….➔…➔Churg Strauss

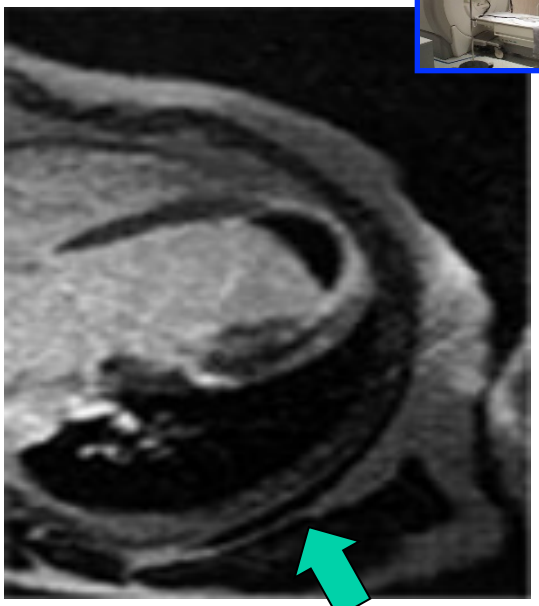
MRI in ACS



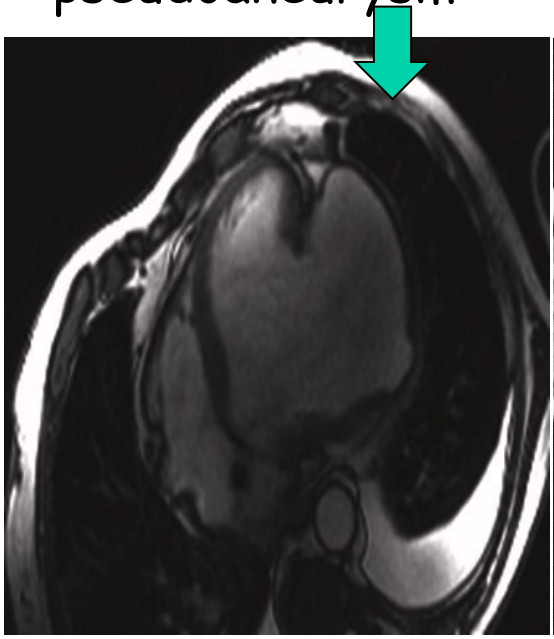
pseudoaneurysm

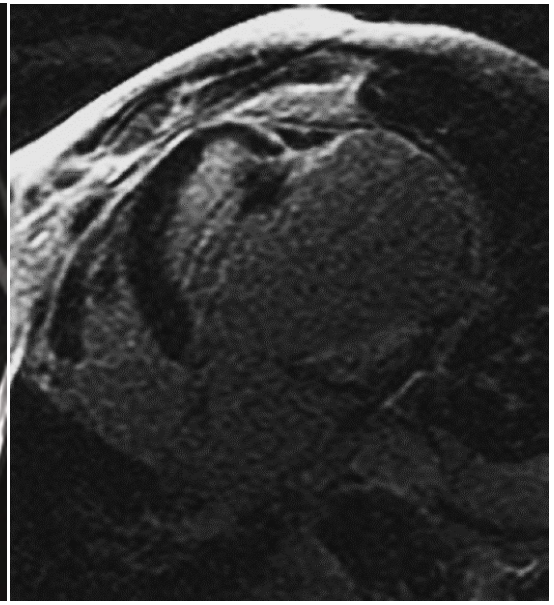


Aneurysm



LV Thrombus





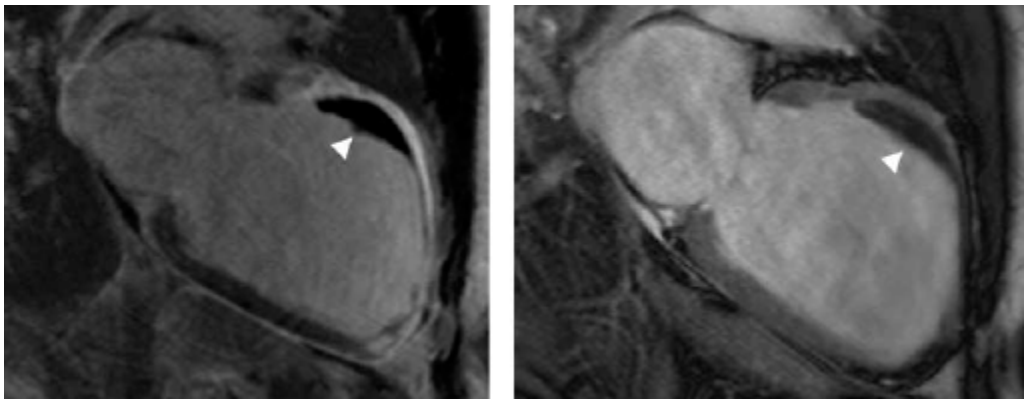
Complication of AMI

MRI in ACS
LV Thrombus

Comparison between CMR, TTE, TEE for LV thrombus detection

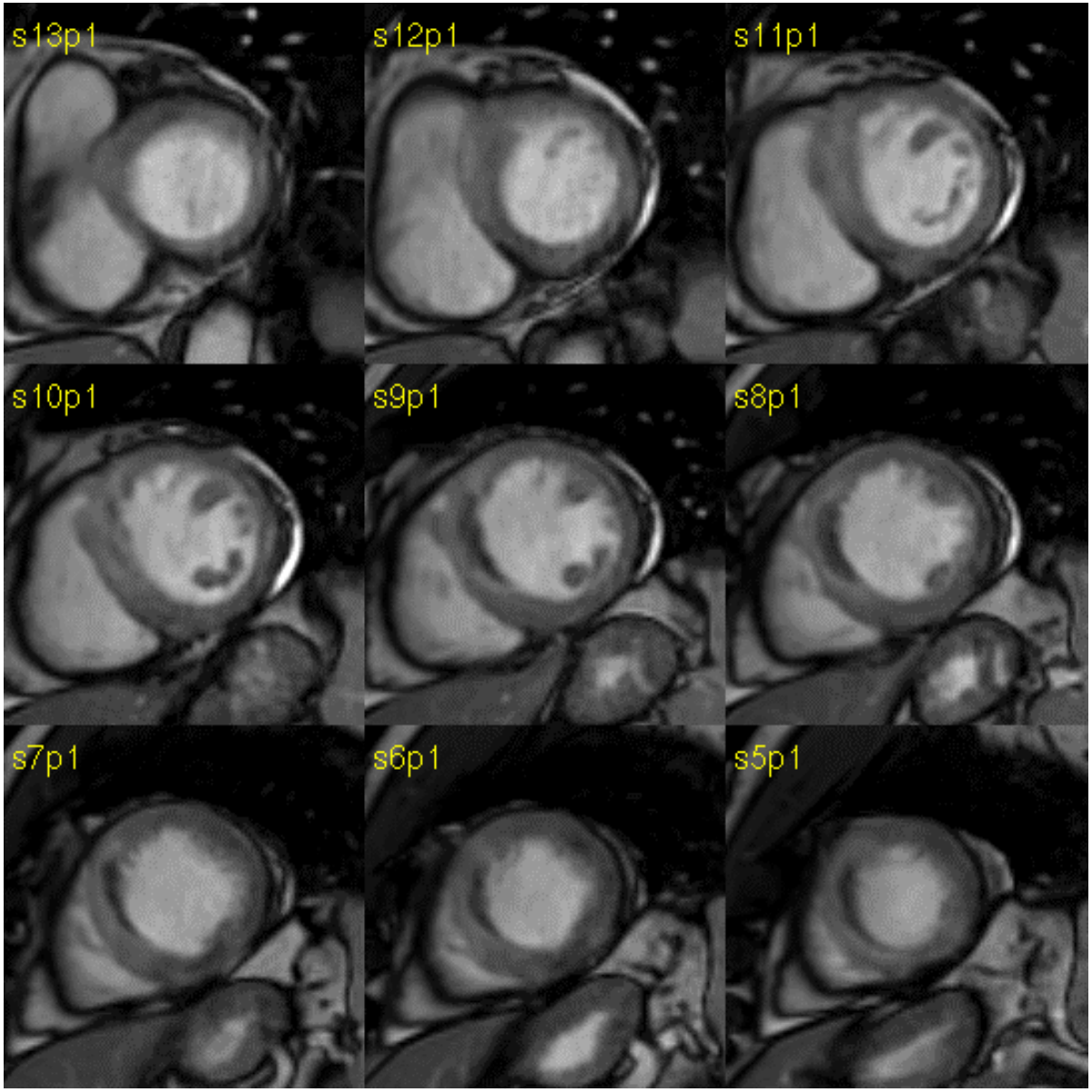
160 patients with all 3 imaging modalities performed within 30 days of surgical or pathological confirmation

ce-MRI: sensitivity 88±9% and specificity 99±2%
TTE: sensitivity 23±12% and specificity 96±3.6%,
TEE: sensitivity 40±14% and specificity 96±3.6%



Srichai, *Am Heart J* 2006

MRI in ACS

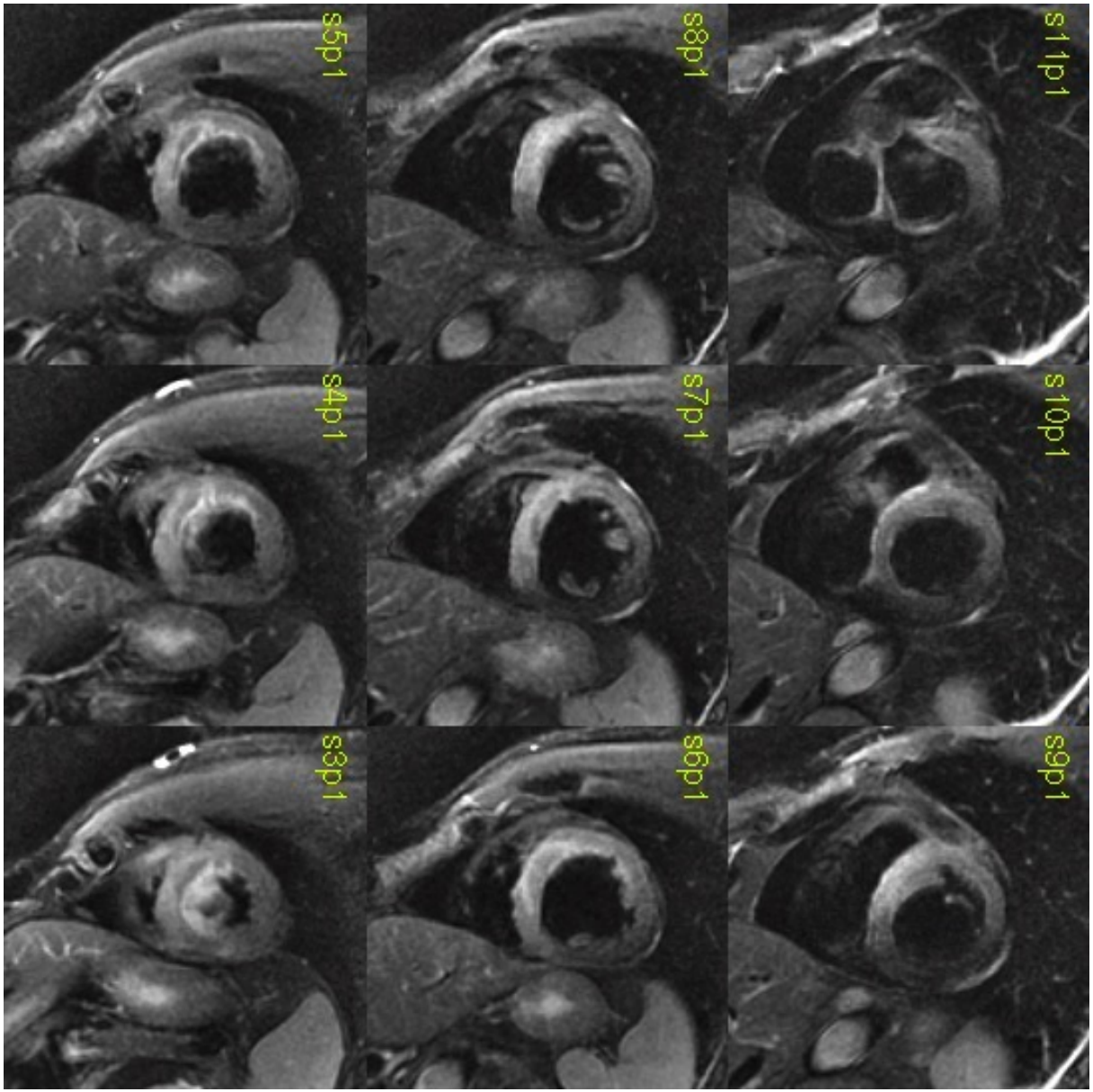


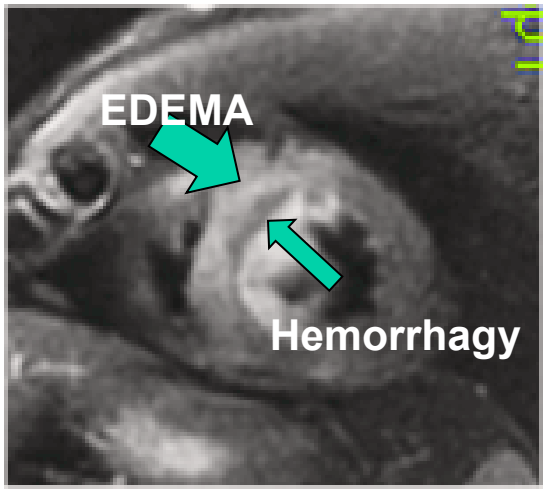
Case Report

M.A 54y
Anterior STEMI
>3h revascularization of LAD

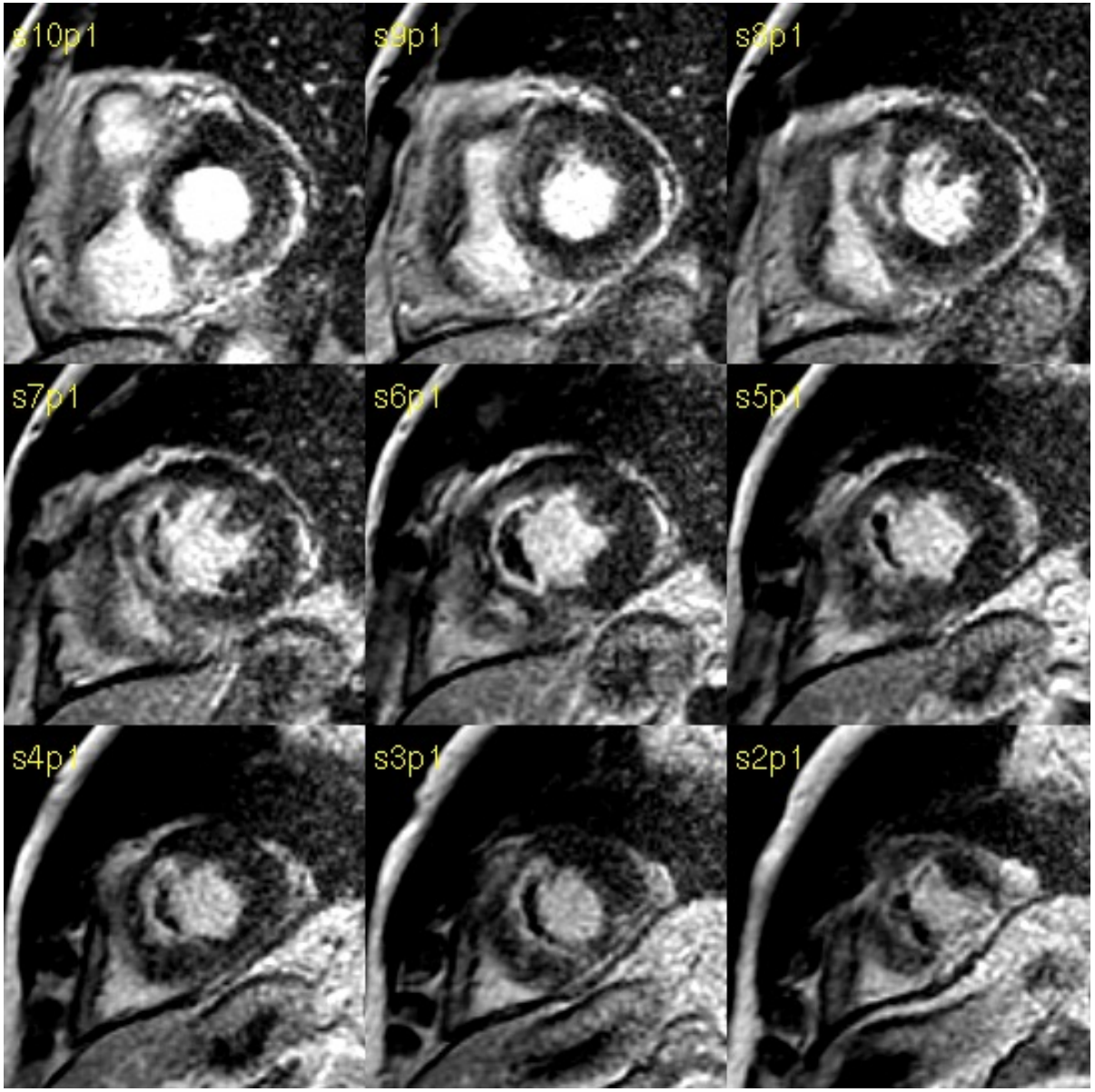
MRI in ACS

Case Report





Case Report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s5p1
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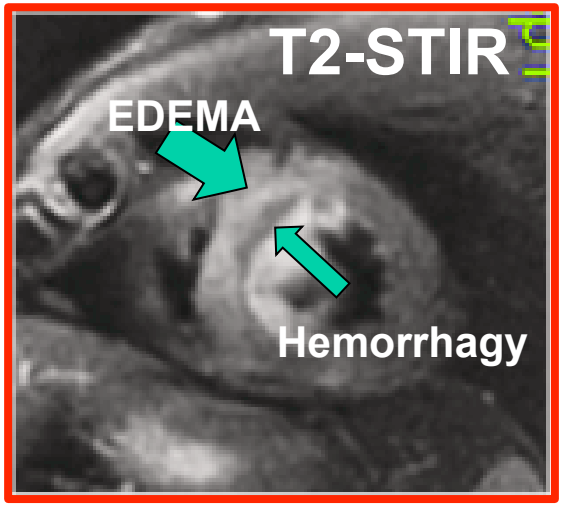
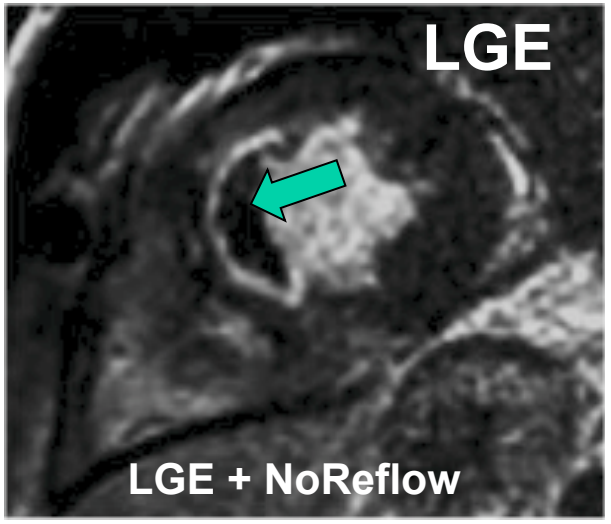
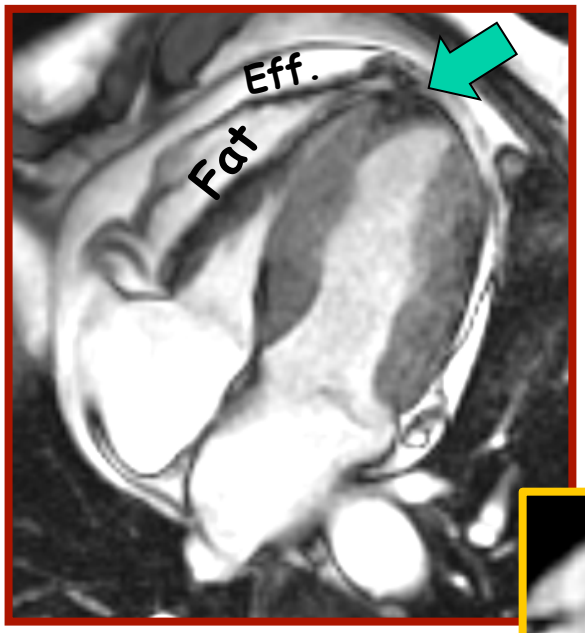
s2p1

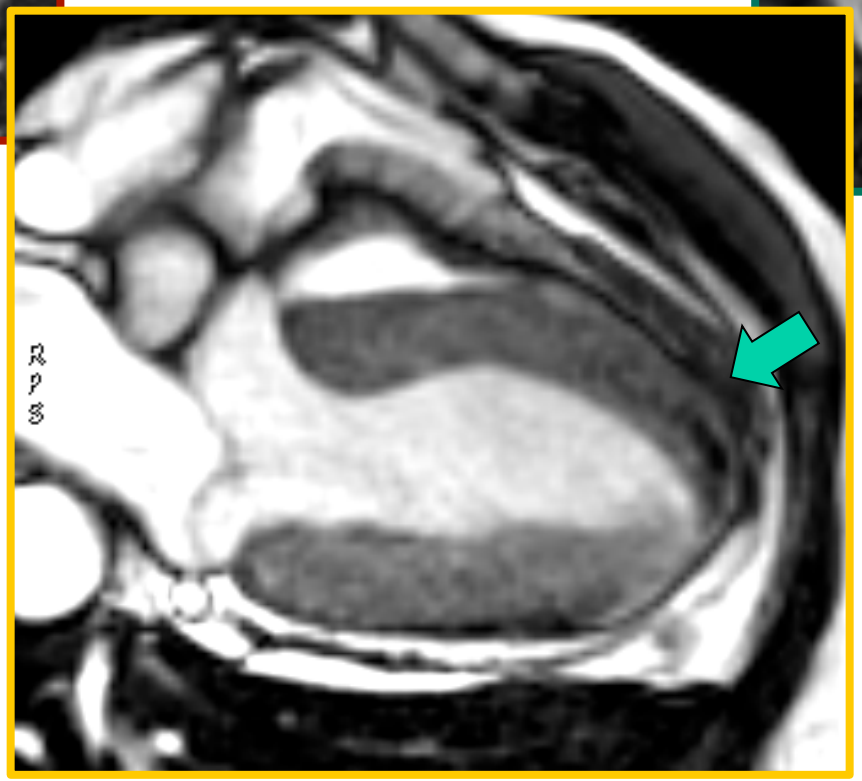

T2-STIR
EDEMA
Hemorrhagy


LGE
LGE + NoReflow

MRI in ACS

Case Report

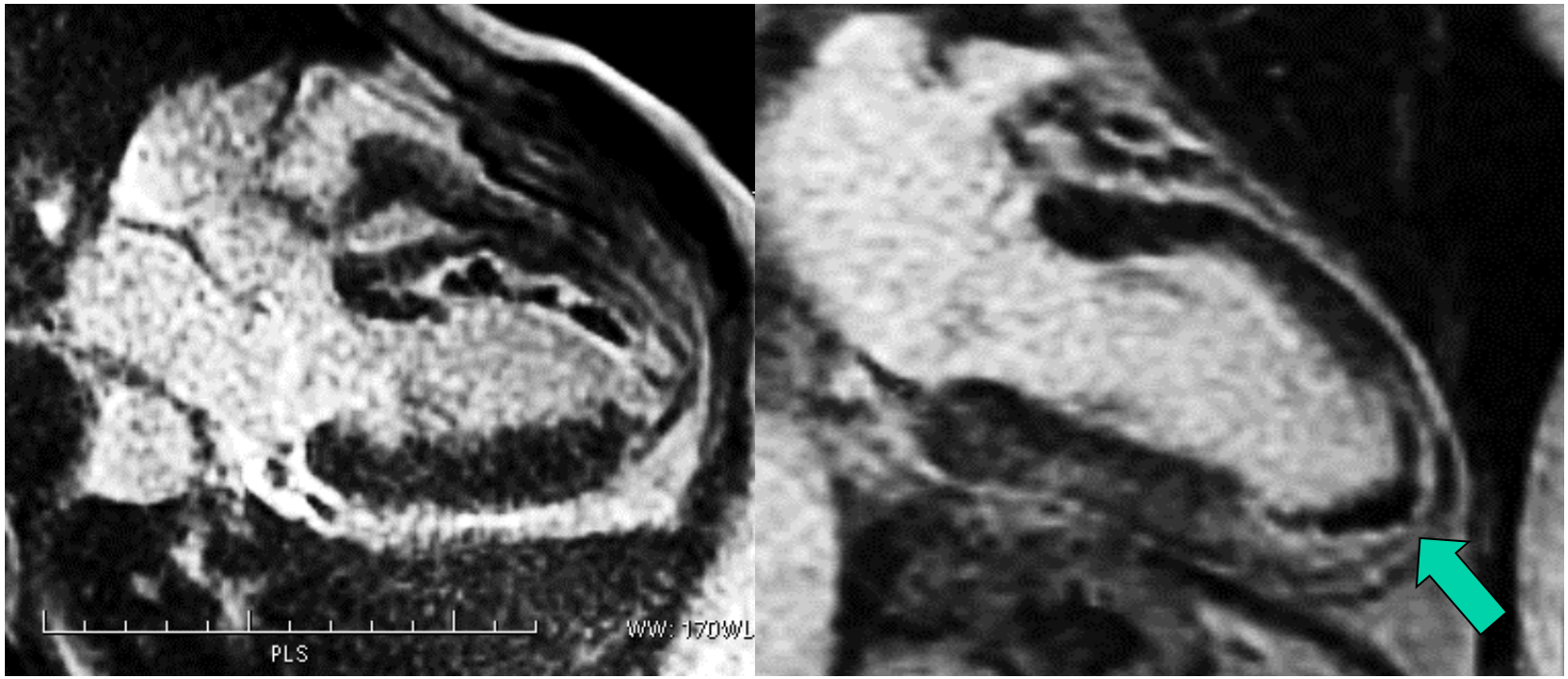




Intrapericardial Thrombus

MRI in ACS

Case Report



MRI in ACS

Conclusions

CMR allows evaluation of AMI and complications

Patients with suspected ACS but with no angiographic evidence of CAD should undergo CMR for alternative diagnosis (Myocarditis, Tako-tsubo etc)

Stress CMR is an alternative of stress echo in low-risk patients

Main disadvantages of MRI are contraindications and the poor diffusion of the technique

aquaro@ftgm.it