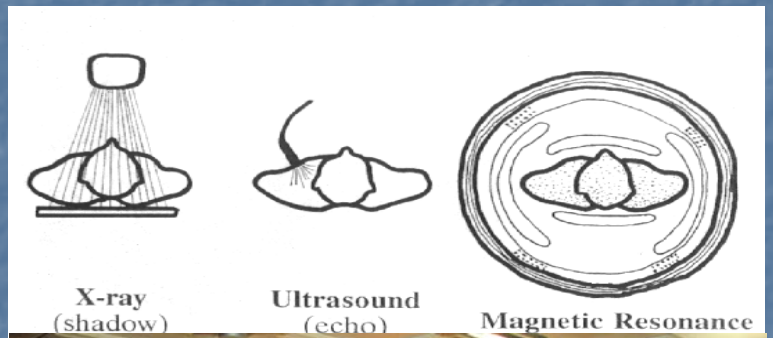
CARDIAC MRI

F.CIVAIA-L.IACUZIO

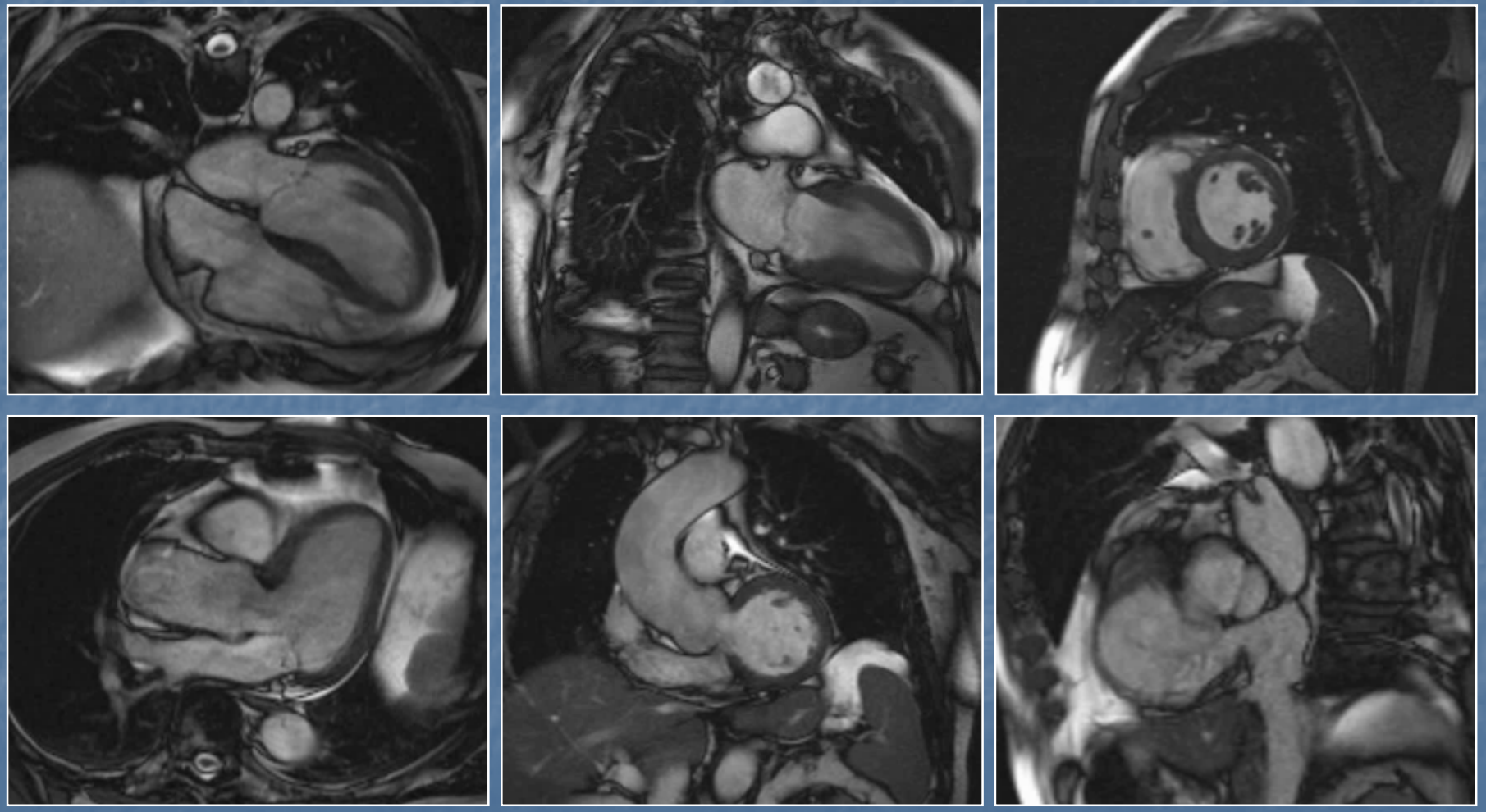
CENTRE CARDIO-THORACIQUE DE MONACO

MRI is a ***complementary*** means of « seeing » inside the body

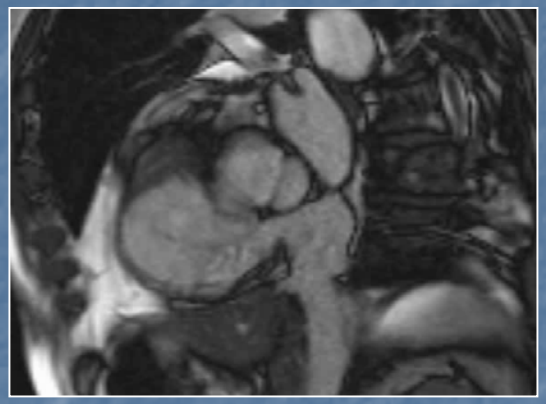
- *Non-invasive imaging technique*
- *High-resolution images in any desired plane*
- *No radiation*
- *Combined modalities (morphology, function …)*
- *Accurate diagnosis*
- *Less observer-dependent*

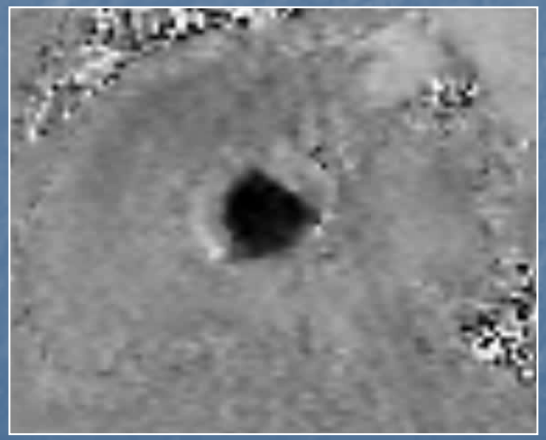


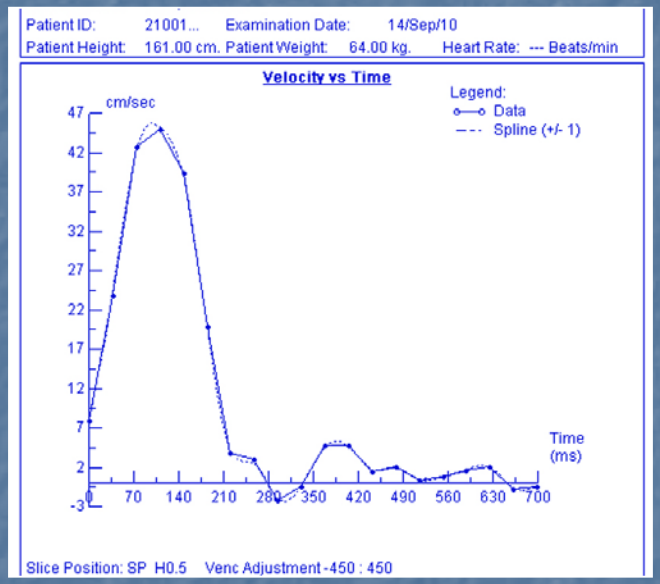
Excellent visualisation of cardiac structures



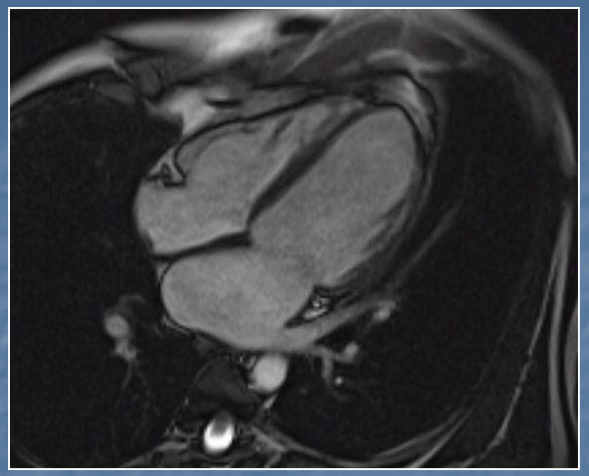
Flow study

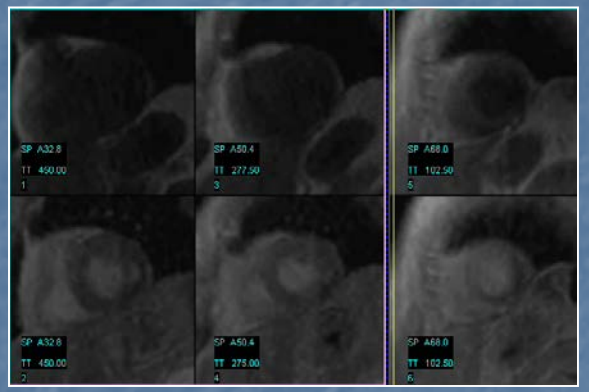


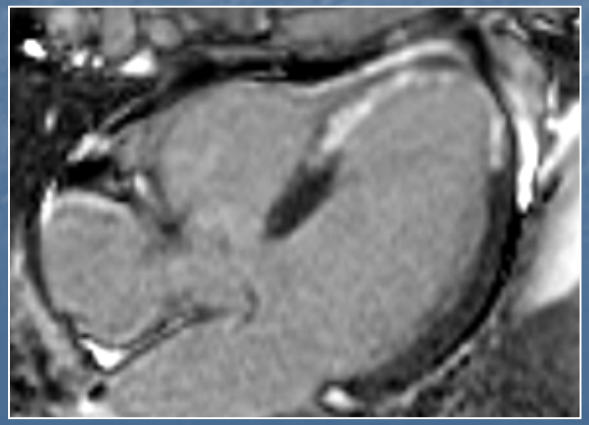


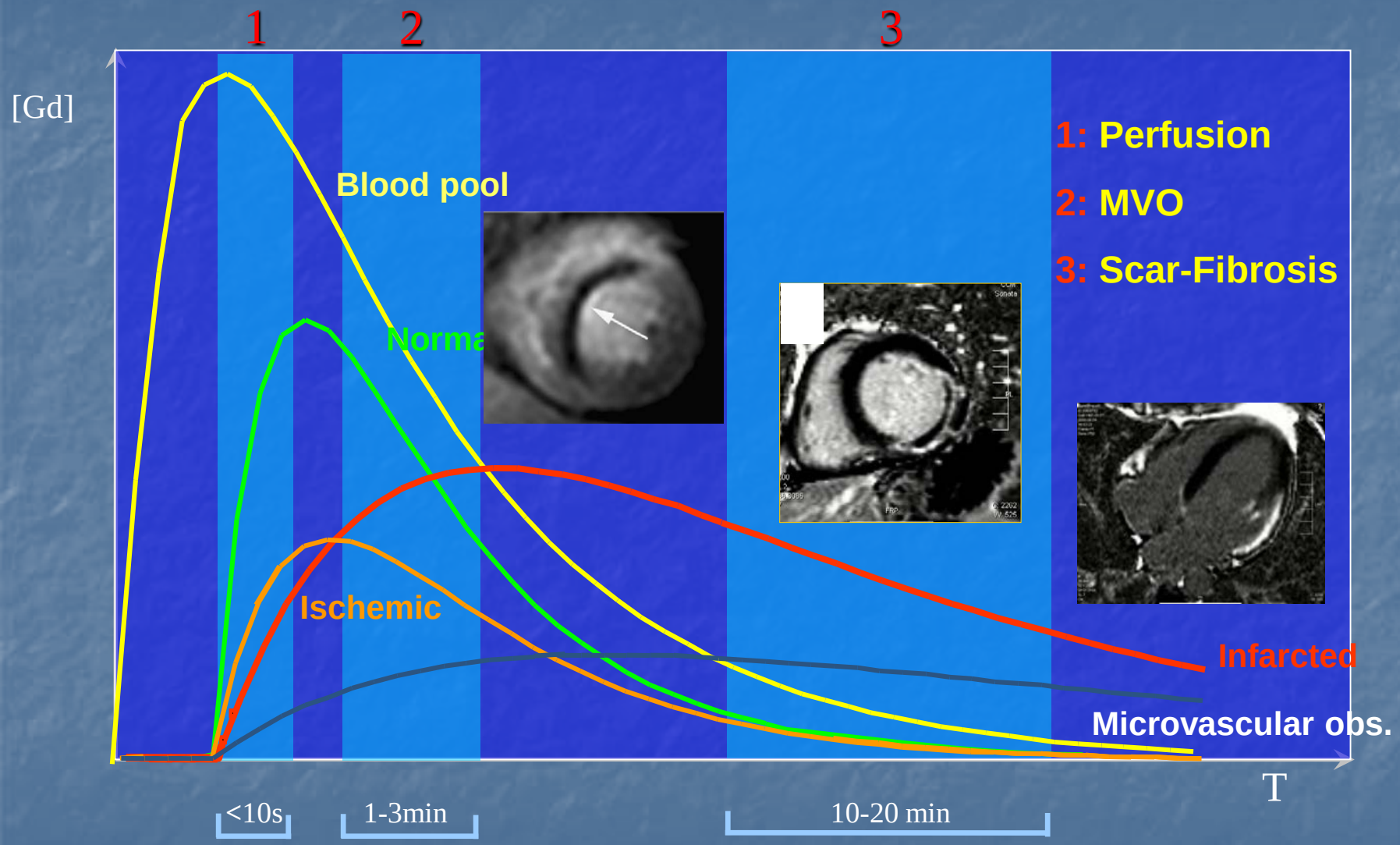

Patient ID: 21001...
Examination Date: 14/Sep/10
Patient Height: 161.00 cm.
Patient Weight: 64.00 kg.
Heart Rate: --- Beats/min
Velocity vs Time
cm/sec
Legend:
Data
Spline (+/- 1)
47
42
37
32
27
22
17
12
7
2
-3
0
70
140
210
280
350
420
490
560
630
700
Time (ms)
Slice Position: SP H0.5
Venc Adjustment -450 : 450

- CINE MRI: morphological and functional study of cardiac structures
- PERFUSION MRI : rest and stress perfusion study
- CONTRAST CMR: early and late enhancement (tissue characterisation)





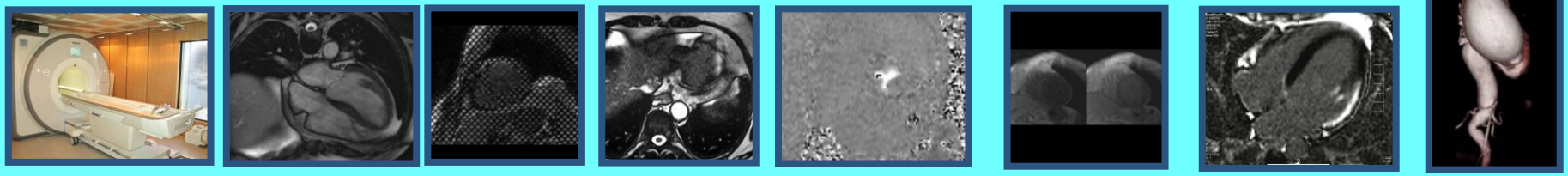


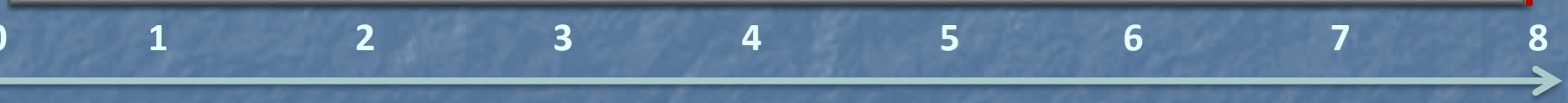


Courtesy: J. Moon (RBH)

Steps of an MRI exam

30 MINUTES





SCOUT

CINE
IMAGING
FUNCTION

TAGGING

MORPHO

VALVES
FLOW

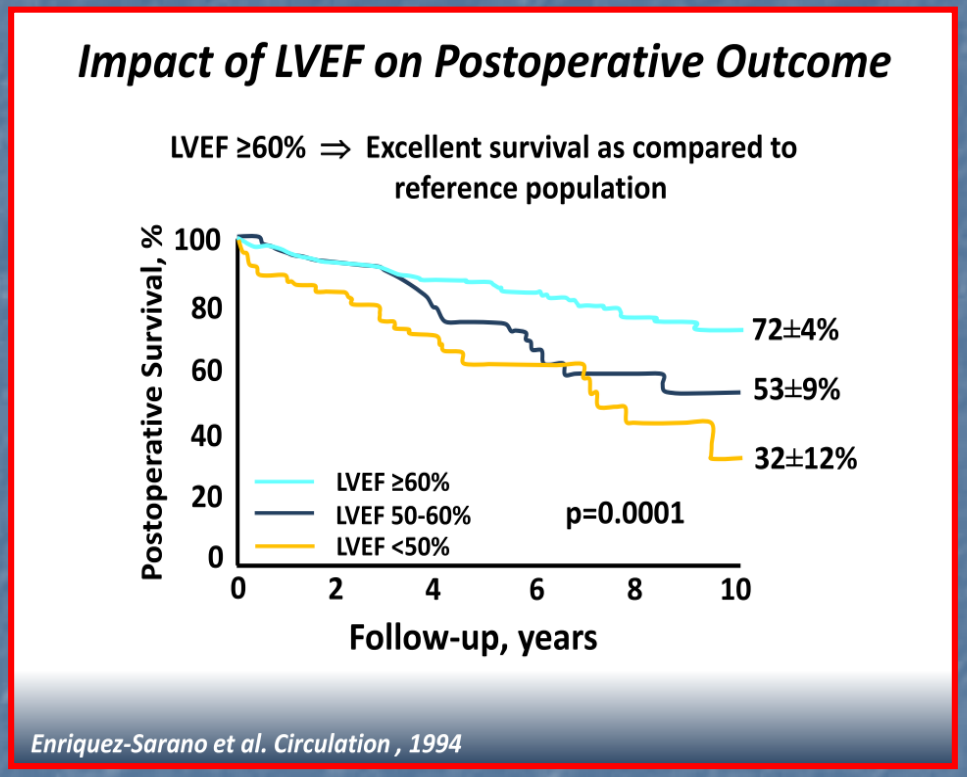
PERFUSION
AT REST

ENHANCEMENT
EARLY
AND LATE

ANGIOGRAPHY

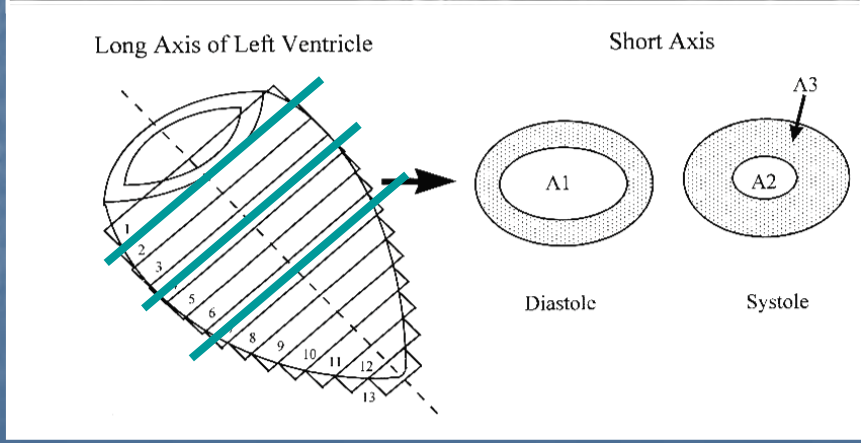
FONCTION

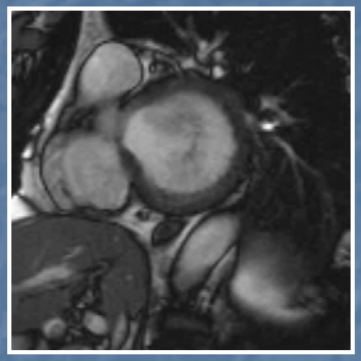
Patient's prognosis closely related to LV function

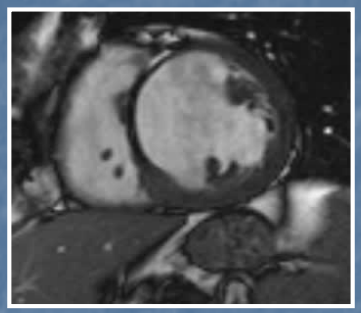


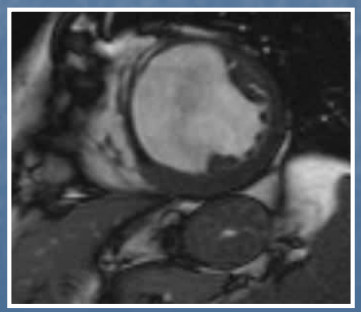
Early detection and treatment *before irreversible damage* is mandatory

RELIABLE EJECTION FRACTION, VOLUME AND MASS









Normal Values

LVEF :

56 - 78 %

EDVI :

47 - 92 ml/m²

ESVI :

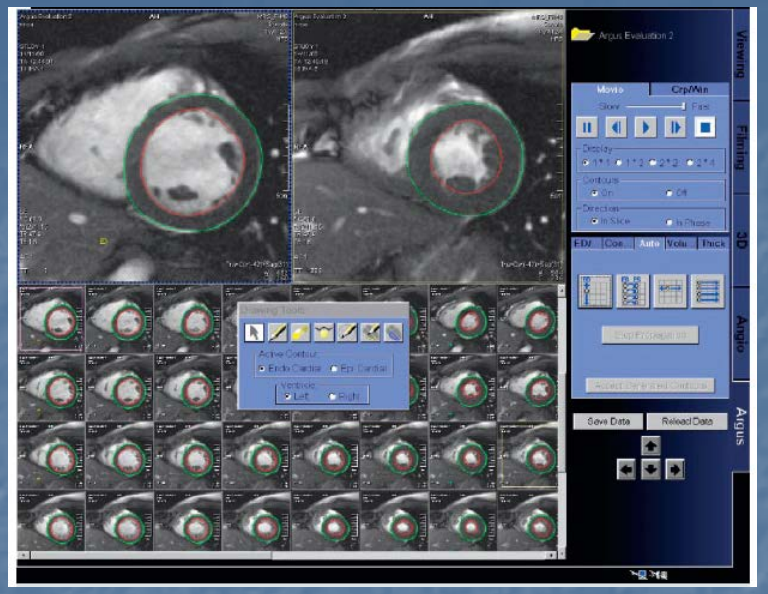
13 - 33 ml/m²

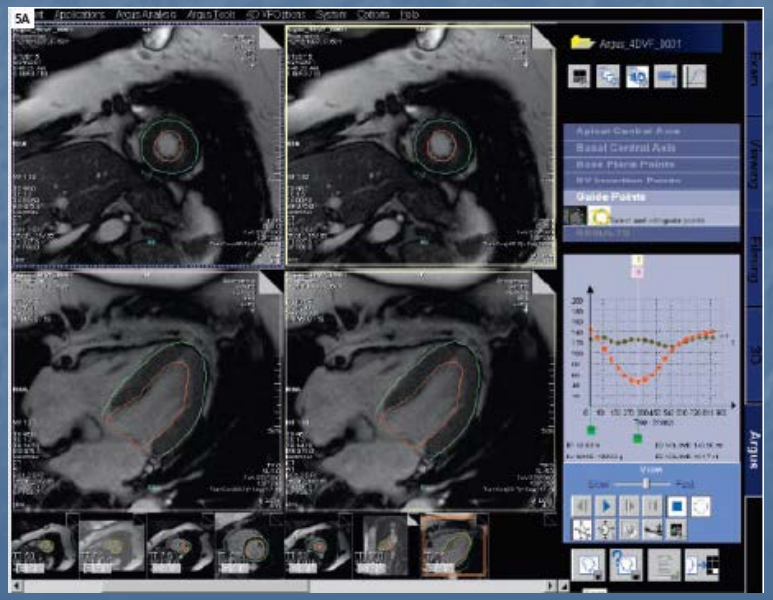
LV Mass :

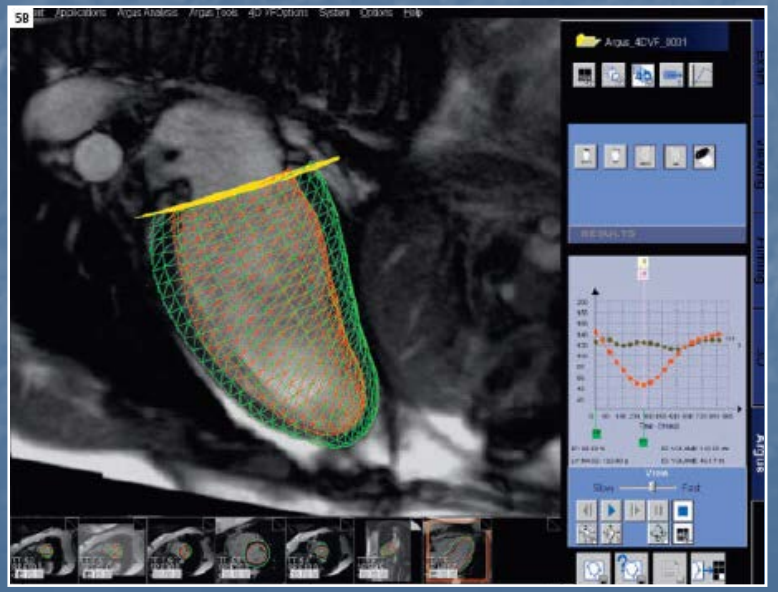
70 - 113 g/m²

- *3 Times more accurate & reliable compared with Angio & 2D Echo (Simpson formula)*
- *Correlated with 3D Echo (+- 3%)*

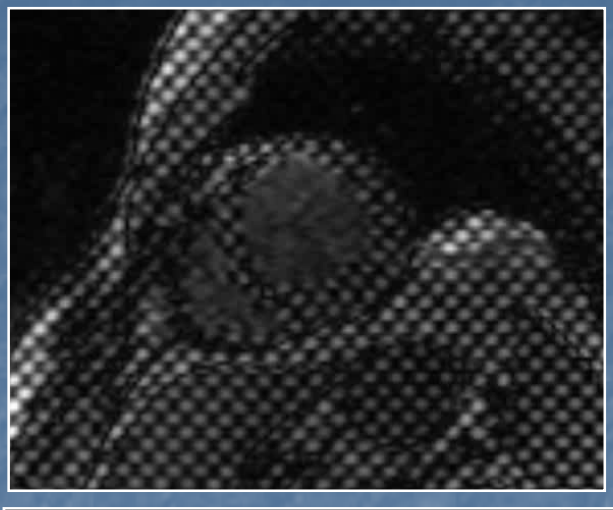
CMR LV function evaluation

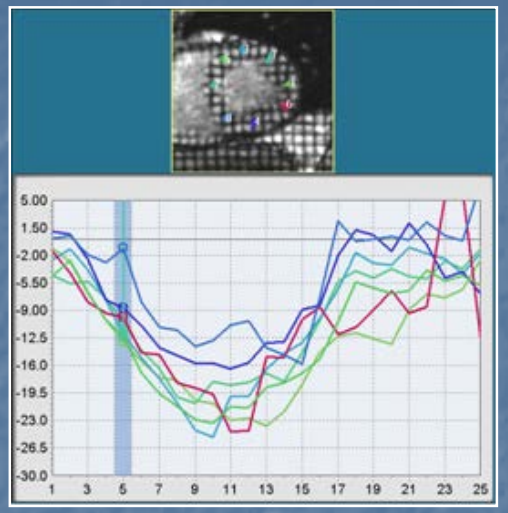


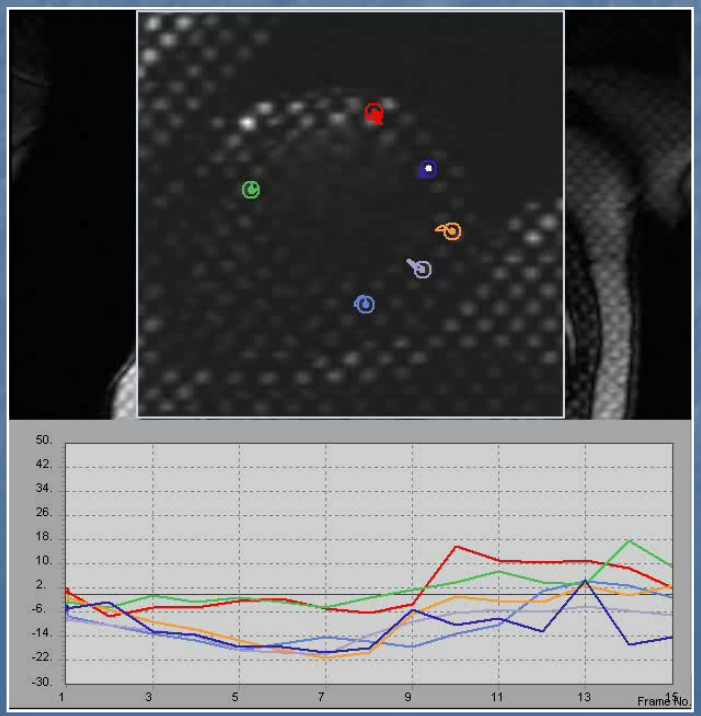


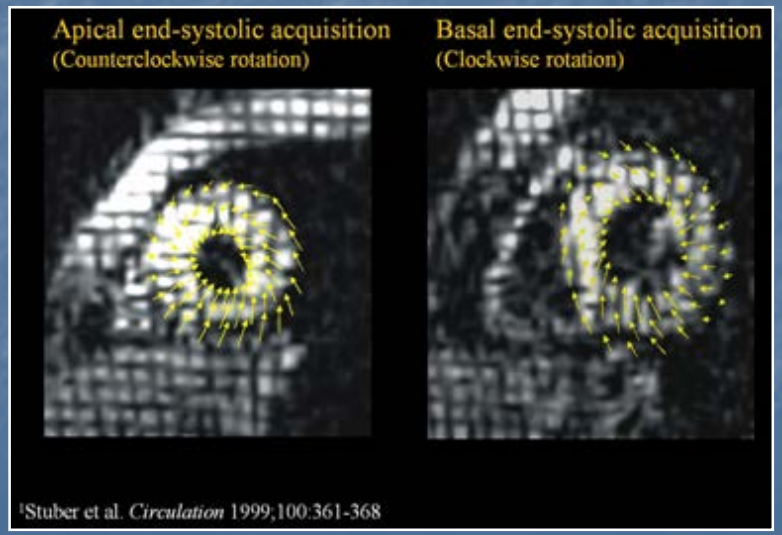


Tagging



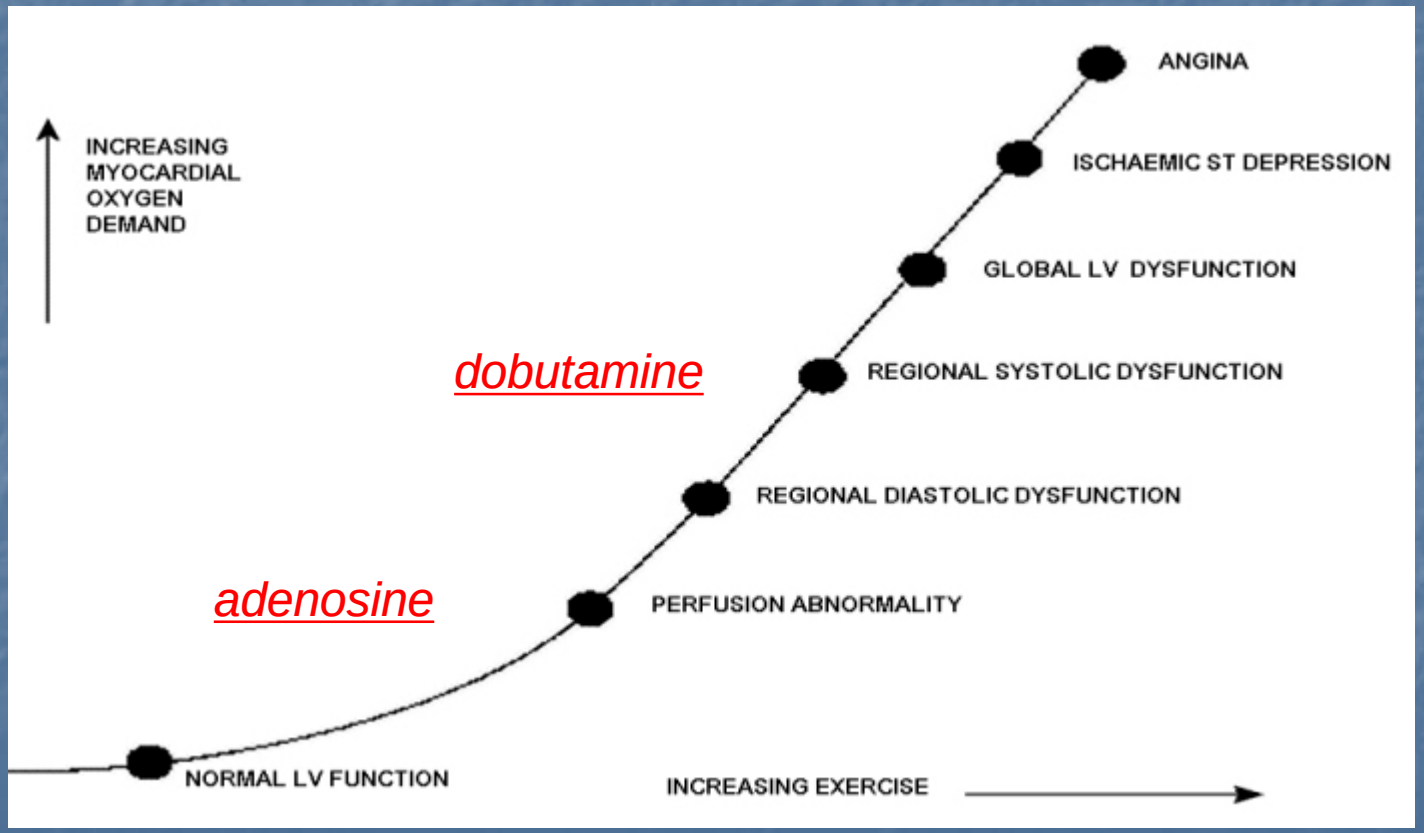

5.00
1.50
-2.00
-5.50
-9.00
-12.5
-16.0
-19.5
-23.0
-26.5
-30.0
1 3 5 7 9 11 13 15 17 19 21 23 25


50.
42.
34.
26.
18.
10.
2.
-6.
-14.
-22.
-30.
1 3 5 7 9 11 13
Frame No.

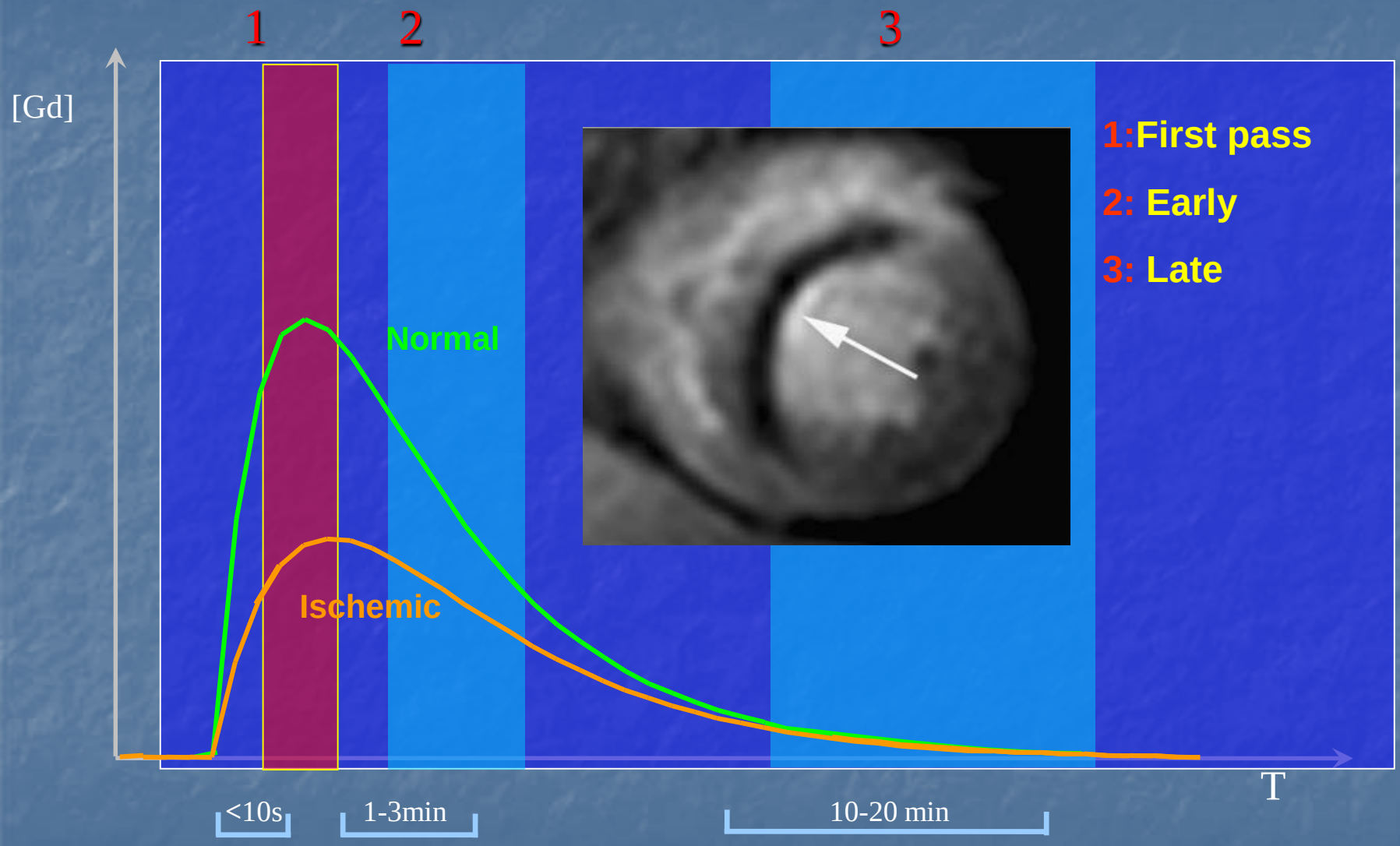

Apical end-systolic acquisition
(Counterclockwise rotation)
Basal end-systolic acquisition
(Clockwise rotation)
[1]Stuber et al. *Circulation* 1999;100:361-368

ISCHEMIA

Sequence of ischemic events



PERFUSION

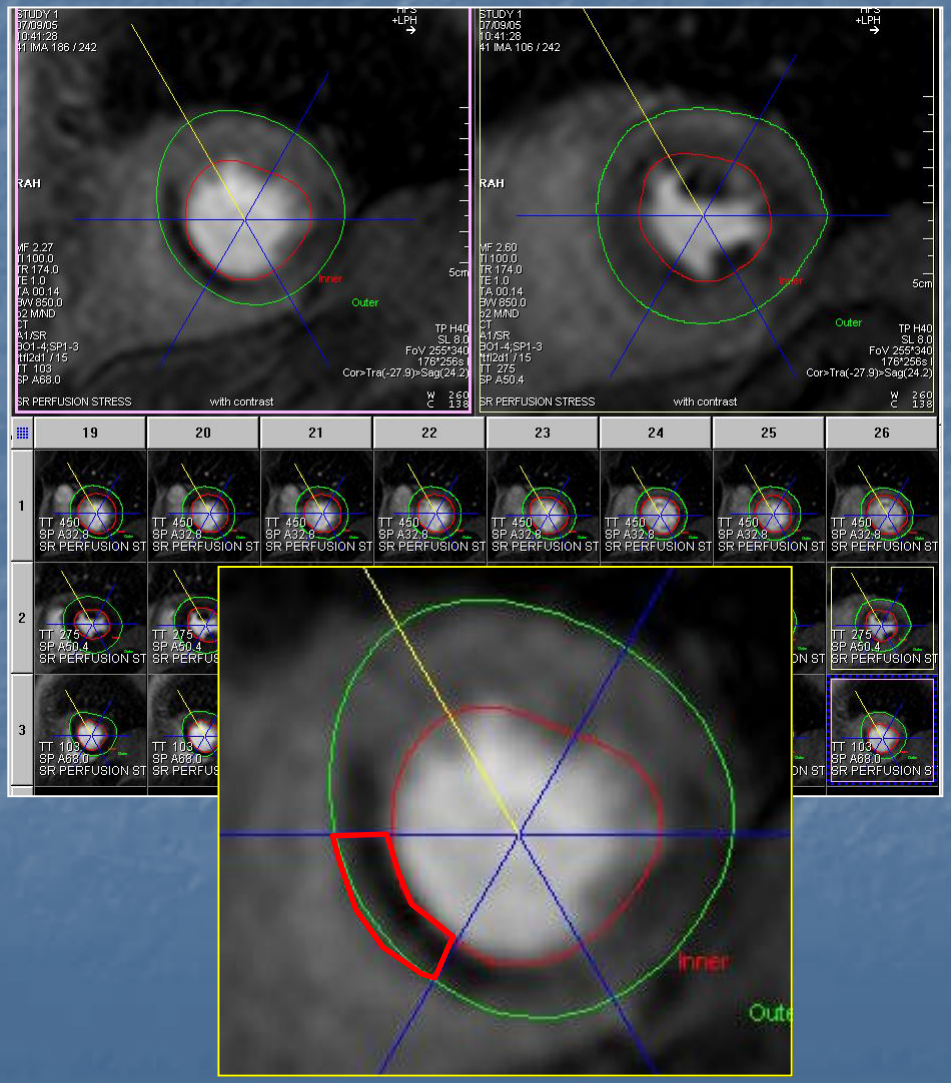


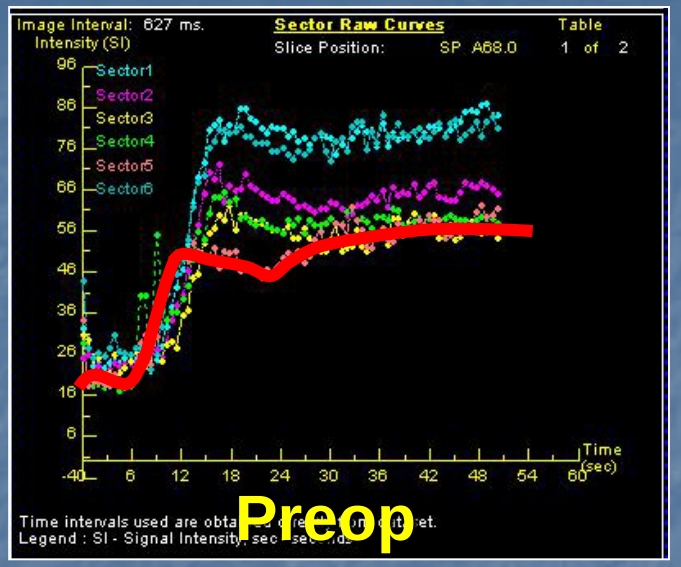
Courtesy: J. Moon (RBH)

Stress MRI

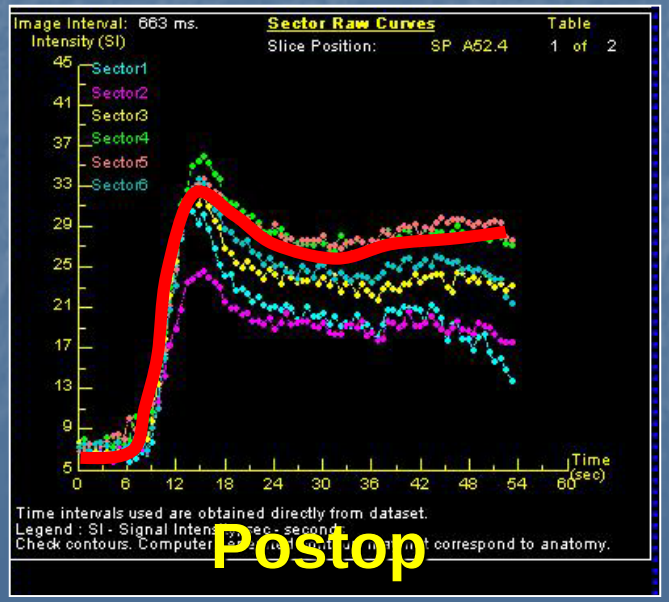
ADENOSINE STRESS CMR

Stress





Preop



Postop

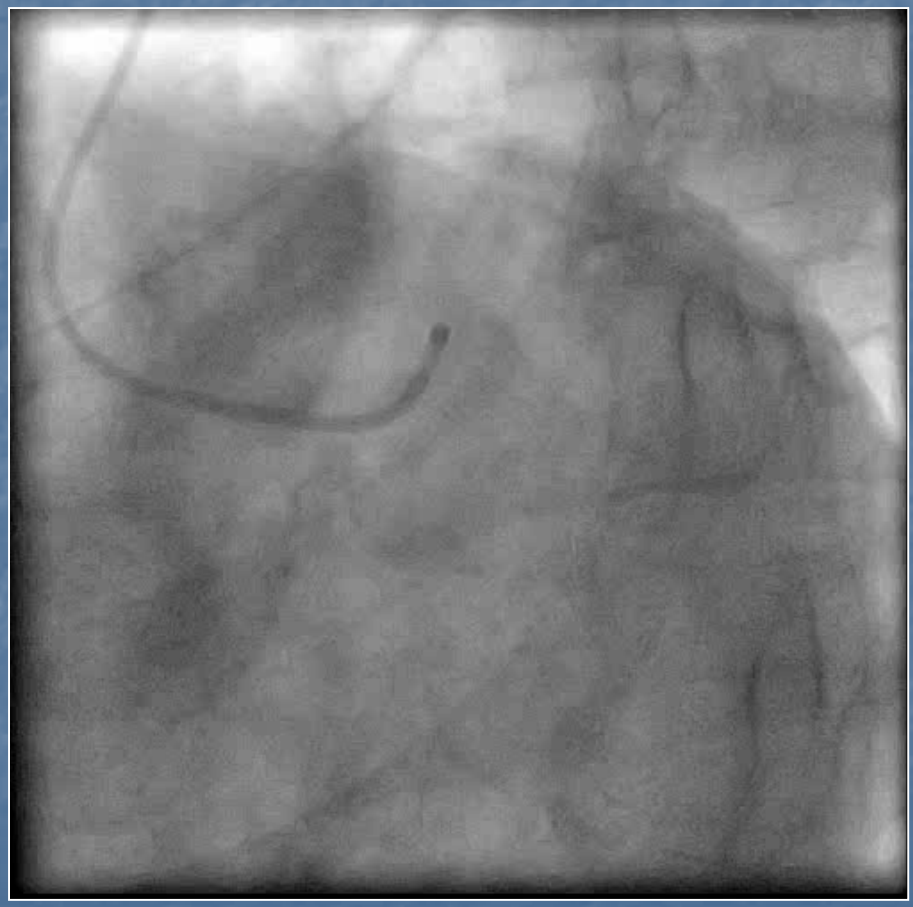
Case 1

Before ORL surgery

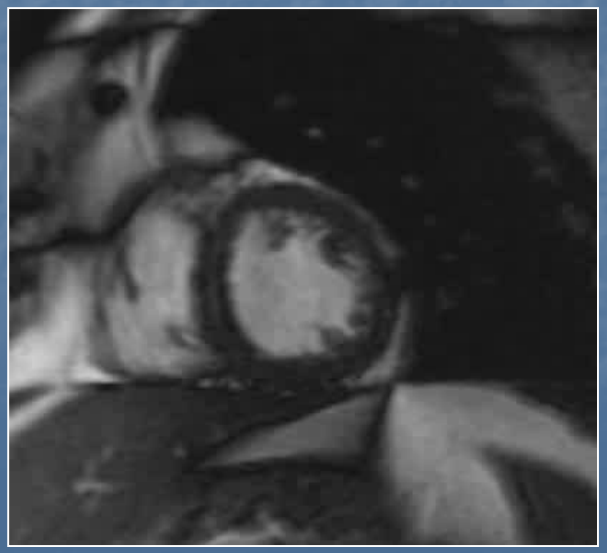
- Male 75 years, hypertension
- Hystory of stroke
- Atypical chest pain

- Treadmill test: not sustaines VT

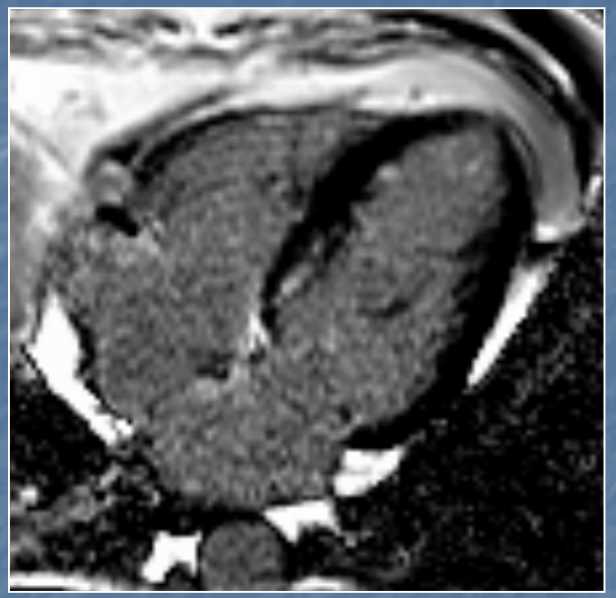
CORO: LCX occlusion

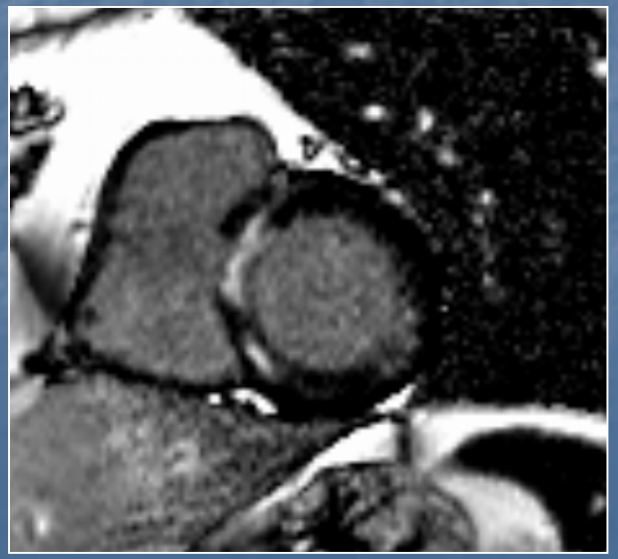


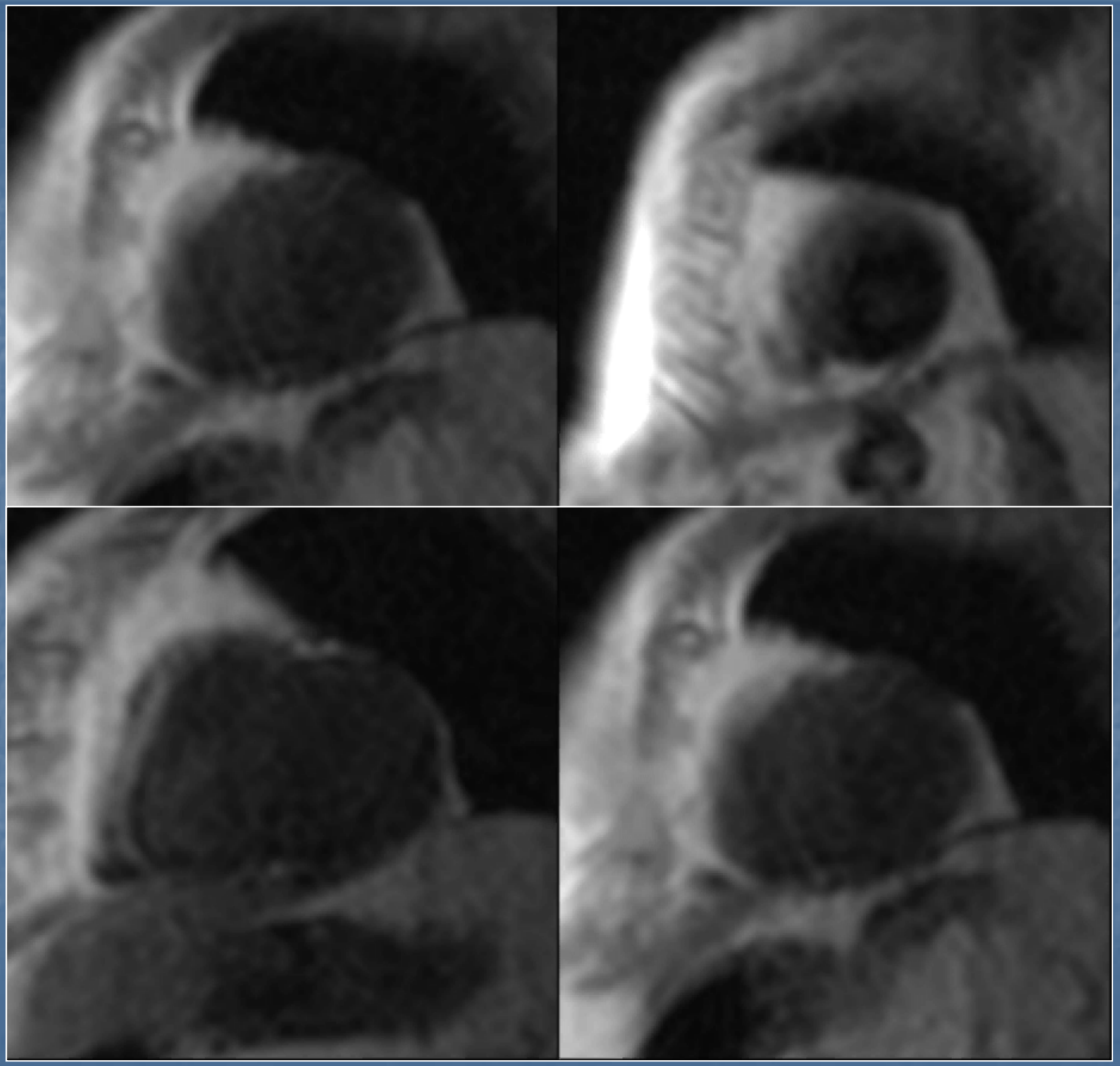
Basal MRI: sub endocardial infero-lateral et basal septal necrosis



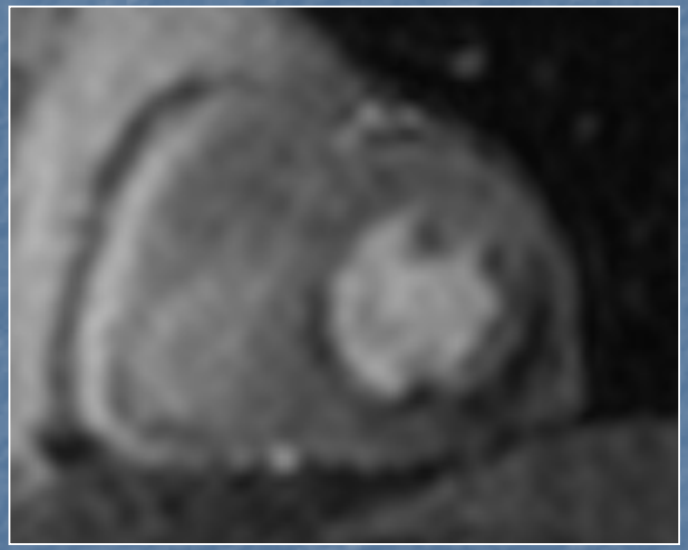
gadolinium LE:

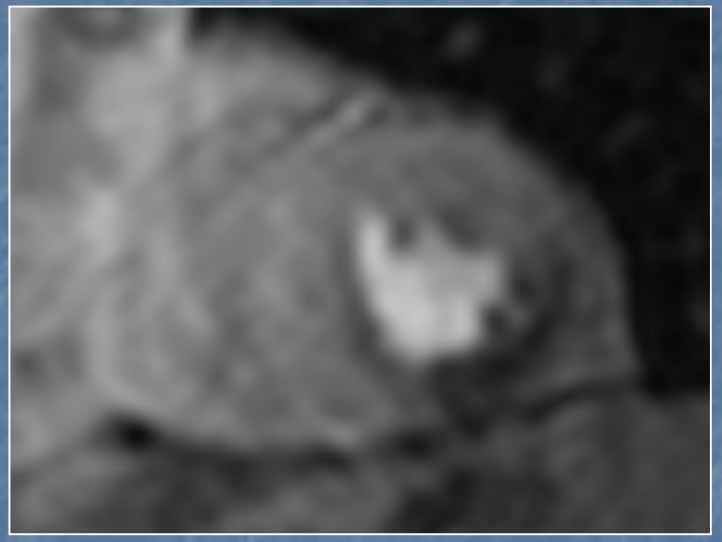






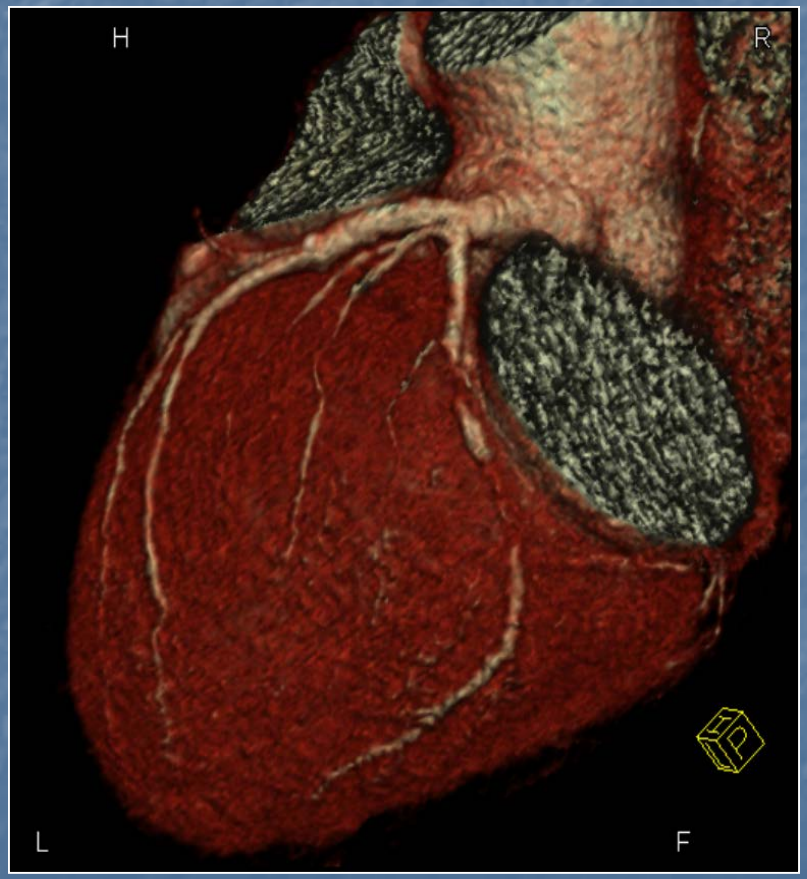
Stress adenosine MRI



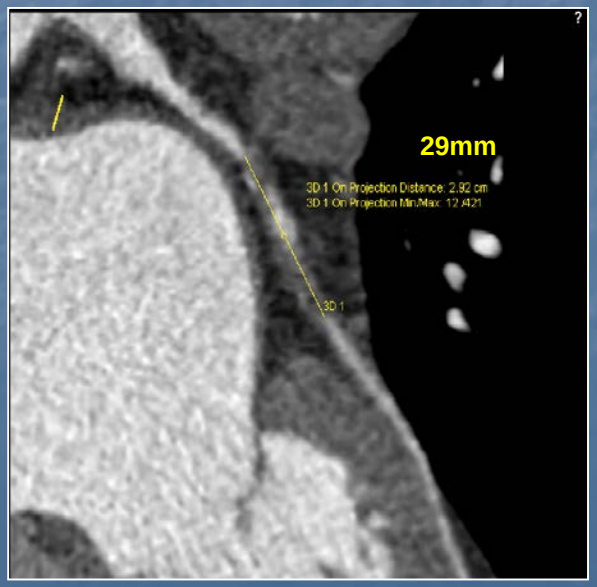


Infero-lateral hypoperfusion

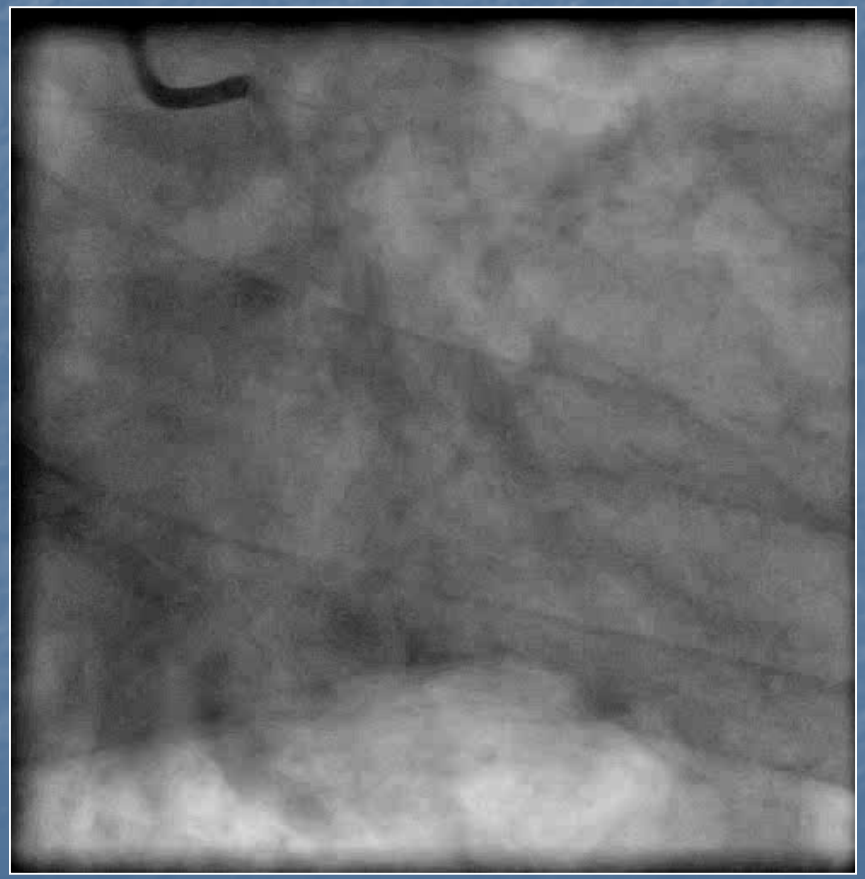
MSCT for evaluation of occlusion and feasibility of PCI

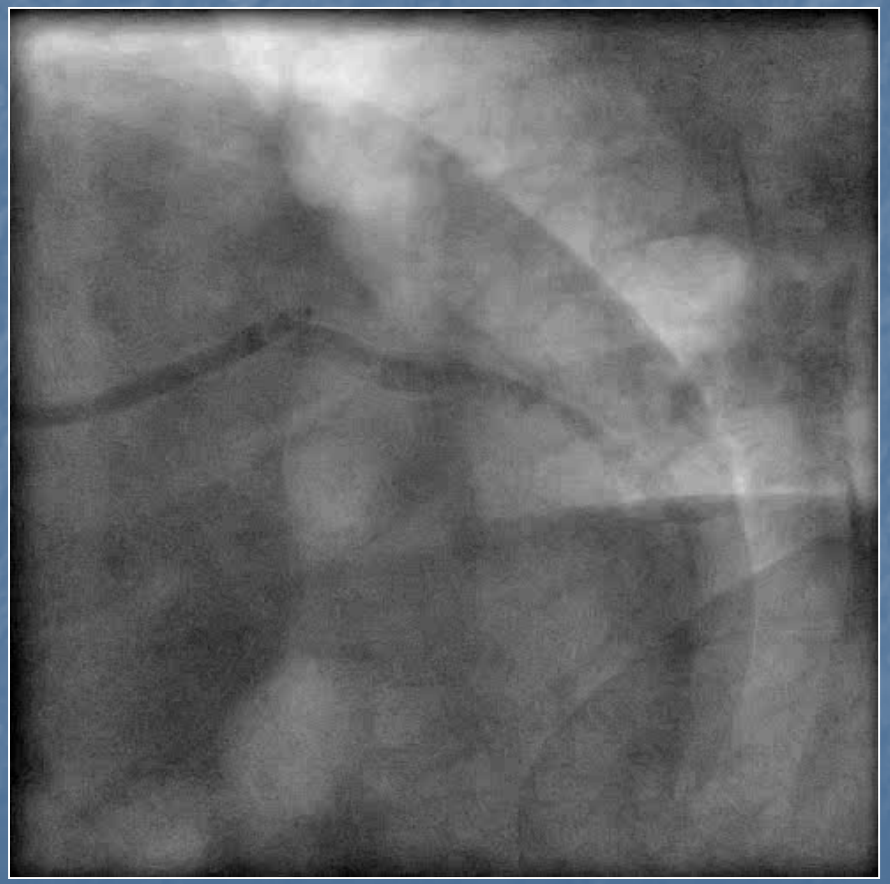


- reperméabilisée
- longue (>15mm)
- avec moignon
- sans tortuosité
- non calcifiée
- sans branche collatérale
- bon champ d'aval

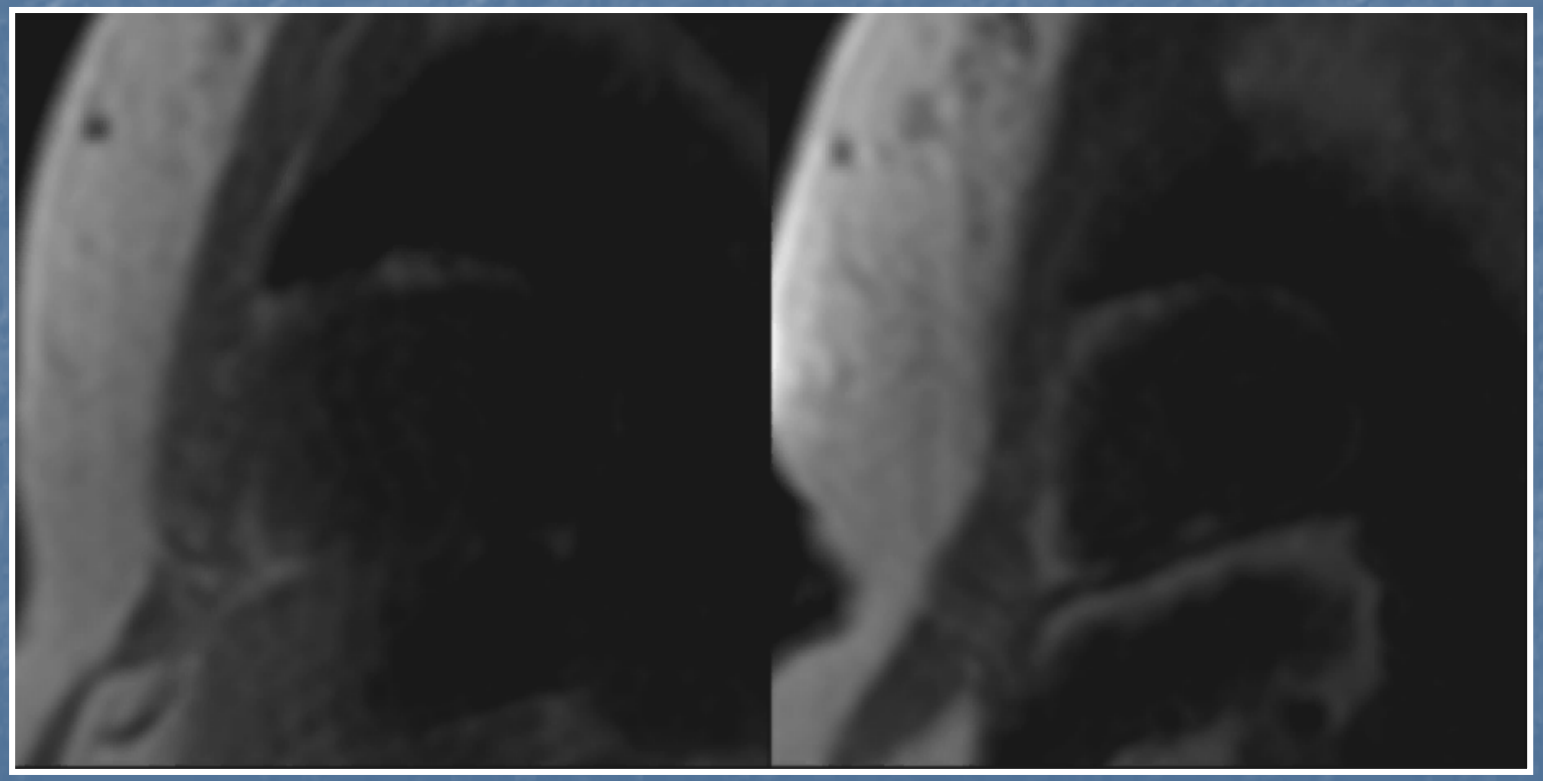


Post PTCA and DES





Stress control



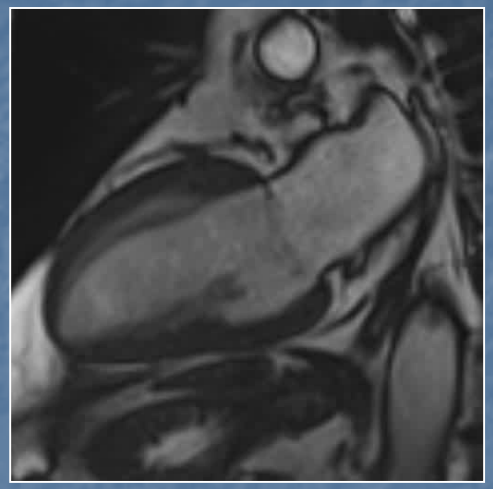
Case 2

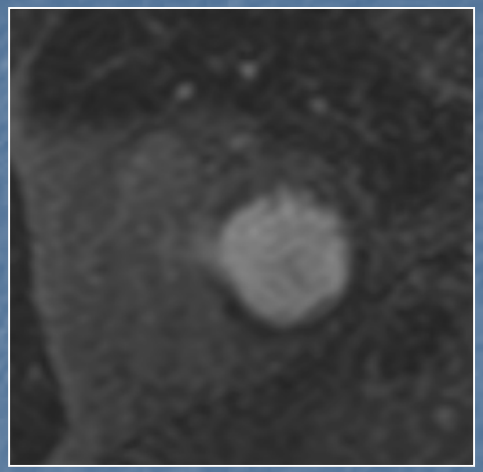
- *65 years-old-man*
- *Asymptomatic without history of CAD*
- *Multiple coronary risk factors: diabetes, dyslipidemia, hypertension*
- *Peripheral vascular disease: known abdominal anevrysm with claudicatio intermittens since 2000 and left internal carotidis stenosis*

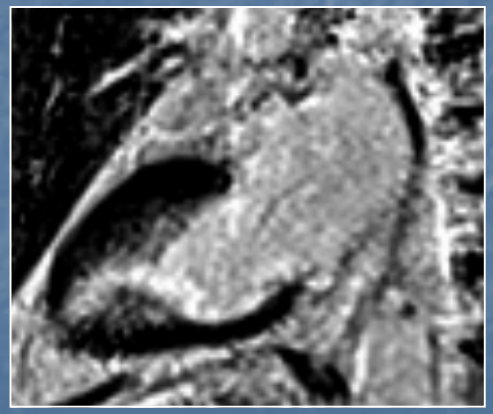
LOWER LIMB & AORTIC MSCT

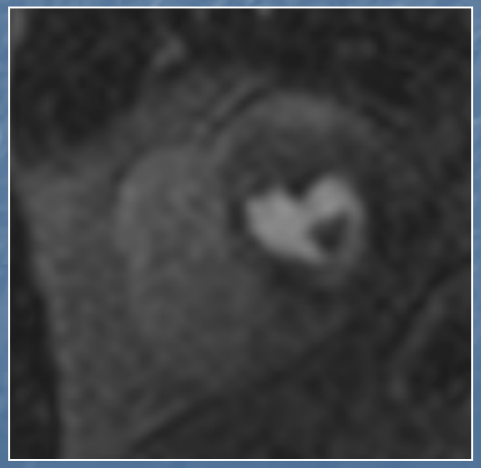
ABDOMINAL AORTIC ANEVRYSM 5.24 x 5.06 cm

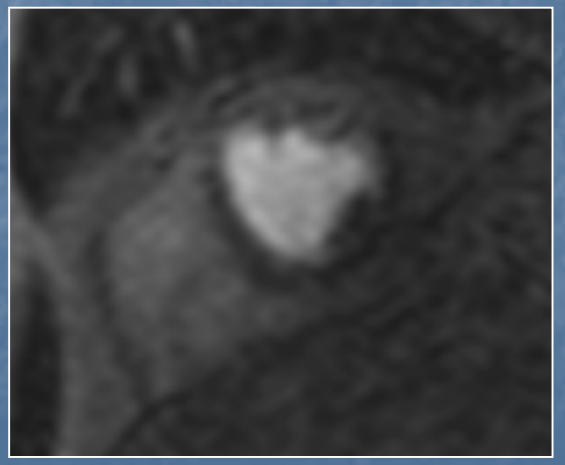
ADENOSINE MRI



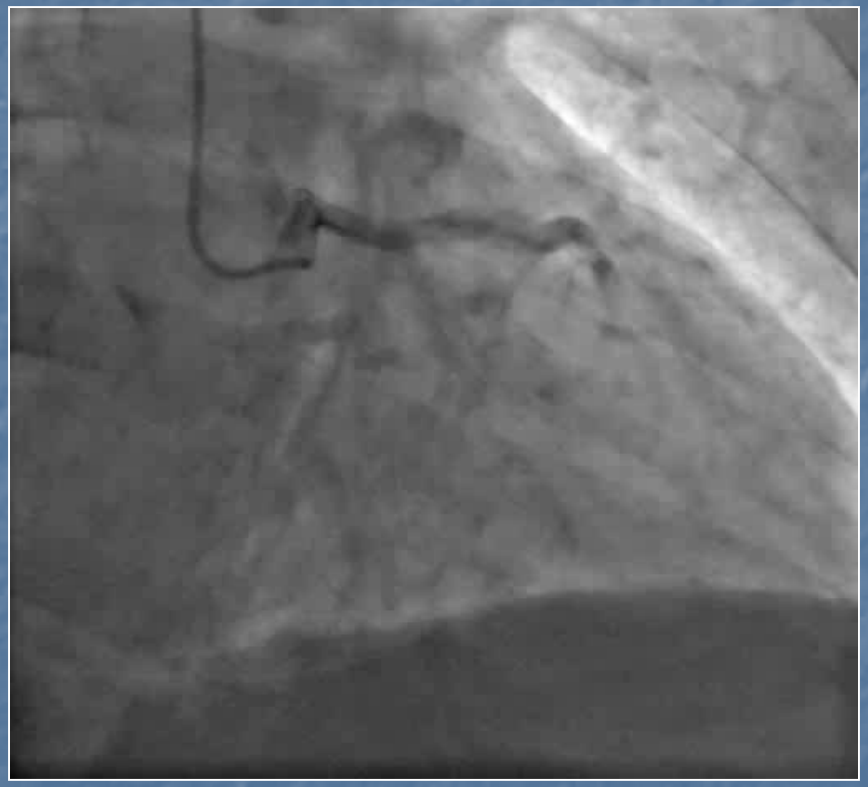


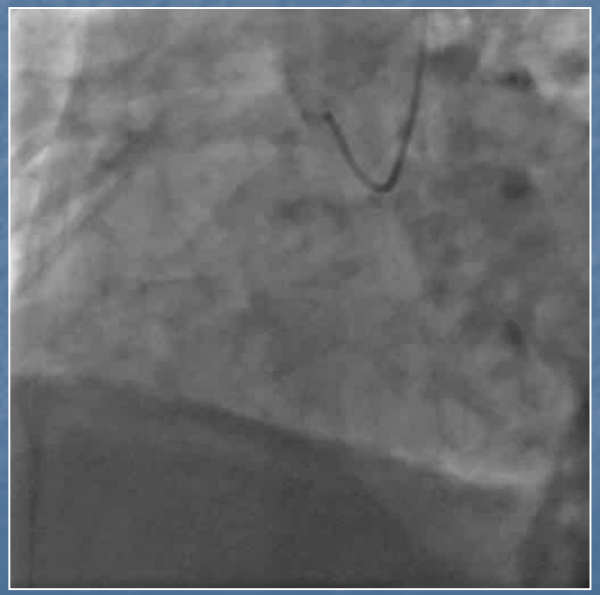




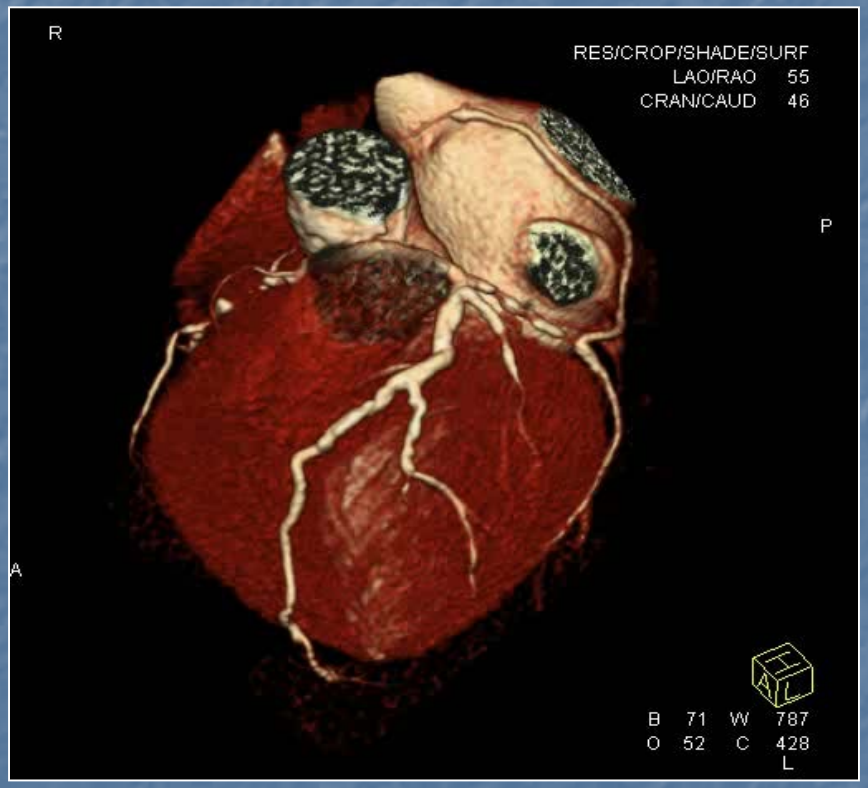


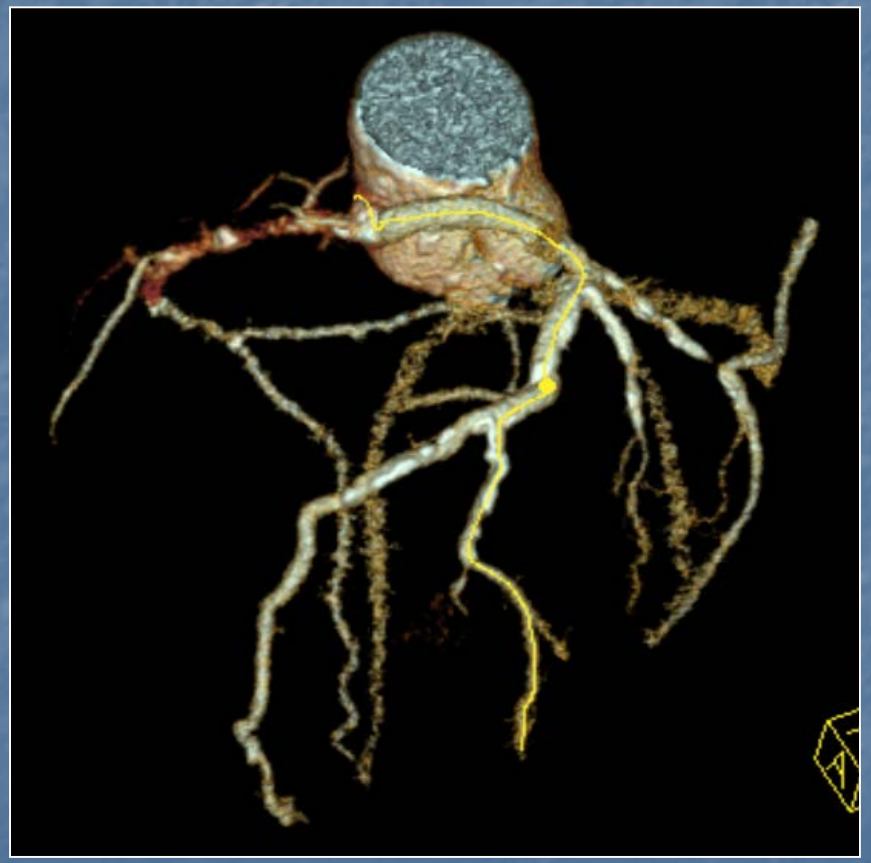
CORONARY ANGIOGRAPHY



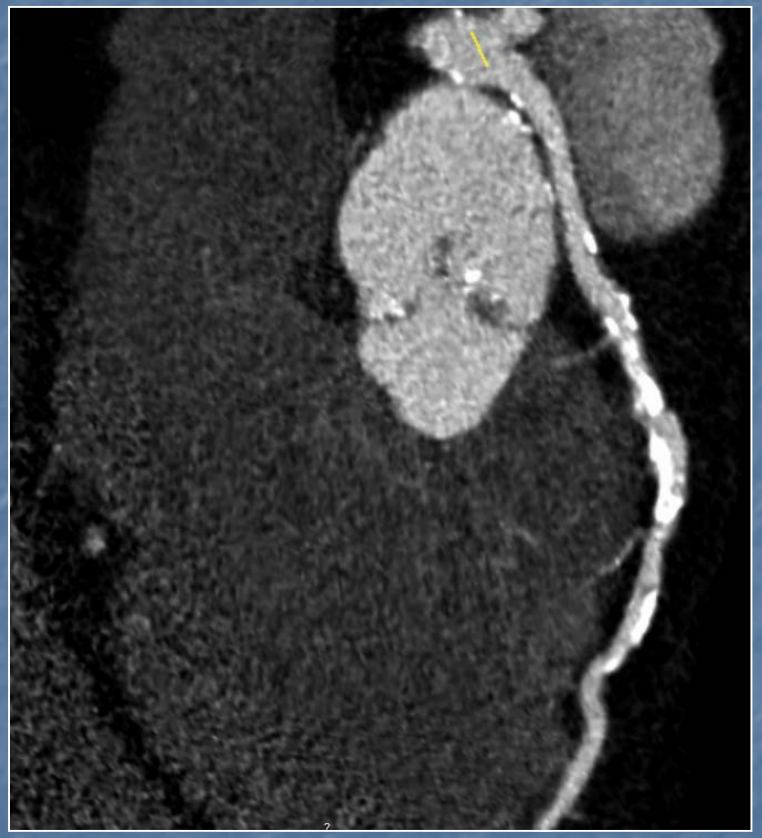


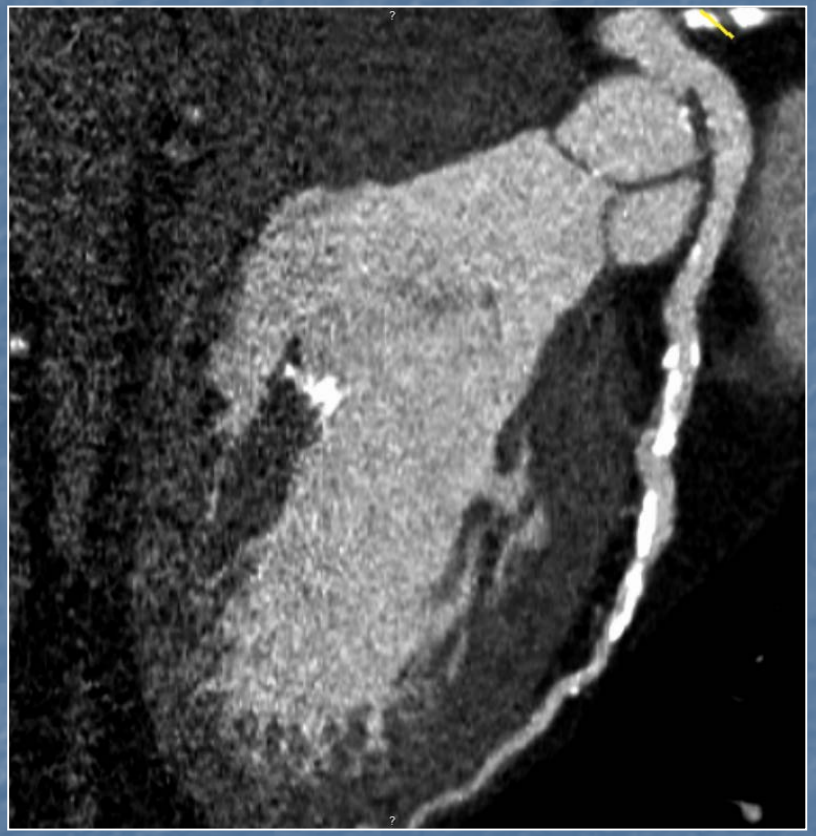
CORONARY MSCT





CORONARY MSCT





THERAPEUTIC DECISION

Tableau IV. Recommandations thérapeutiques nord-américaines sur les anomalies de connexion proximale coronaire de l'adulte.

Classe I
Une revascularisation chirurgicale doit être proposée dans les cas suivants : • Tronc commun ectopique avec trajet entre l'aorte et l'artère pulmonaire (niveau de preuve B) • Ischémie documentée due à une compression avec trajet entre les gros troncs artériels ou intramural (niveau de preuve B) • Coronaire droite ectopique avec trajet entre l'aorte et l'artère pulmonaire et ischémie documentée (niveau de preuve B) • Connexion de la coronaire gauche sur l'artère pulmonaire (niveau de preuve C)
Classe IIa
Une revascularisation chirurgicale peut être bénéfique en cas d'hypoplasie vasculaire, de compression coronaire ou d'obstruction documentée du flux coronaire, sans tenir compte de l'incapacité à documenter une ischémie myocardique (niveau de preuve C).
Classe IIb
Une revascularisation chirurgicale peut être raisonnable chez les patients avec anomalie de l'interventriculaire antérieure passant entre l'aorte et l'artère pulmonaire (niveau de preuve C).

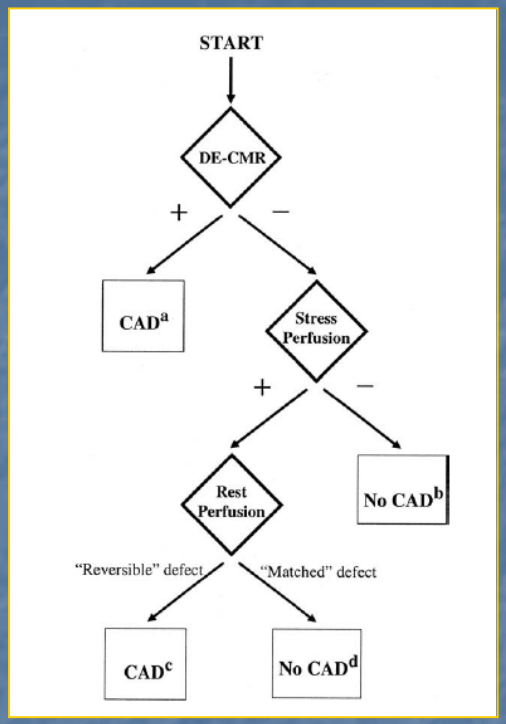
- *SURGERY in asymptomatic pts.*
- LIMA -----> LAD
- RIMA------> RCA

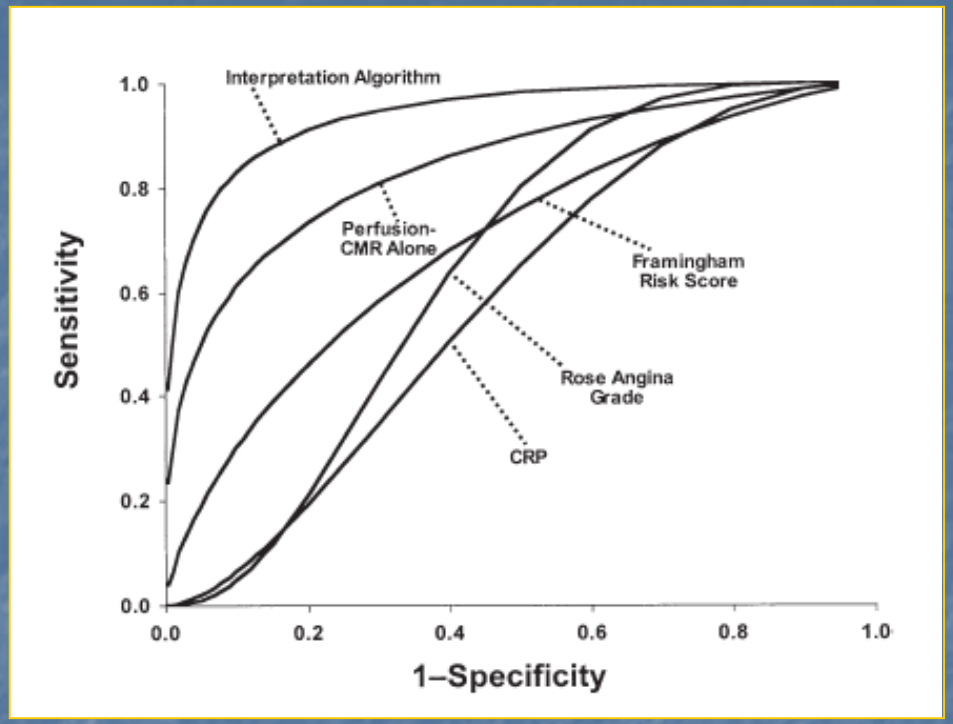
Non invasive imaging modalities: diagnostic accuracy

Table 3. Diagnostic accuracy of noninvasive modalities for detection of CAD

Imaging modality	Sensitivity (%)	Specificity (%)
CT angiography	91	93
Stress echocardiography	79	87
MPI-SPECT	86	74
MPI-PET	89	90
Stress MR perfusion	91	81
Stress MR wall motion	83	86
MR coronary angiography	73	86
Exercise electrocardiogram	68	77

Improved detection of CAD by stress MR with use of delayed enhancement





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Cardiac Imaging

Improved Detection of Coronary Artery Disease by Stress Perfusion Cardiovascular Magnetic Resonance With the Use of Delayed Enhancement Infarction Imaging

Igor Klem, MD,*† John F. Heitner, MD,* Dipan J. Shah, MD,* Michael H. Sketch, JR, MD,* Victor Behar, MD,* Jonathan Weinsaft, MD,* Peter Cawley, MD,* Michele Parker, RN, MS,* Michael Elliott, MD,* Robert M. Judd, PHD,* Raymond J. Kim, MD*

Durham, North Carolina; and Stuttgart, Germany

JACC
Journal of the American College of Cardiology

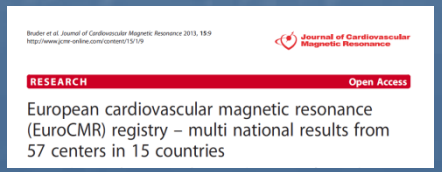
Prognostic value of CMR

Normal CMR → MACE 1% per year

Abnormal CMR → MACE in 2,7% per year

Normal CMR : normal EF /vol; no LGE, no ischemia

MACE: all cause of death, aborted SCD, non-fatal MI



Incremental value of normal adenosine perfusion CMR: Long-term outcome

- 300 patients
- Follow up 5,5 y
- The annual cardiac event rate was 1.3%
- 0.78% in the first 3 y
- 1.9% between the fourth and sixth year.

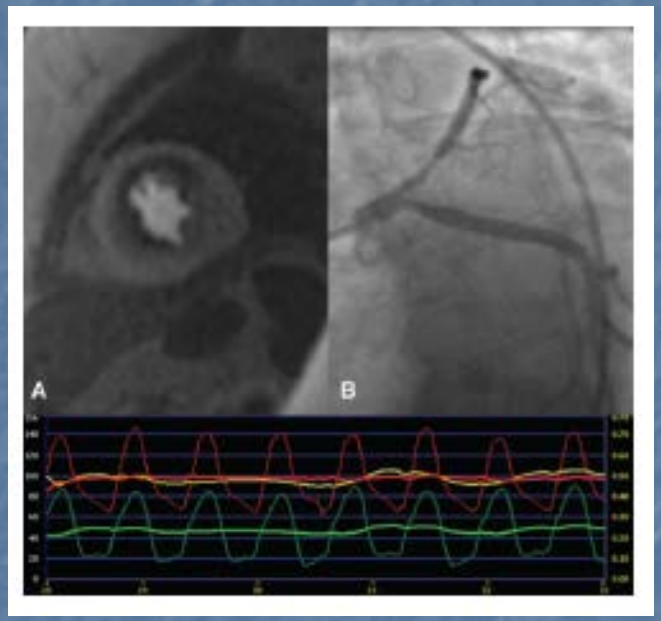
Ends point: global mortality and MACE

Iacuzio Civaia et al,
JACC ACC, March 2014
AM H J 2015

Adverse Cardiac Events Distribution

Iacuzio Civaia et al,
JACC abstract book, March 2014
AM H J 2015

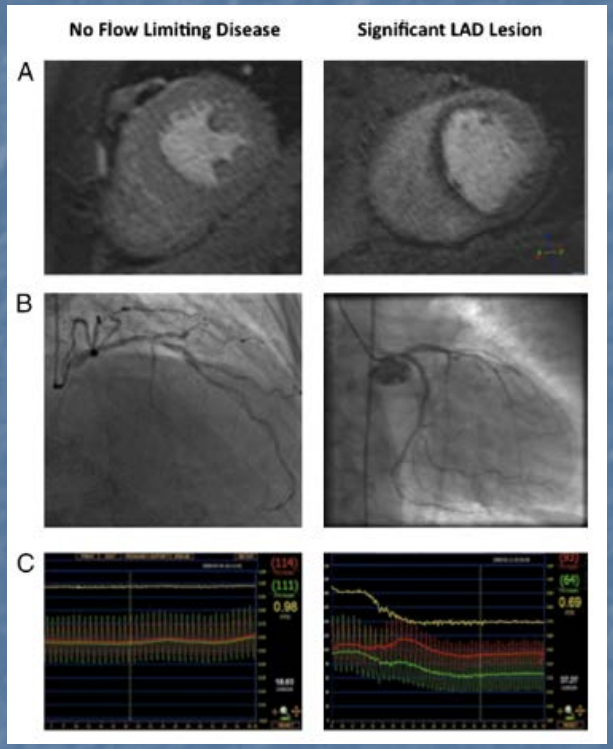
Adenosine stress MRI vs FFR



FFR < 0.75

Sensibility 0,82
Specificity 0,94

AUC 0,92

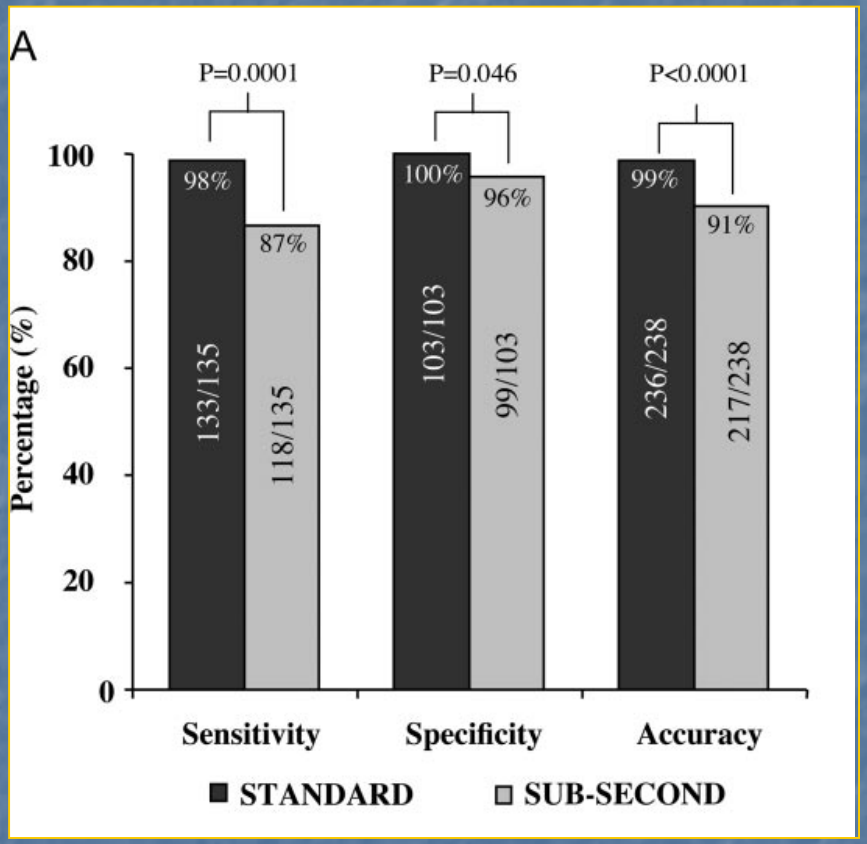


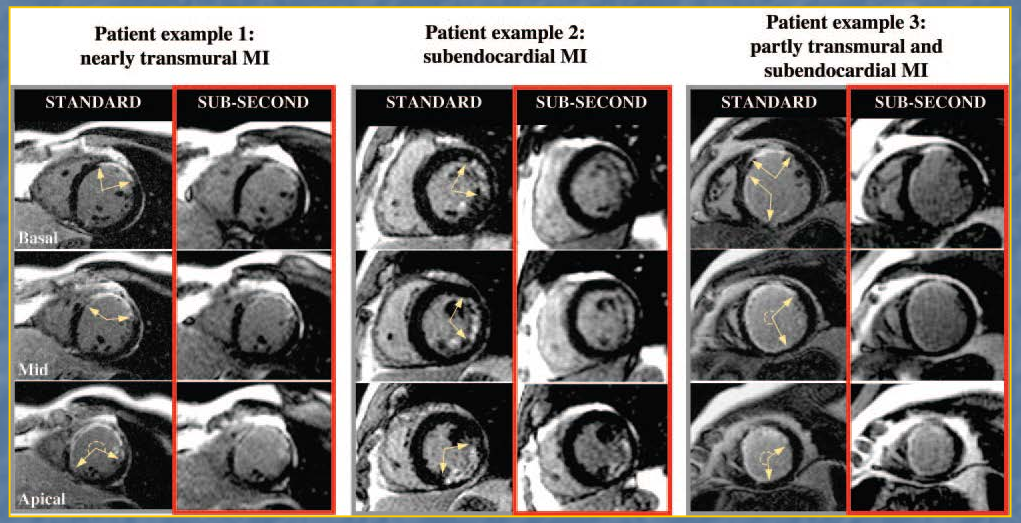
CIRC 2009

JACC 2011

VIABILITY

Sensitivity, specificity and accuracy in the detection of MI

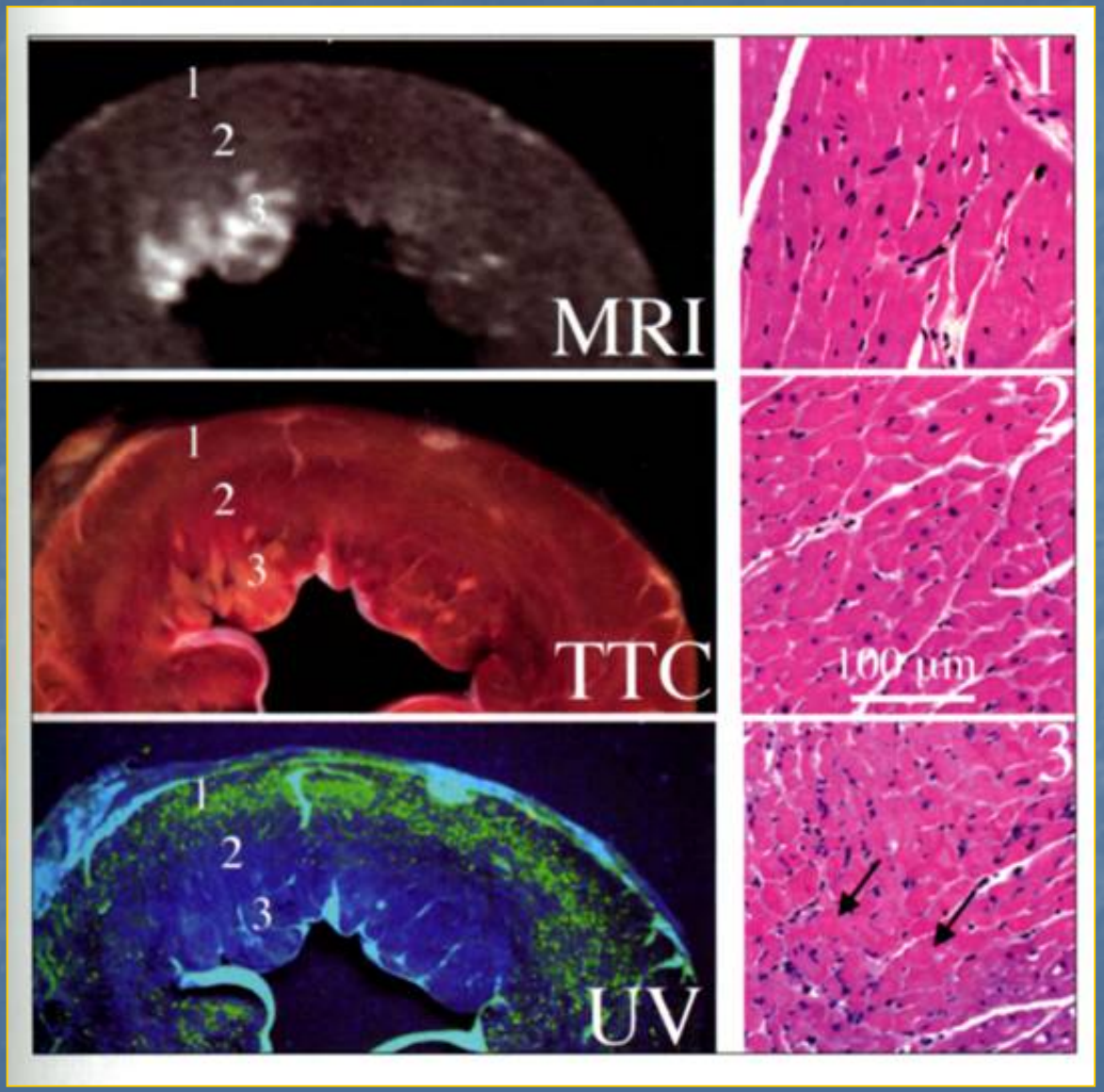




Comparison between breath-holding and free-breething sequences

CIRCULATION 2007

VALIDATION STUDIES



Unrecognized MI and prognosis:

higher mortality than recognized MI

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ISSN 0735-1097/06/$32.00
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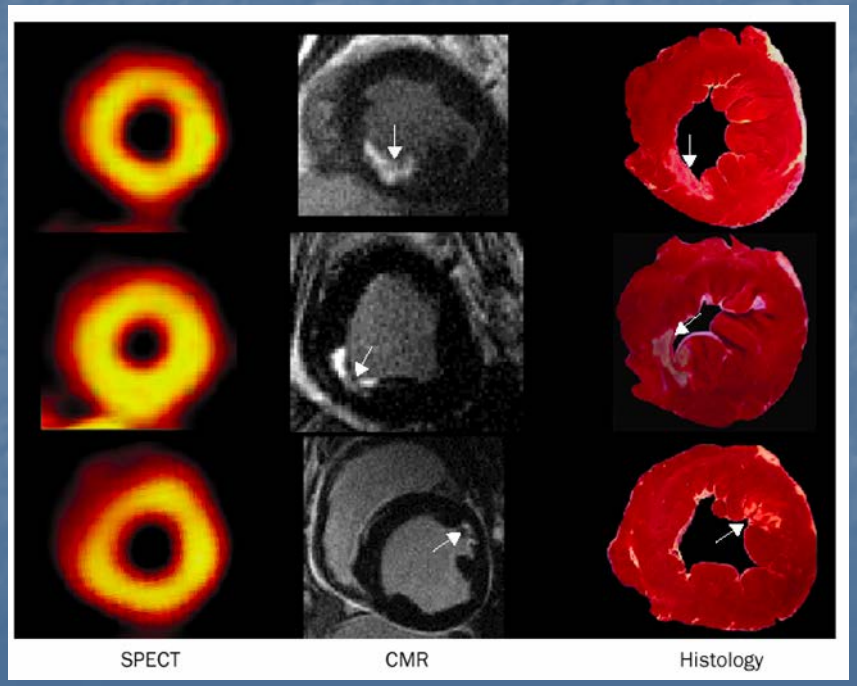
Cardiac Imaging

Myocardial Scars More Frequent Than Expected

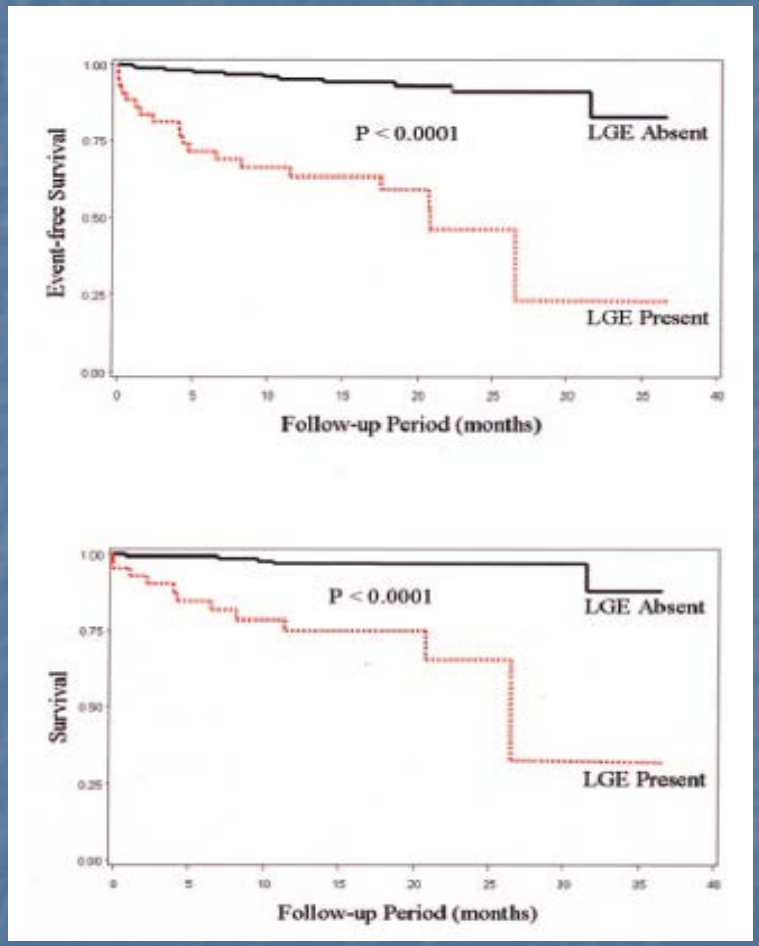
Magnetic Resonance Imaging Detects Potential Risk Group

Charlotte Ebeling Barbier, MD,* Tomas Bjerner, MD, PHD,* Lars Johansson, PHD,*†
Lars Lind, MD, PHD,†‡ Håkan Ahlström, MD, PHD*
Uppsala and Gothenburg, Sweden

Jacc 2006

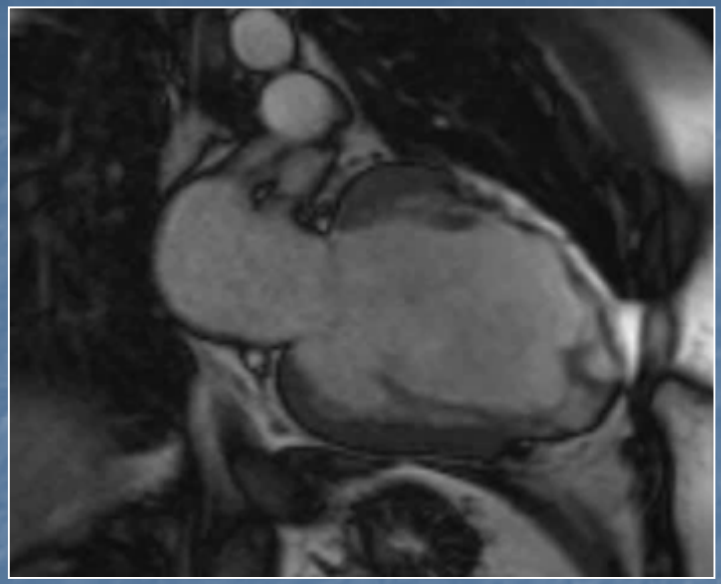


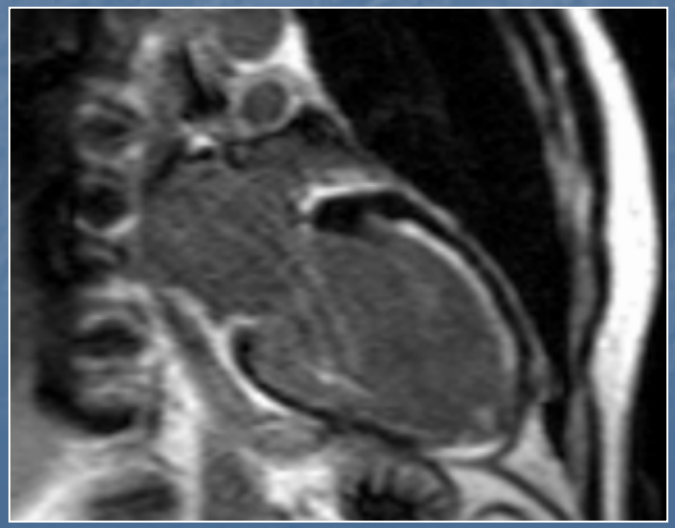
Lancet 2004

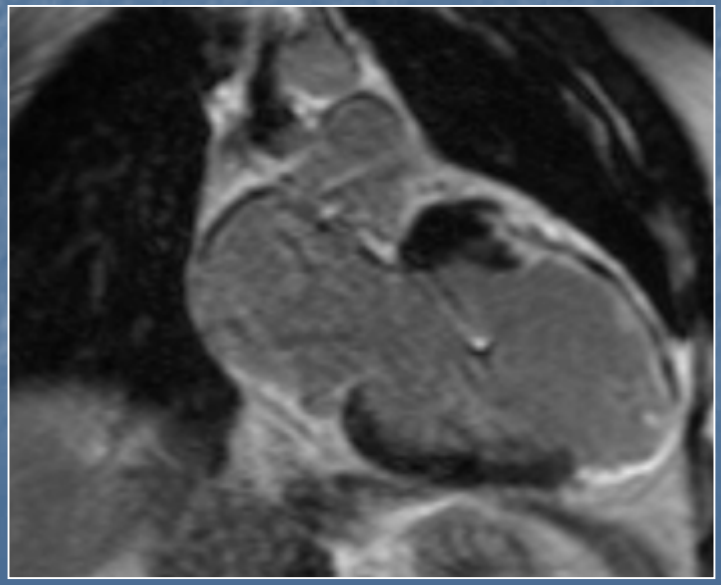


Circulation 2006

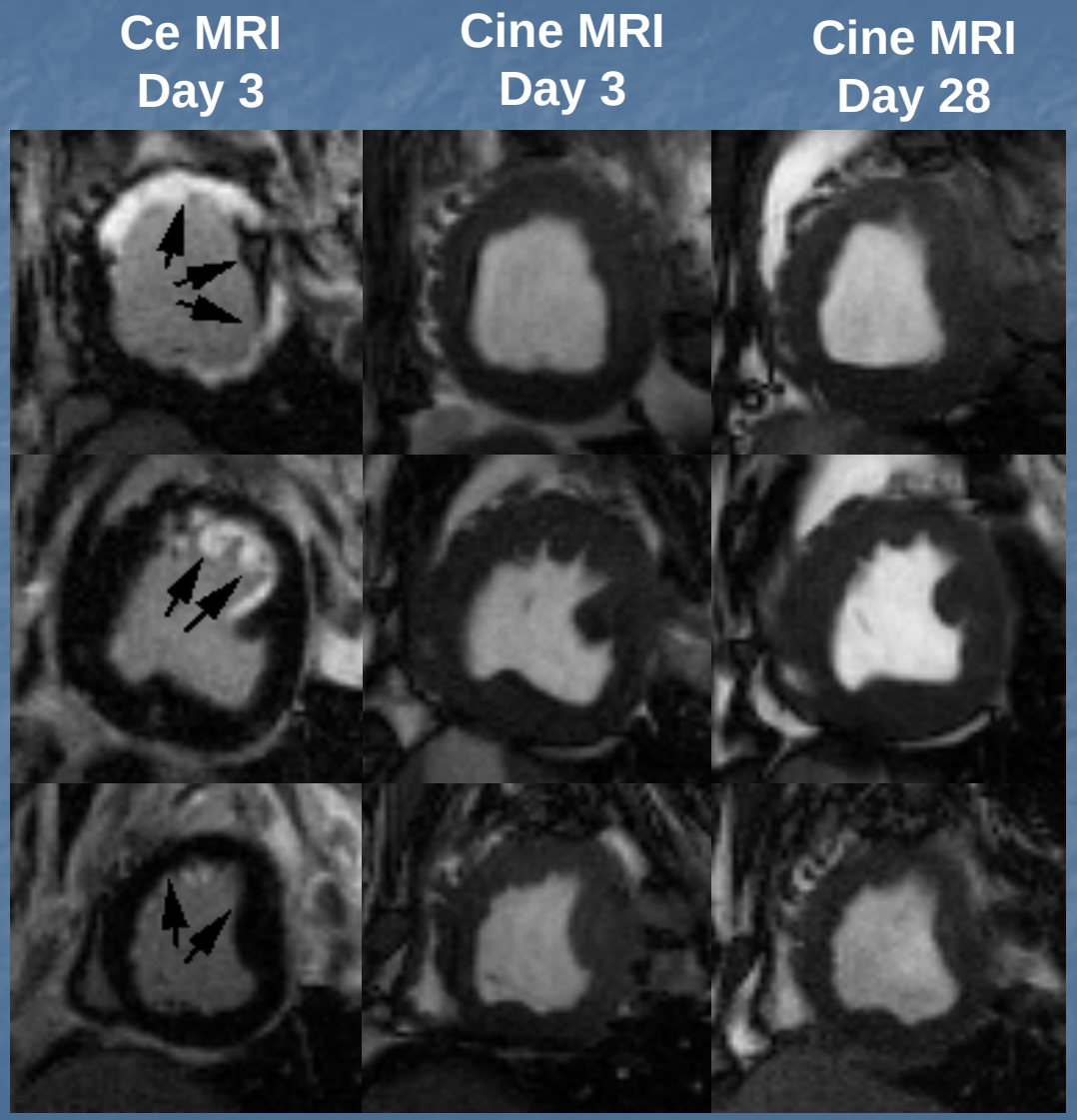
Sub-endocardial or Transmural Scar





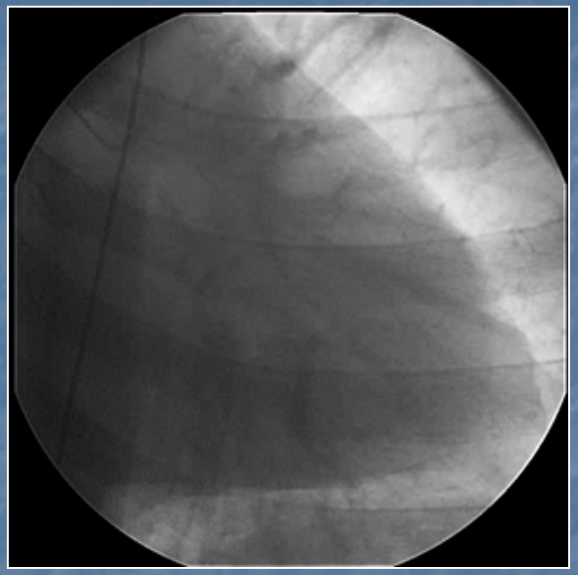


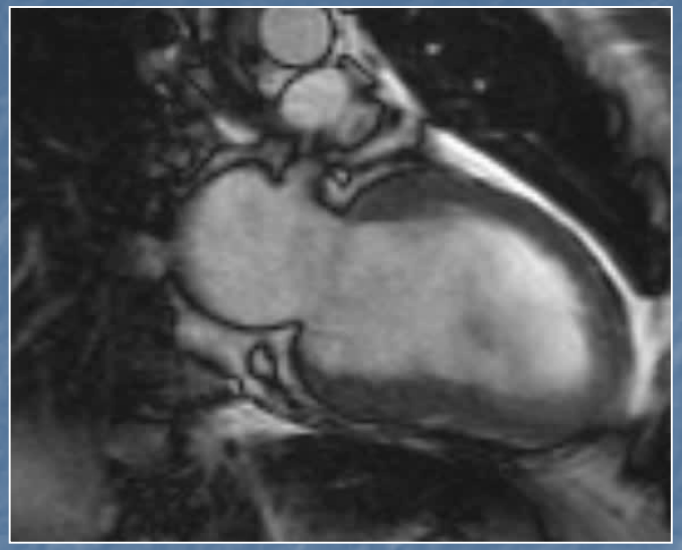
CMR and late enhancement

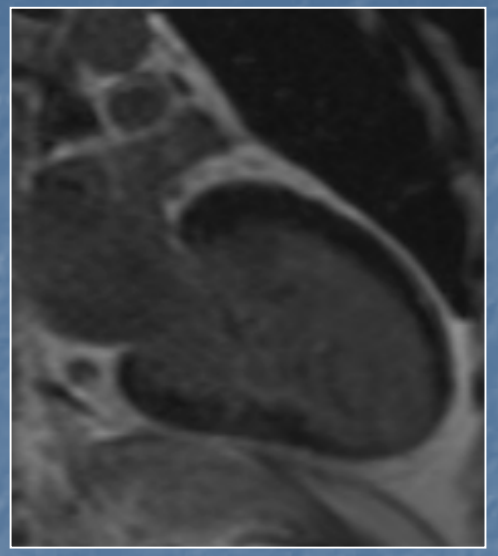


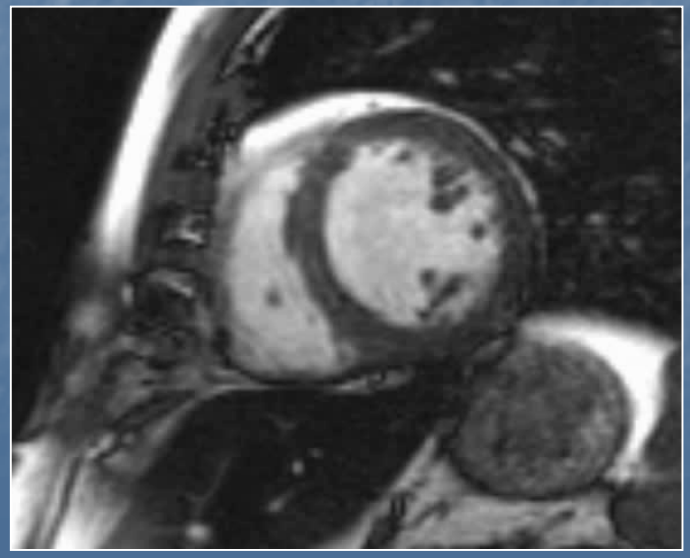
Hillenbrand et al., CIRCUL 2000

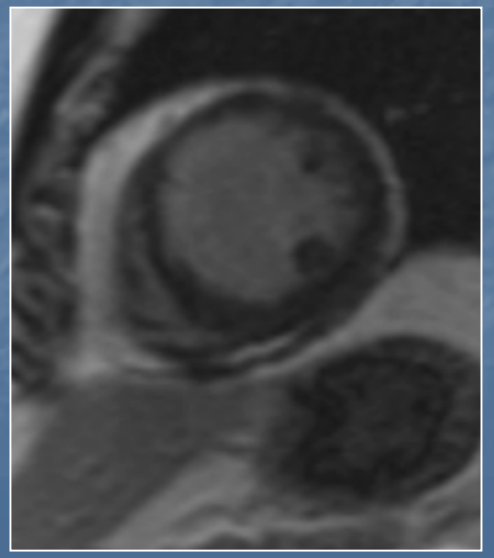
Mr. Ger. 54 y, ant MI ?









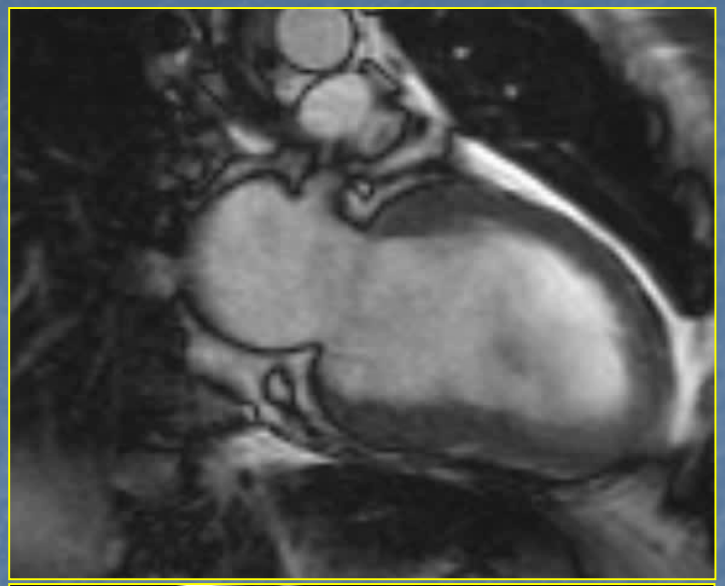


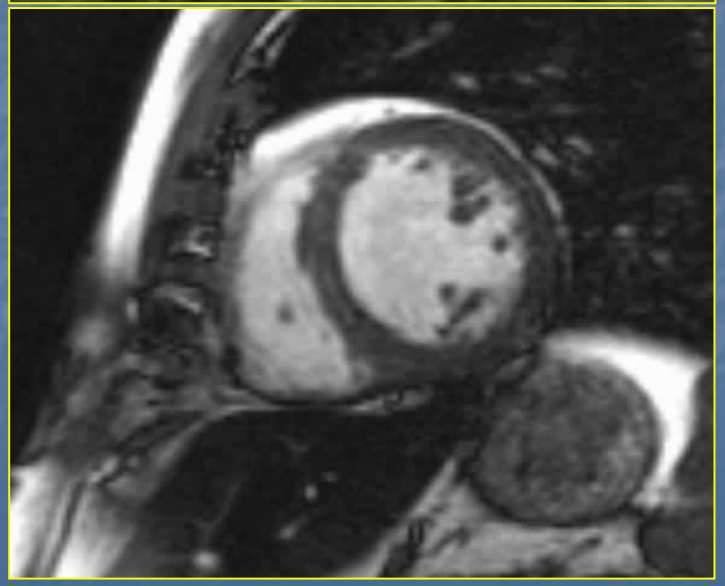
EF 43 %
EDVI : 87 ml/m²
ESVI : 50 ml/m²

Hibernating

Mr. Ger. 54 y, ant MI ?

PREOP



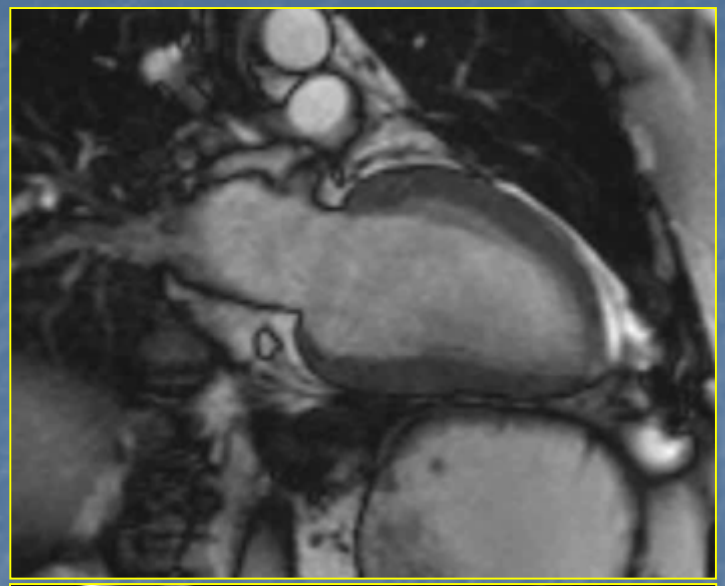


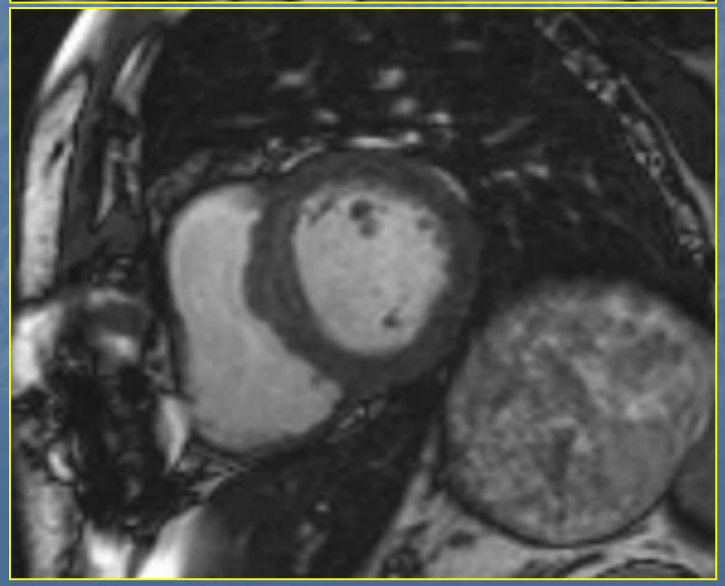
→ **LIMA-LAD, Diag**
RIMA – RC

02/02/04 :

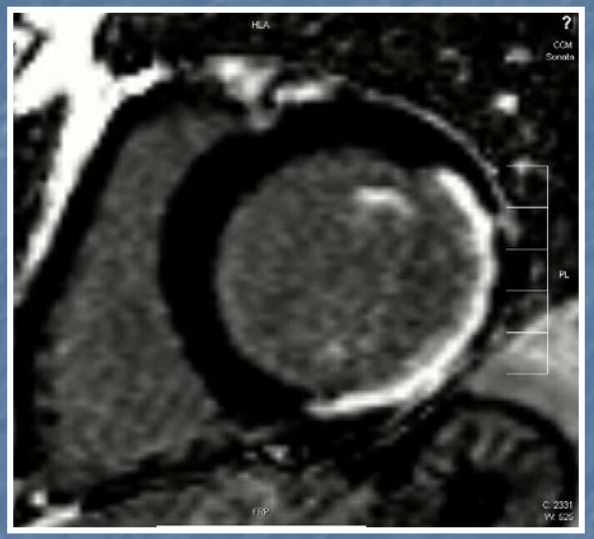
EF 72 %
EDVI 67 ml/m²
ESVI 19 ml/m²

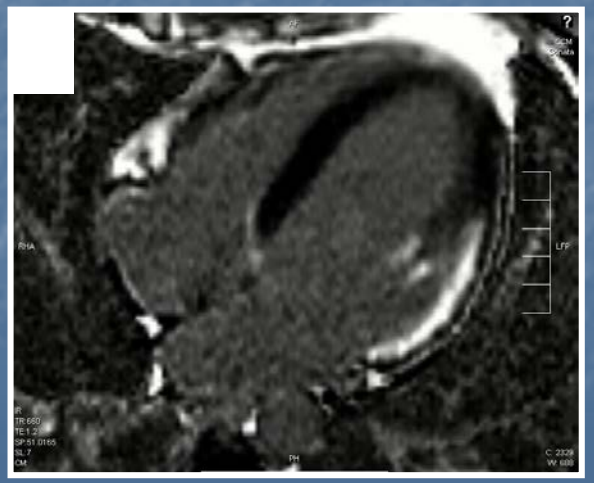
POSTOP

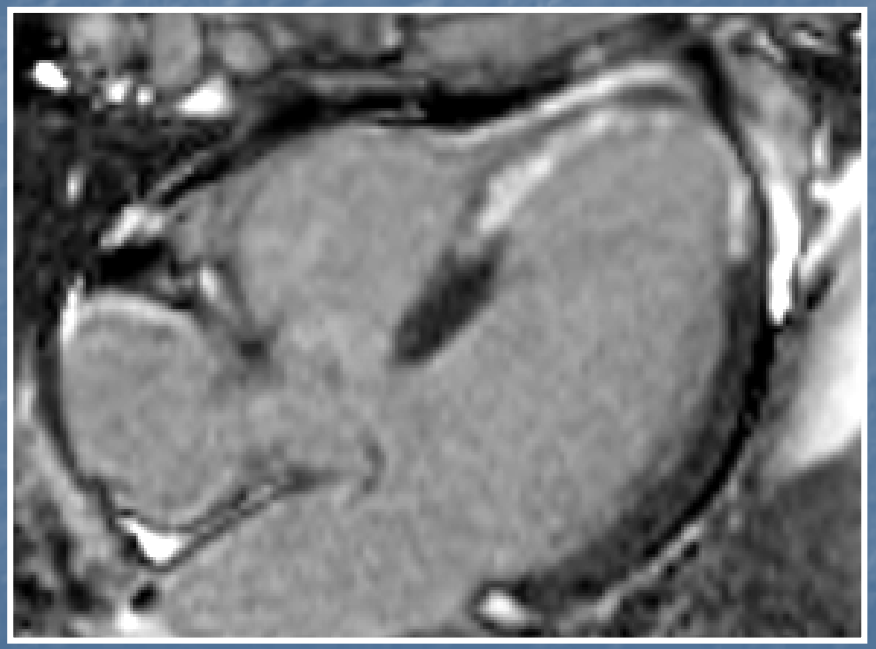




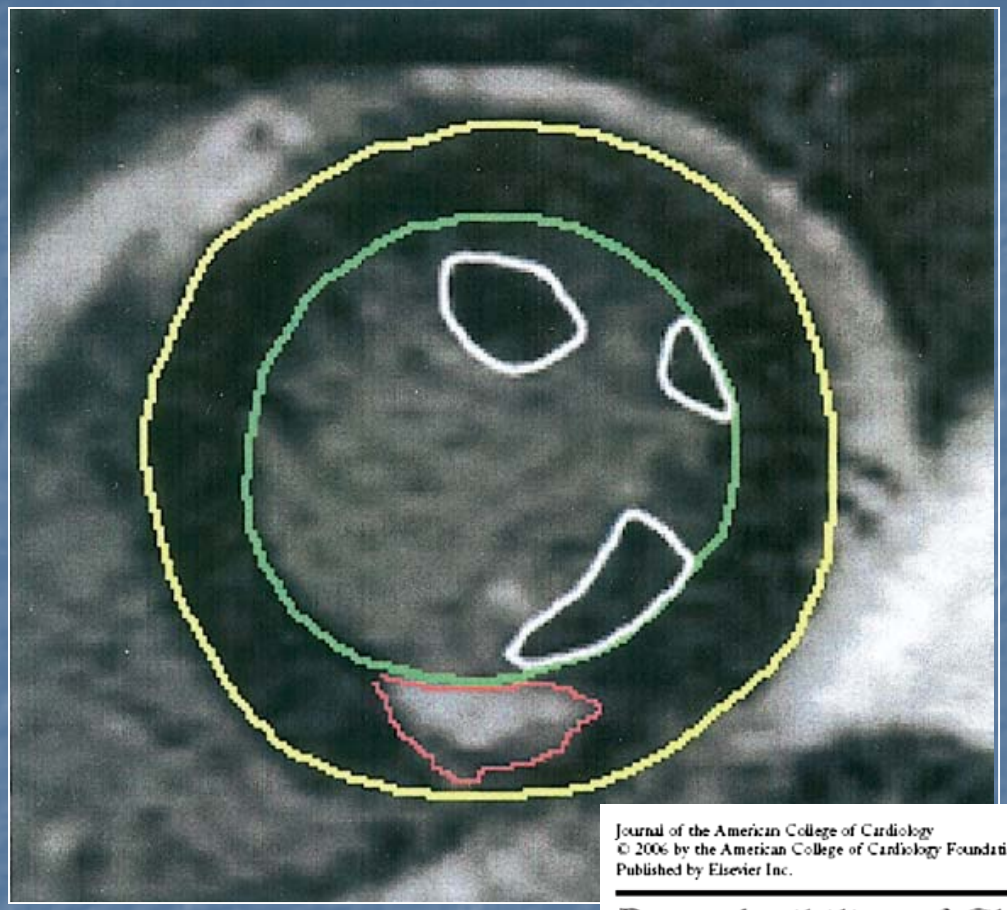
Transmural scar : no recovery







Reproducibility of infarct size measurement by CMR



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doi:10.1016/j.jacc.2005.11.065

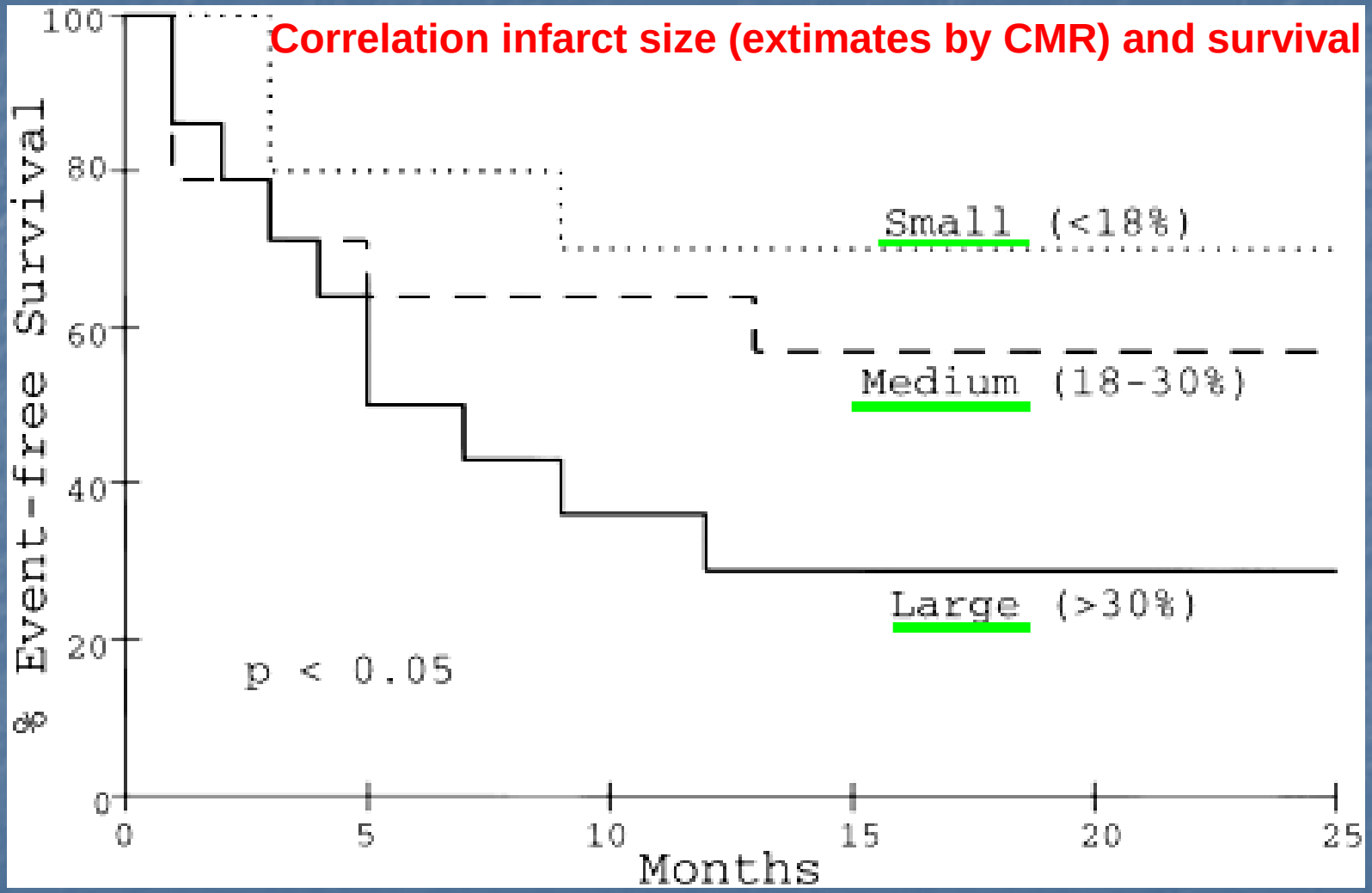
Reproducibility of Chronic and Acute Infarct Size Measurement by Delayed Enhancement-Magnetic Resonance Imaging

Holger Thiele, MD,* Mathias J. E. Kappl, MD,* Stefan Conradi, MD,† Josef Niebauer, MD, PHD,* Rainer Hambrecht, MD,* Gerhard Schuler, MD*

Leipzig, Germany

JACC 2006

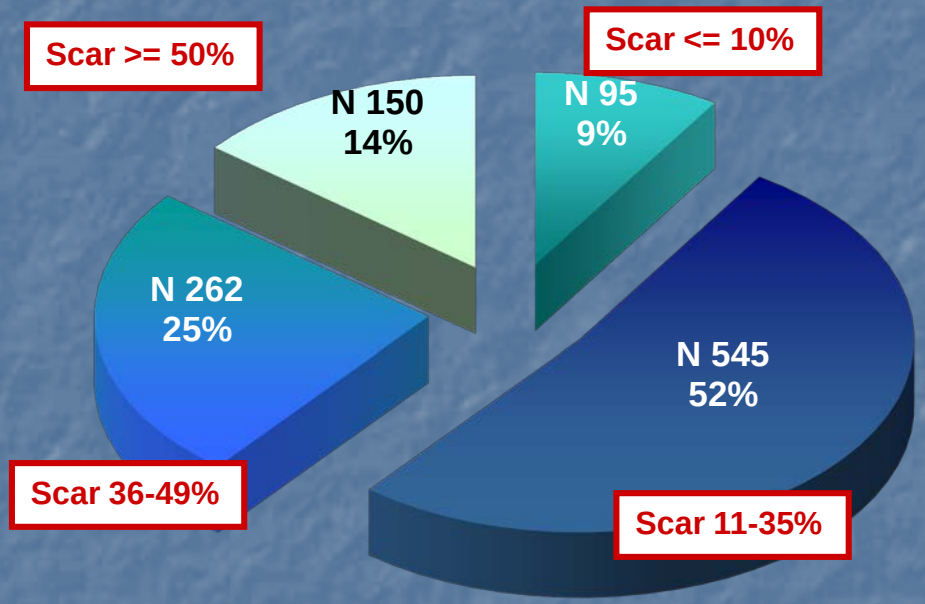
Correlation infarct size (extimates by CMR) and survival



K.C.Wu CIRC 1998

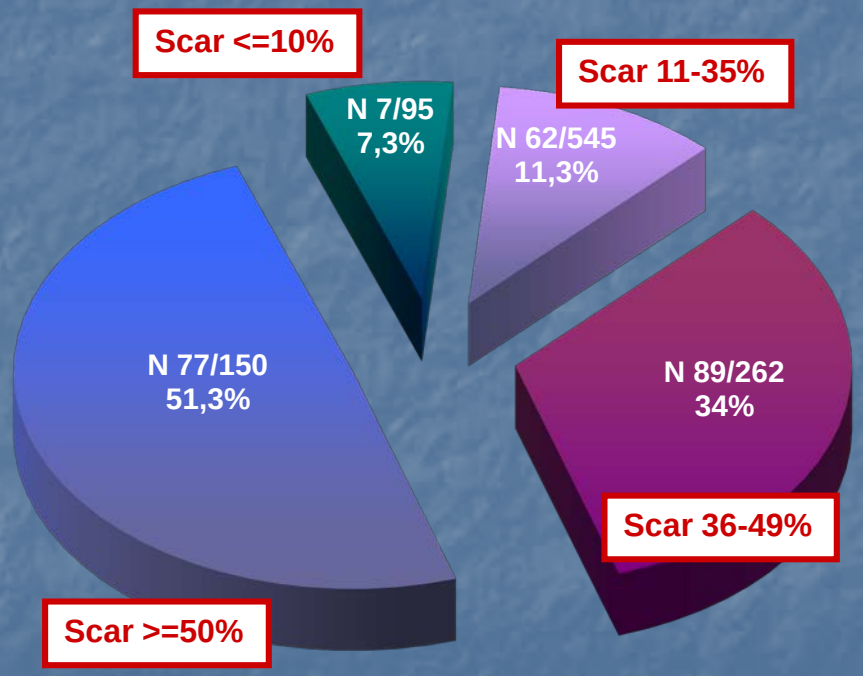
Relationship infarct size / advanced Heart Failure* I

N= 1 052 patients post MI GLE maps with mean valve of scare extension



% of scared LV circumference

% of AHF



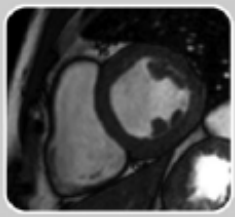
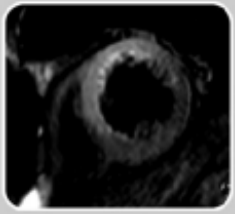
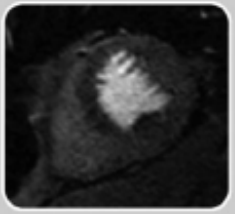
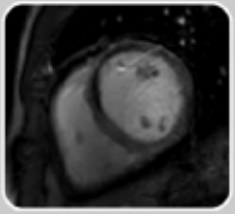
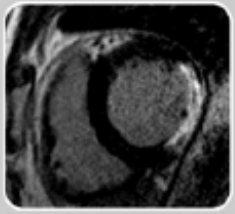
N= 235/1052 patients = 22.3%

** Advanced HF = chronic HF III/IV, acute HF, & adv. HF ESC definitions*

ACUTE CORONARY SYNDROMES & MVO

Acute coronary syndromes

A

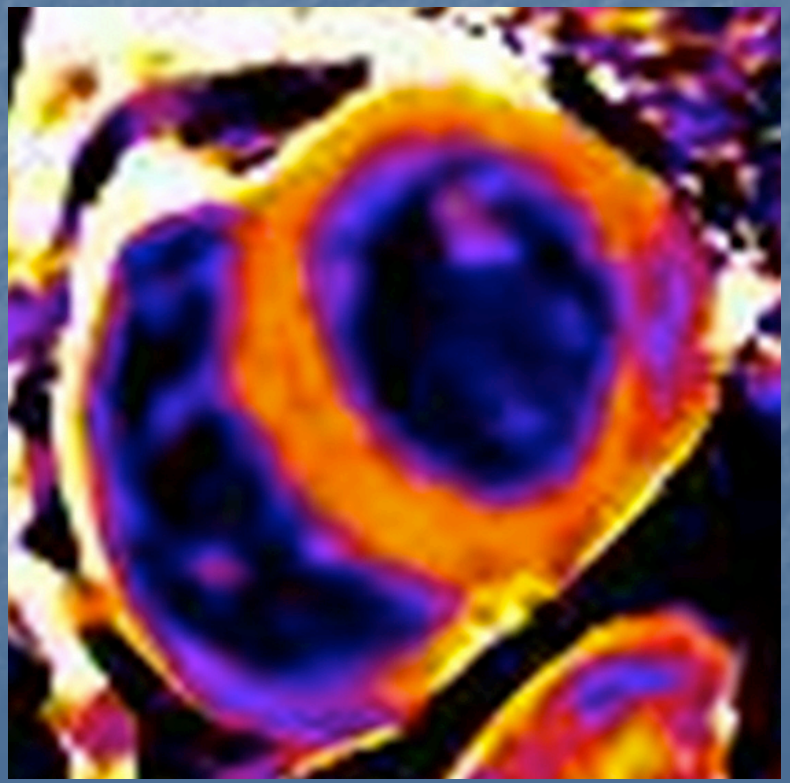






Cine Imaging (rest/stress)	T2-Weighted Imaging	First Pass Perfusion (rest/stress)	Early Gadolinium Enhancement	Late Gadolinium Enhancement
Contractile function	Tissue edema	Regional myocardial blood flow	Microvascular integrity	Myocardial necrosis/fibrosis
LV function/ ischemia/viability	Infarct age/ myocardial salvage	MVO/ischemia	No reflow/ MVO	Infarct size/viability

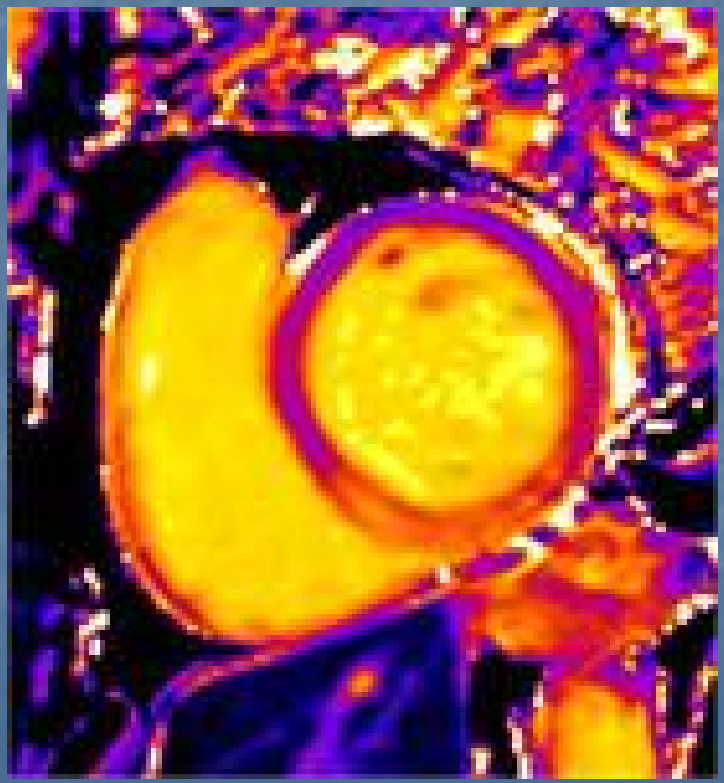
B

Tissue characterization

T1 maps: lateral fibrosis

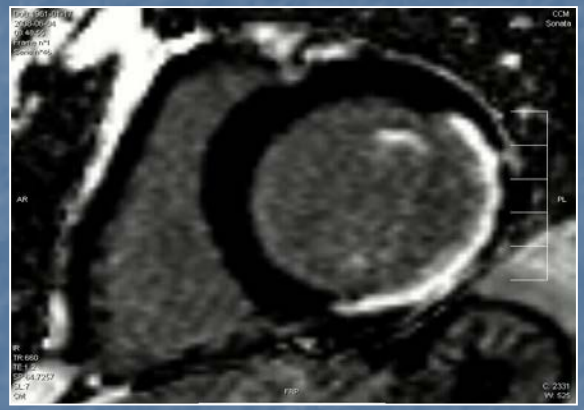


T2 maps: inferior edema

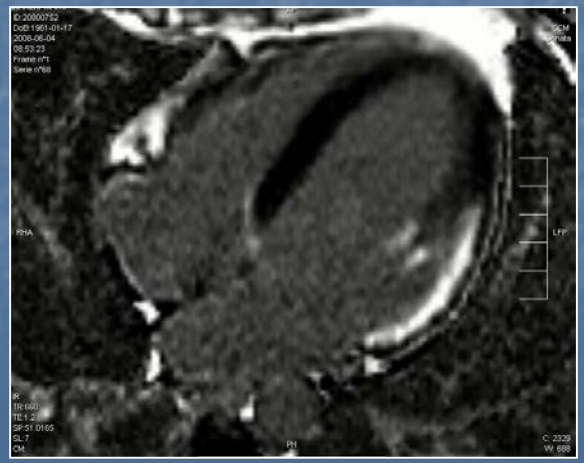


Acute and chronic Gad up-take

2 days after



6 weeks after

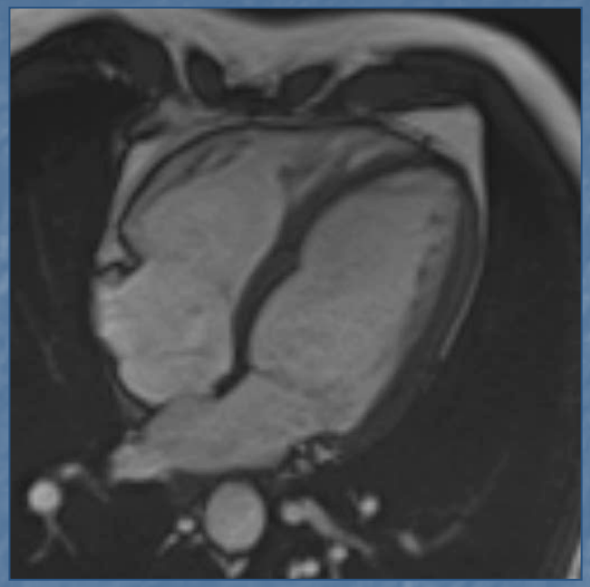


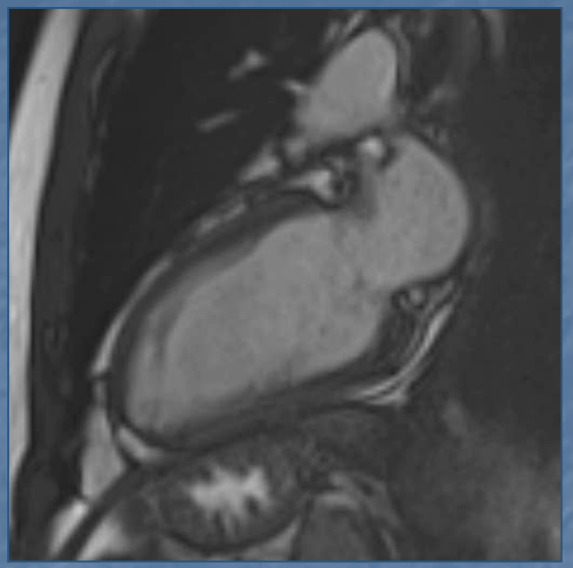
Case 3-4

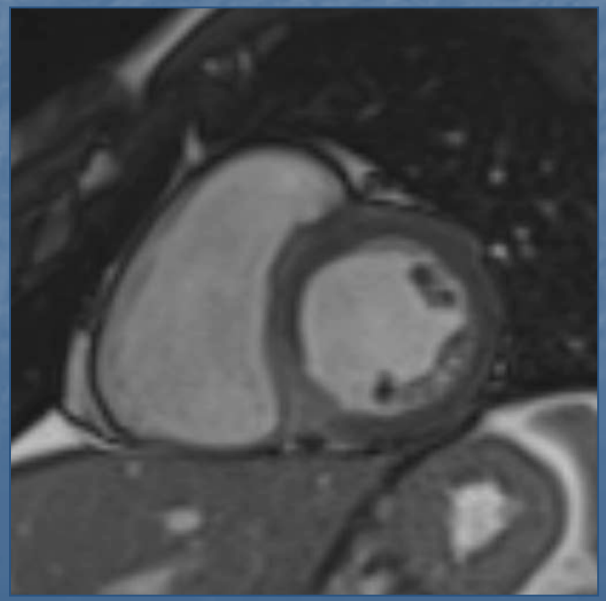
Mr. 47, male

- RF: smoke, familiarity
- Fever
- Chest pain and ECG typical for pericarditis
- Troponin: 14 ng/ml
- PCR: 25

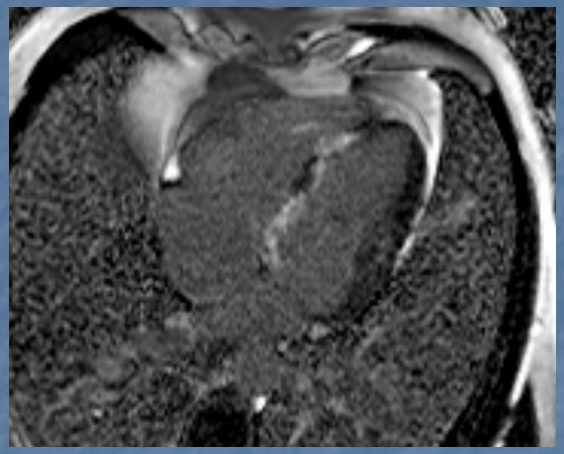
Mr. 47 y, male

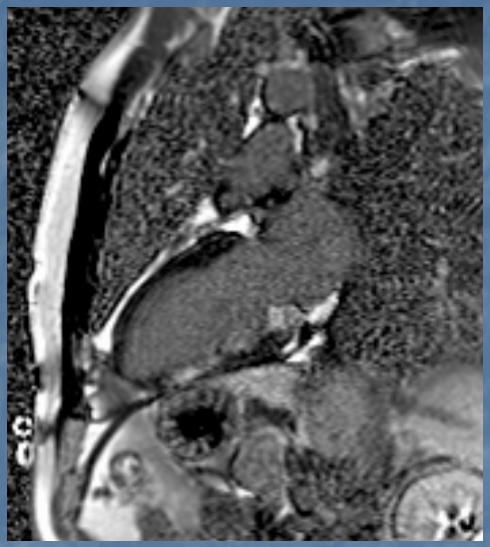


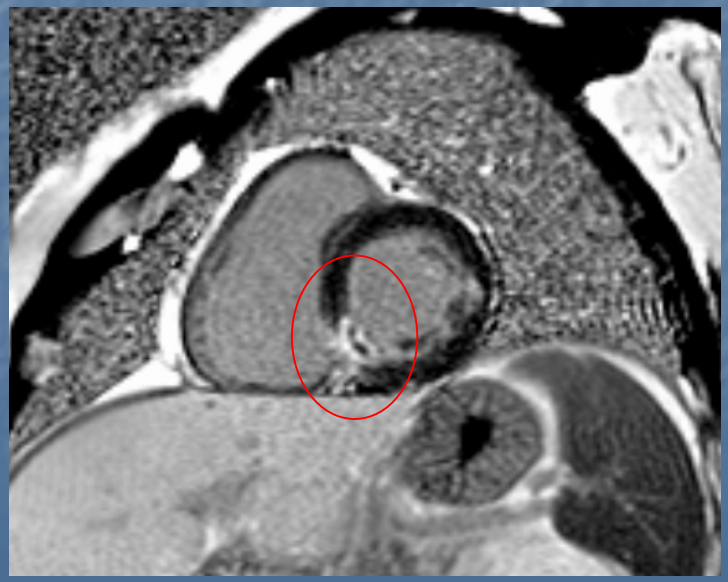




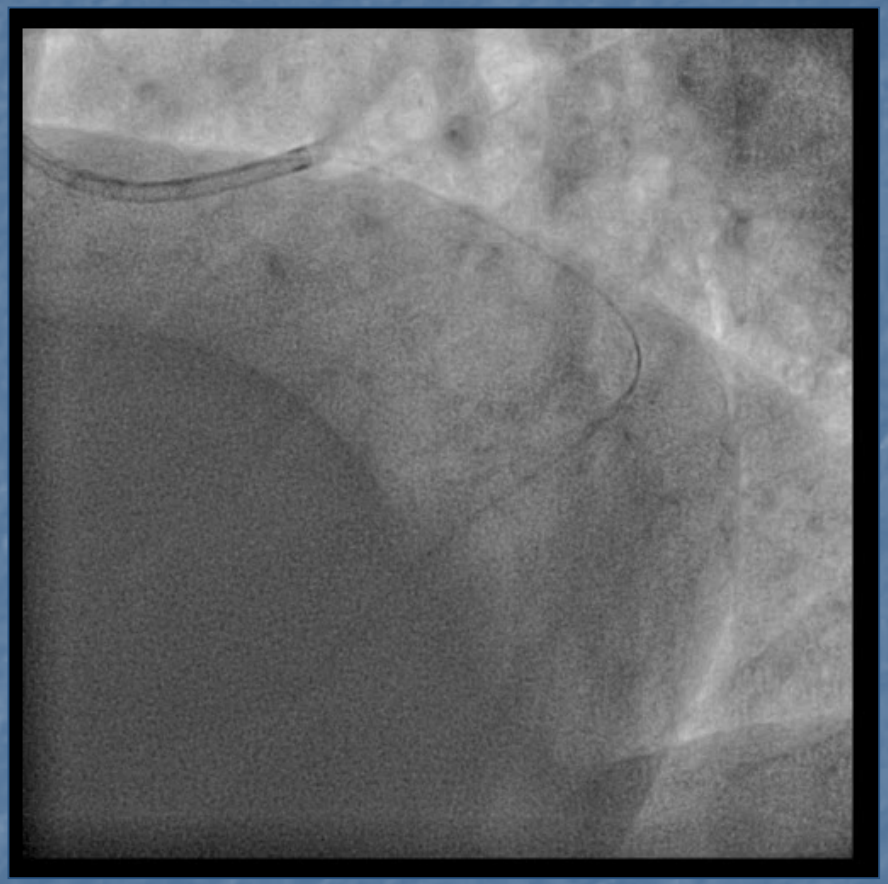
Mr. 47 y, male







Mr. 47 y, male

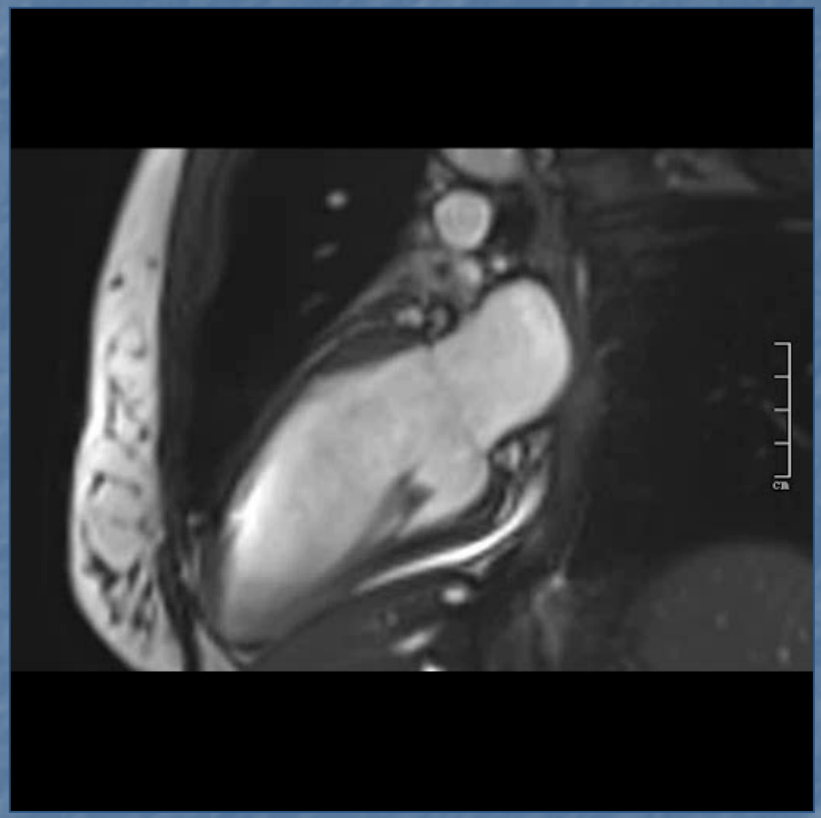


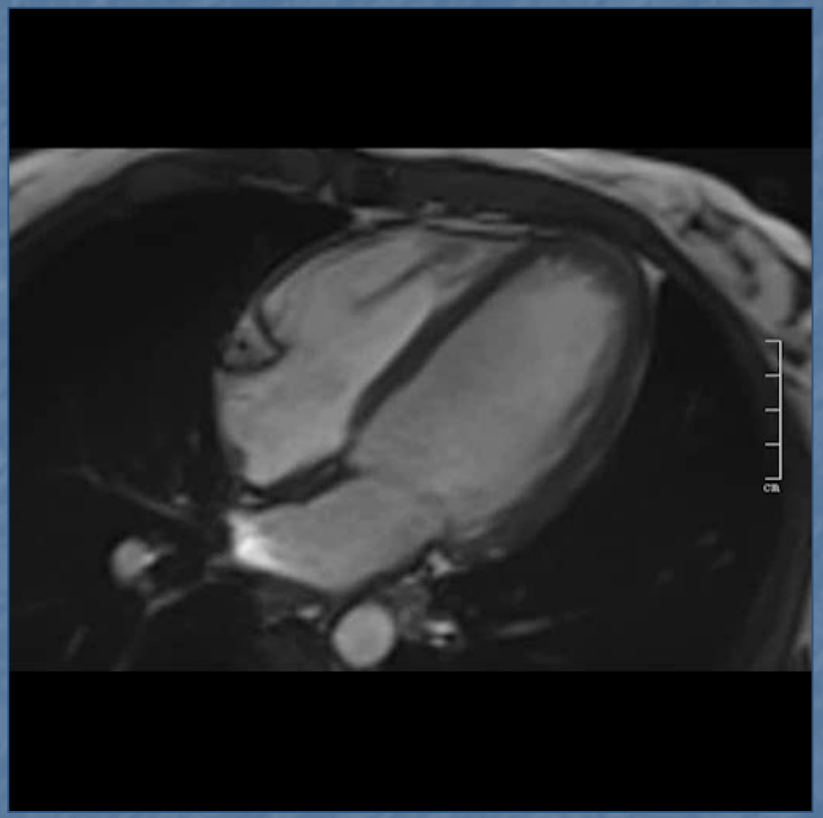
PTCA distal circonflex

Ms. 36 y, woman

- Chest pain
- Tropo 6 ng/ml
- normal ECHO and ECG

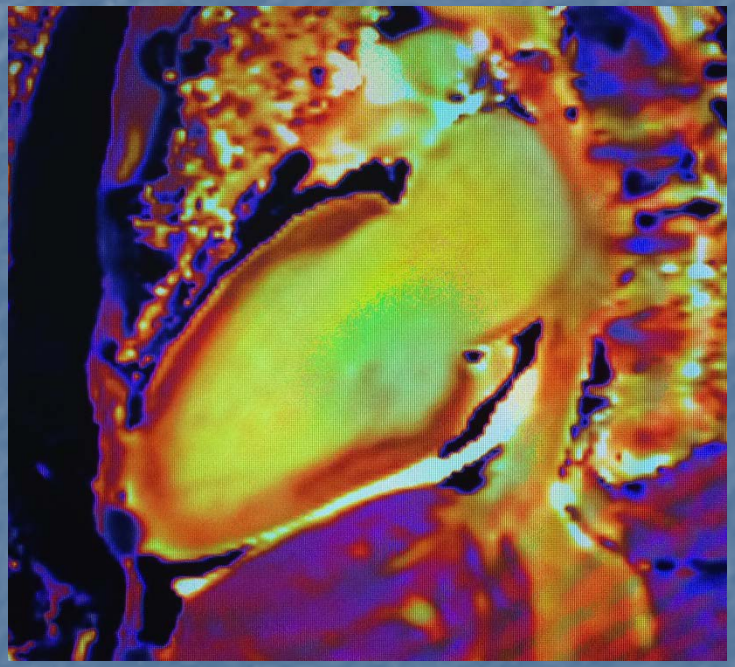
Ms. 36 y, woman

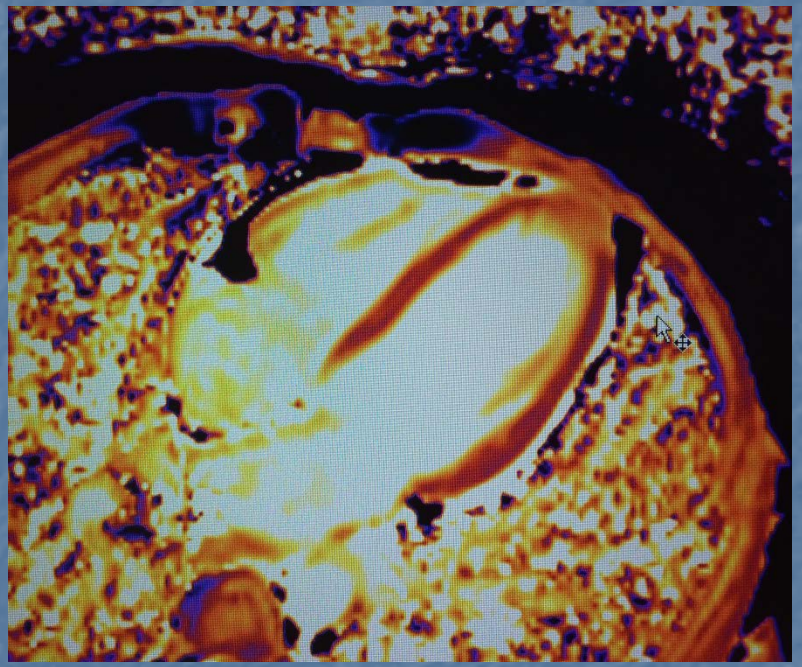




Ms. 36 y, woman

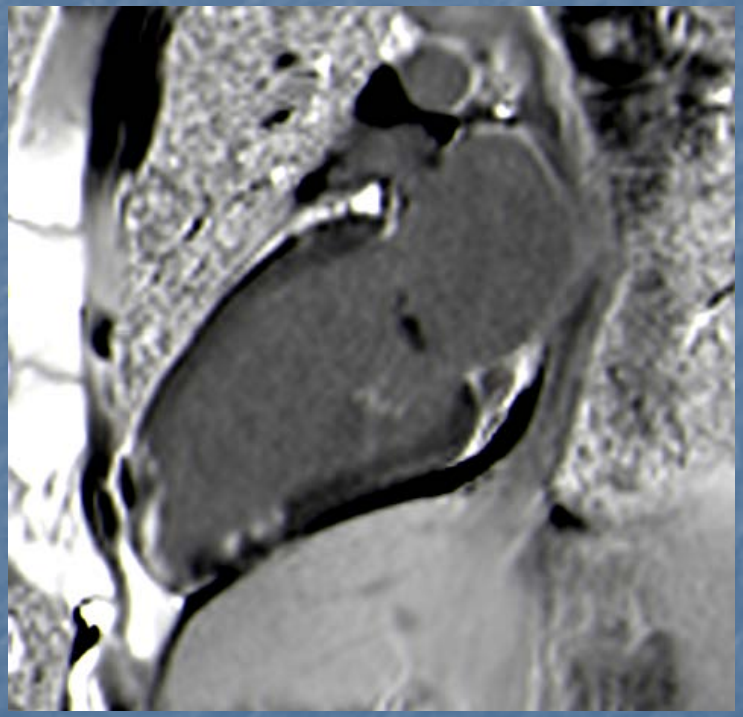
T2 mapping: edema

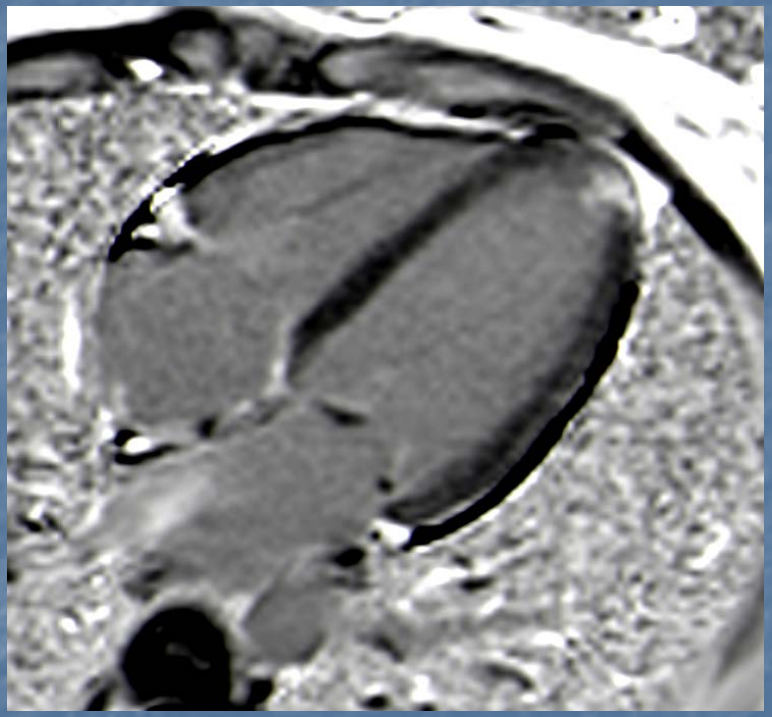




Ms. 36 y, woman

Delayed enhancement

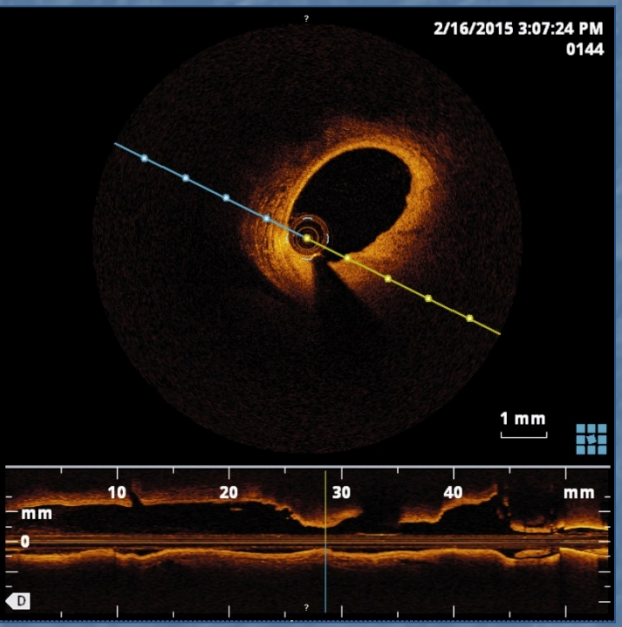


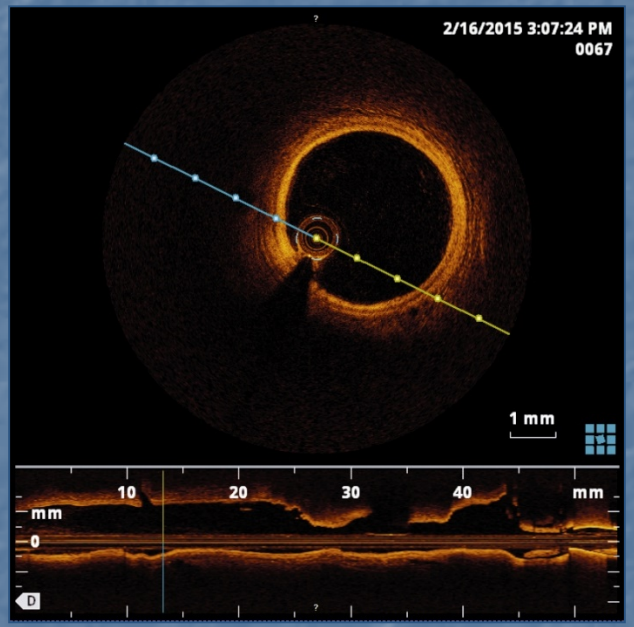


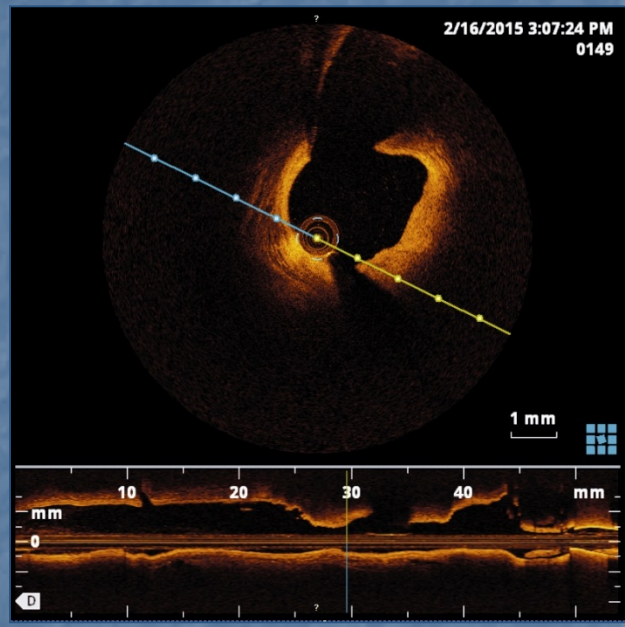
Ms. 36 y, woman

Ms. 36 y, woman

OCT







Ms. 36 y, woman

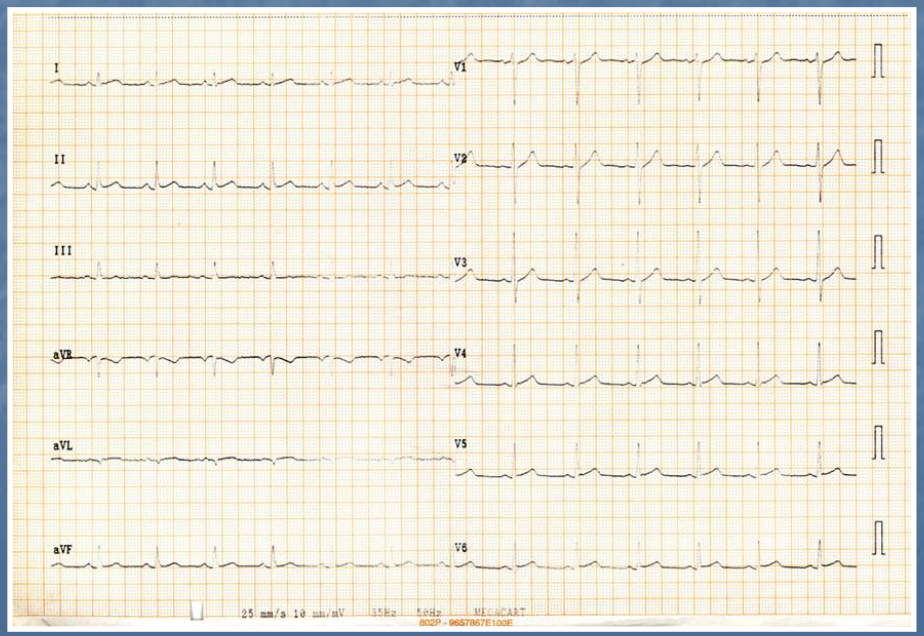
Risk factors:

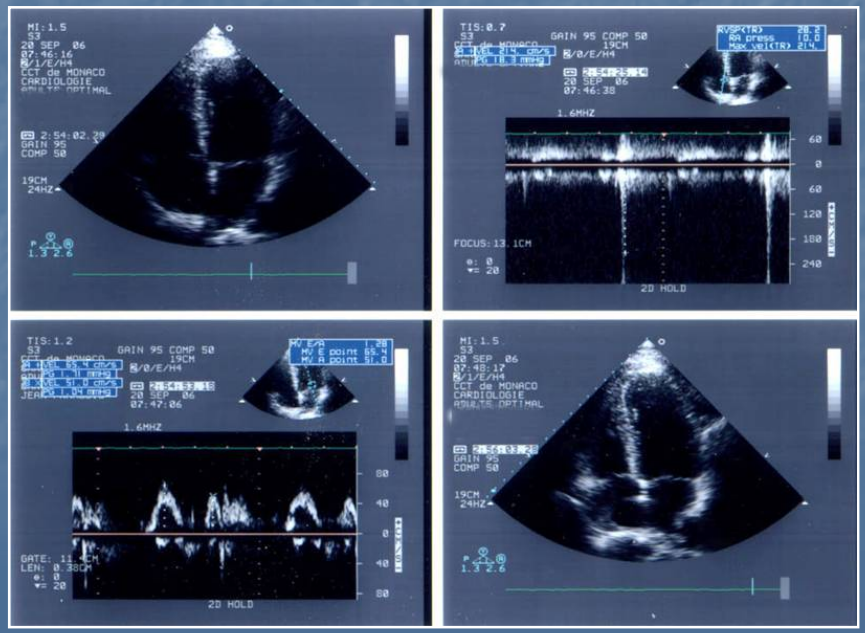
- Smoke
- Cocaine

Case 5

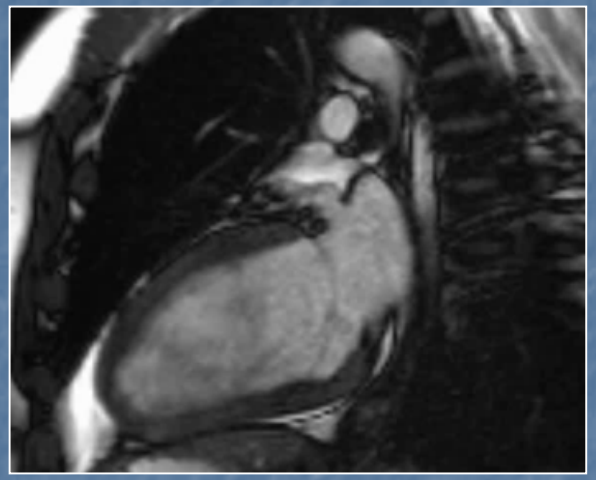
- ***Biological markers***

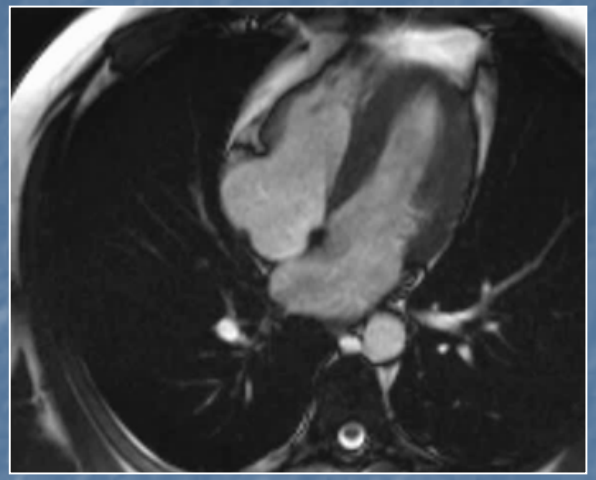
- Troponine 7.19
- CPK peak 749
- CPK-MB 61.2
- WBC 7250 with normal formula
- CRP 6.5

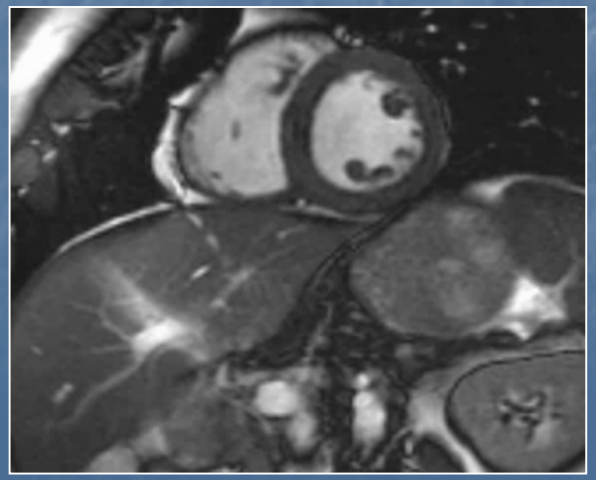


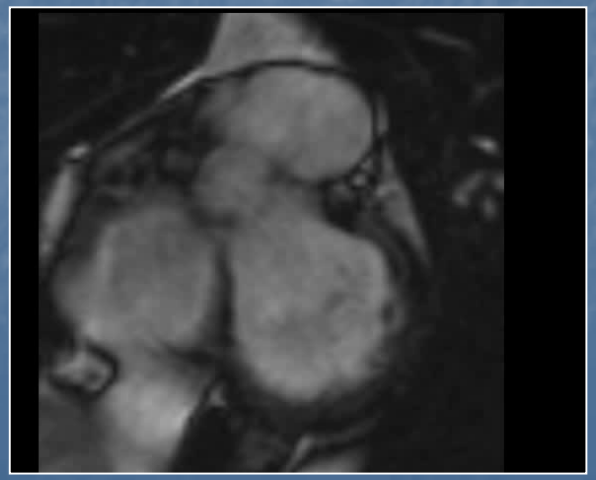


MR 22/09/2006









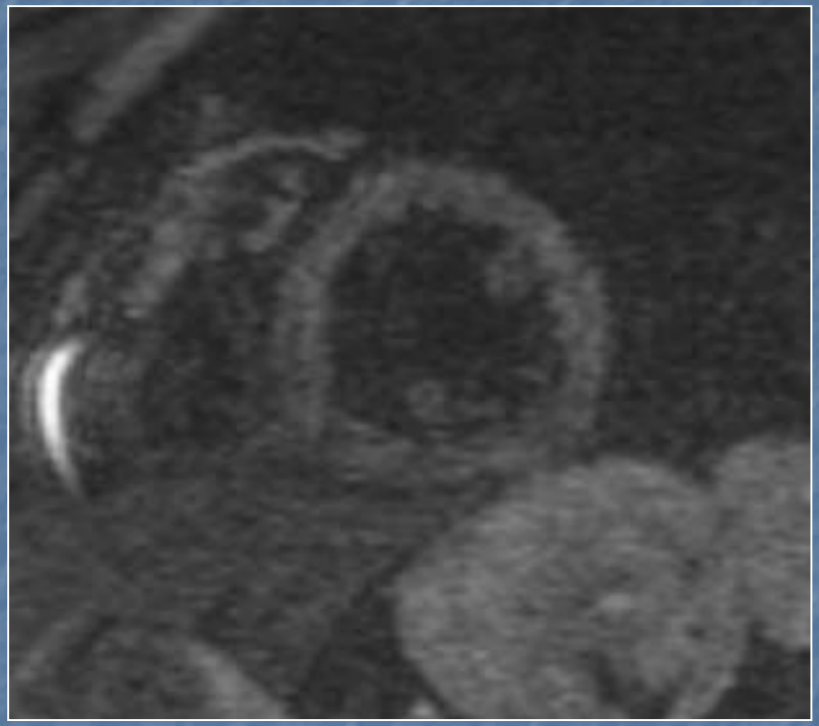
E.F. 65%

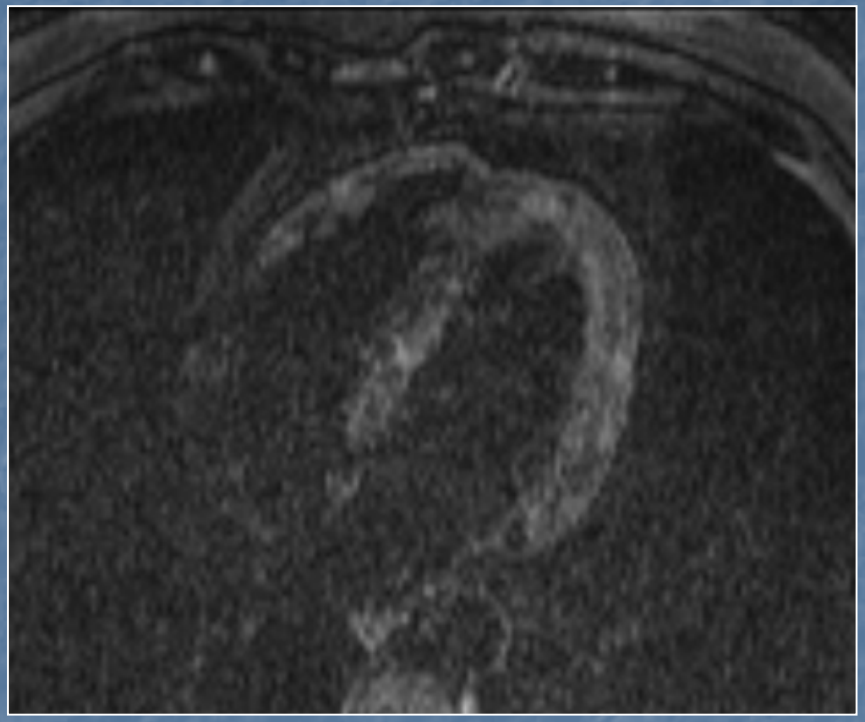
EDVI 60 ml/m2

ESVI 21 ml/m2

Mass 89 g/m2

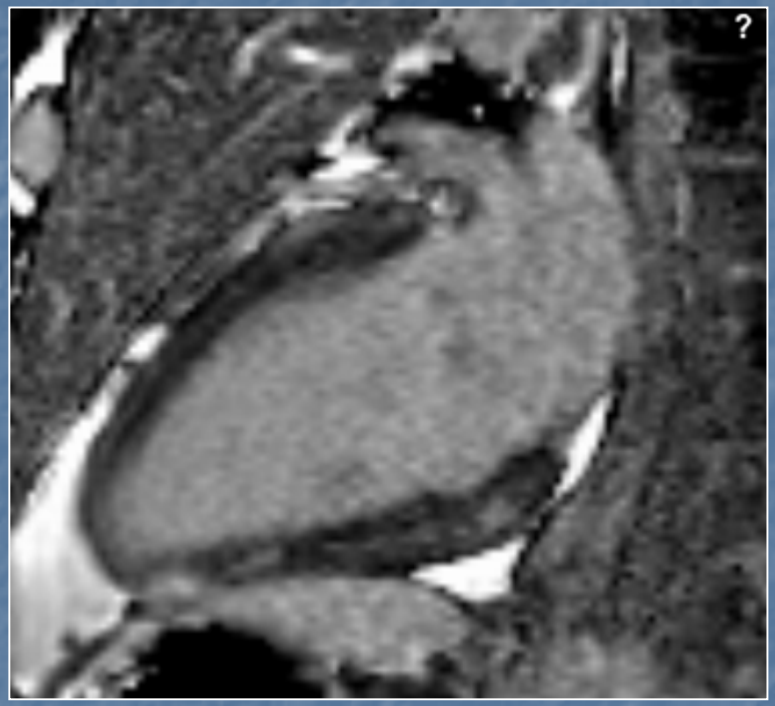
MR 22/09/2006

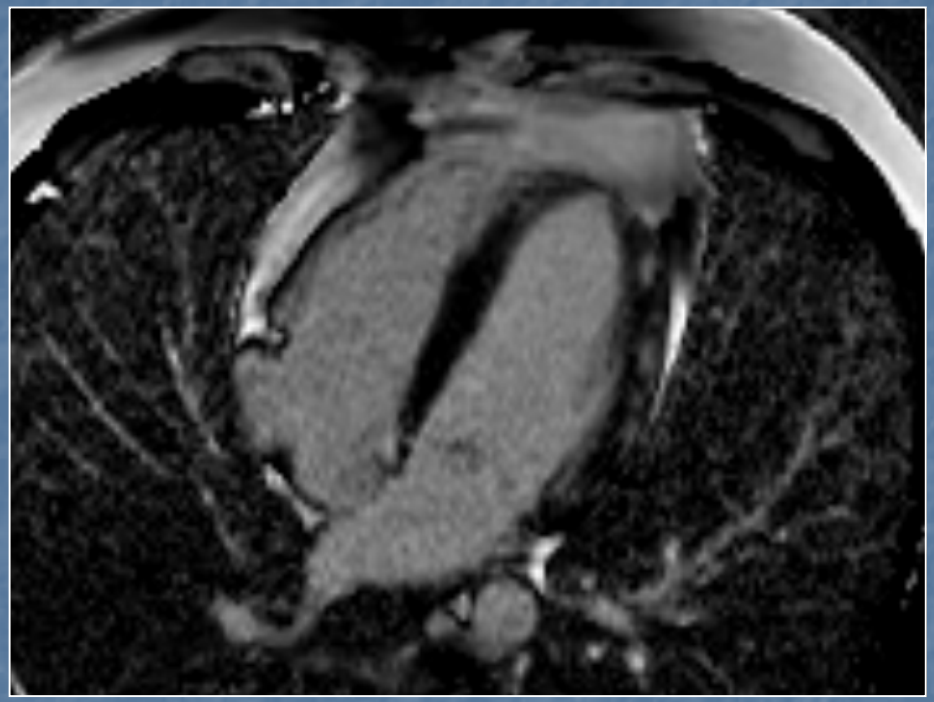




T2-weighted image shows regional oedema in lateral and septal wall

MR 22/09/2006

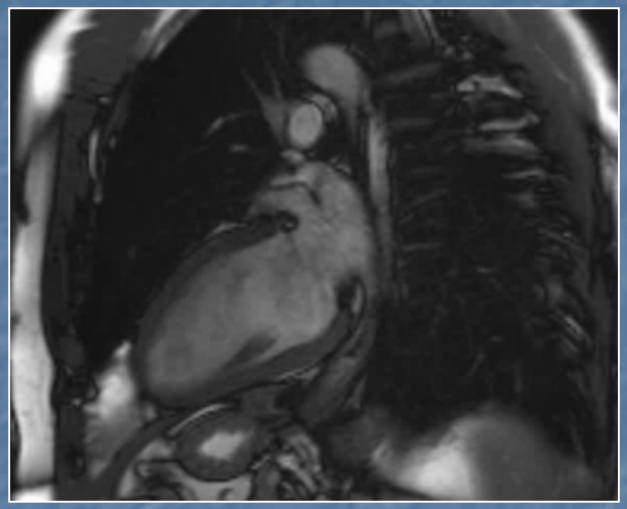


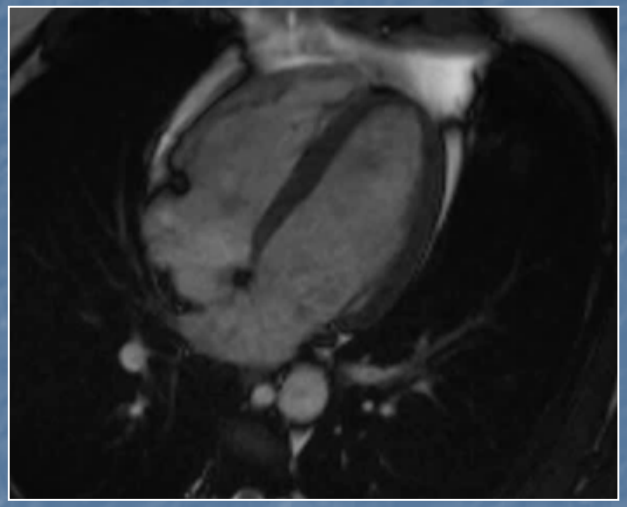


Patchy LE areas with predominant subepicardial and mainly lateral distribution

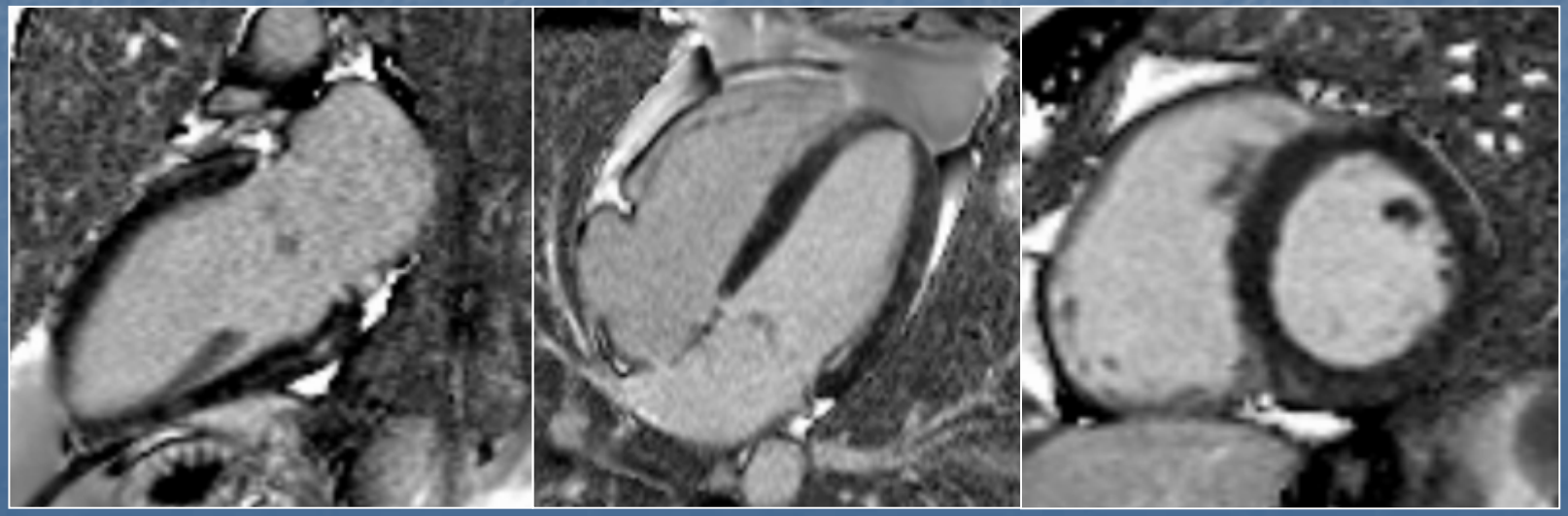
Focal contrast enhancement

MR 11/12/2006



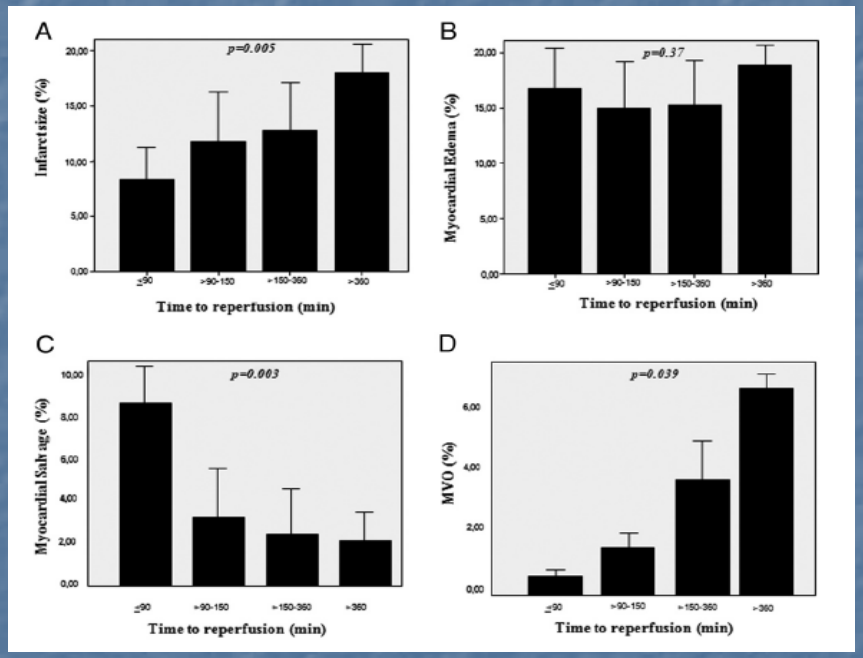


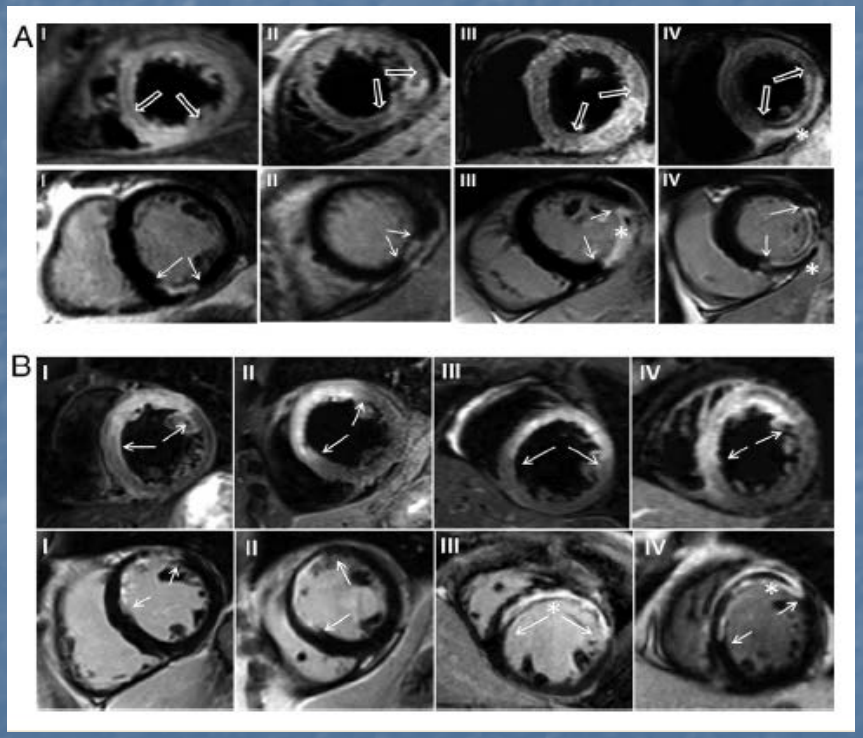
Decrease of area of LV contrast enhancement



Case 6

Impact of primary PCI delay

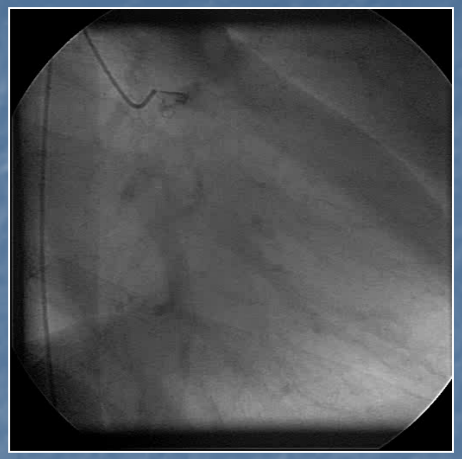


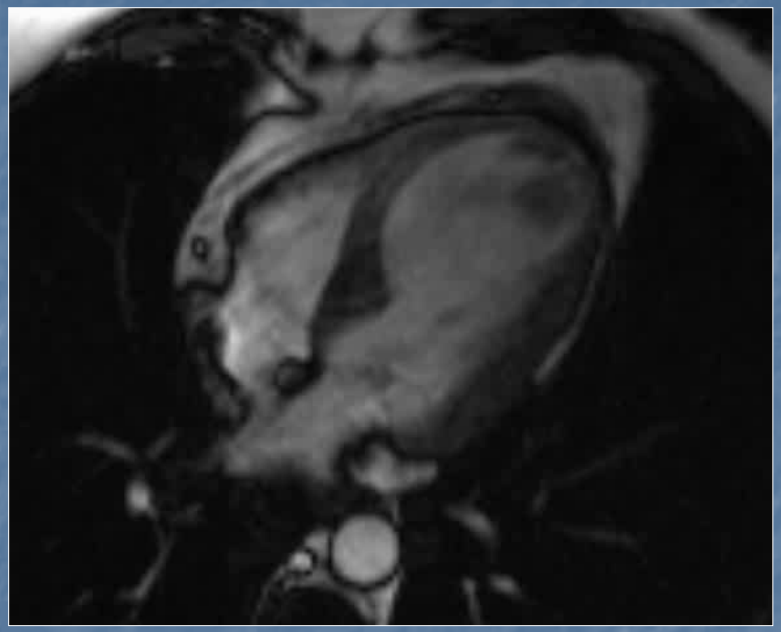


JACC 2009

Mr. LE. 61 y, ant MI August 2005

PCI active stent + IABPC

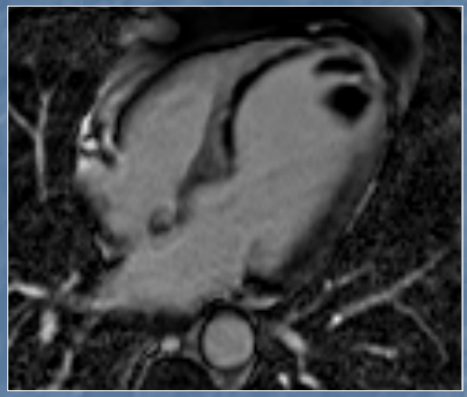


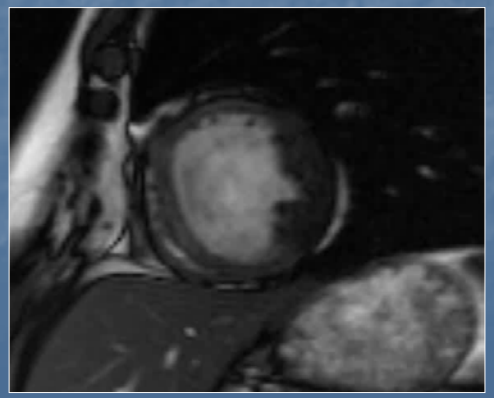


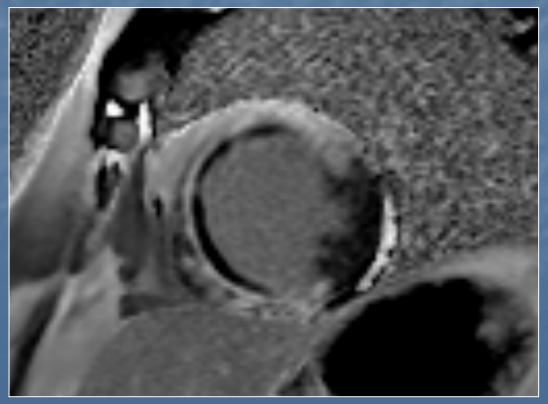
E.F. : 30%
EDVI : 68 ml/m²
ESVI : 47 ml/m²
BNP : 835

Heart failure

The day after



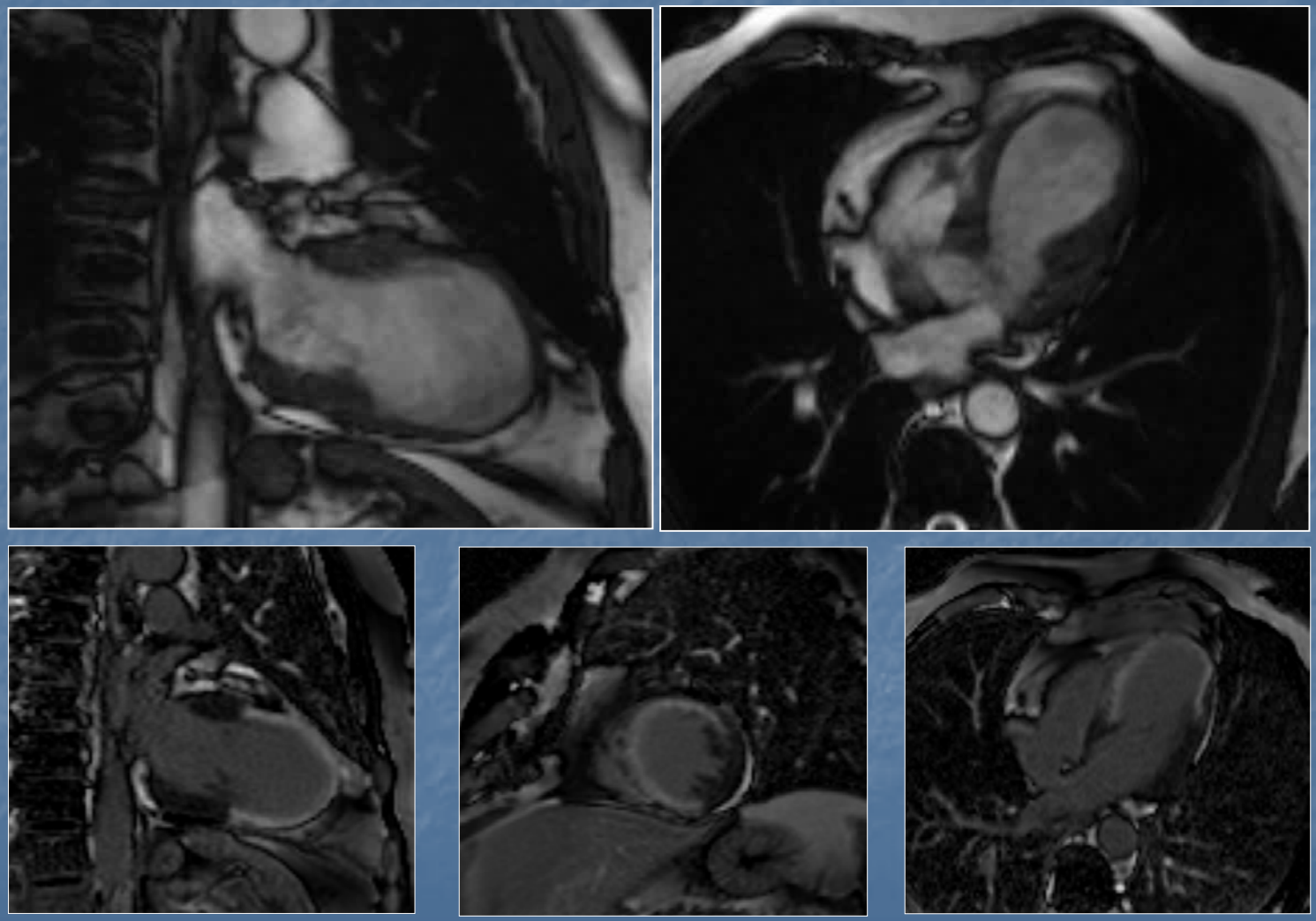




Mr. LE. 61 y, ant MI August 5 2005

PCI active stent, severe CHF → IABP
September MRI control 1 month later

Sept. 27:
EF 35 %
GLE > 50 %

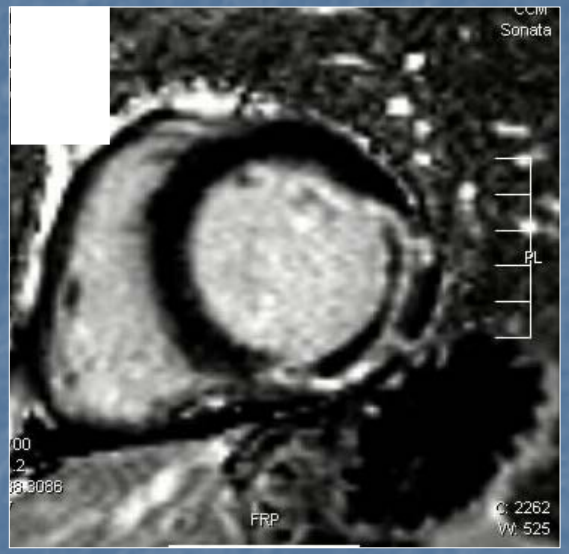


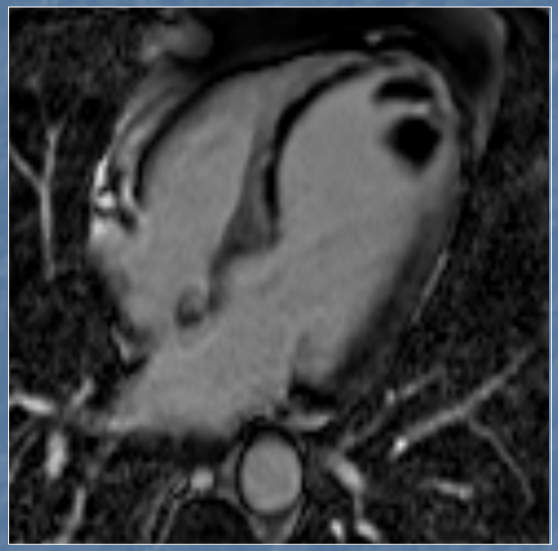
MICROVASCULAR OBSTRUCTION

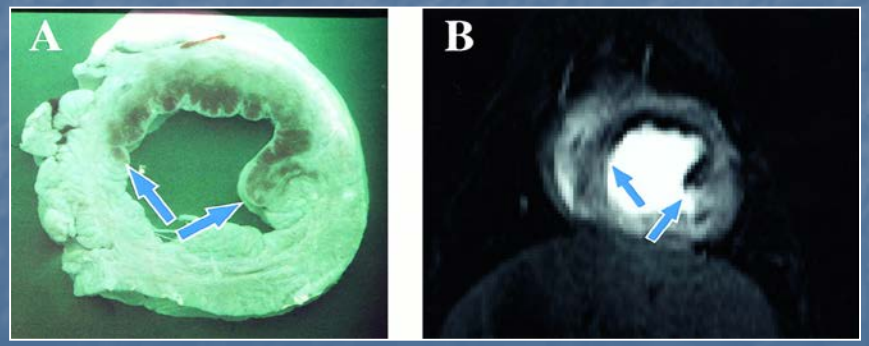
Hypoenhancement due to delayed contrast penetration

Related to reduced functional capillary density

No reflow area

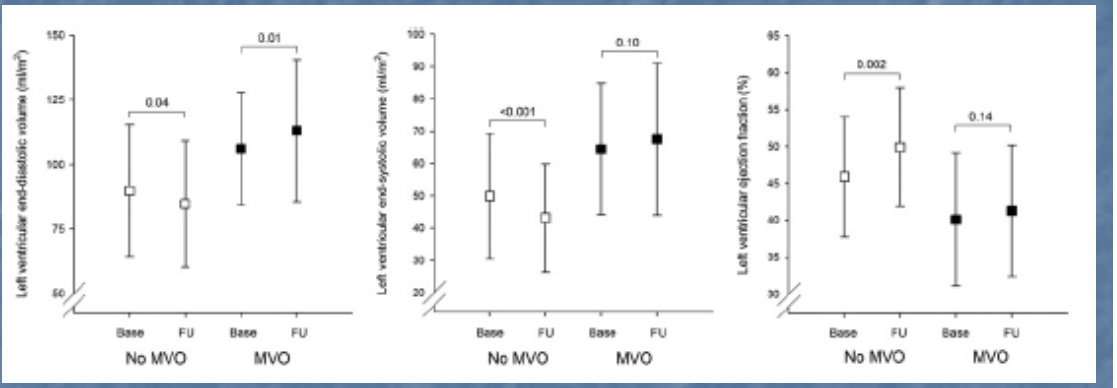


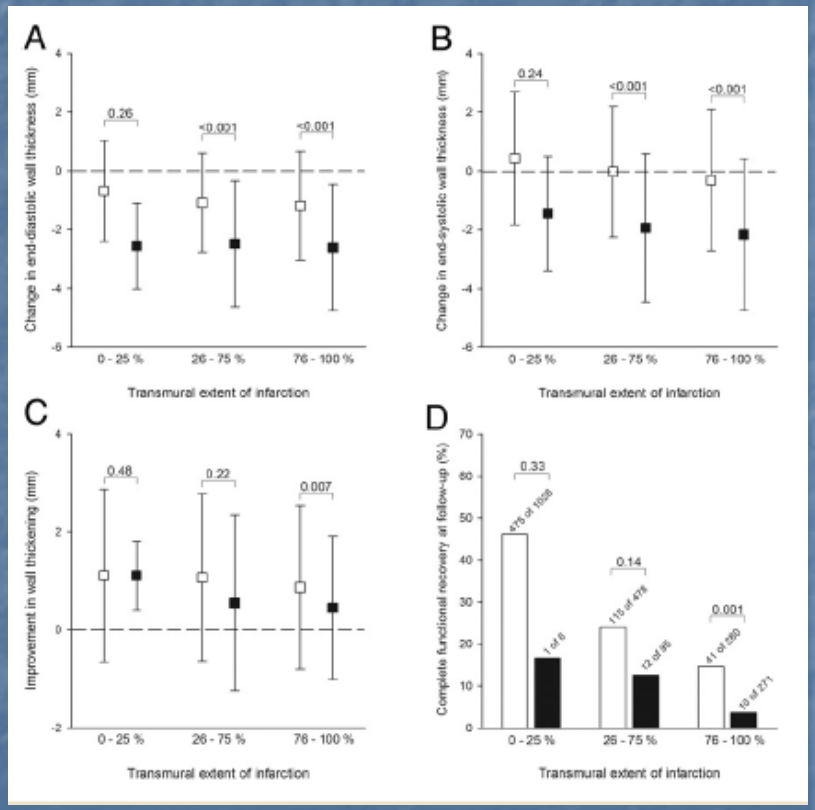




LATE MVO: predictor of functional recovery

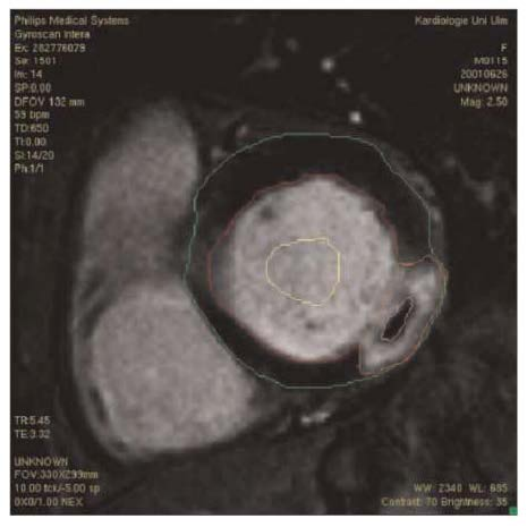
PTS AFTER REVASCULARIZED AMI

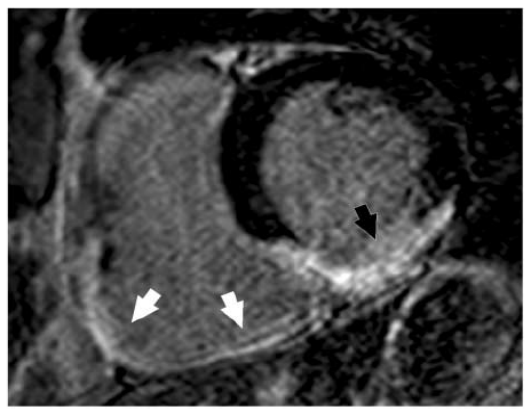




NIJVELDT ET AL. JACC 2008

PERSISTENT MVO AND SURVIVOR





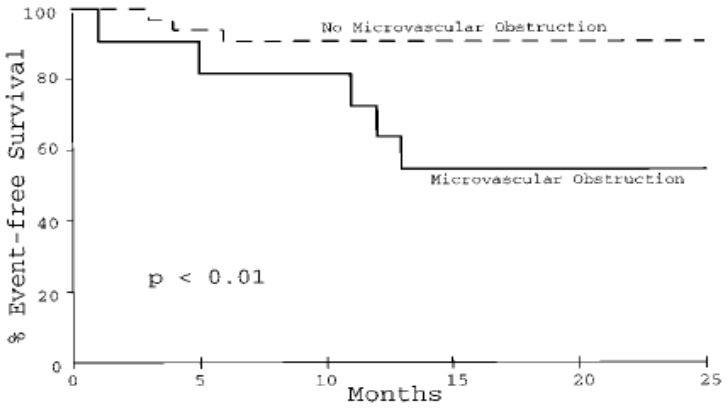
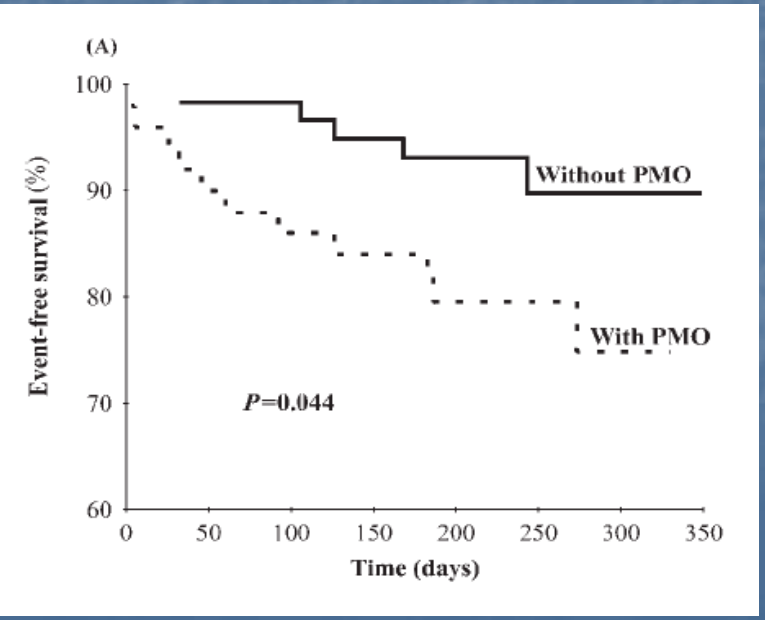


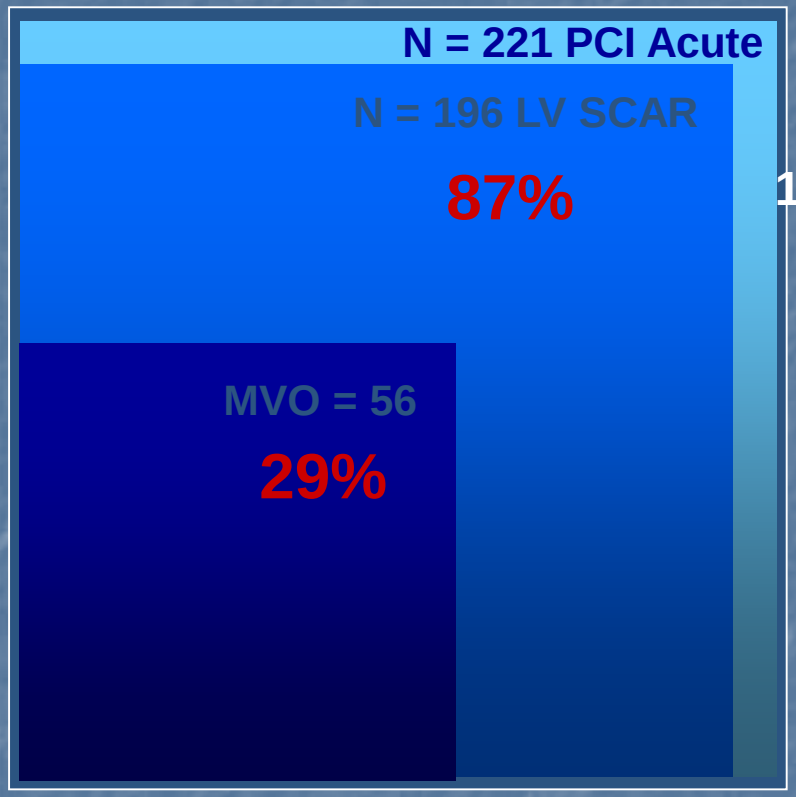
Figure 4. Event-free survival (clinical course without cardiovascular death, reinfarction, congestive heart failure, or stroke) for patients with and without MRI microvascular obstruction.

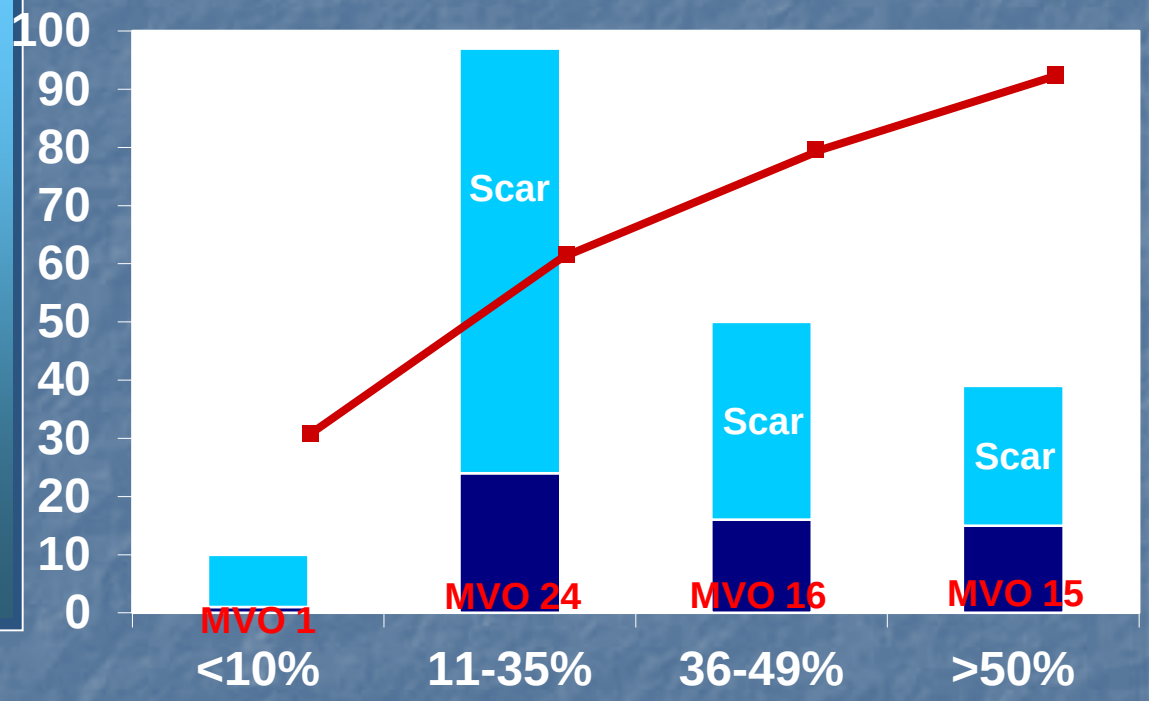
Circulation 1998



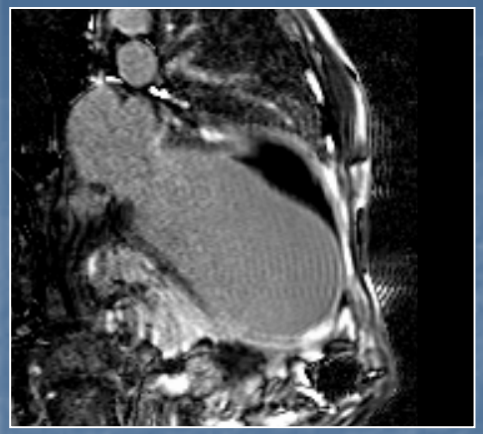
EHJ 2005

Relationship Infarct Size / advanced Heart Failure* III





Mr. NIC. 75 y. A.M.I 04/07, stenting LAD at day 6. Stent thrombosis

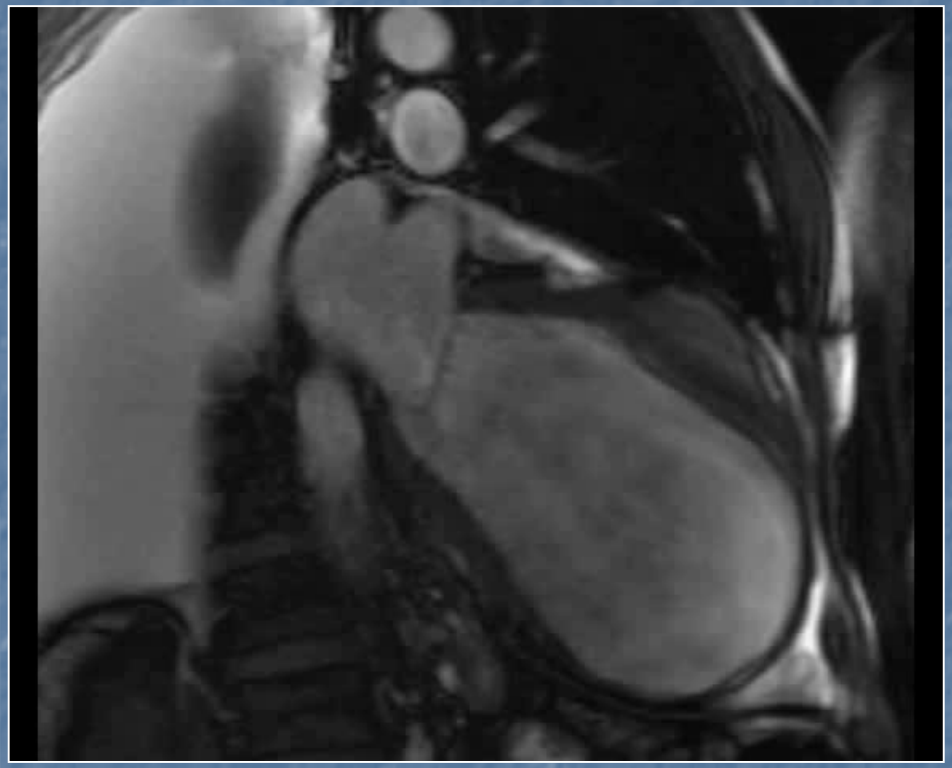


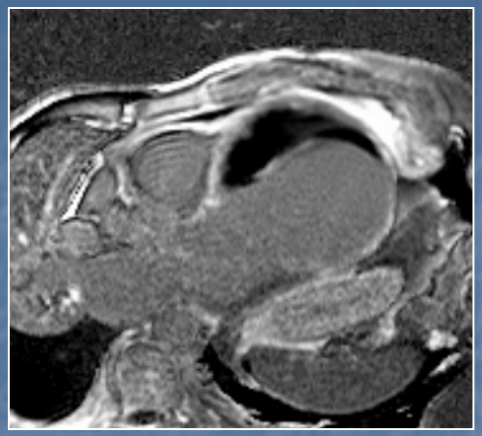
GLE > 75 %

July 07

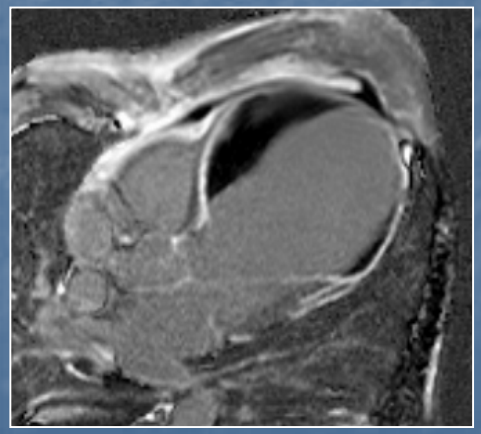
Euroscore : > 18

(mortality risk > 75 %)





GLE > 75 %

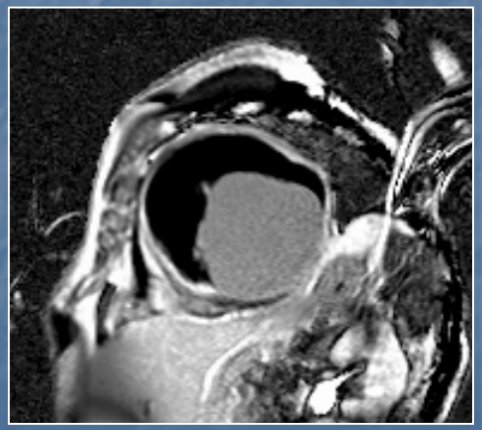


LVEF : 9 %

EDVI : 320 ml/m²

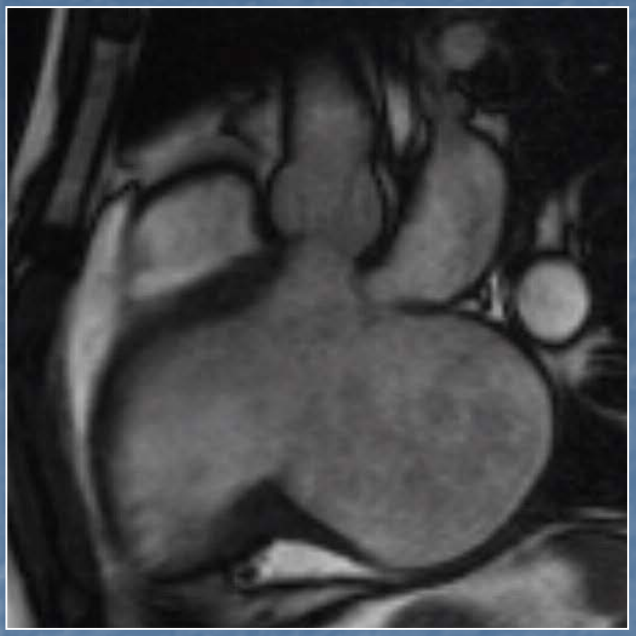
ESVI : 289 ml/m² !

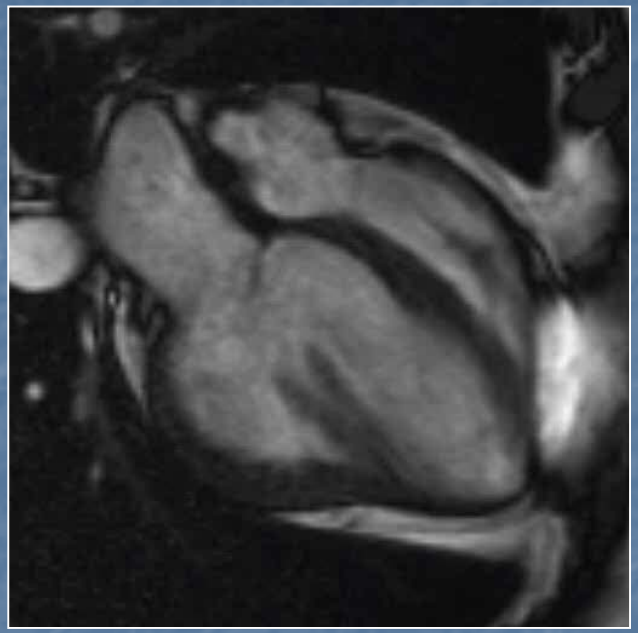
Mitral diam. : 40 mm

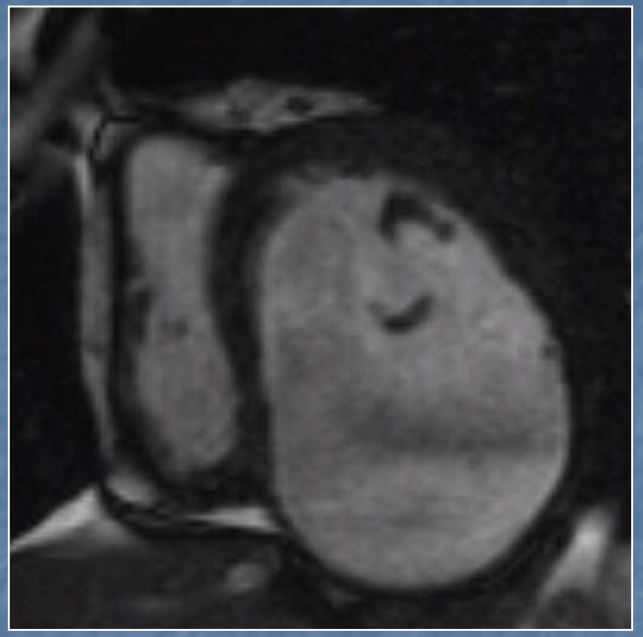


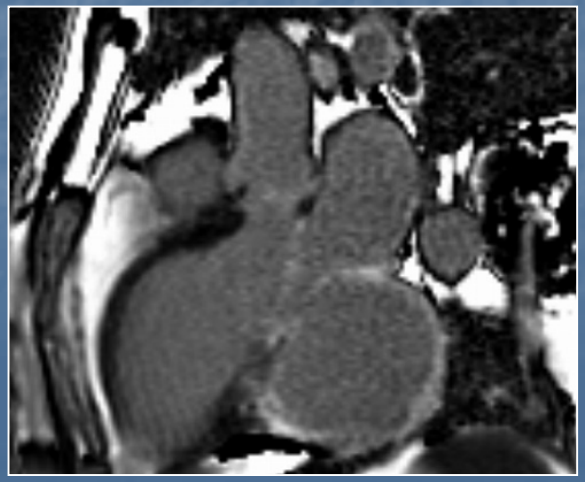
MR. G. 56 Y, Posterior LV aneurysm

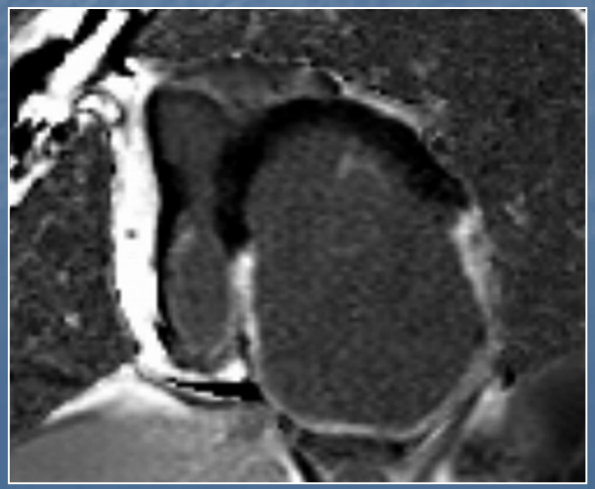
Circulatory arrest after ventricular arrhythmia and pulmonary oedema











CMP

The dilated CMP

KEY POINTS

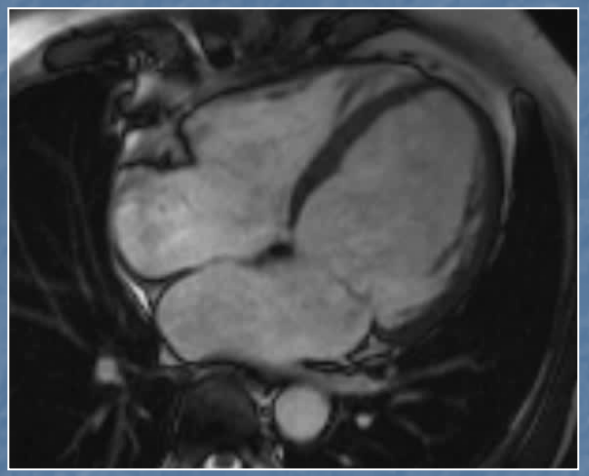
- Ischemic vs. non-ischemic diagnosis and prognosis
- Chagas disease and sarcoidosis (detect cardiac involvement)
- Myocarditis (gold standard for diagnosing)

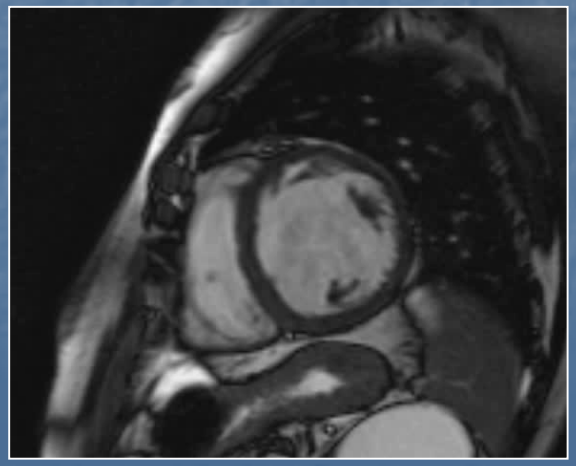
Male 52 y. NYHA III

E.F. 33%

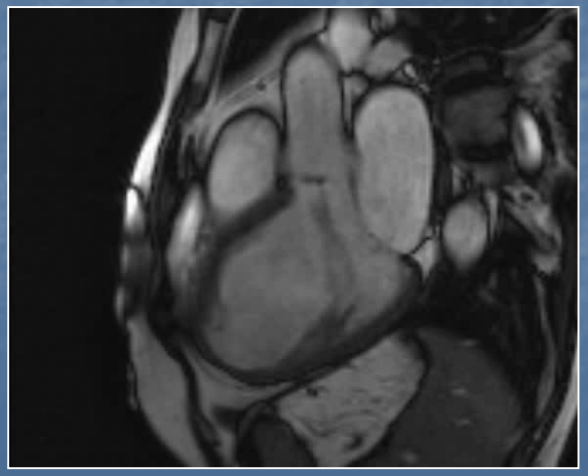
EDVI:118 ml/m2

ESVI: 79 ml/m2



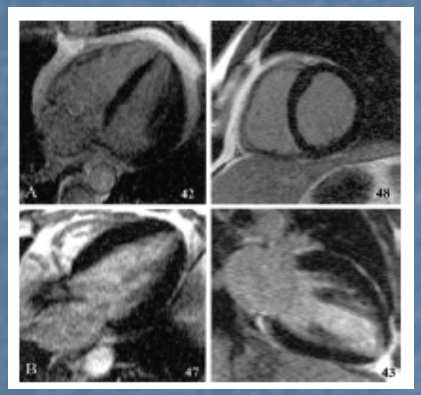


Wall thinning



Differentiation of heart failure related to DCMP and CAD

1

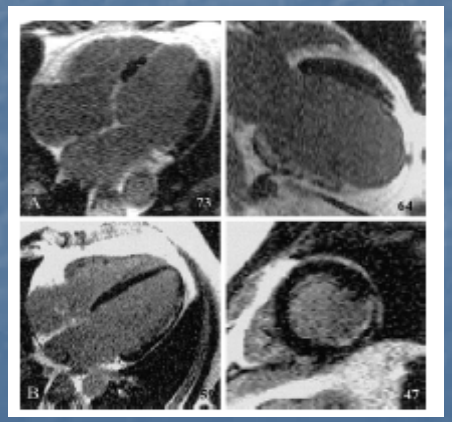


DCM

No LE

59%

2

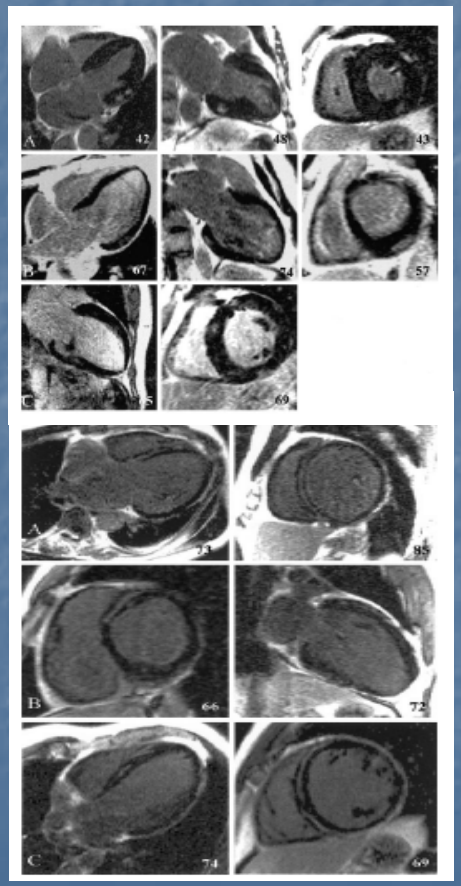


DCM

LE: sub endo or transmural

13%

3



DCM

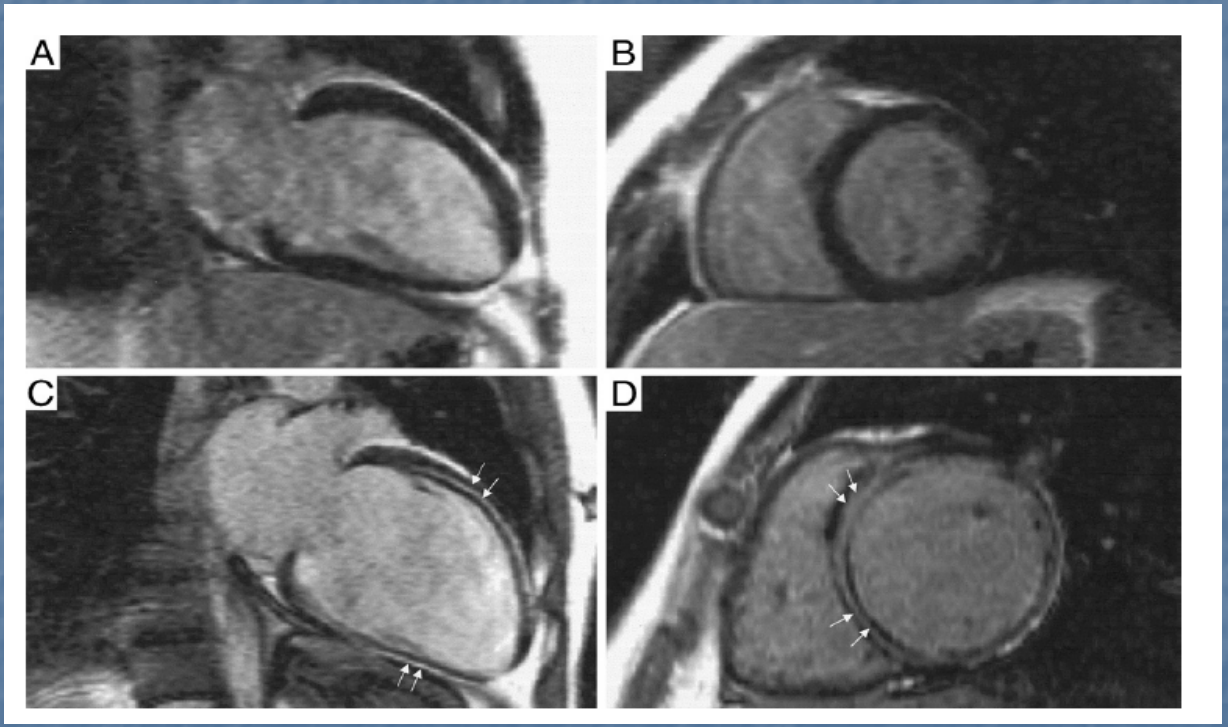
LE: patchy foci and longitudinal midwall striae

28%

J.A. McCrohon CIRC 2003

The enhancement pattern:

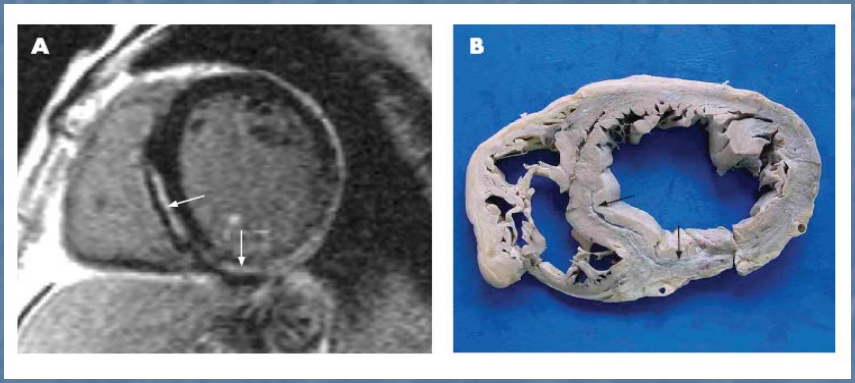
- sparing the subendocardium
- non coronary territory distribution



R.G.Assomull

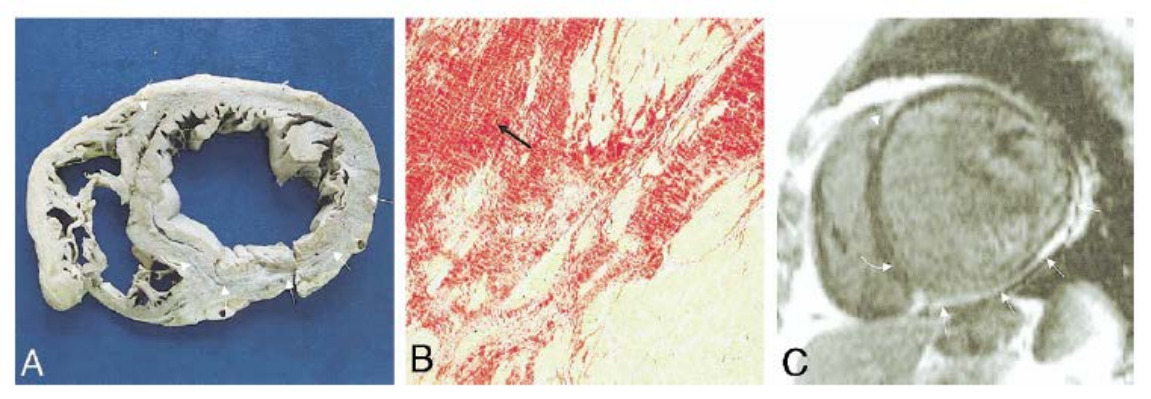
JACC 2006

Does fibrosis predict outcome of pts. with DCM ?



Pattern of patchy midwall LGE in infero-lateral wall

Autopsy sample with similar pattern of fibrosis

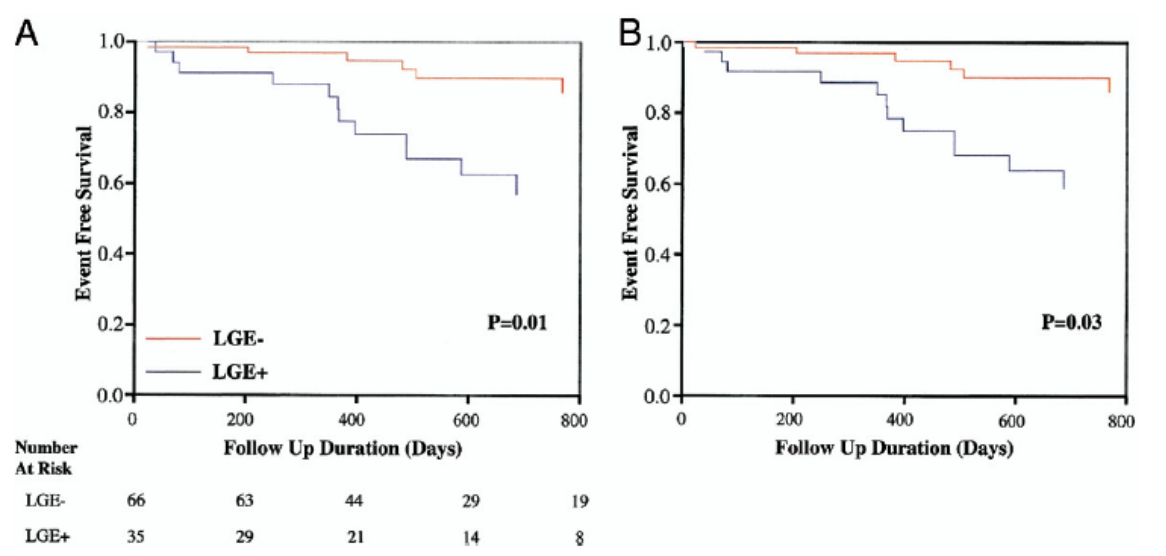


R.G. Assomull

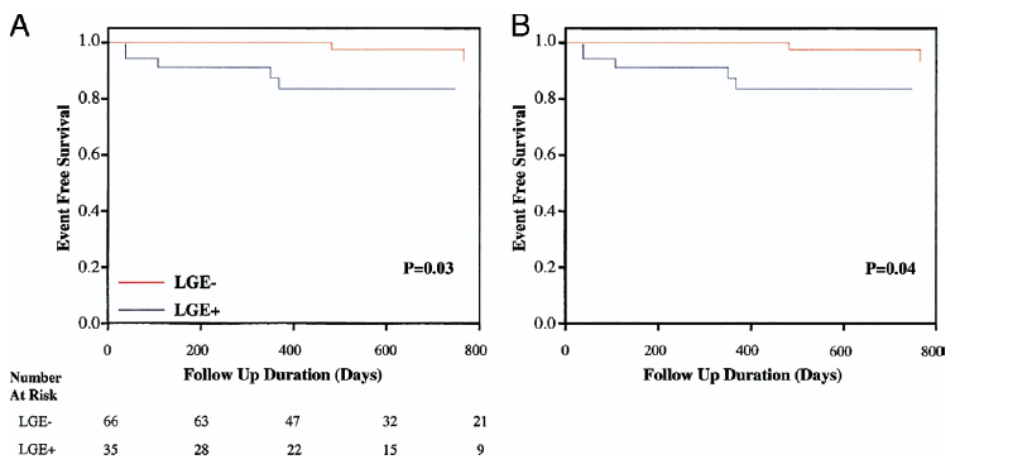
JACC 2006

HEART 2008

Primary end-point: all cause mortality or hospitalization due to cardiovscular causes



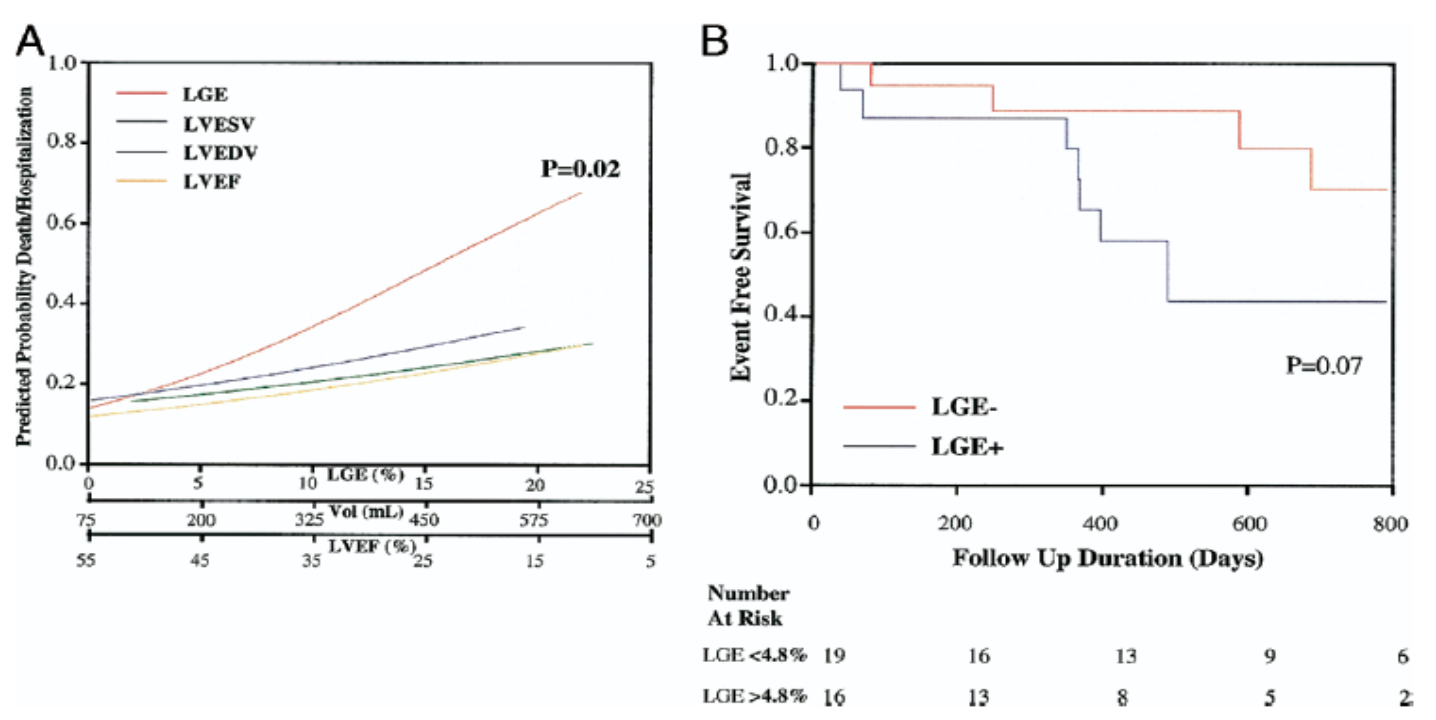
Adjusted for age, LVEDV, LVESV, LVEF, RVEF



R.G. Assomull

JACC 2006

Secondary end-point: sudden cardiac death or sustained VT



R.G. Assomull

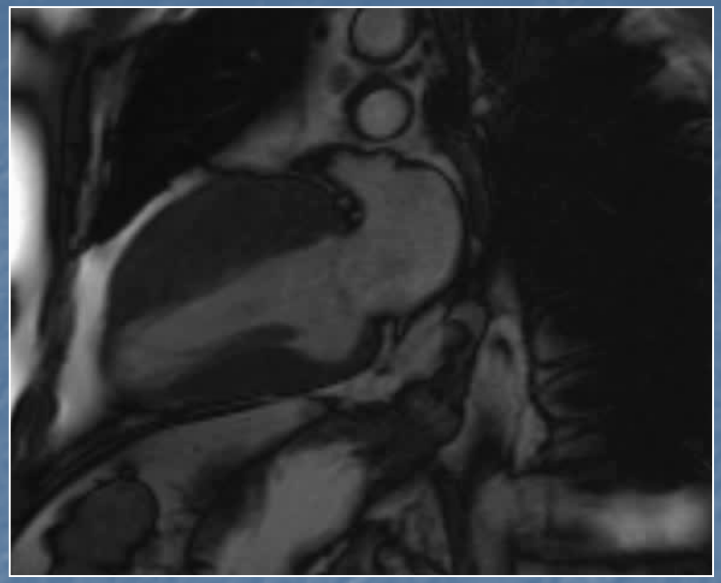
JACC 2006

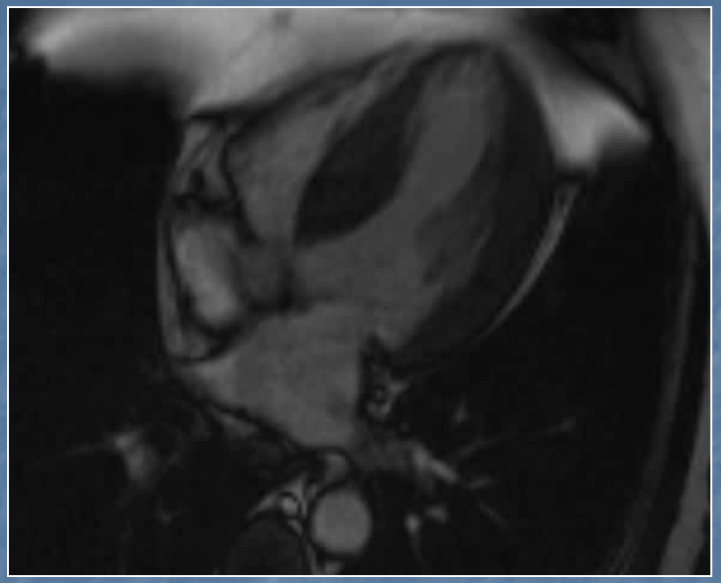
The hypertrophic CMP

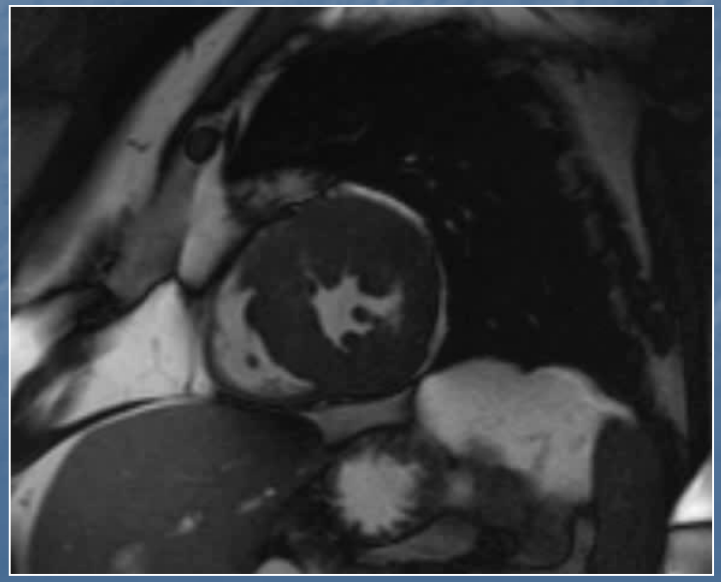
KEY POINTS

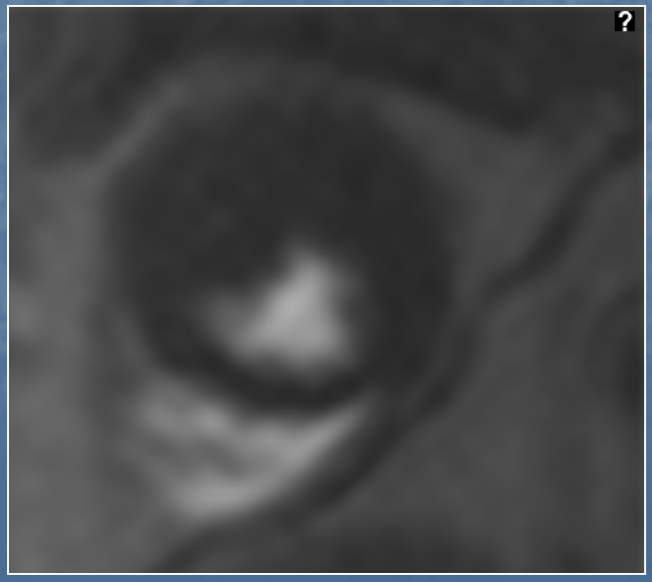
- Differentiate physiological from pathological hypertrophy
- Differentiate between familial HCM and cardiac involvement of restrictive disease like amyloidosis and Anderson-Fabry
- Identify pts. at risk for SCD or VT (late enhancement): prognosis !!

ASYMMETRIC HYPERTROPHIC……

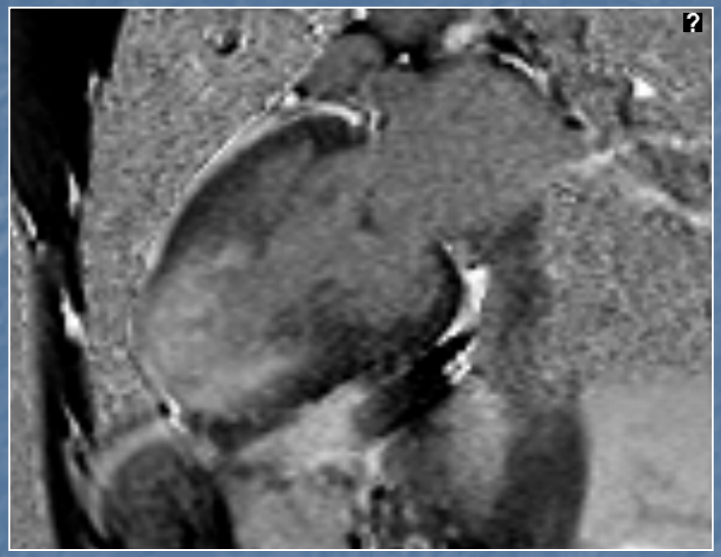


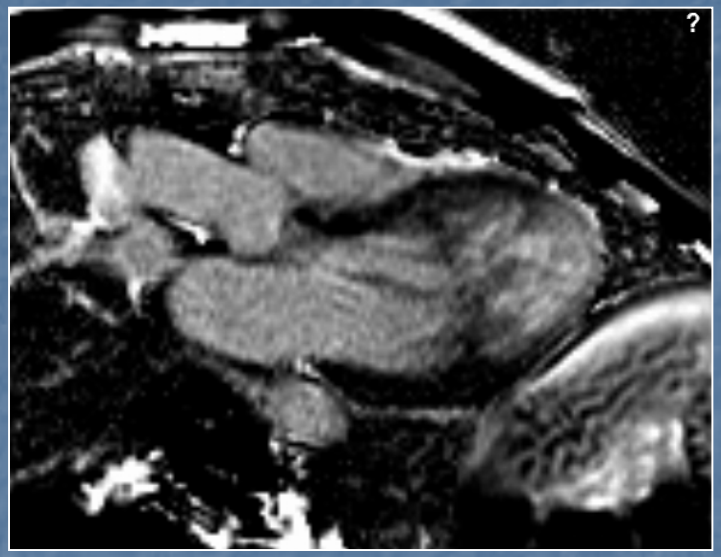


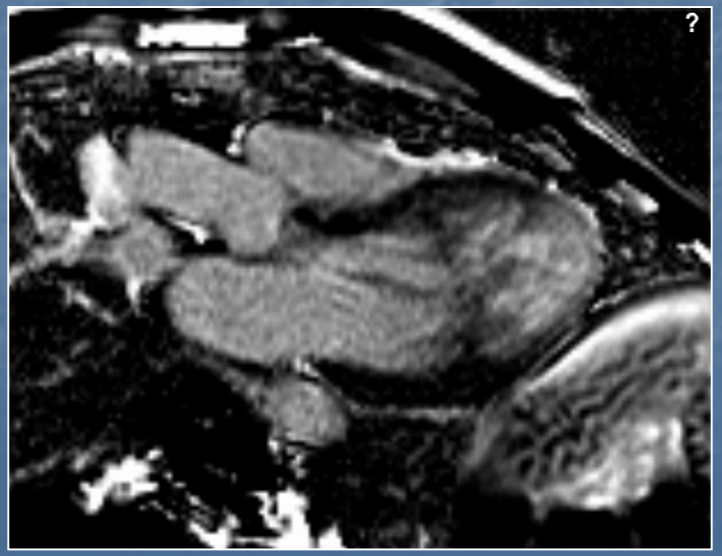




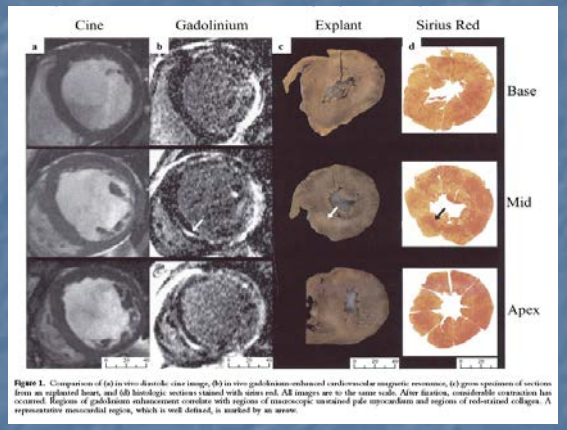
.....AND FIBROSIS







FIBROSIS – LATE ENHANCEMENT – HYPERTROPHIC CMP



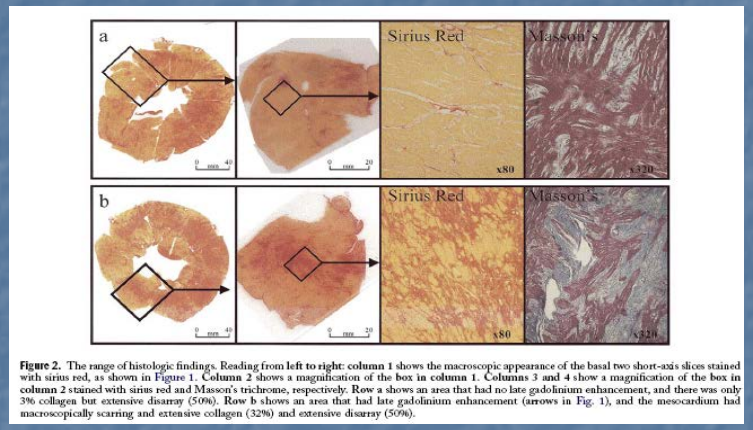
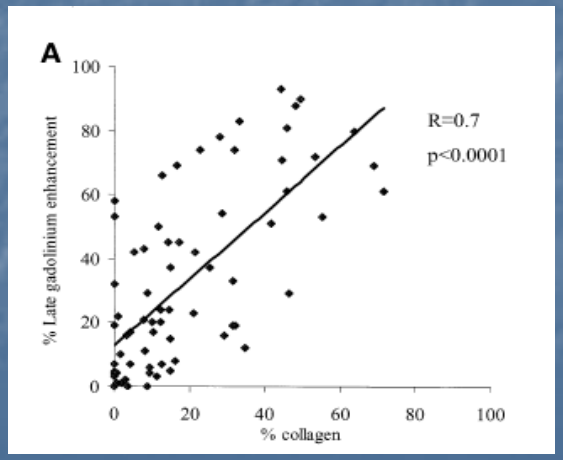


Figure 2. The range of histologic findings. Reading from left to right: column 1 shows the macroscopic appearance of the basal two short-axis slices stained with sirius red, as shown in Figure 1. Column 2 shows a magnification of the box in column 1. Columns 3 and 4 show a magnification of the box in column 2 stained with sirius red and Masson's trichrome, respectively. Row a shows an area that had no late gadolinium enhancement, and there was only 3% collagen but extensive disarray (50%). Row b shows an area that had late gadolinium enhancement (arrows in Fig. 1), and the mesocardium had macroscopically scarring and extensive collagen (32%) and extensive disarray (50%).



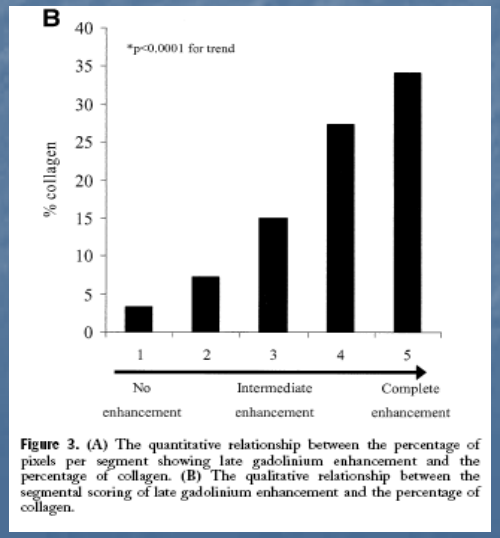
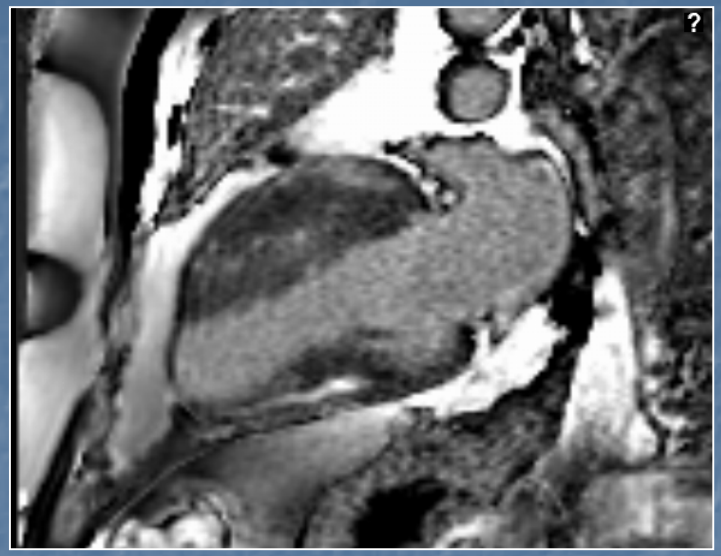
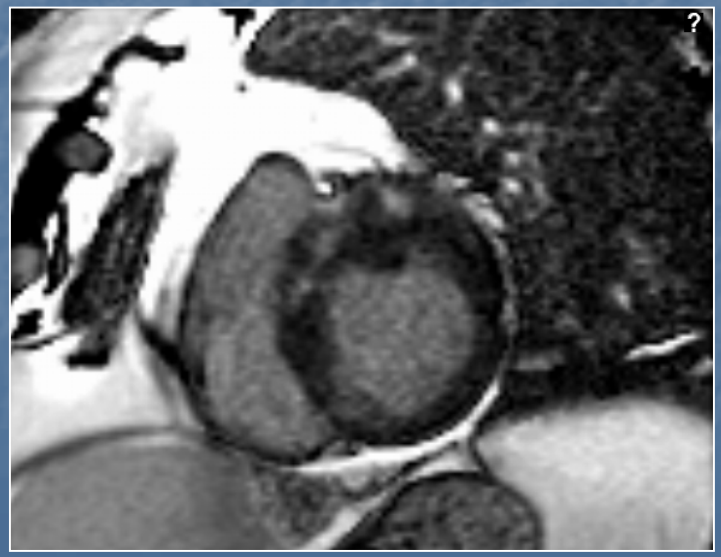


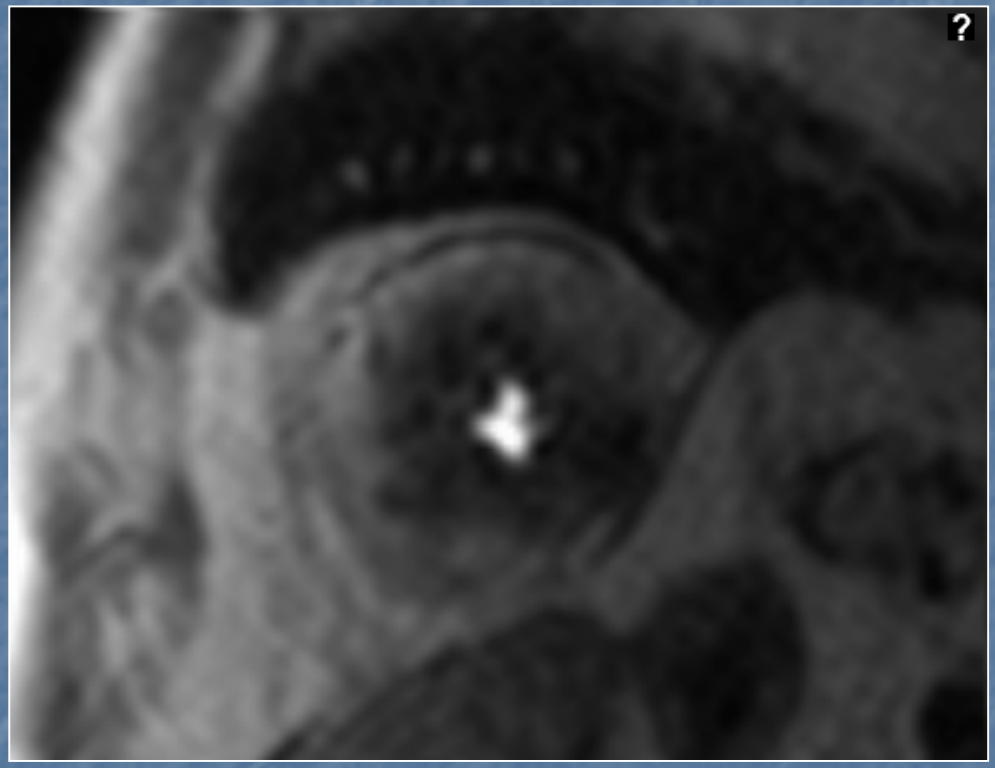
Figure 3. (A) The quantitative relationship between the percentage of pixels per segment showing late gadolinium enhancement and the percentage of collagen. (B) The qualitative relationship between the segmental scoring of late gadolinium enhancement and the percentage of collagen.

JACC 2004

……AND MICROVASCULAR DYSFUNCTION







CMR for identification of HCM patients with increased susceptibility to ventricular arrythmia

Occurrence and Frequency of Arrhythmias in Hypertrophic Cardiomyopathy in Relation to Delayed Enhancement on Cardiovascular Magnetic Resonance

A. Selcuk Adabag, MD, MS,* Barry J. Maron, MD,† Evan Appelbaum, MD,‡§
Caitlin J. Harrigan, BA,§ Jacqueline L. Buros, BA,§ C. Michael Gibson, MD, MS,‡§
John R. Lesser, MD,† Constance A. Hanna, RN,† James E. Udelson, MD,‖
Warren J. Manning, MD,‡§ Martin S. Maron, MD‖

Minneapolis, Minnesota; and Boston, Massachusetts

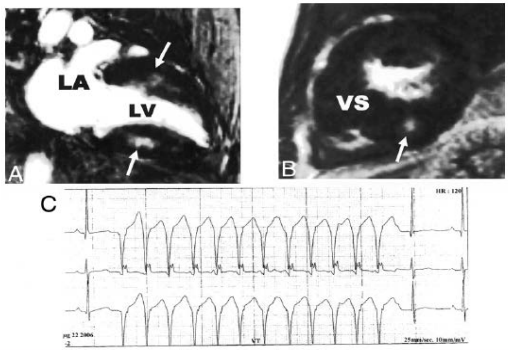


Figure 3 Cardiovascular Magnetic Resonance Image From a 36-Year-Old Hypertrophic Cardiomyopathy Patient

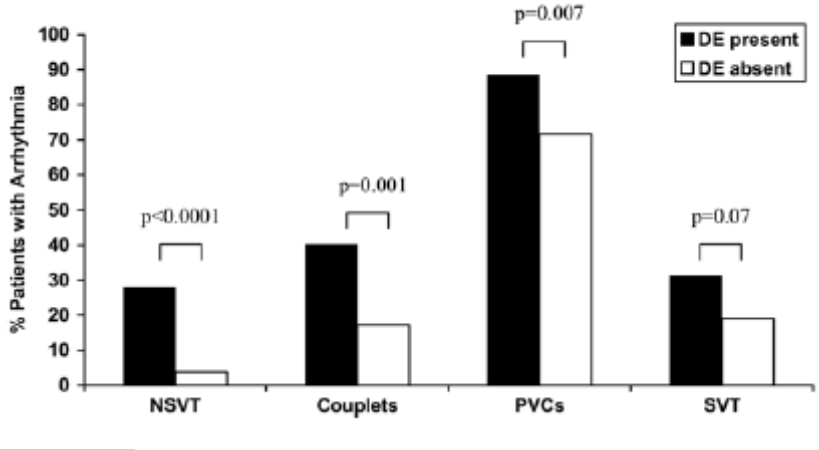
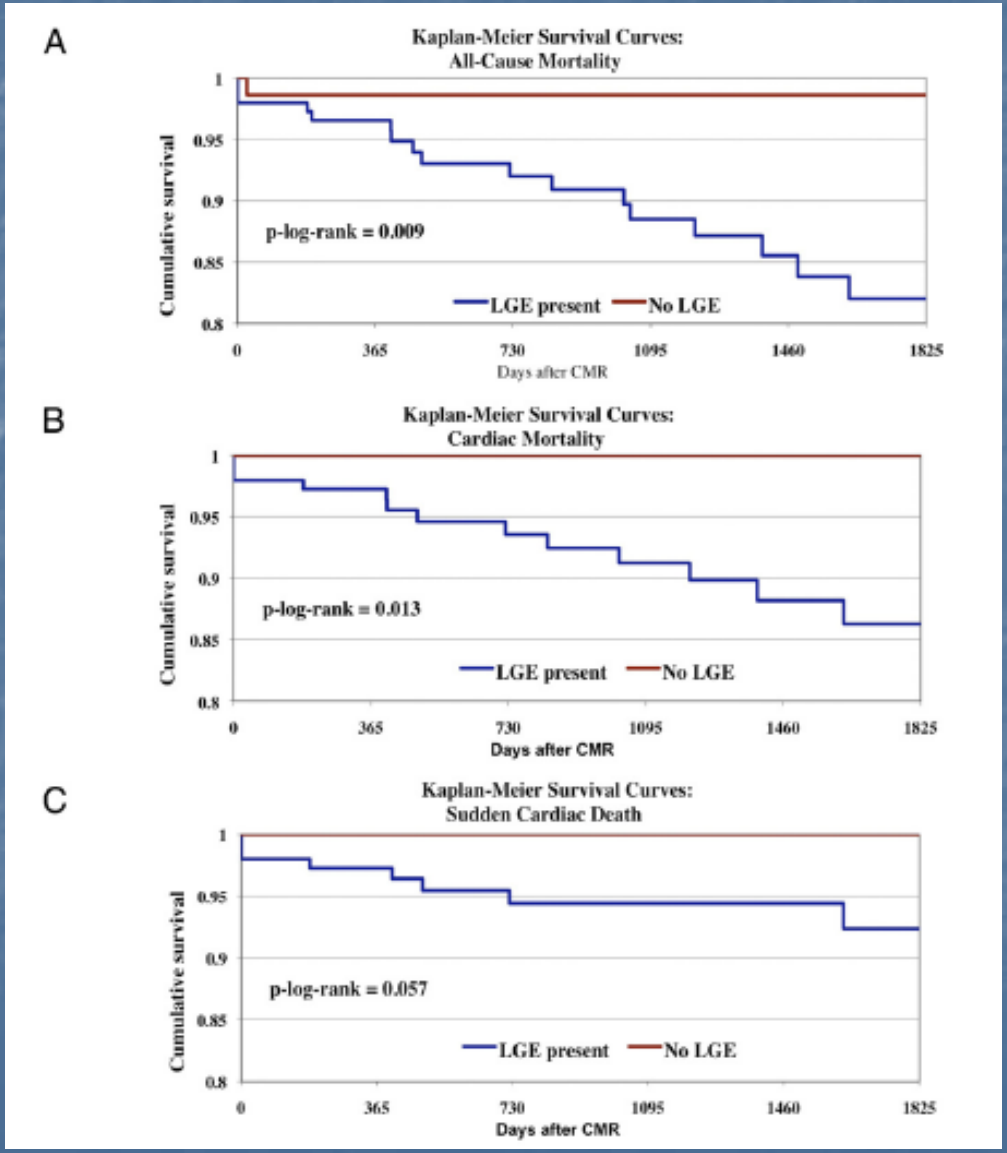


Figure 1 Prevalence of Arrhythmias on 24-h Holter ECG With Respect to DE in 177 HCM Patients

DE = delayed enhancement; ECG = electrocardiogram; HCM = hypertrophic cardiomyopathy; NSVT = nonsustained ventricular tachycardia; PVC = premature ventricular contraction; SVT = supraventricular tachycardia.

Prediction of major adverse events



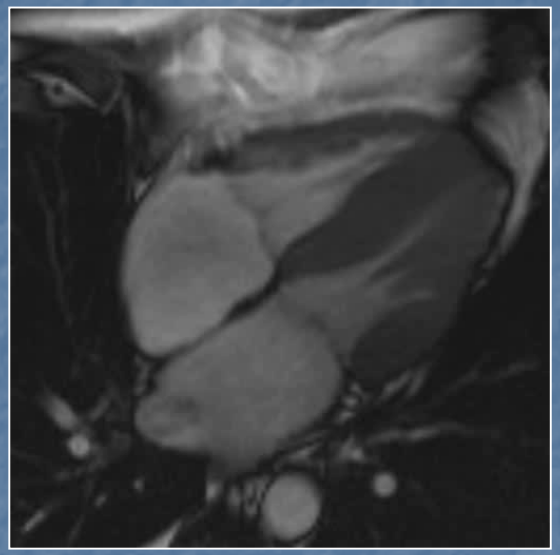
JACC 2010

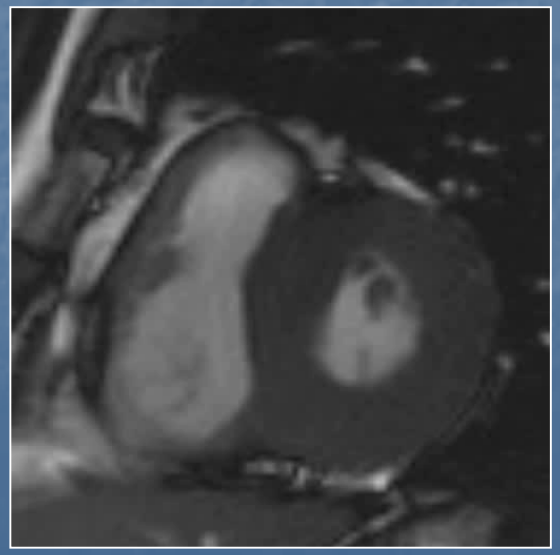
The restrictive CMP

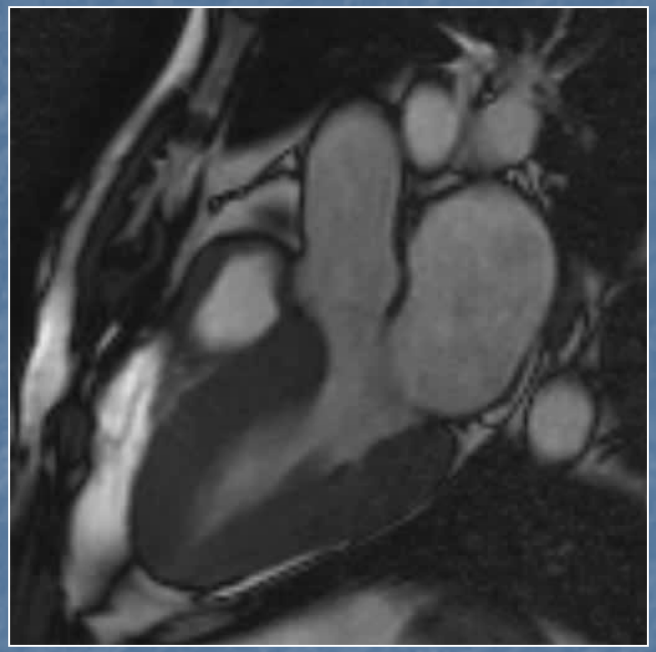
KEY POINTS

- Endomyocardial disease
- Constrictive pericarditis
- *Iron overload*
- Cardiac involvement in *amyloidosis*

Cardiac magnetic resonance







EF. 64%

ITDV 56 ml/m2

ITSV 20 ml/m2

Mass 105 g/m2

CI 2.2 l/min

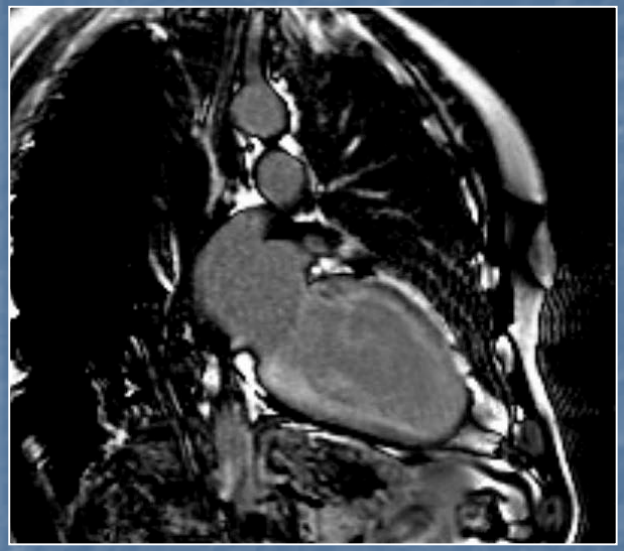
LA 63 ml/m2

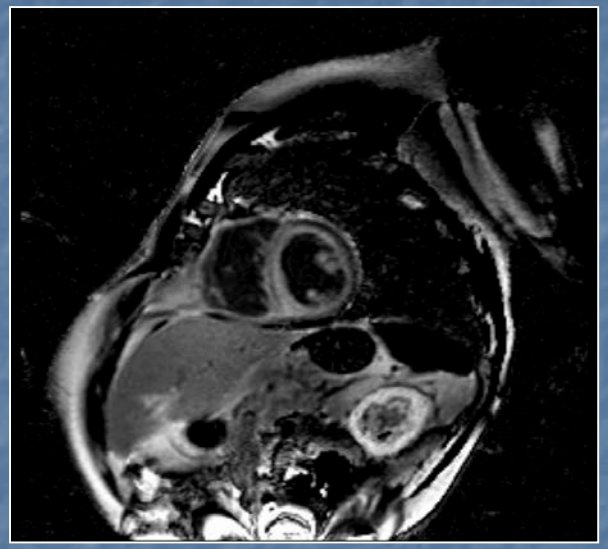
RA 5.6x6 cm.

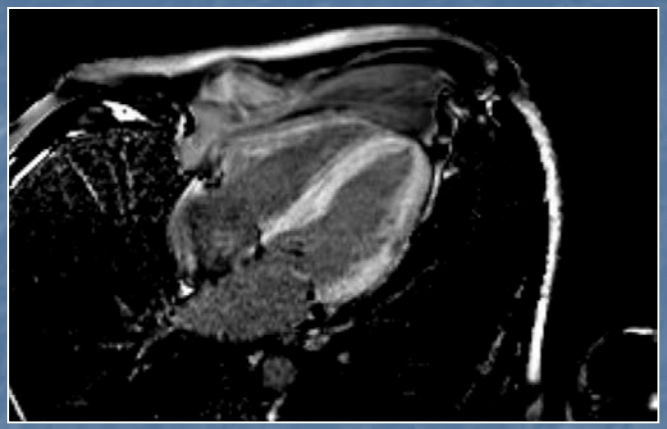
- *THICKENNING OF VENTRICULAR WALLS*
- *ENLARGEMENT OF ATRIA*
- *NO RV DILATATION*

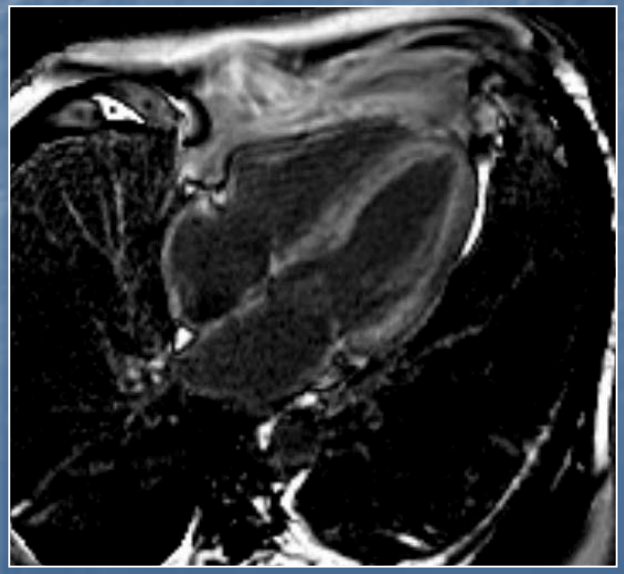
Late enhancement:

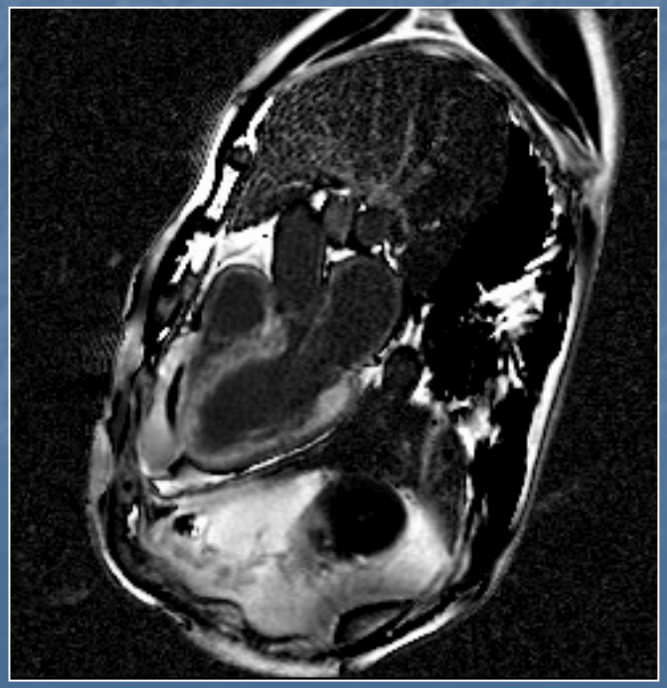
Nulling the myocardium not possible or difficult











VALVES, AORTA
&
MASSES

The ischemic MR

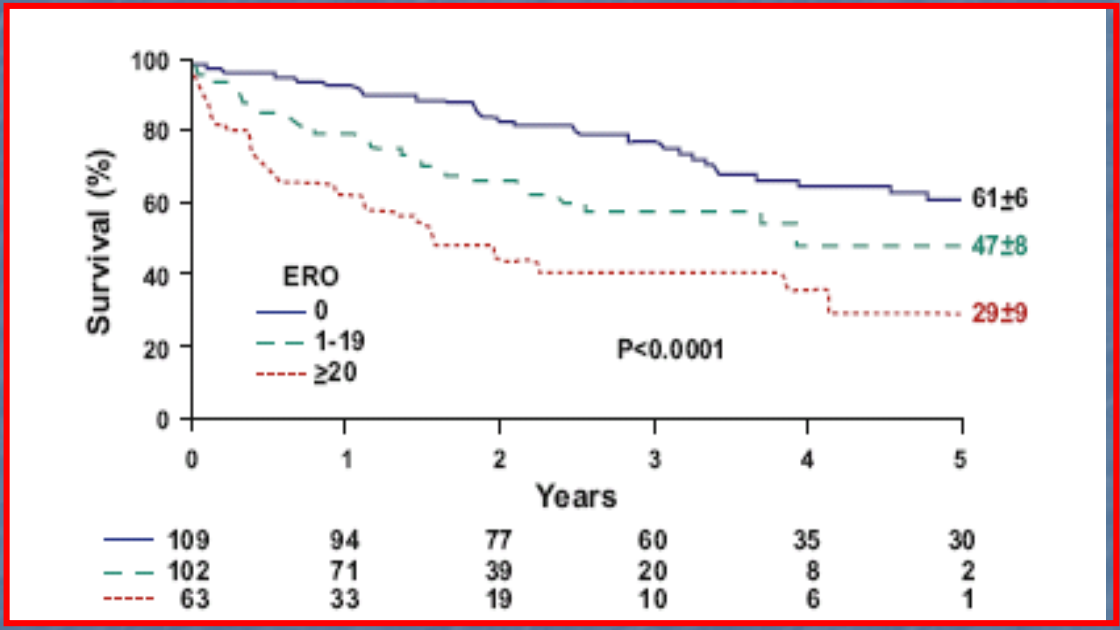
Abnormal function of normal leaflets in the context of *impaired ventricular function* resulting from ischaemic or dilated cardiomyophaties...

..it represents the consequence of LV disease

European Association of Echocardiography

It worsens the prognosis

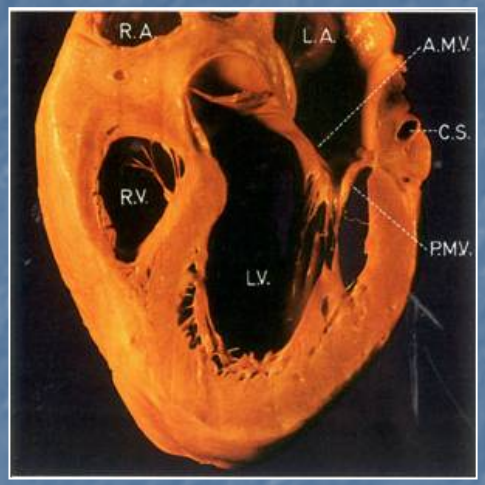
Survival after MI according to degree of MR



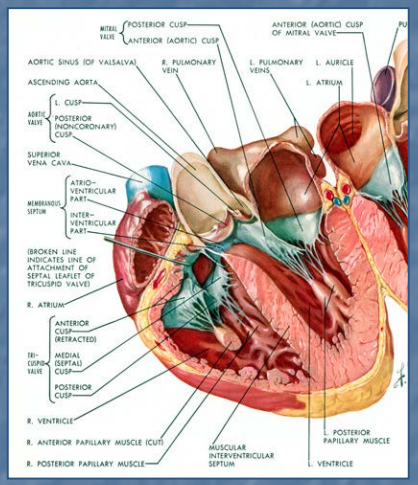
Circulation 2001

LV REMODELING & MITRAL REGURGITATION

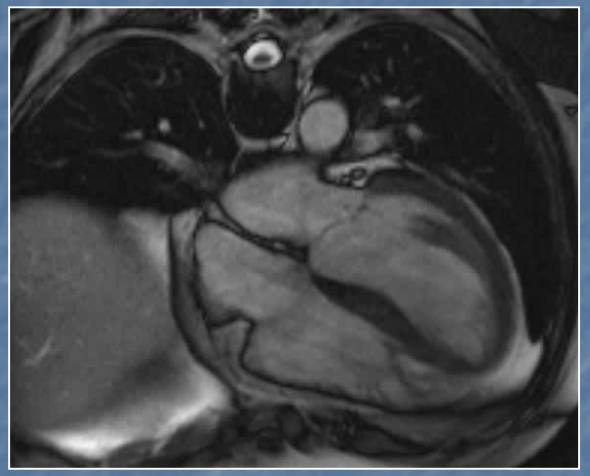
AUTOPSY

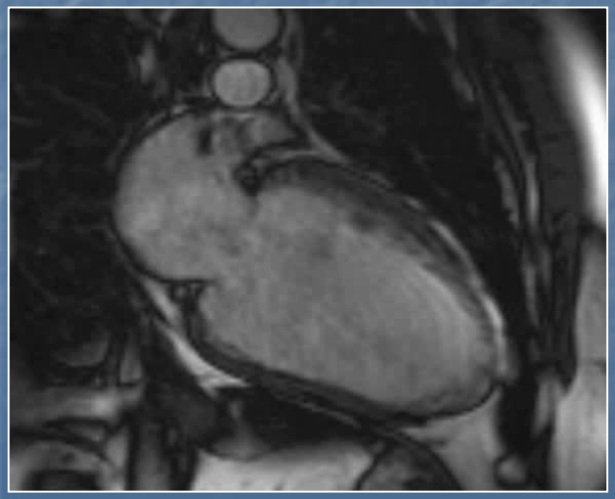


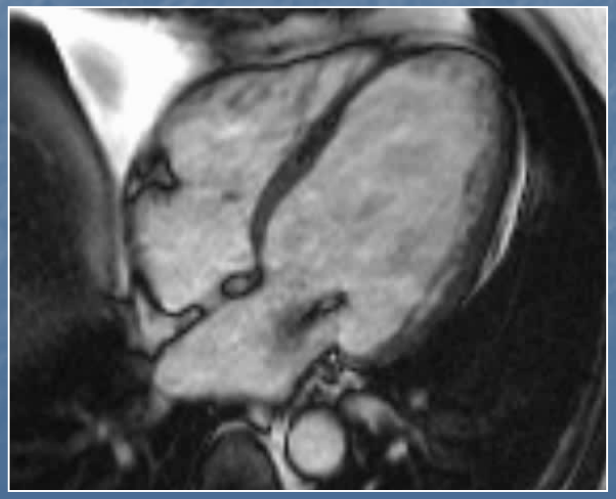
ANATOMY

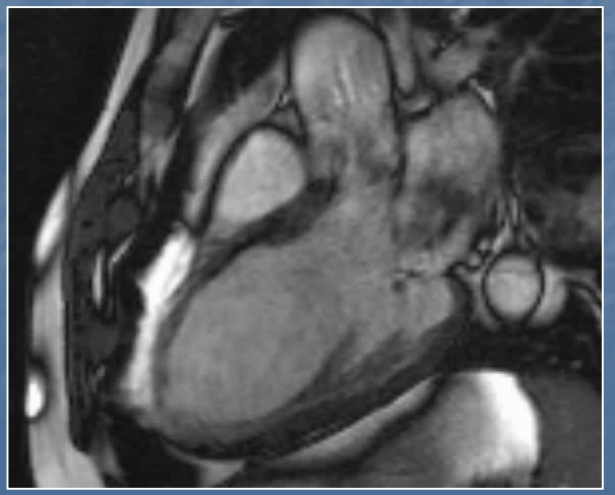


M.R.I









Ischemic mitral regurgitation is related to ANNULUS DILATATION ≥ 35 mm.
Papillary muscles are involved

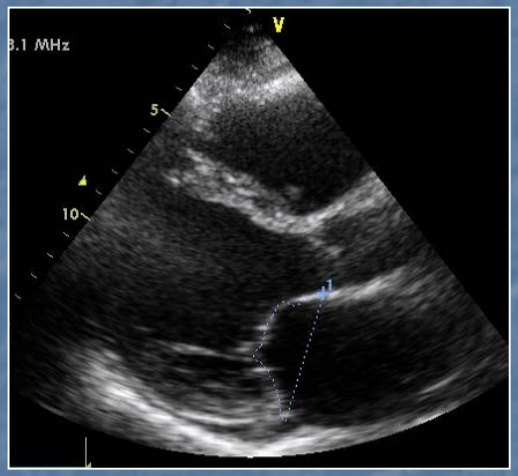
Coaptation depth

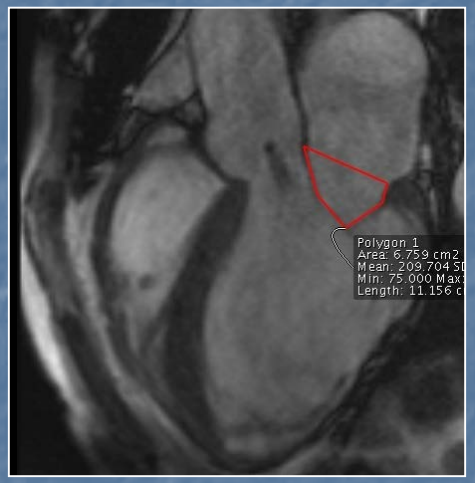
- Definition = shortest distance during systole from coaptation point to anular plane
- 11 mm (by echo) = predictor of anunuloplasty failure

When possible : - Regurgited Volume

- Regurgited Area

Tenting area (TA)
Tenting volume (TV)

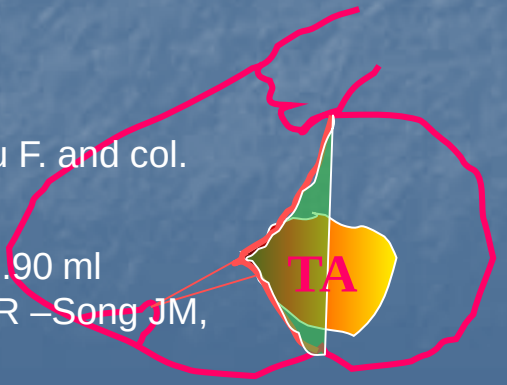




Normal value = ??

Tenting area - 4.4 +/- 0.8 cm2 Siu F. and col. Circulation2000

Tenting volume (3 D eho) >or=3.90 ml identified significant functional MR –Song JM, Am J Cardiol. 2006

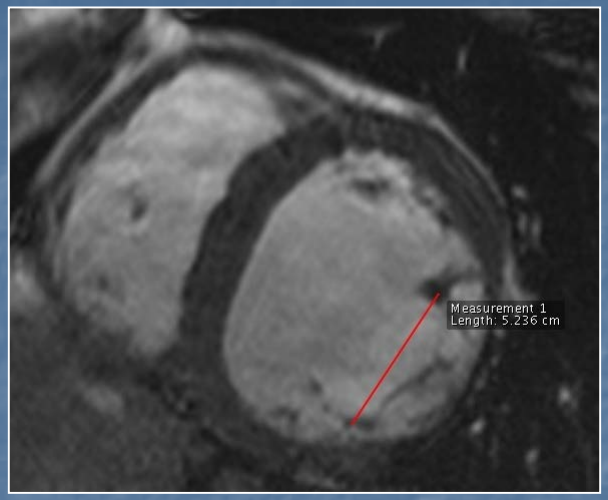


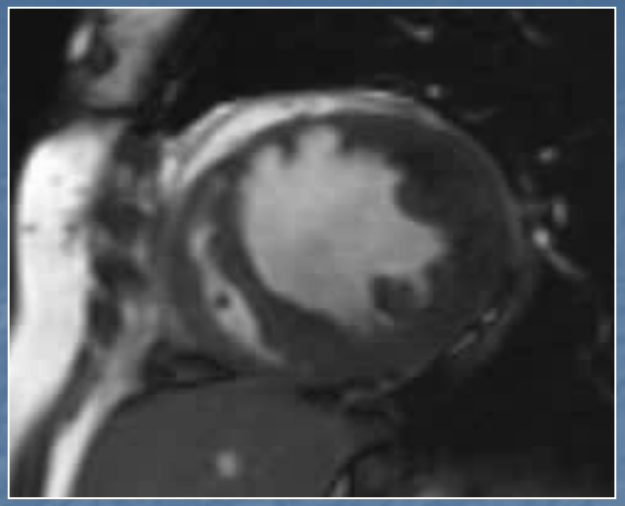
Unfavourable characteristic for MV repair in functional MR

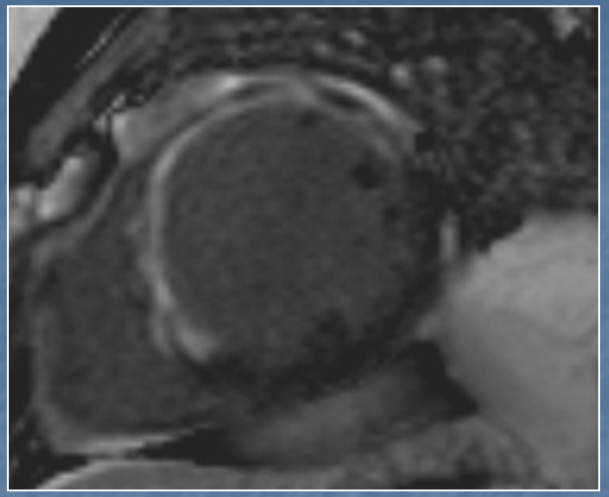
- *Local LV remodelling*
- - interpapillary muscle distance > 20 mm
- - posterior papillary-fibrosa distance > 40 mm
- - lateral wall motion abnormalities
- *Global LV remodelling*
- - EDD > 65 mm, ESD >51 mm (ESV > 140 ml)
- - systolic sphericity index > 0.7

Papillary muscles implication

TPM



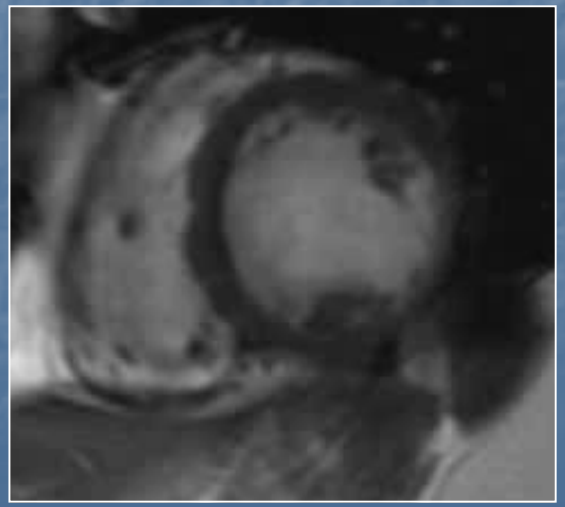


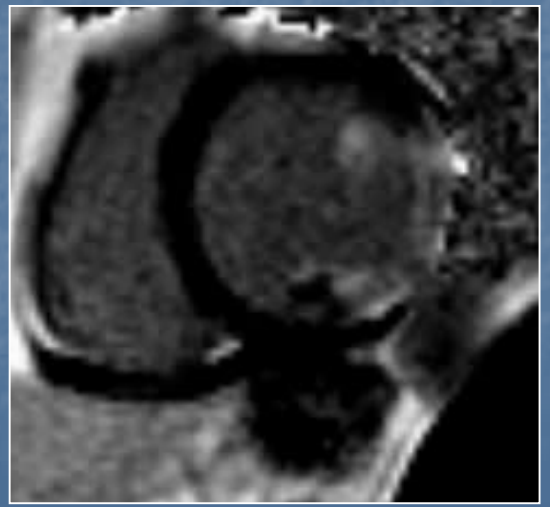


Tips interpapillary distance greater than 32 mm *Yu Hy J Thorac Cardiovasc Surg. 2004*

ASA infarction

BPM





Lateral infarction with increased interpapillary distance after displacement of posterior muscle (TPM- tips papilary distance, BPM- basal papillary distance)

Prognosis

Severe mitral valve disease is characterized by progressive accumulation of interstitial myocardial fibrosis (MF) and impairement of myocyte ultrastructure

The amount of MF and the degree of myocyte degeneration are

inversely related to both LV systolic and diastolic function

LGE and arrhythmia

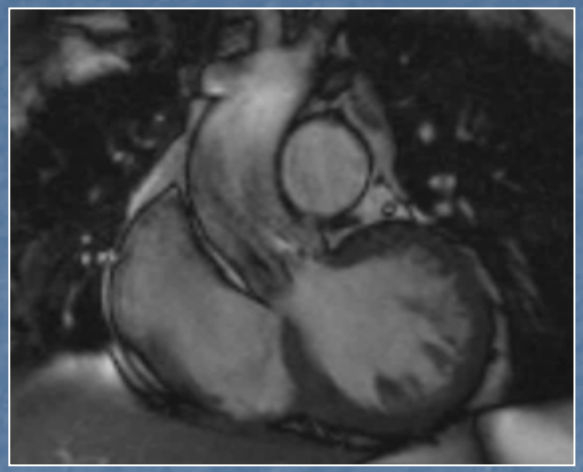
JACC IMAGING 2008

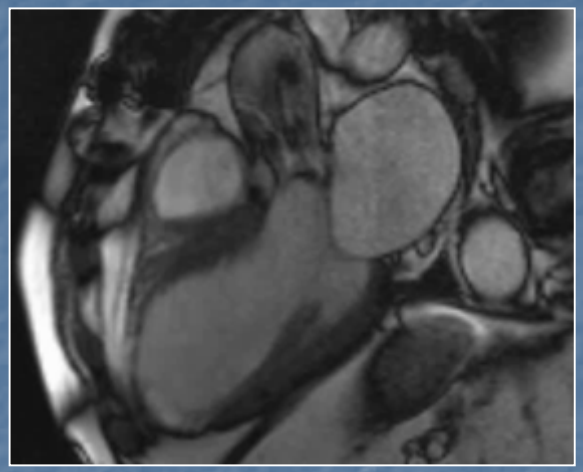
Table 5. LGE and CVA in MVP Patients

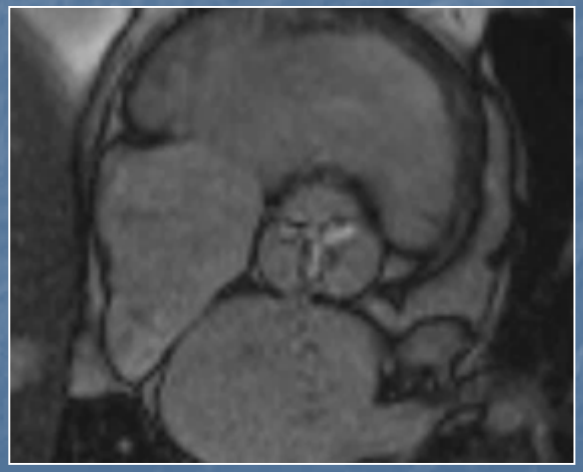
LGE in Papillary Muscle	CVA (≥III)	Non-CVA (0, I)	Total
Yes	8	2	10
No	0	6	6
Total	8	8	16

Using Fisher's exact test, p = 0.007 for papillary muscle LGE and CVA.
CVA = complex ventricular arrhythmia; other abbreviations as in Tables 1 and 4.

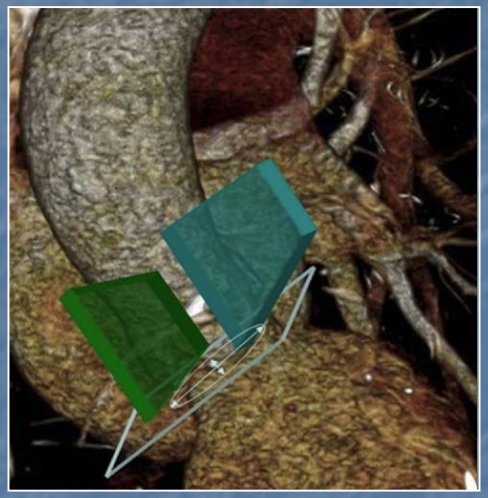
Aortic stenosis

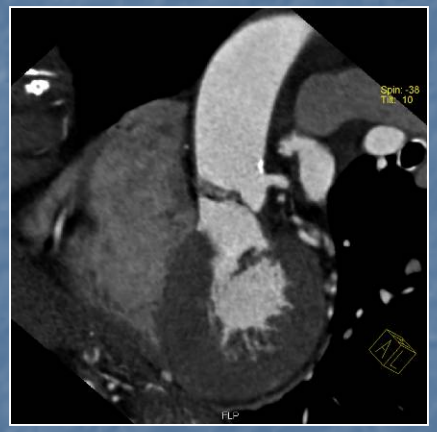


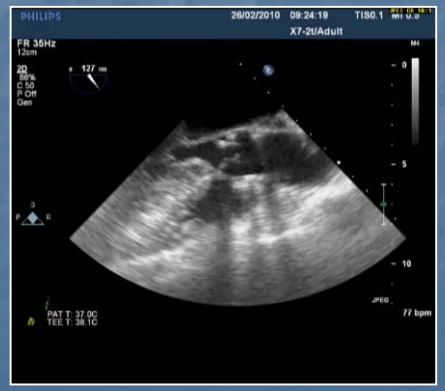


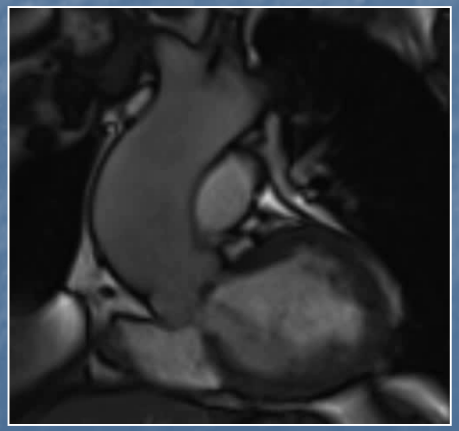


Multimodality assessement of aortic annulus diameter



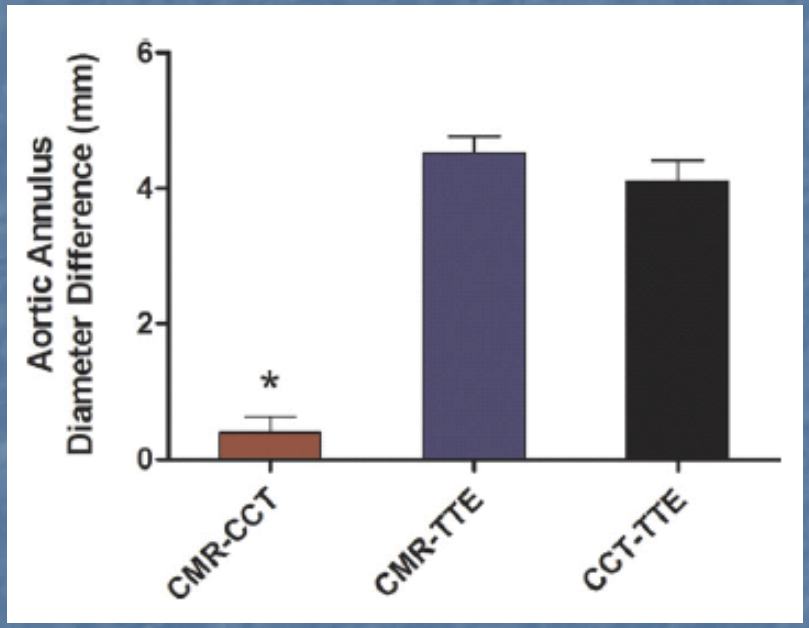






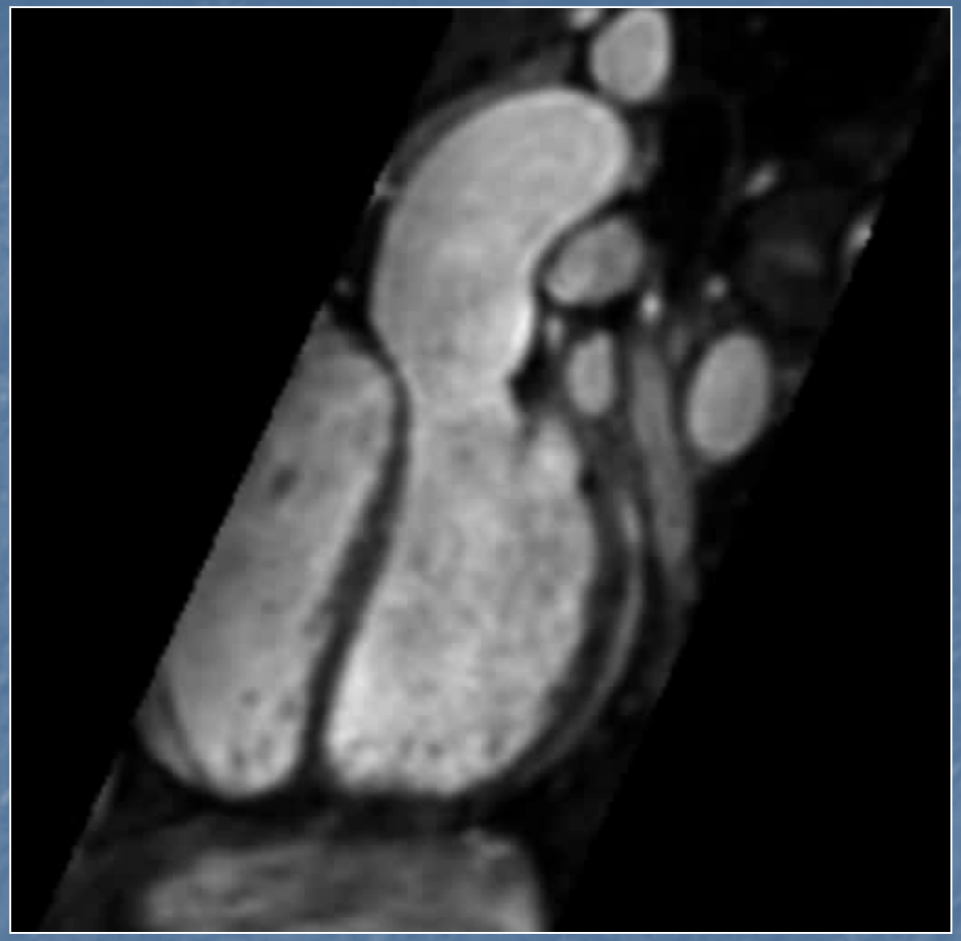
Comparison of bias among imaging modalities

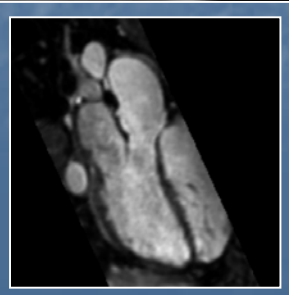
- Aortic root measurements by CMR and MSCT are highly reproducible and show close agreement



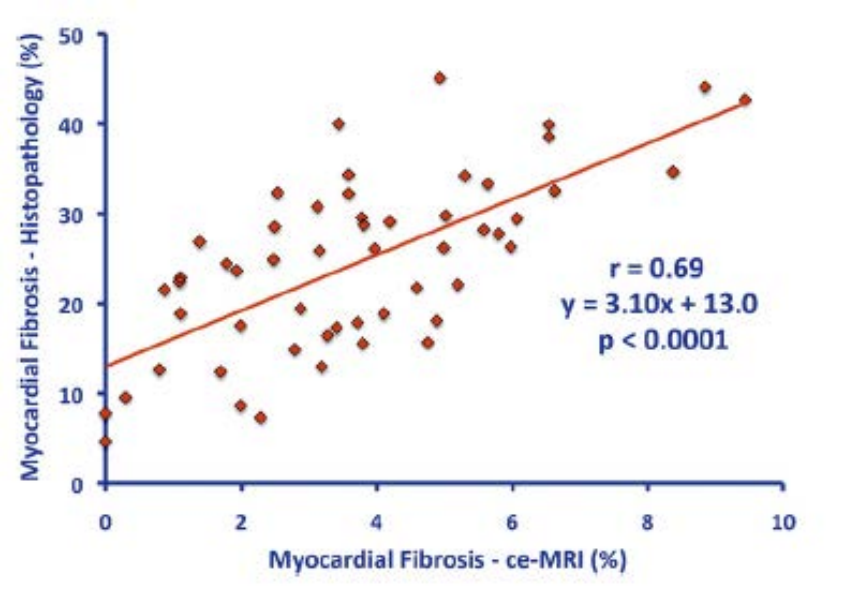
Jacc 2011

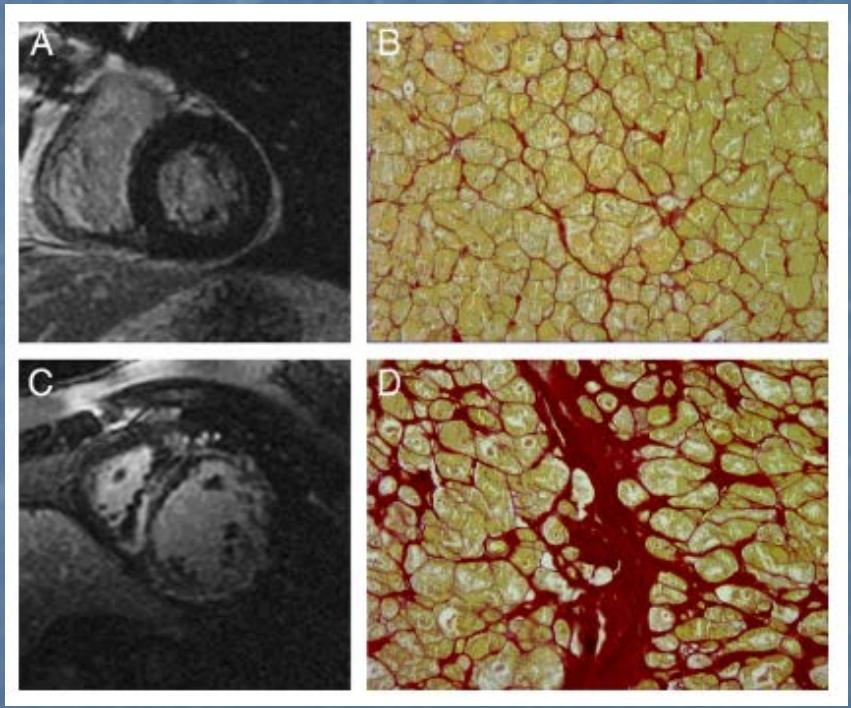
MRI without contrast





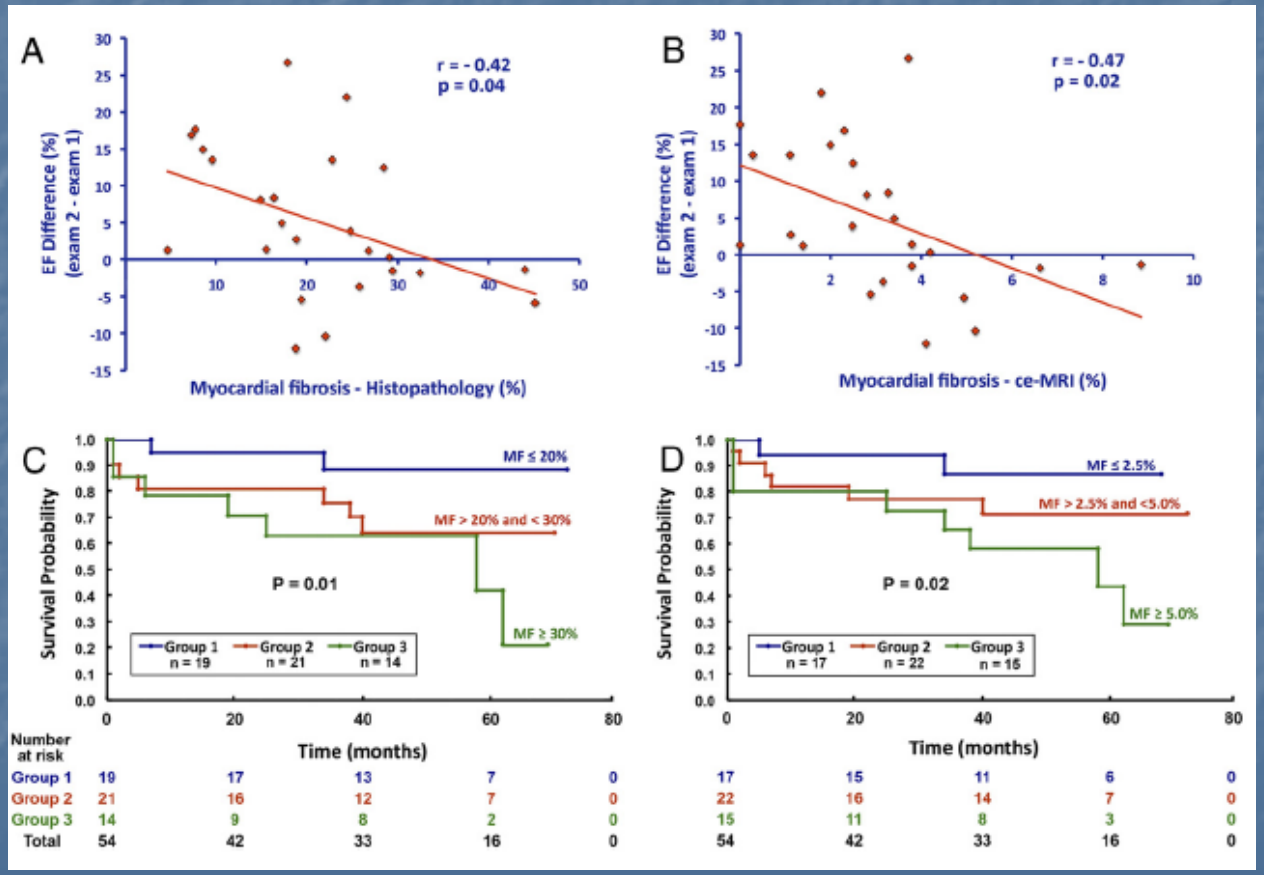
Correlation between myocardial fibrosis by hystopathology and LGE



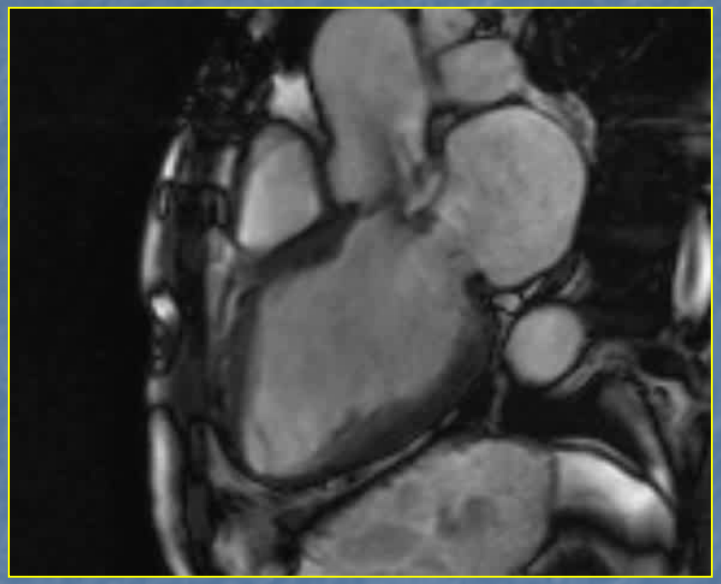


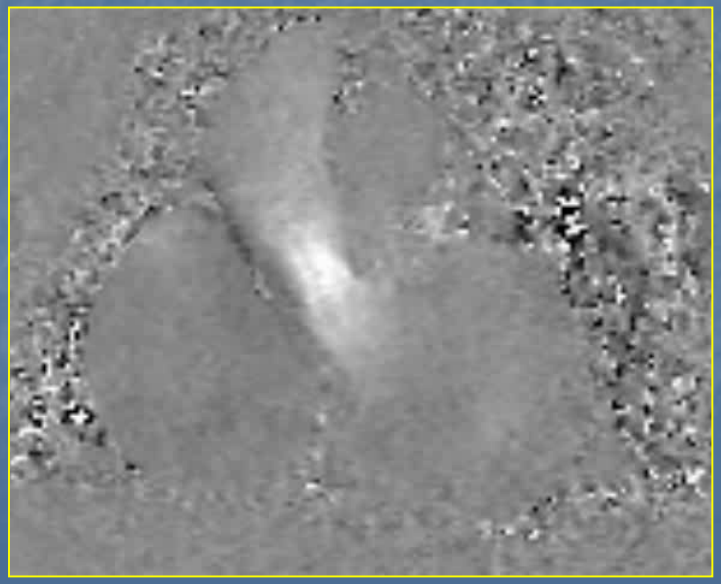
JACC 2010

Relationship between MF and LV functional improvement and survival after AVR



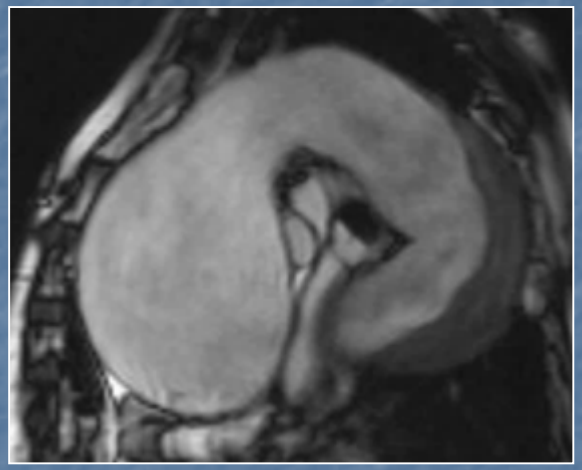
JACC 2010

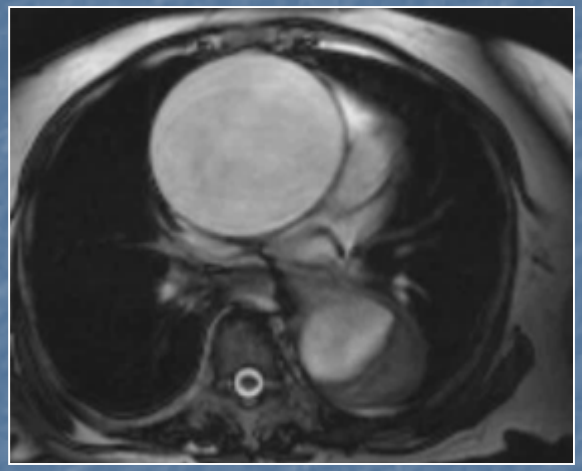


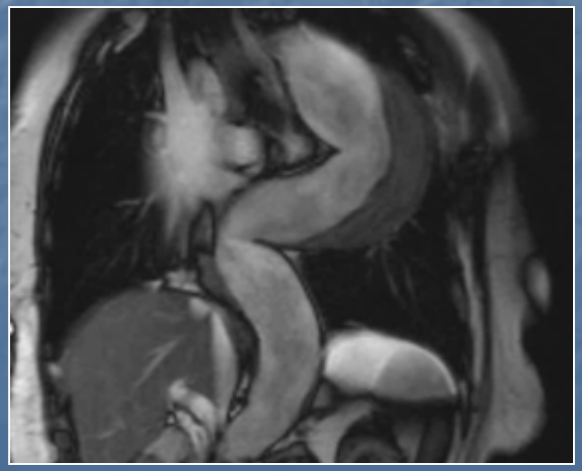


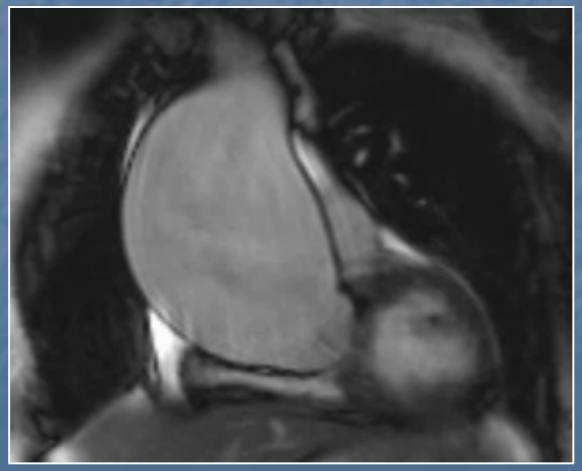
Peri valvular leak

The aorta

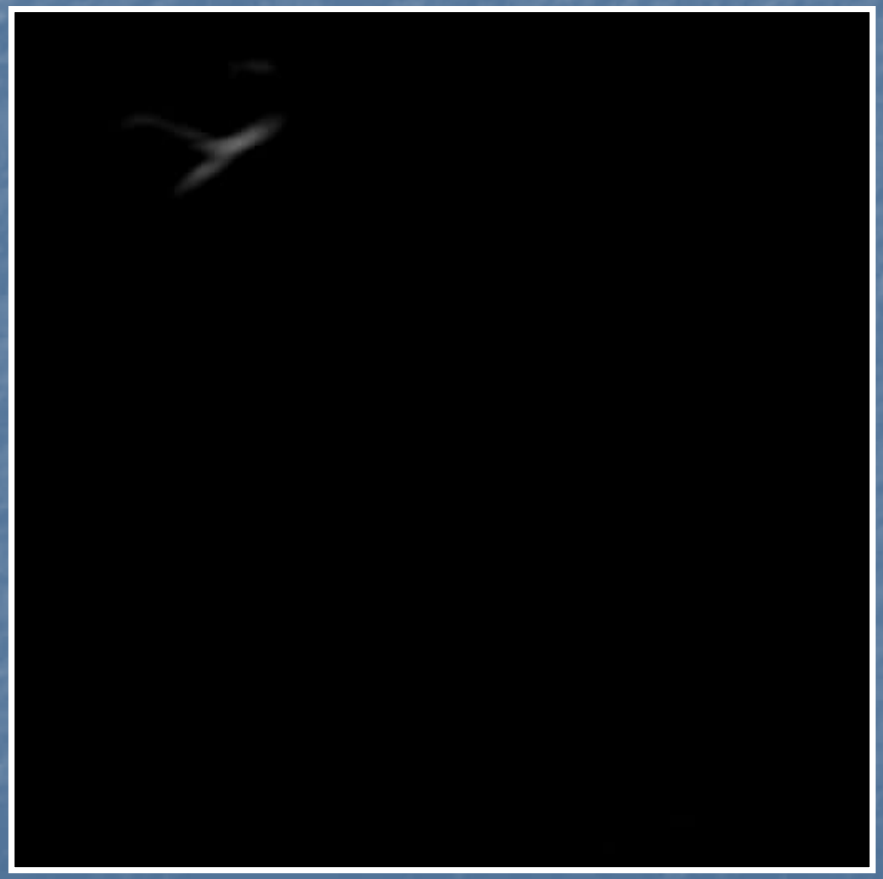




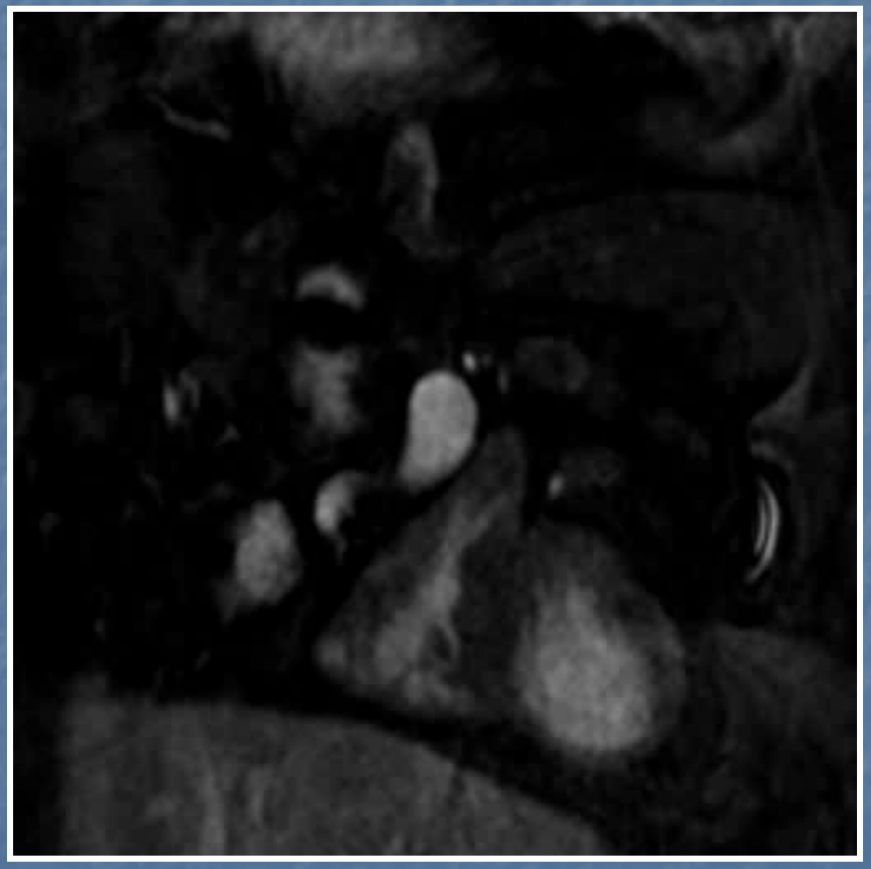




REAL TIME



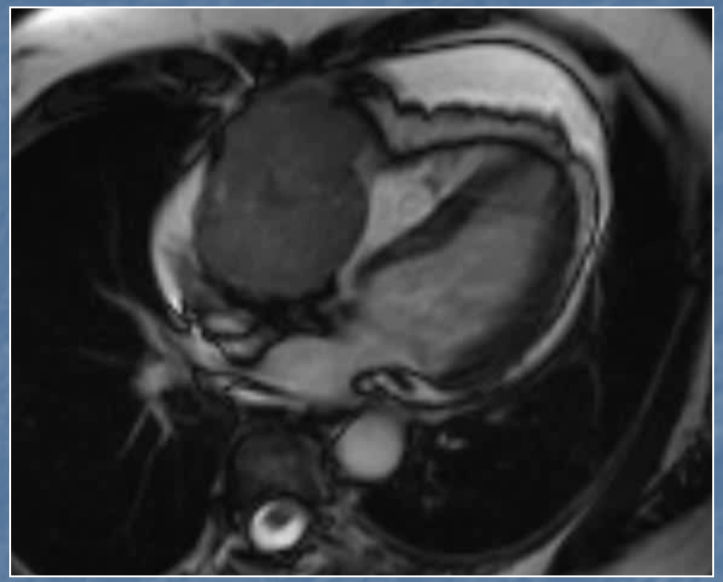
NO CONTRAST

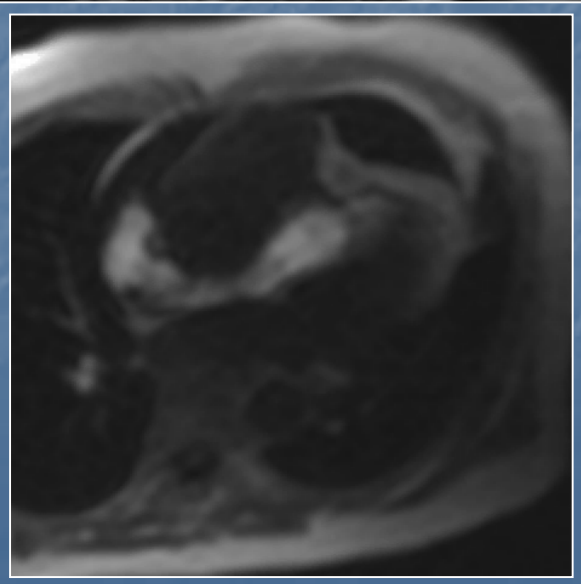


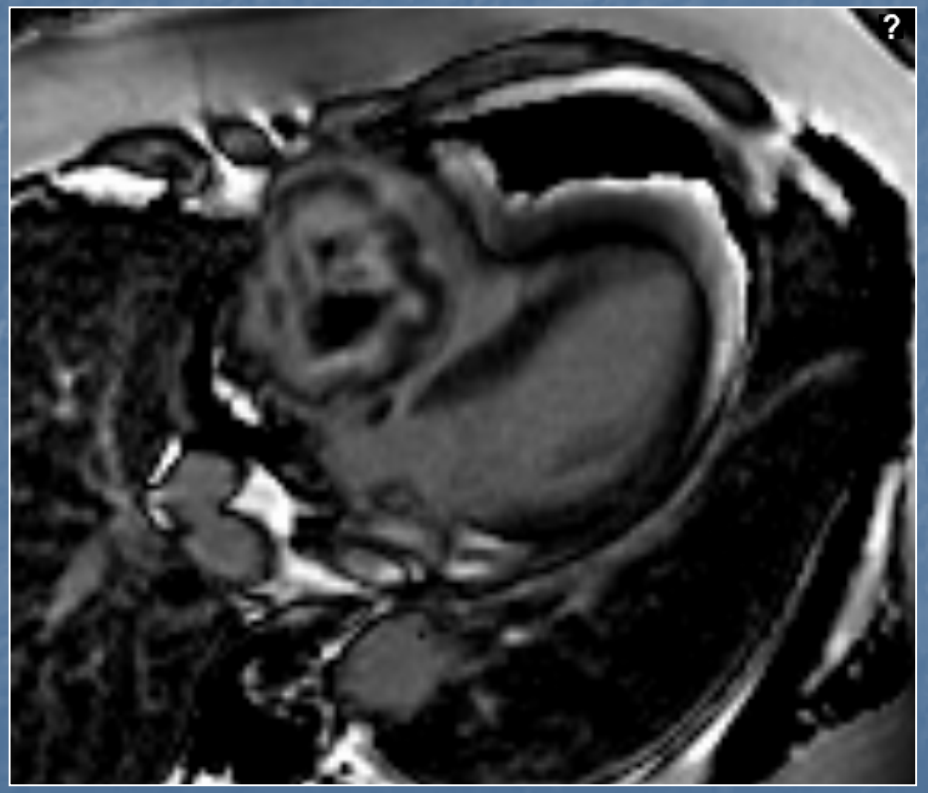
4D flow


PETIT^MARLENE
21401466
^16/01/1978
F, 037Y
1
STUDY MR20150826141125
26/08/2015
15:16:30.82
129 IMA 80
CCM
Skyra
syngo MR E11
HFS
113.10
cm/sec
0.10
cm/sec
*fl3d1_34
t: 0 msec
Cardiac Cycle: 1
TR 314.5
TE 1.5
*fl3d1_34 / 20.00
SIEMENS

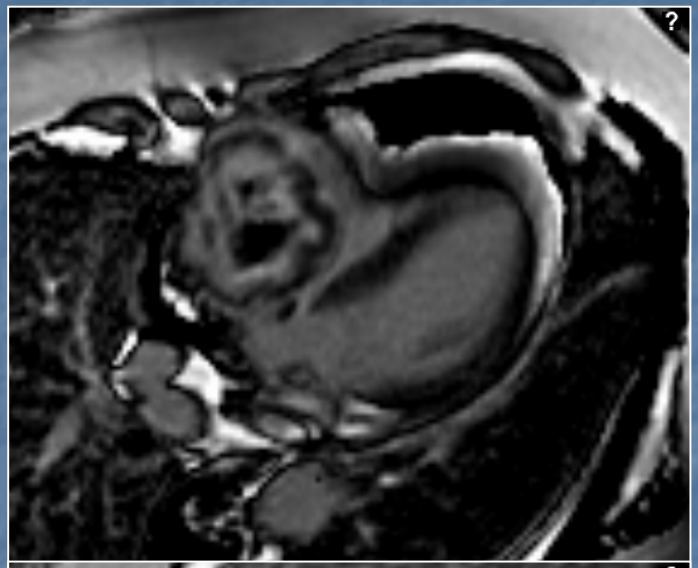
The masses







PARAGANGLIOMA



CONGENITAL

- CHD represent 7 to 19 of 1000 live births

- Success of pedriatic cardiology and cardiac surgery *increases number of adults with CHD* (more than 2000 new pts./year in France)

- Management:

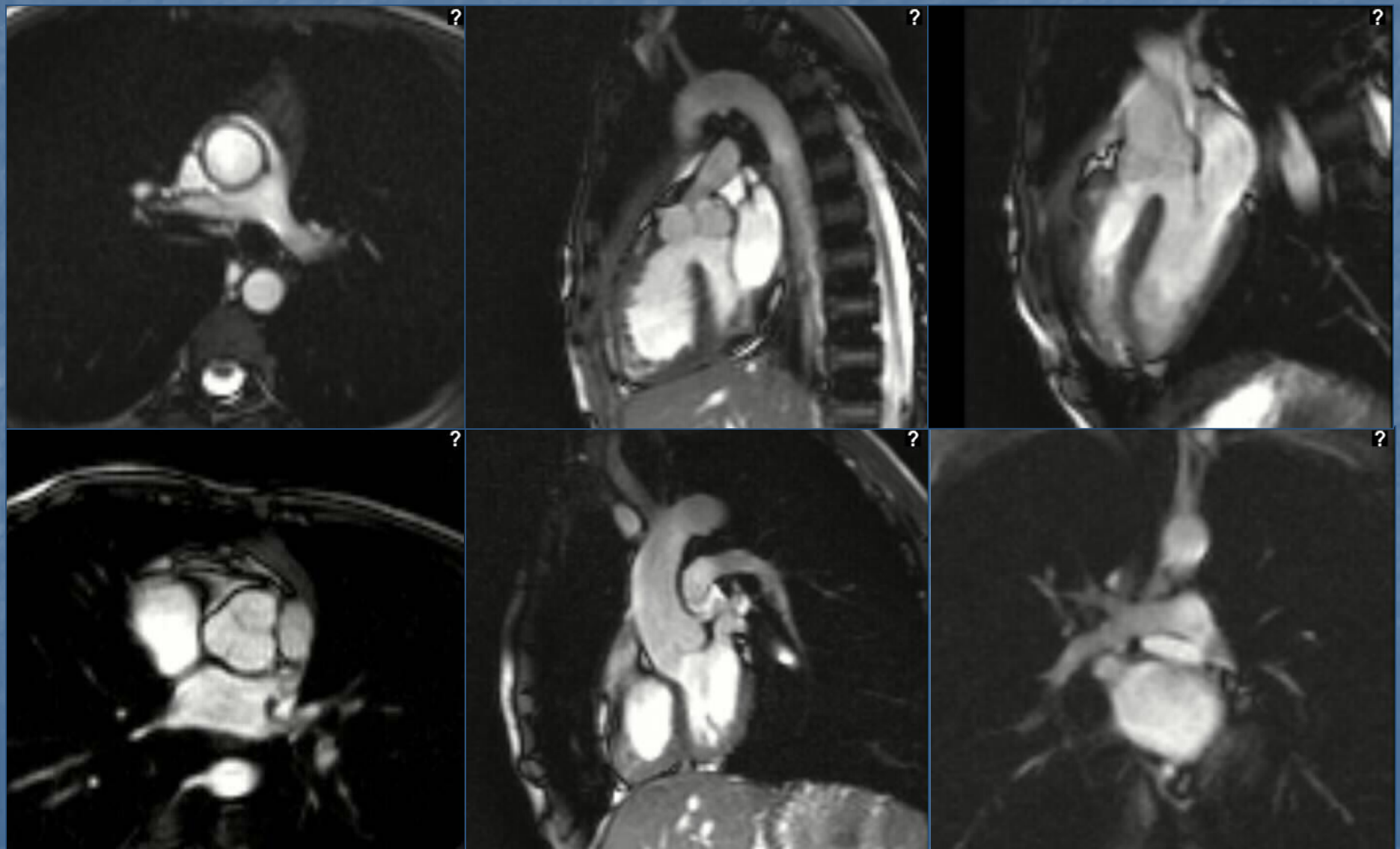
  Multidisciplinary: pediatric cardiologist
  cardiac surgeon

  Imaging play a fundamental role

  - limitations of TTE → CMR (no X ray → repeat)
  - alternative to cath lab

Tetralogy of Fallot

Pre operative study

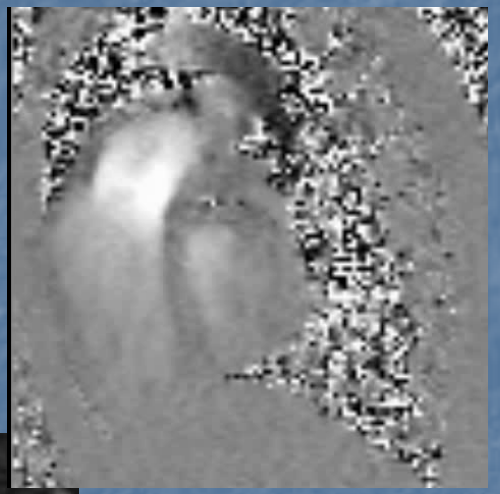


Tetralogy of Fallot

Post operative follow-up:

- timing of surgical intervention

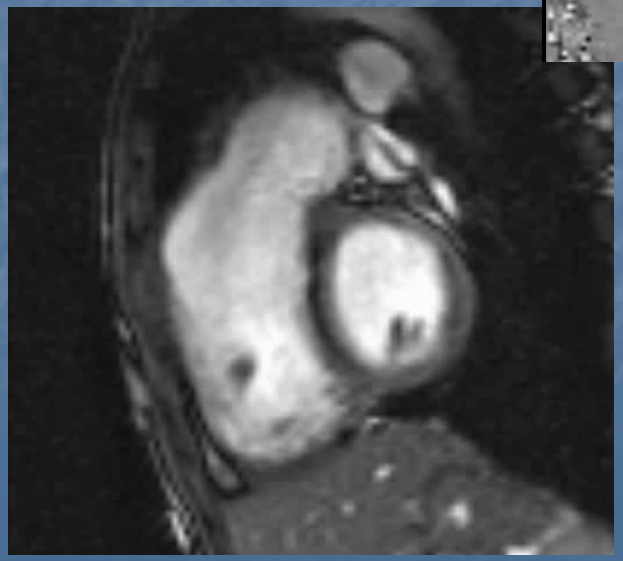
-Pulmonary regurgitation



-Re-intervention (pulmonary prosthesis) if

RVEDV > 160 ml/m²

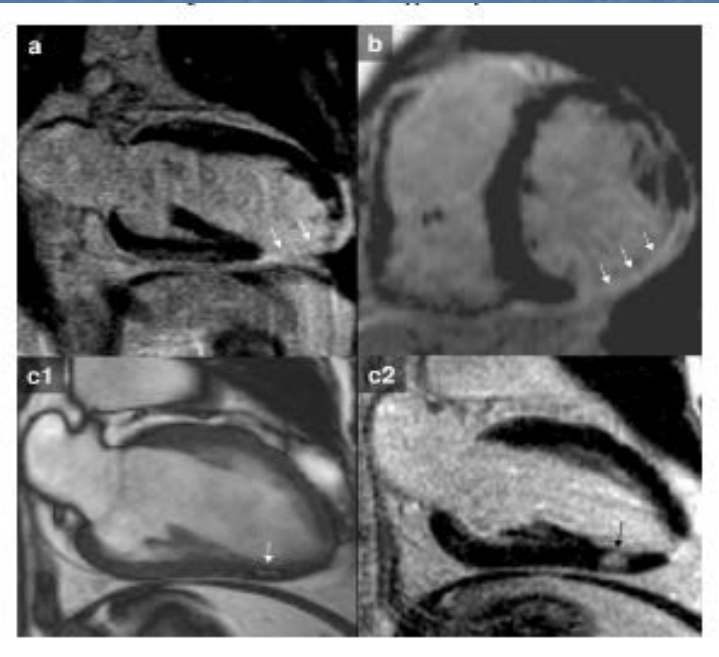
RVESV > 80 ml/m²

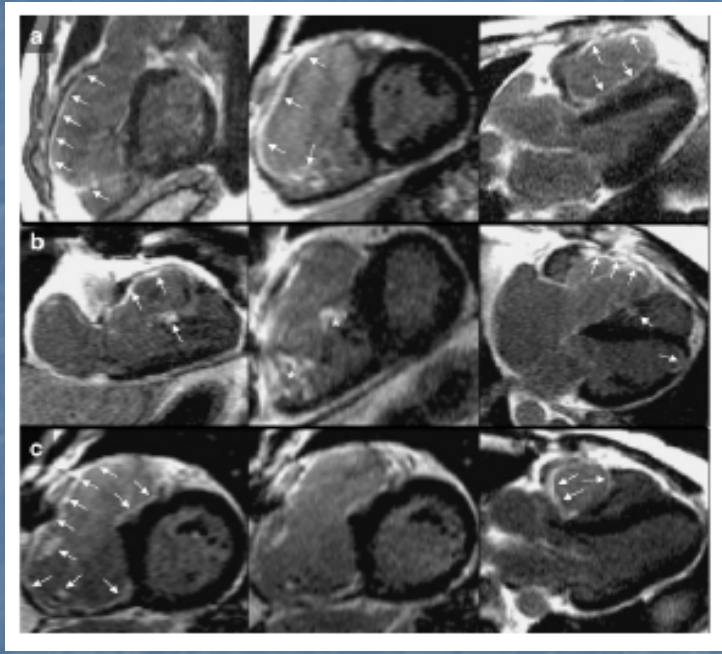


-Anatomy of pulmonary branches

RF 63%

Tetralogy of Fallot

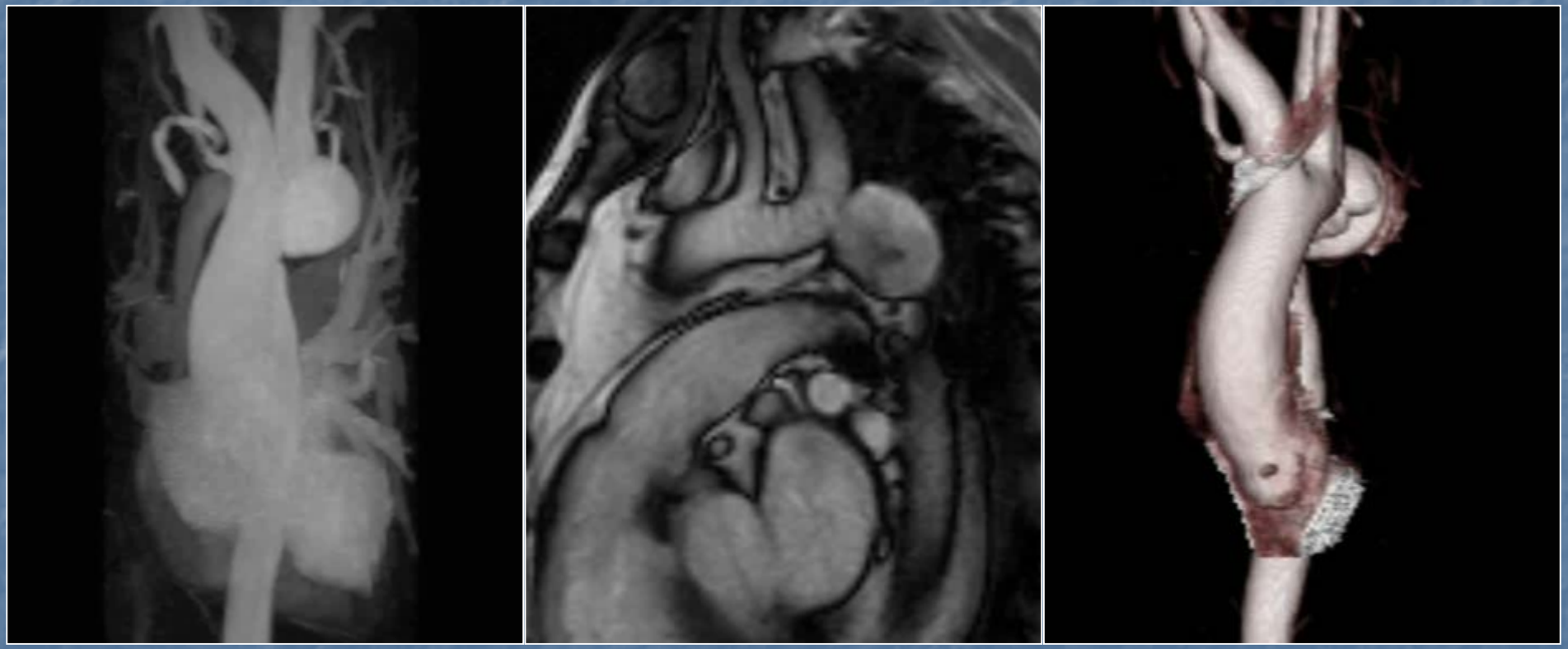




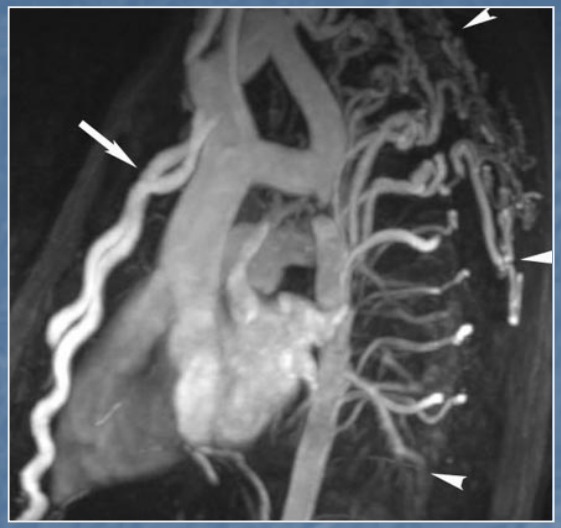
Ventricular fibrosis like a marker of adverse clinical outcome

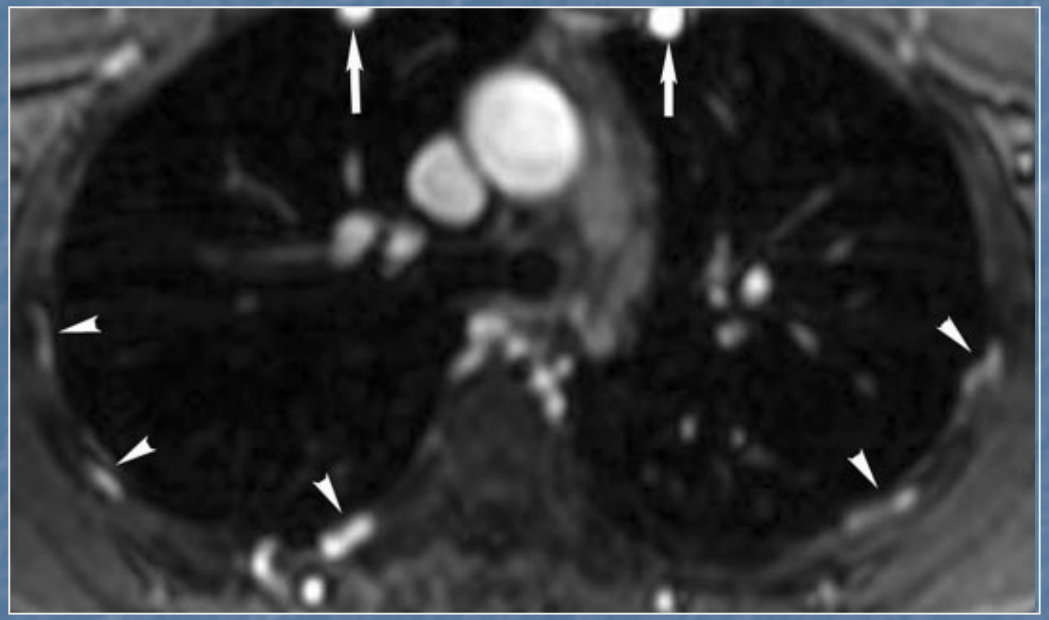
CIRC 2008

The PRE OP evaluation of an aortic coarctation

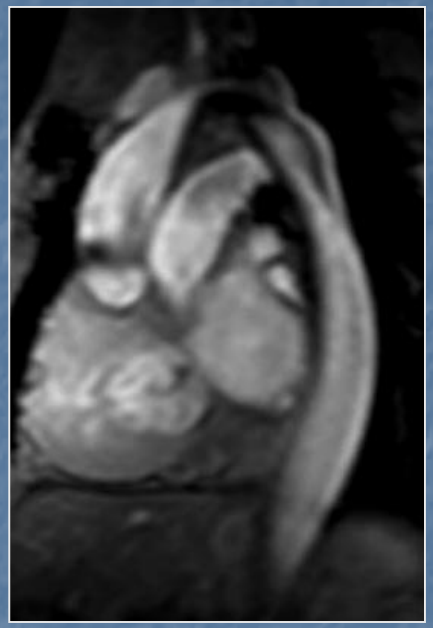


identifying collateral circulation





estimating pressure gradients



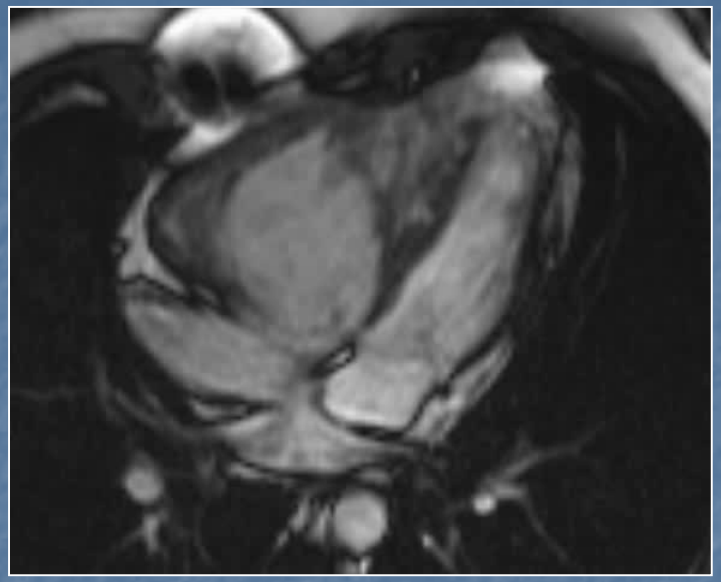
Transposition of great arteries

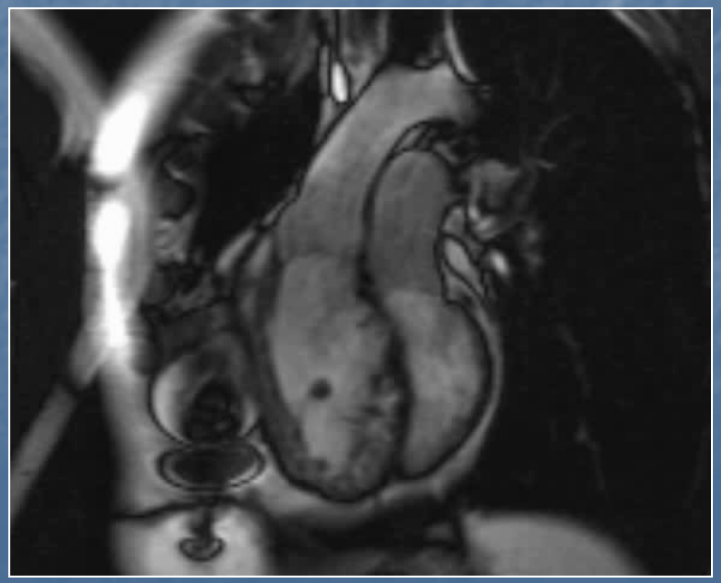
Mustard intervention

Arterial switch

Mustard for TGA

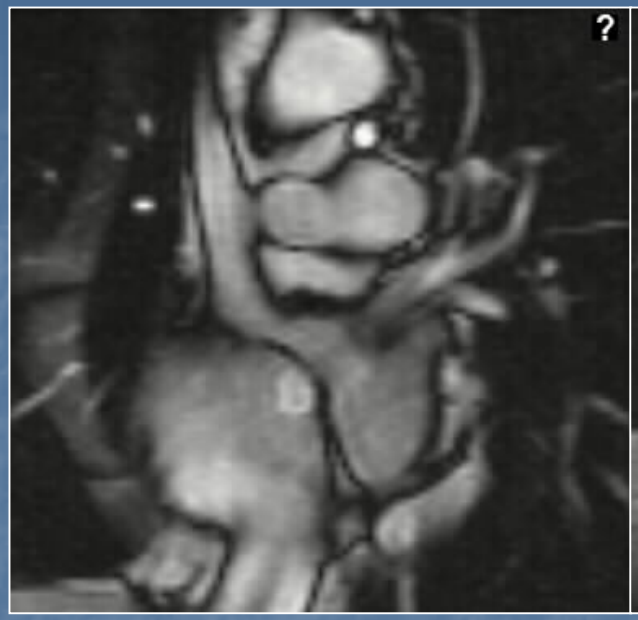
- 34 y man
- Mustard at 1y
- asymptomatic





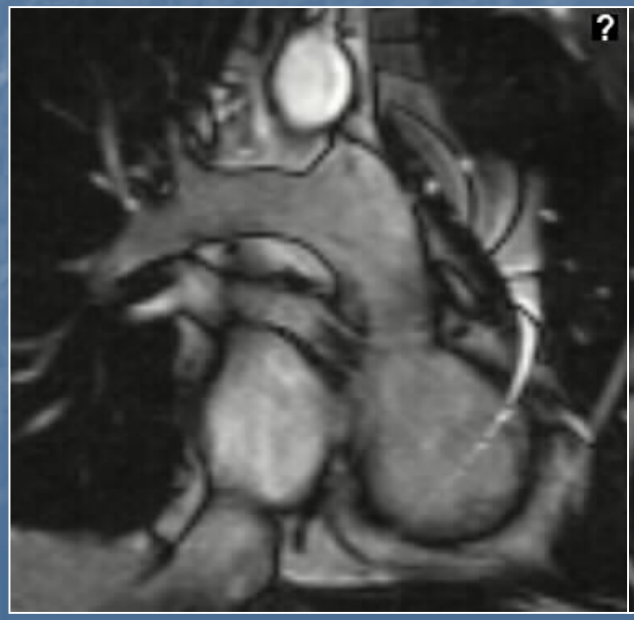
RV:
EF 42%
EDVI 110 ml/m²
ESVI 64 ml/m²

SVC-LA connexion

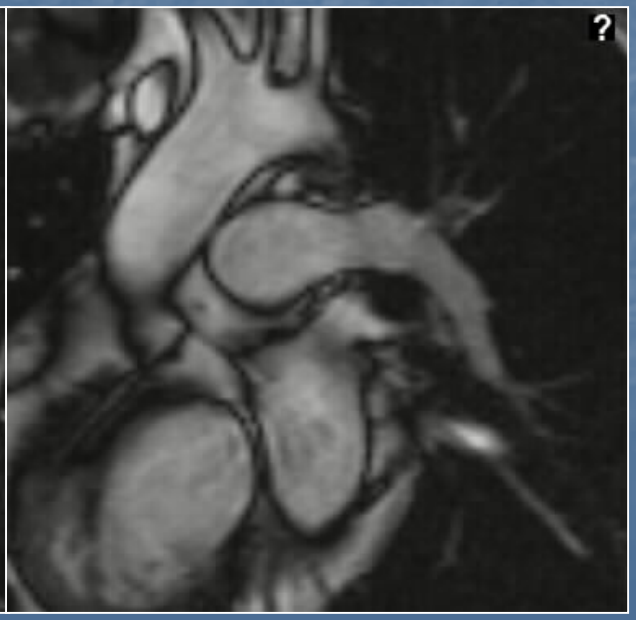


IVC-LA connexion

Pulm VV – RA connexion



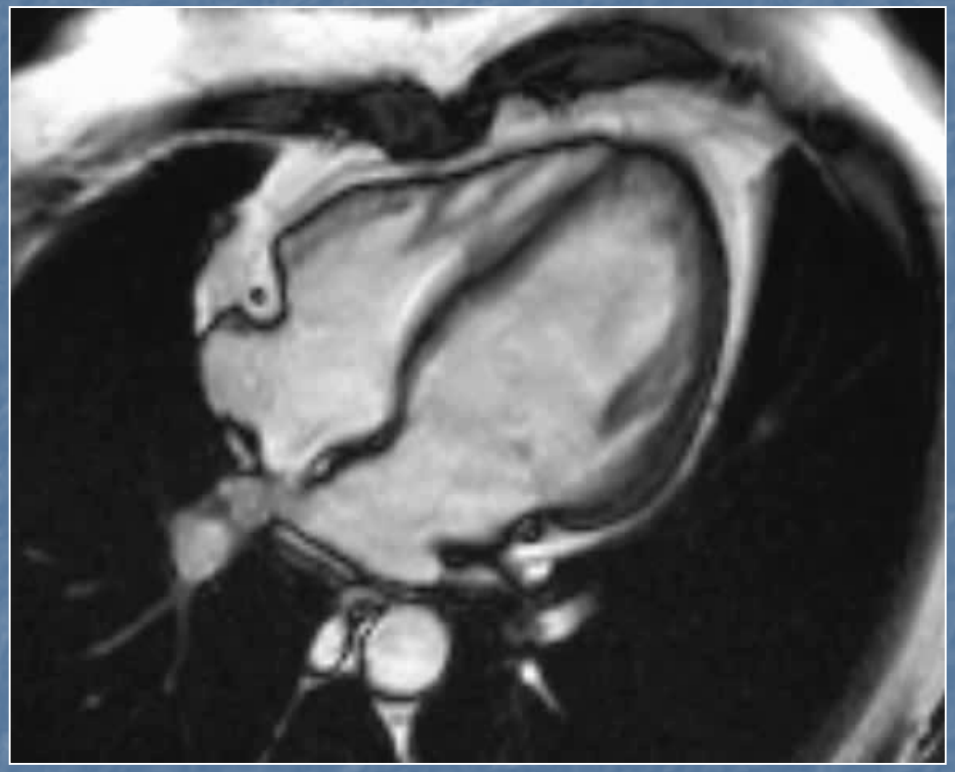
RPA



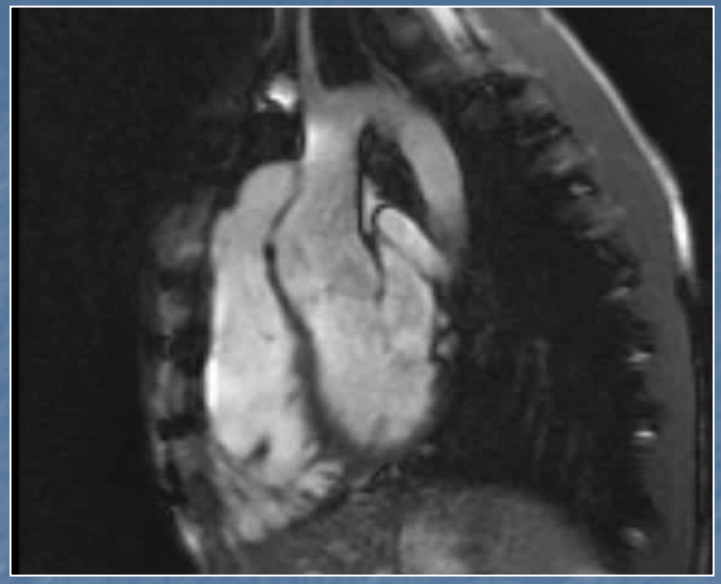
LPA

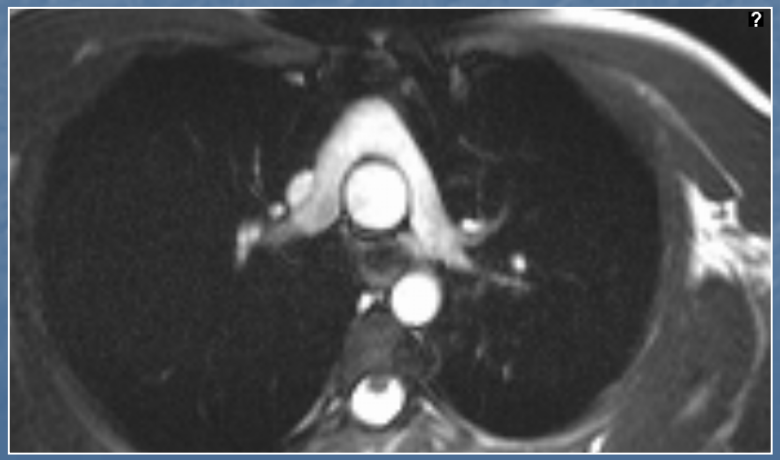
Study of baffles, connections and pulmonary arteries stenosis

TGA: arterial switch



Follow the LV and RV volumes and EF





FOLLOW:

-Pulmonary and aortic valve

-Valsalva and PA dilation

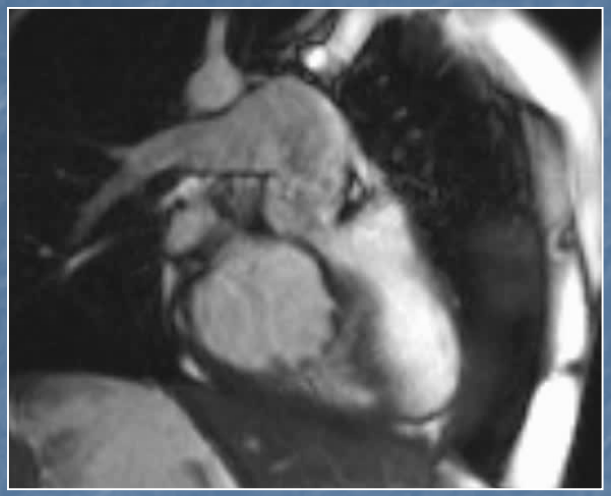
-Lecompte manoever

UNIVENTRICULAR HEART : 14 y, girl

Study of residual pulmonary stenosis and sub-aortic gradient: 50 mmhg

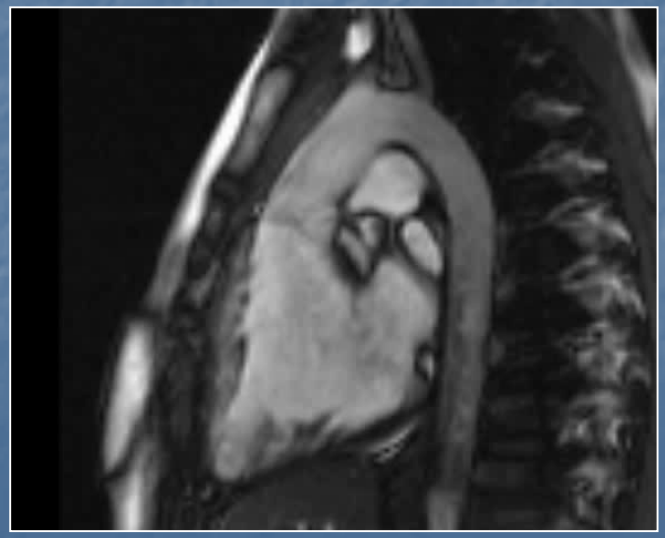
DOUBLE DISCORDANCE

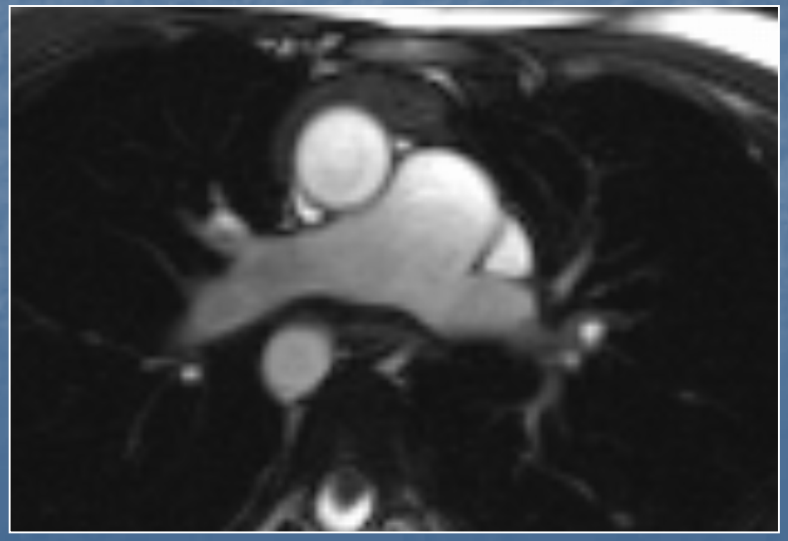
-Fonction of systemic right ventricle
-Study of tricuspid regurgitation
-Study of pulmonary branches



LV-pulm

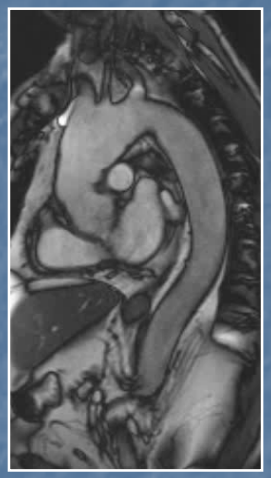
RV-aorta

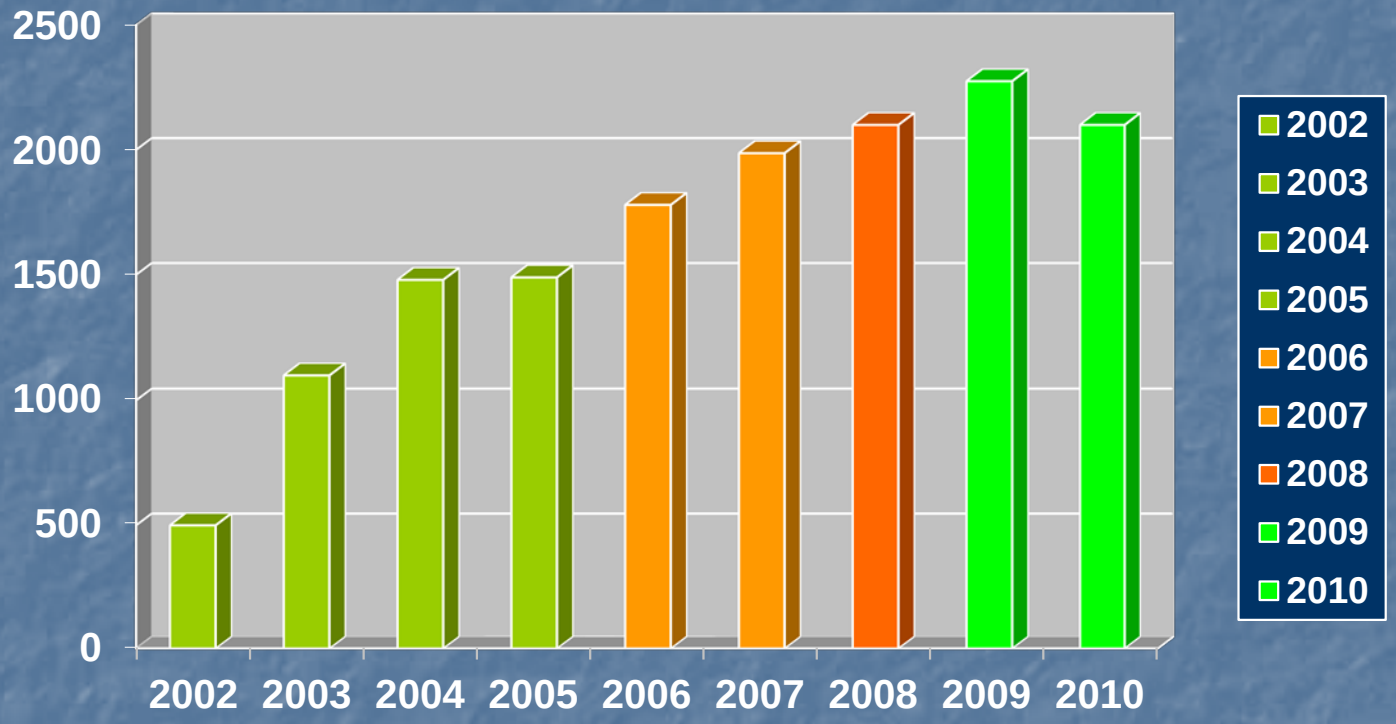


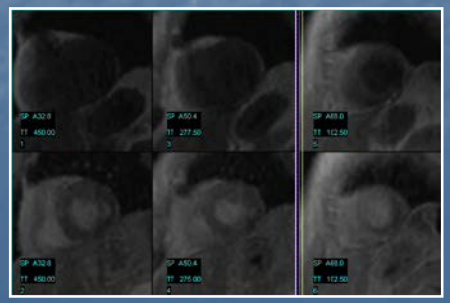


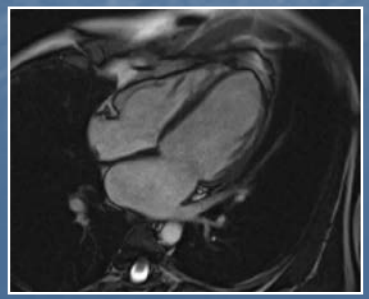
TAKE HOME MESSAGES

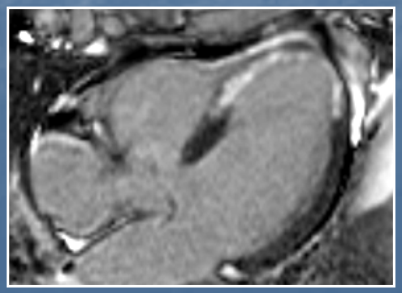
NEW DIAGNOSTIC AND PROGNOSTIC TOOL



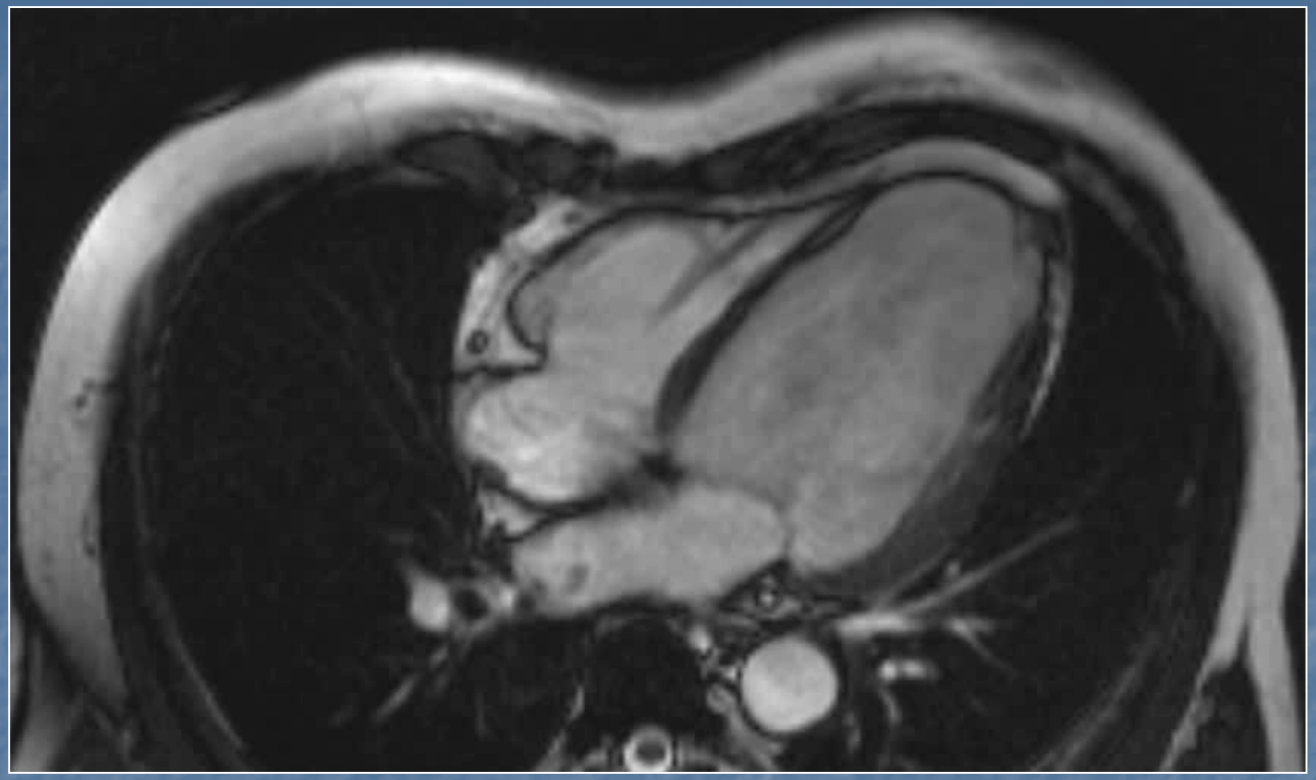








Cardiovascular Magnetic Resonnance (CMR)



The Anatomy,

The Function,

The Perfusion

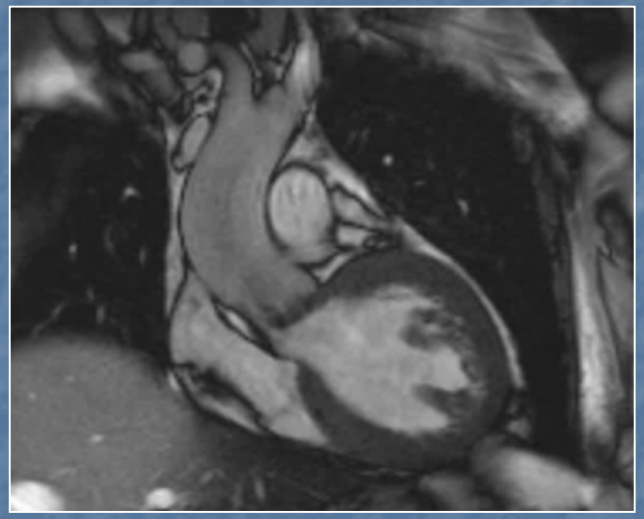
The Viability

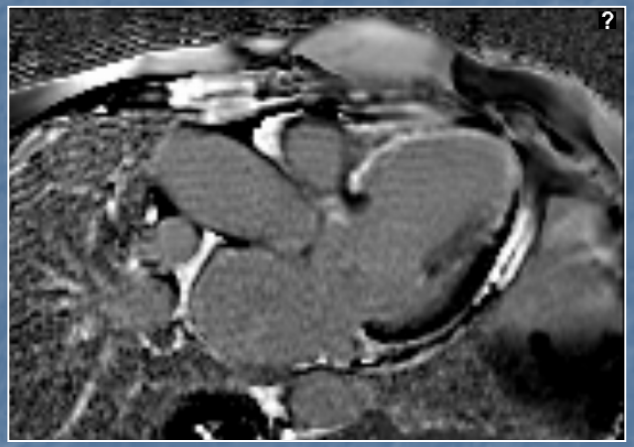
The Scar

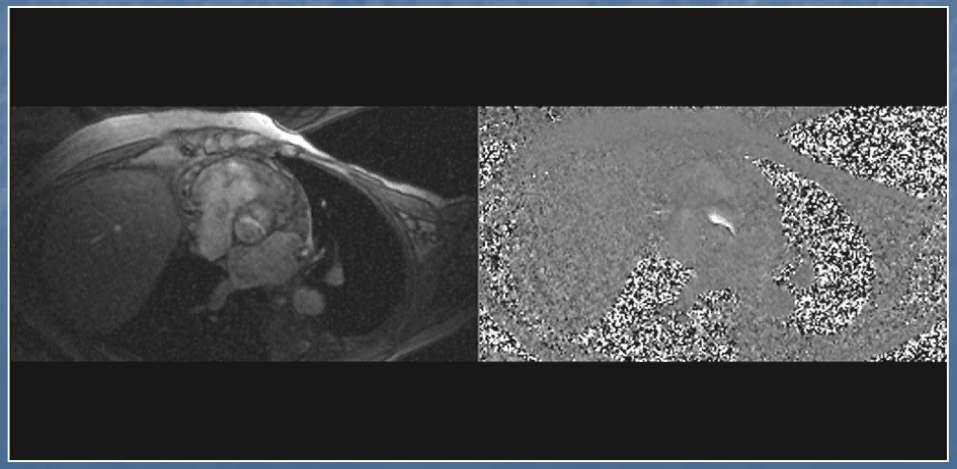
LVEF 24 %, EDVI 148 ml/m², ESVI 112 ml/m², 6 years after LAD recanalization

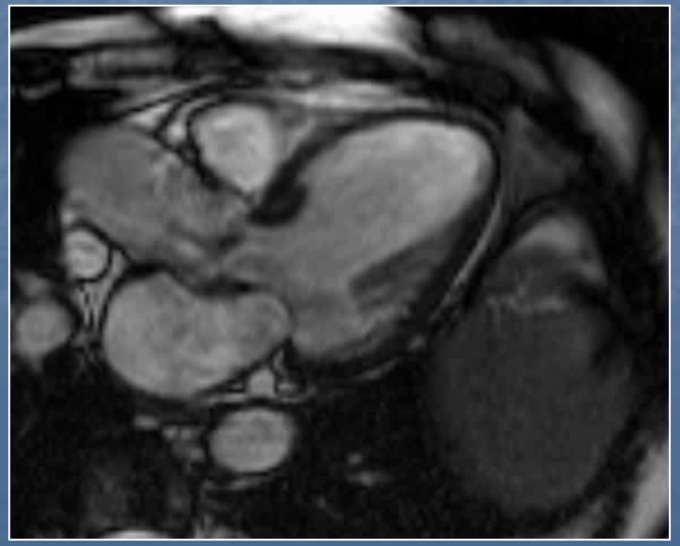
- Clinical indications for CMR : consensus panel report. D.J. Pennell, & al. : *European Heart Journal (2004) 25,1940-65*

COMBINED MODALITIES









CMR is safe

Table 2 Complications related to no stress vs. stress CMR

	All (n = 27396)		No stress (n = 17136)		Stress (n = 10228)	
Complications						
None	96.3%	(n = 26395)	98.6%	(n = 16893)	92.6%	(n = 9476)
Mild	3.6%	(n = 994)	1.4%	(n = 243)	7.3%	(n = 745)
Severe	0.0%	(n = 7)	0.0%	(n = 0)	0.1%	(n = 7)

Values are **%** (n).

No patient died for CMR

Bruder *et al. Journal of Cardiovascular Magnetic Resonance* 2013, **15**:9
http://www.jcmr-online.com/content/15/1/9

Journal of Cardiovascular Magnetic Resonance

RESEARCH Open Access

European cardiovascular magnetic resonance (EuroCMR) registry – multi national results from 57 centers in 15 countries

Impact of CMR on patient management

		N or quartiles
All	100%	27781
Completely new diagnosis not suspected before	8.7%	2354/27006
Therapeutic consequences		
Change in medication	25.0%	6689/26743
Invasive procedure	16.8%	4510/26778
Hospital discharge	10.2%	2738/26771
Hospital admission	1.4%	386/26780
Impact on patient management (new diagnosis and/or therapeutic consequence)	61.8%	16677/27006

Values are % (n).

In 2/3, patient's management changes after CMR

Bruder *et al. Journal of Cardiovascular Magnetic Resonance* 2013, **15**:9
http://www.jcmr-online.com/content/15/1/9

Journal of Cardiovascular Magnetic Resonance

RESEARCH Open Access

European cardiovascular magnetic resonance (EuroCMR) registry – multi national results from 57 centers in 15 countries

Additional diagnostic procedure avoided due to results of CMR

Table 6 Additional diagnostic procedures avoided due to results of CMR

	All (n = 27025)		No stress (n = 16526)		Stress (n = 10113)	
Invasive angiography	24%	(n = 6483)	11.6%	(n = 1921)	45%	(n = 4555)
Nuclear (SPECT/PET)	20.6%	(n = 5574)	9.8%	(n = 1624)	39%	(n = 3946)
Coronary CT	11.8%	(n = 3182)	5.9%	(n = 976)	21.8%	(n = 2202)

Values are % (n).
PET Positron emission tomography.

In 45% cases invasive coronarography could be avoided

Role of CMR stress testing as a gatekeeper for invasive angiography


Bruder et al. Journal of Cardiovascular Magnetic Resonance 2013, 15:9
http://www.jcmr-online.com/content/15/1/9

Journal of Cardiovascular Magnetic Resonance

RESEARCH Open Access

European cardiovascular magnetic resonance (EuroCMR) registry – multi national results from 57 centers in 15 countries

Impact of CMR on patient management in clinical routine

Integrating CMR in clinical routine does not increase the overall costs of patient care, but reduces costs between 11% and 65% in most cases

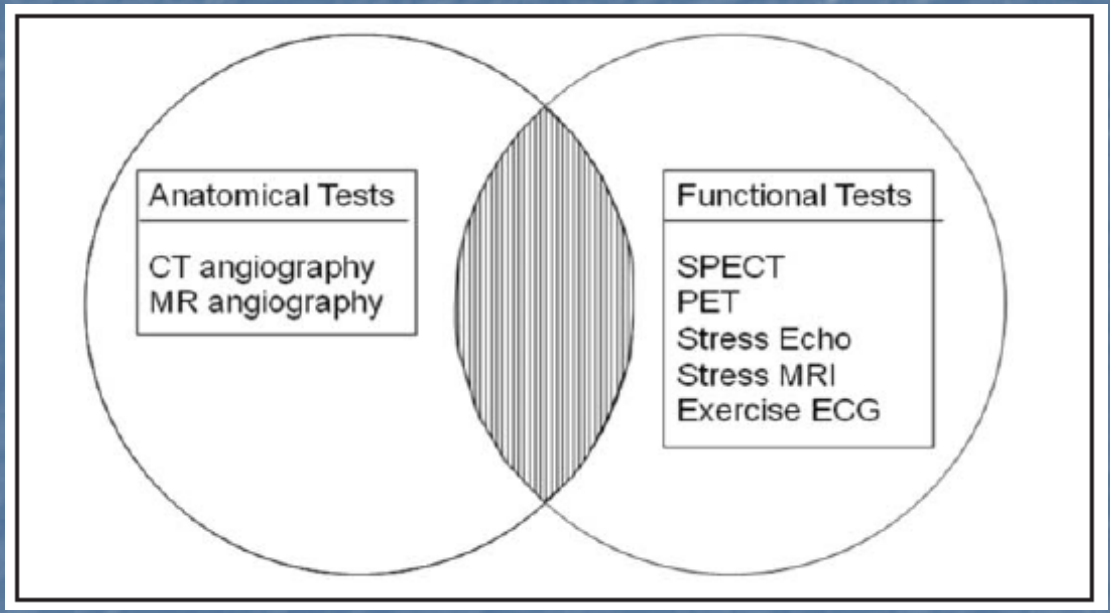
CARDIAC IMAGING MODALITIES
Selecting the best test !

- What's the patient's *DIAGNOSIS* ?
- *Likelihood of having CAD*

- What's the patient's *PROGNOSIS* ?
- *Risk of future CV events*

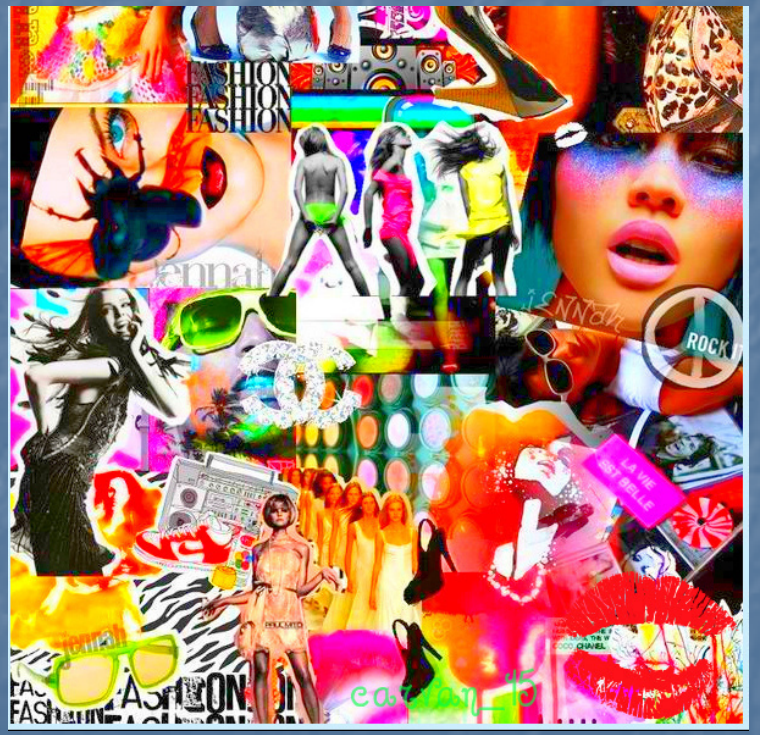
CARDIAC IMAGING MODALITIES

Selecting the best test !



THE CHOICE: depends on the clinical question at hand

Fashion victims !



Thank for your attention

Centre Cardiothoracique de Monaco

MRI and CONTRAST AGENTS

- Frequency of all adverse events ranges from 0.07 to 2.4 %
- **Allergic reactions** from 0.004 to 0.7 %
- Breast feeding mothers and pregnant pts.
- **Chronic severe renal insufficiency**

  (GFR < 30 ml/min/1.73m2)
- **Nephrogenic systemic fibrosis (NSF)**

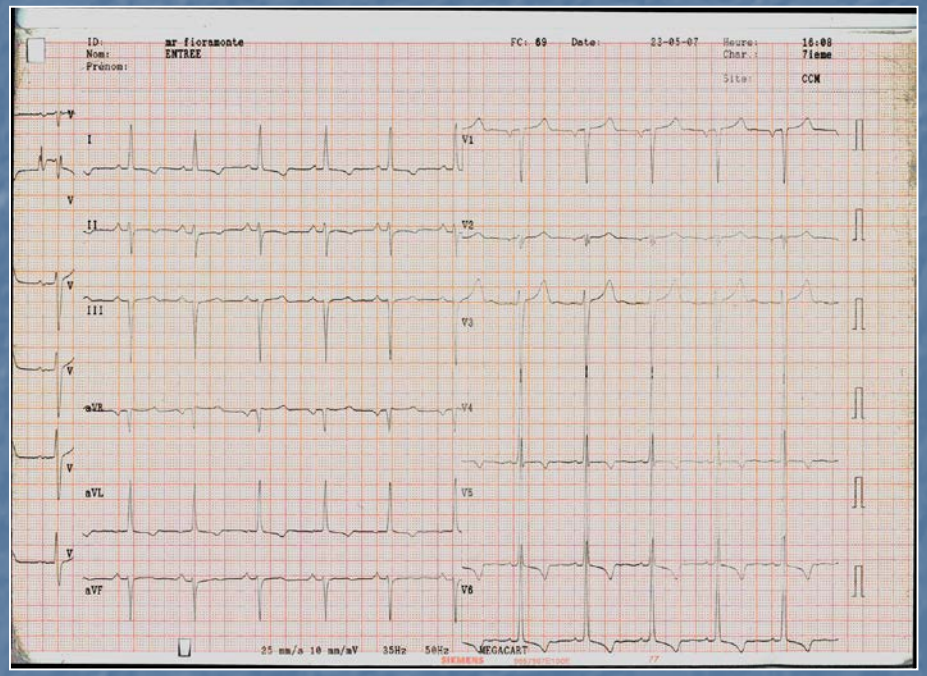
Nephrogenic systemic fibrosis (NSF)

- Systemic fibrosing disorder ; visible effects of the skin, muscle hardening and or weakness, burning, itching or severe sharp pain in areas of involvement
- Male = female, children and elderly
- No definitive cure
- Develops in 90% in the first 6 months after the last exposure to Gd
- Progressive disease and can be fulminant in 5% of cases and can be fatal

Case 6

Male 65 y, acute chest pain, ECG ?, troponine < 0.5

BP 190-110



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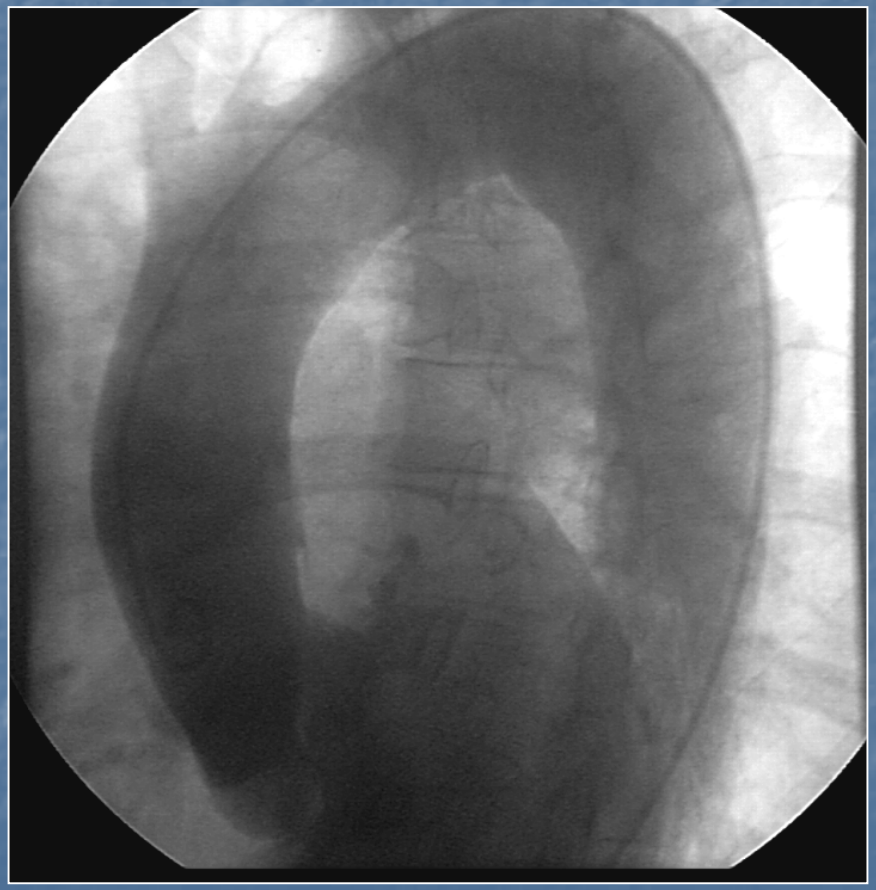
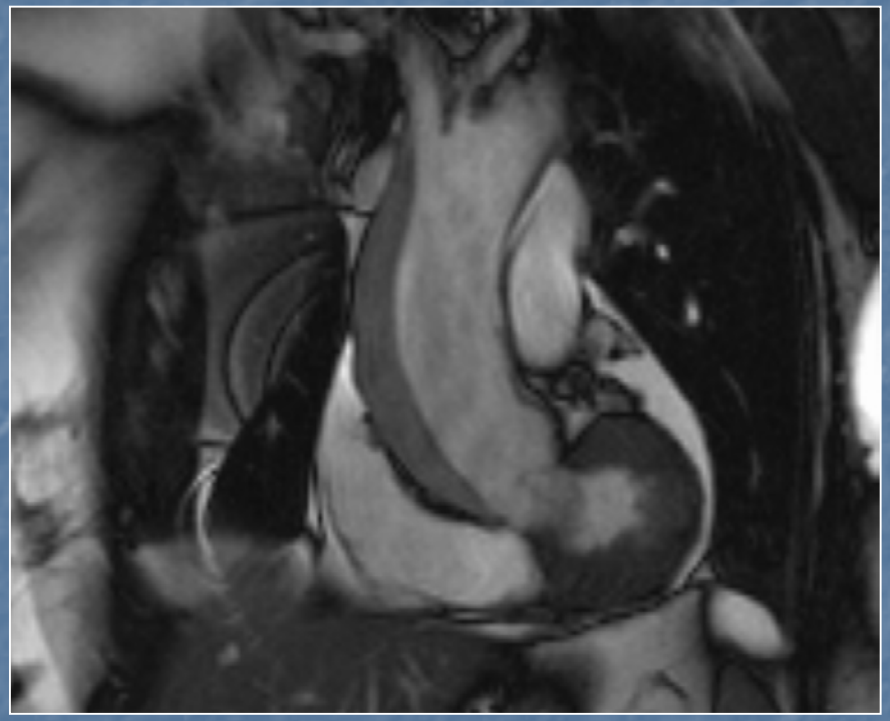
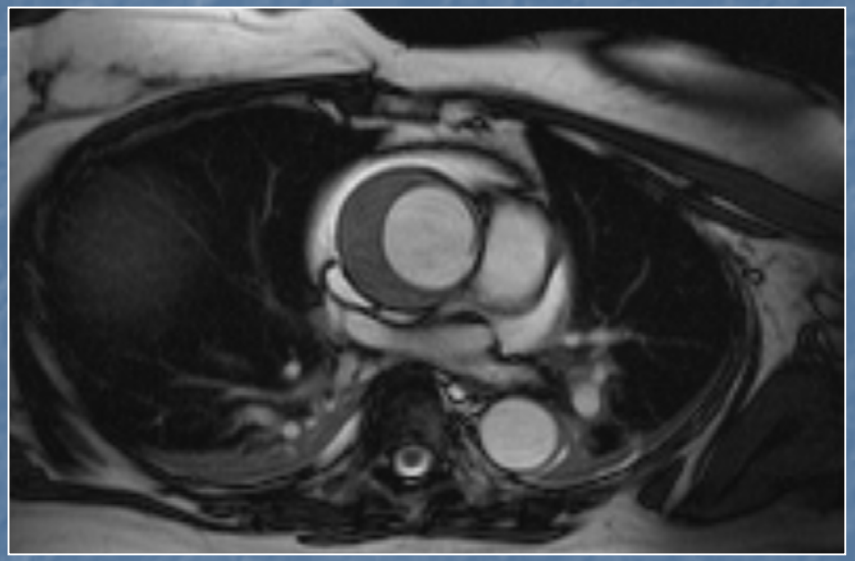


MRI





CORONARY

Coronary artery disease

- Identifying coronary anomalies and aneurysm
- Determining coronary artery patency
- Identifying pts. with multivessel disease
- Advantages: no X ray (children and young pts.) and iodinate contrast agents

3 Tesla ???