CORSO AVANZATO DI ECOCARDIOGRAFIA DI "ECOCARDIOCHIRURGIA"

con uno sguardo all'imaging integrato

La Risonanza Magnetica Presentata agli Ecocardiografisti

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Acerra (Napoli)

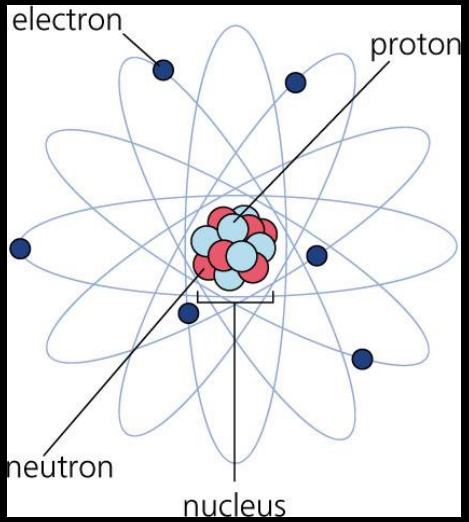
Risonanza Magnetica Cardiaca

Come funziona?

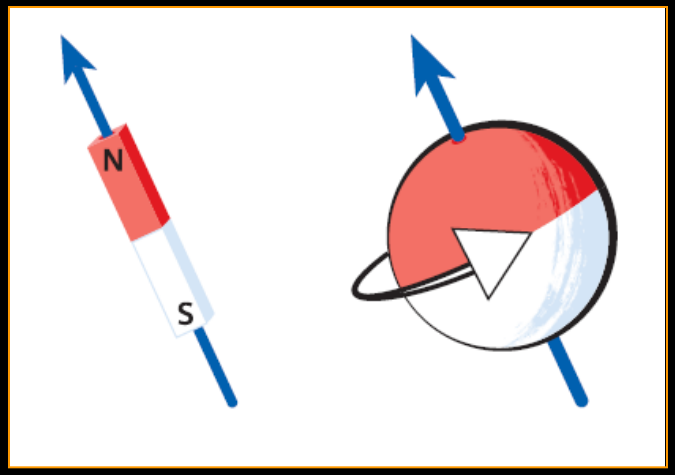
A cosa serve?

Magnetic Properties of the Atom

- **Different atomic particles (neutrons, protons, electrons) display magnetic properties. For the purpose of magnetic resonance imaging (MRI), we will focus only on protons.**



- Protons generate a small electromagnetic field. In nuclei with an even number of protons, the net magnetic field is zero. In nuclei with an odd number of protons, there is a resultant net magnetic field. We exploit this net magnetization for MRI.

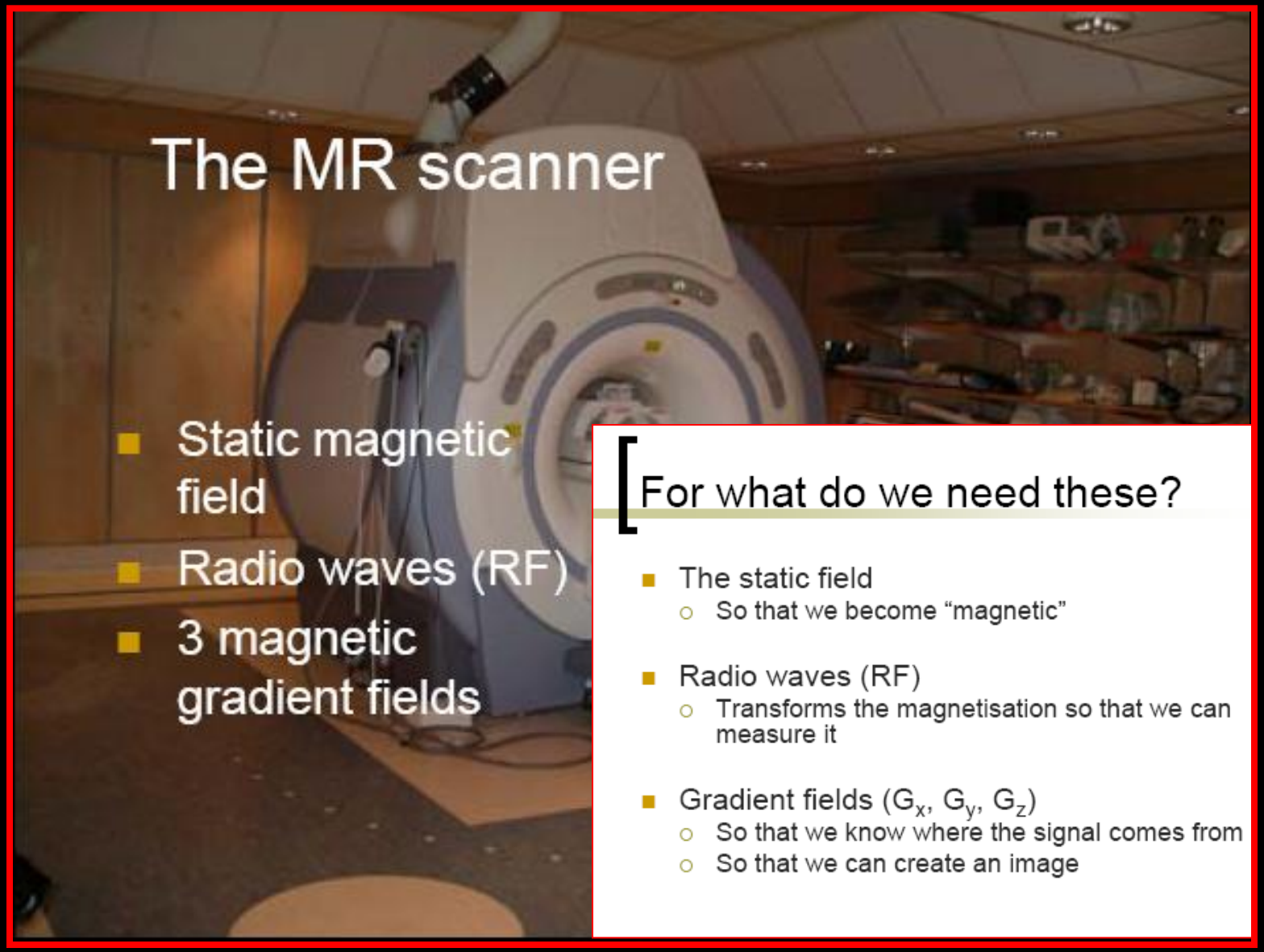


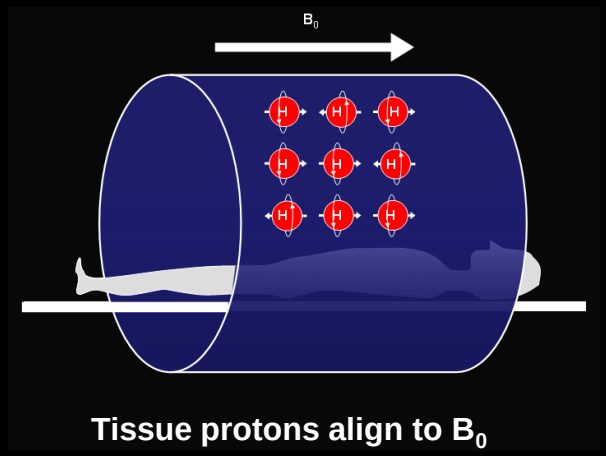
MR Active Nuclei in the Body

	Isotope	Gyromagnetic ratio [MHz/T]	Abundance
Hydrogen (H)	1	42,6	63 %
Phosphor (P)	31	17,2	0,2 %
Carbon (C)	13	10,7	0,1 %
Natrium (Na)	23	11,7	0,03 %
Fluor (F)	19	40,1	< 0,01 %

- The hydrogen (^{1}H) nucleus, composed by 1 proton, is most commonly employed for medical imaging. ^{1}H is universally distributed in the body in the form of water.

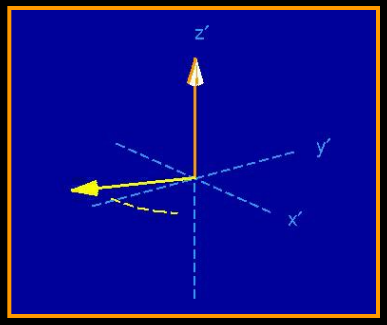
MR Imaging: the Ingredients





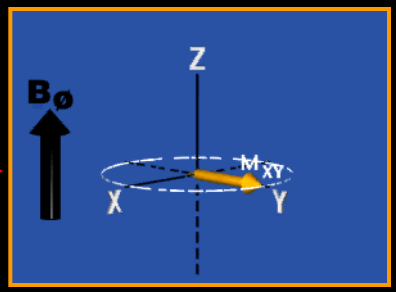
Tissue protons align to B_0

RF Pulse ON



Protons absorb energy
Magnetization tipped off axis

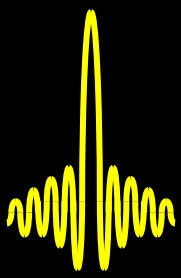
RF Pulse OFF



Protons relax and recover magnetization

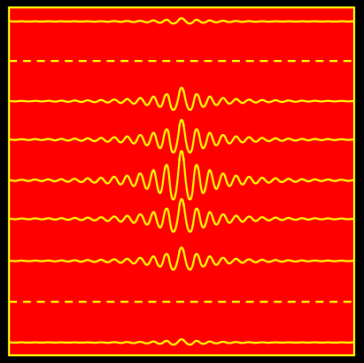
Signal Emitted

Magnetic Gradients



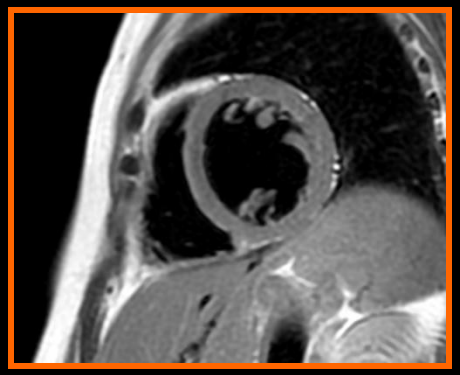
MR signal

K space filling



K space

Fourier transform

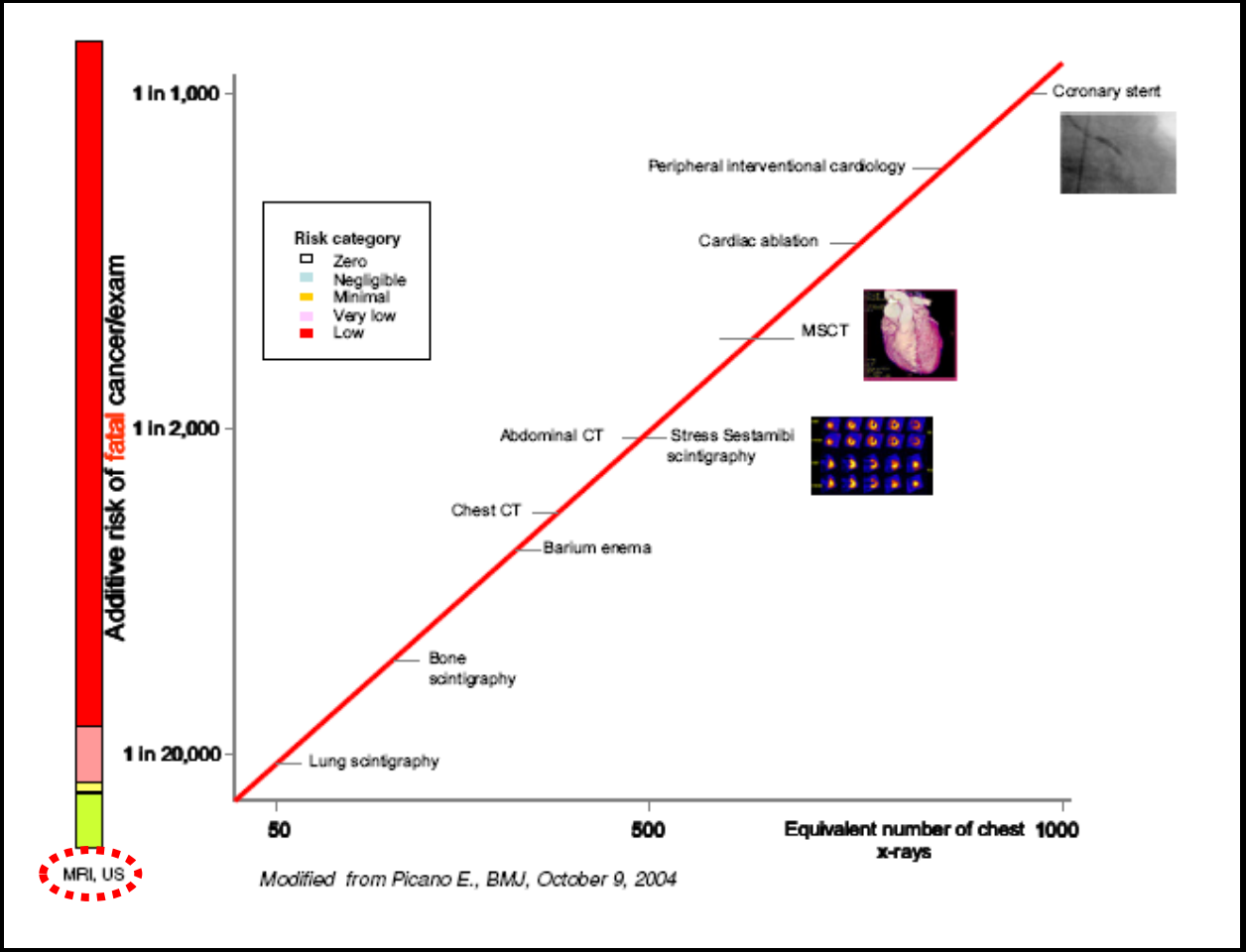


MRI image

Dellegrottaglie S et al. Fundamental Principles of MRI.
In: Mukherjee D, Rajagopalan S, Dellegrottaglie S and Sanz J eds.
CT and MR Angiography of the Peripheral Circulation. 1st edition.
Taylor & Francis Group, 2007

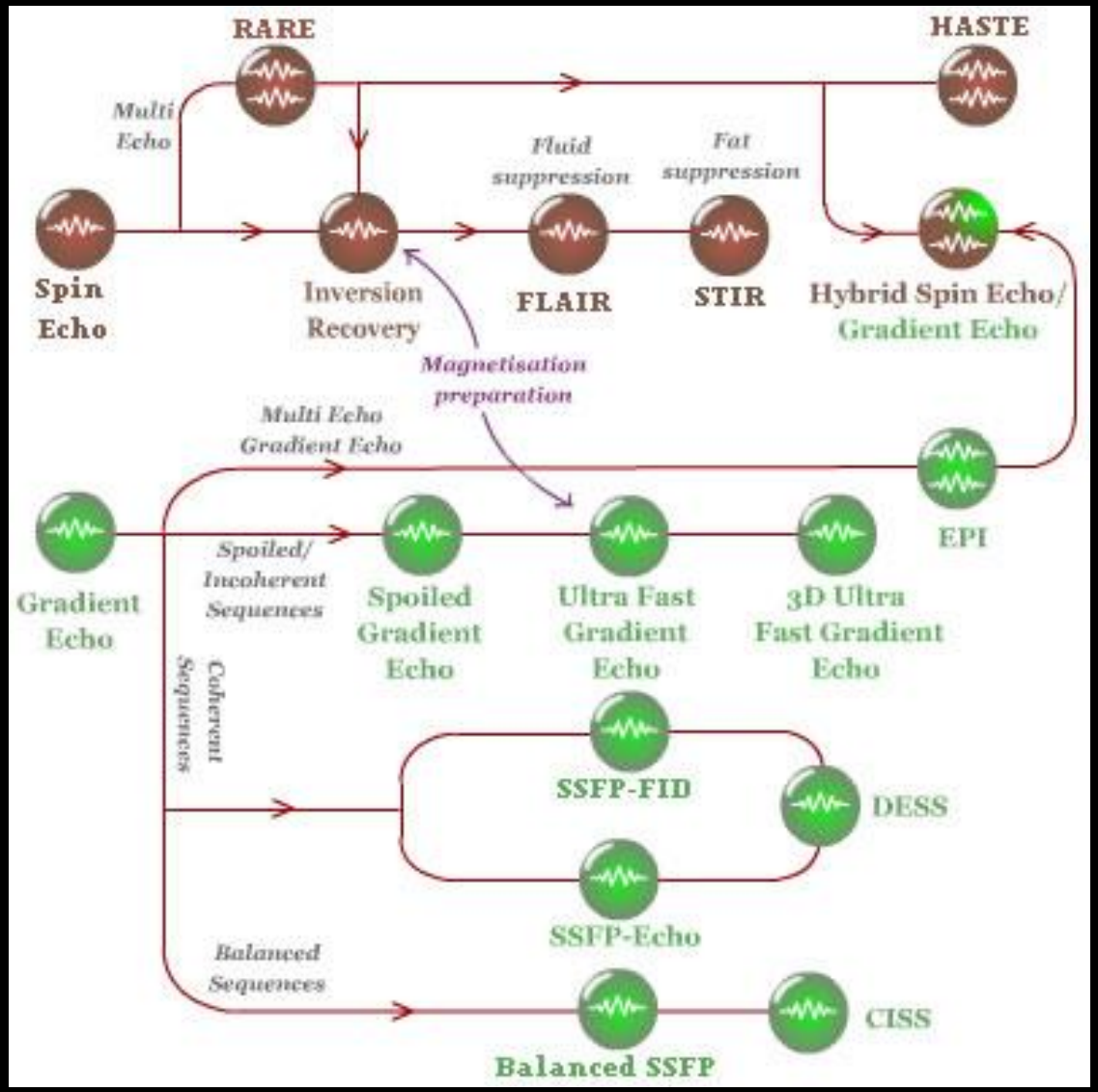
Cancer risk and Radiation Dose for Some Common Cardiovascular Examinations

Picano E. *BMJ* 2004



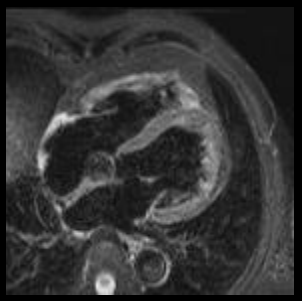
Taxonomy of MRI Sequences

Boyle GE et al. *RadioGraphics* 2006

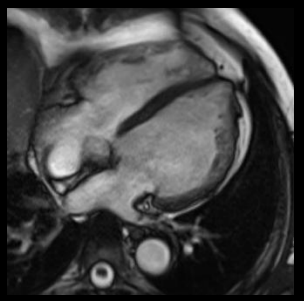


T1W- TSE

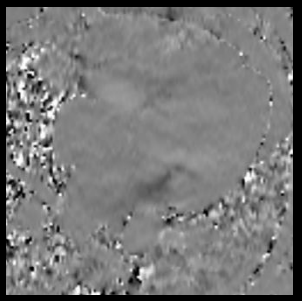
T2W- STIR



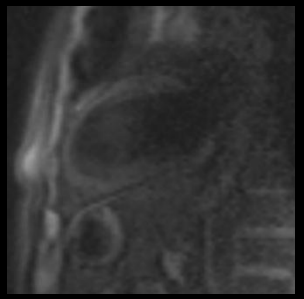
Cine-SSFP



PC-FLASH

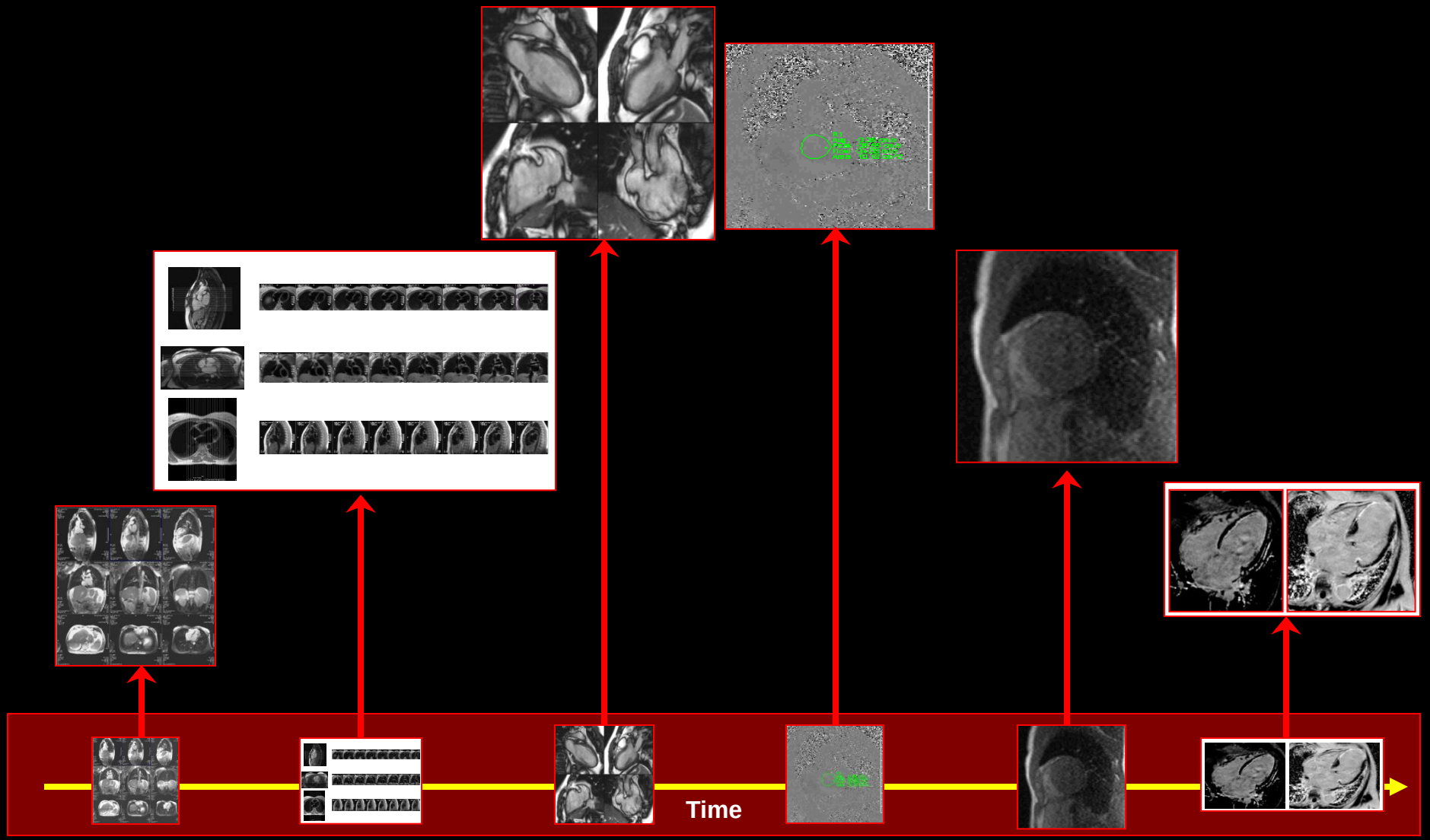


First Pass-FLASH

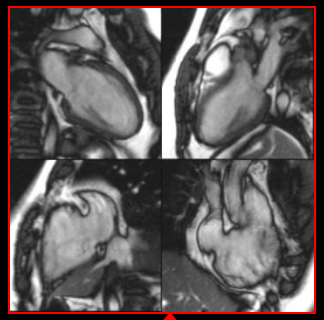


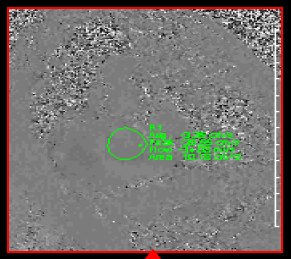
Late- FLASH

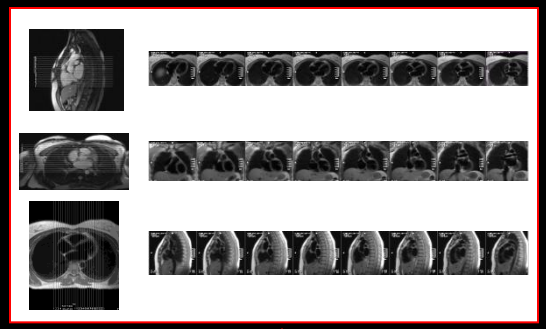
CMR Imaging Protocol

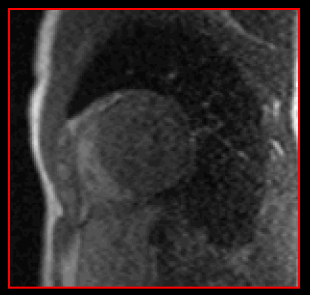


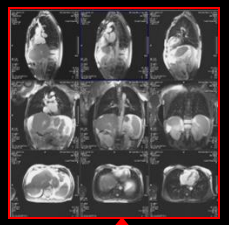
CMR Imaging Protocol

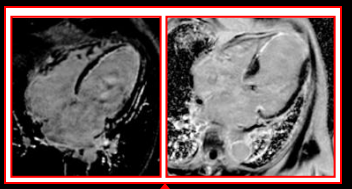












35-40 min

Localization | Morphology | Cardiac Function | Velocity/Flow Quantification | First-Pass Perfusion | Late-Enhancement

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

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ACCF/ACR/AHA/NASCI/SCMR 2010 Expert Consensus Document on Cardiovascular Magnetic Resonance: A Report of the American College of Cardiology Foundation Task Force on Expert Consensus Documents

WRITING COMMITTEE MEMBERS, W. Gregory Hundley, David A. Bluemke, J. Paul Finn, Scott D. Flamm, Mark A. Fogel, Matthias G. Friedrich, Vincent B. Ho, Michael Jerosch-Herold, Christopher M. Kramer, Warren J. Manning, Manesh Patel, Gerald M. Pohost, Arthur E. Stillman, Richard D. White and Pamela K. Woodard

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ACCF/ACR/SCCT/SCMR/ASNC/NASCI/SCAI/SIR APPROPRIATENESS CRITERIA

ACCF/ACR/SCCT/SCMR/ASNC/NASCI/SCAI/SIR 2006 Appropriateness Criteria for Cardiac Computed Tomography and Cardiac Magnetic Resonance Imaging*

A Report of the American College of Cardiology Foundation Quality Strategic Directions Committee Appropriateness Criteria Working Group, American College of Radiology, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, American Society of Nuclear Cardiology, North American Society for Cardiac Imaging, Society for Cardiovascular Angiography and Interventions, and Society of Interventional Radiology

CCT/CMR WRITING GROUP

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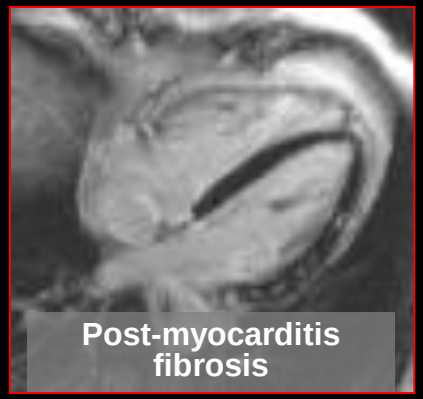
Michael Poon, MD, FACC‡

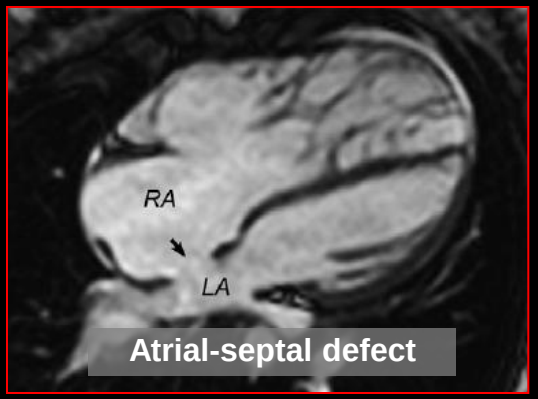
Cardiac MR: Clinical Indications

Ischemic Heart Disease

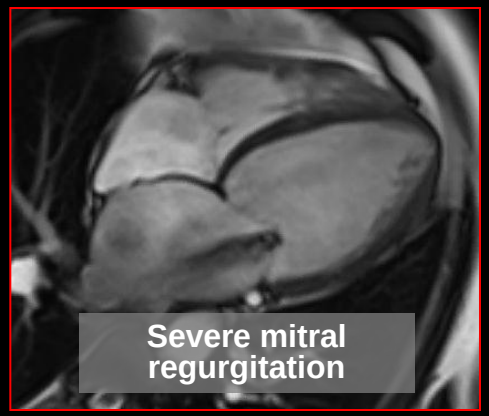
Cardiomyopathies / Myocarditis



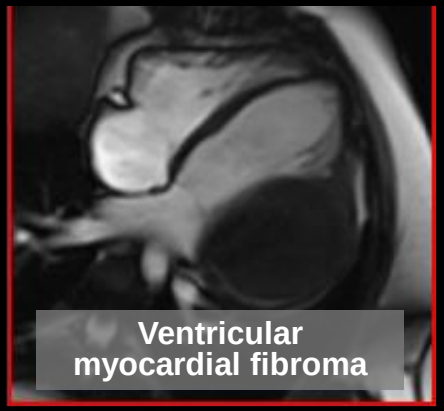
Congenital Heart Diseases



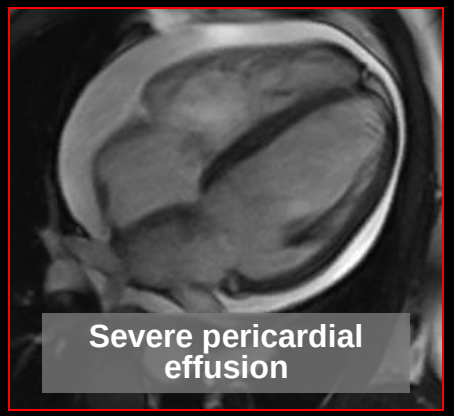
Valvular Heart Diseases



Cardiac Masses / Tumors

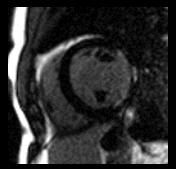


Pericardial Diseases



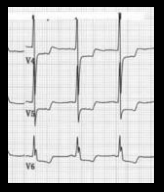
Evaluation of Coronary Artery Disease by Cardiac MR

Late Enhancement Imaging



Myocardial Scar

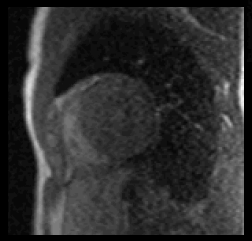
Symptoms



ECG Changes

Cine Imaging

Systolic Dysfunction



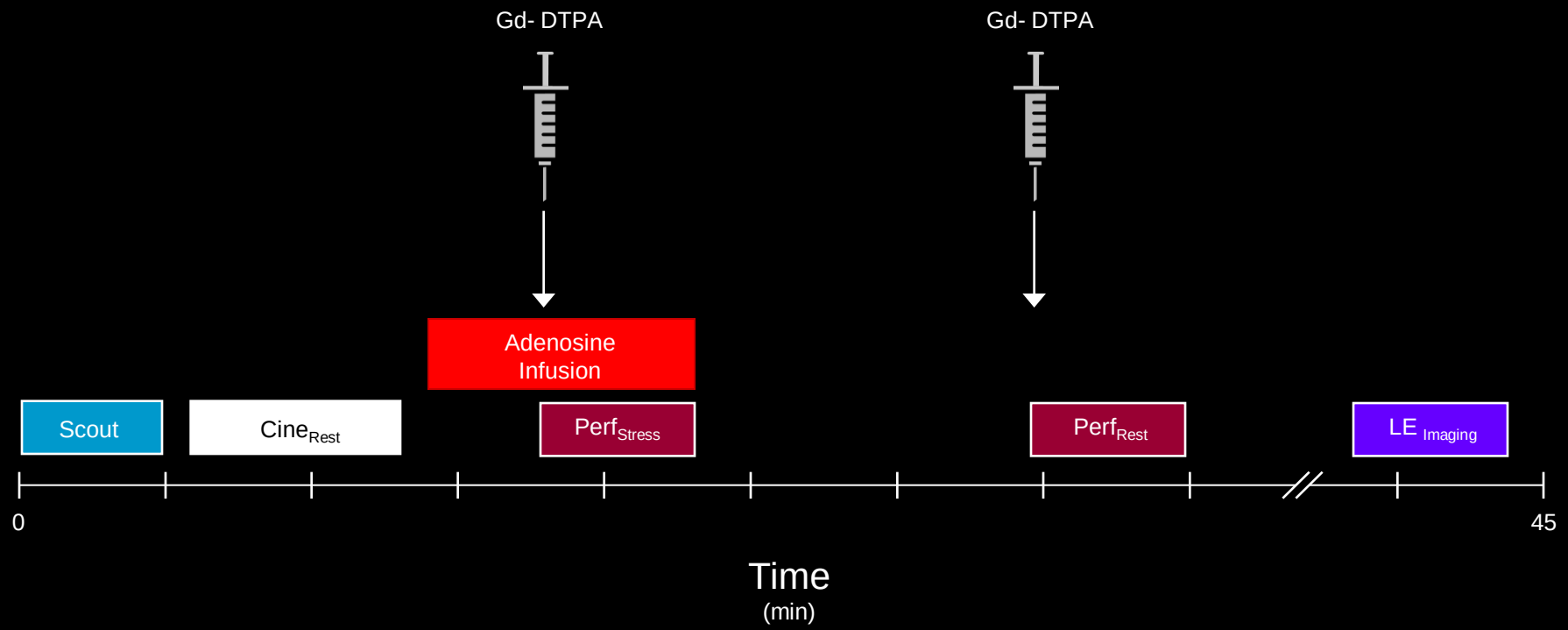
Perfusion Imaging

Perfusion Defects

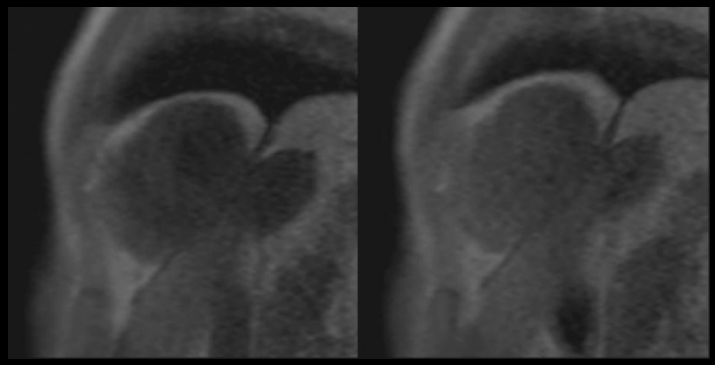
Time of Ischemia

Coronary Stenosis

Adenosine Stress CMR Protocol: Perfusion Analysis



Stress
(140 µg/kg/min)

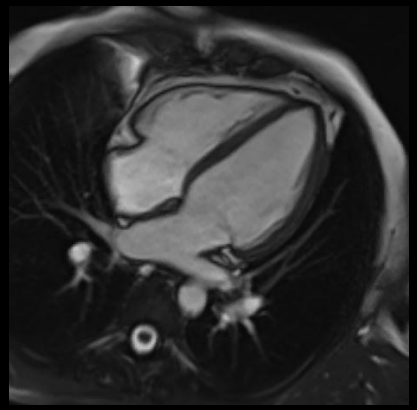


Rest

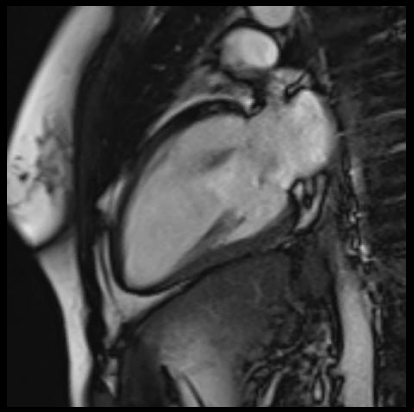
Evaluation of Ventricular Function

Cine-SSFP
ECG gated
Breath-hold (8-12 sec)

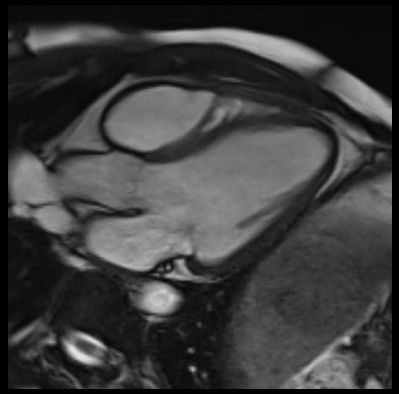
Long-Axis Views



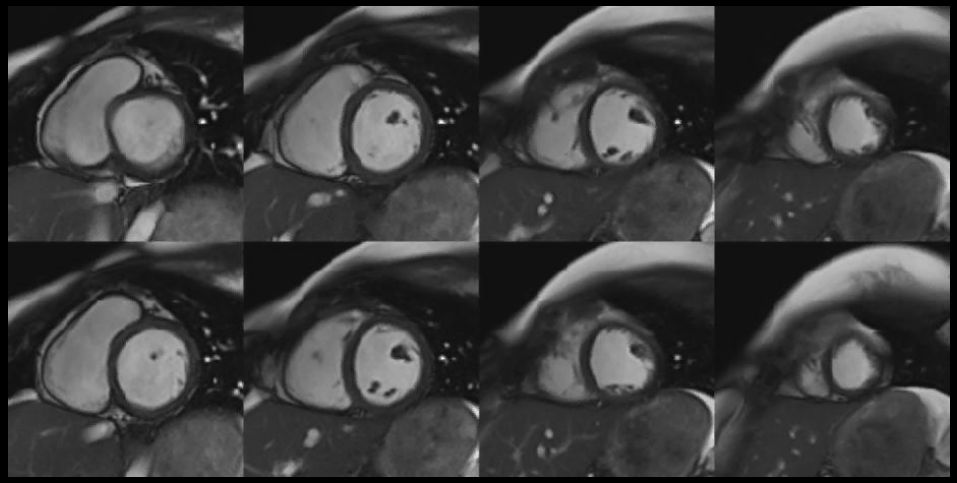
4-Chamber View



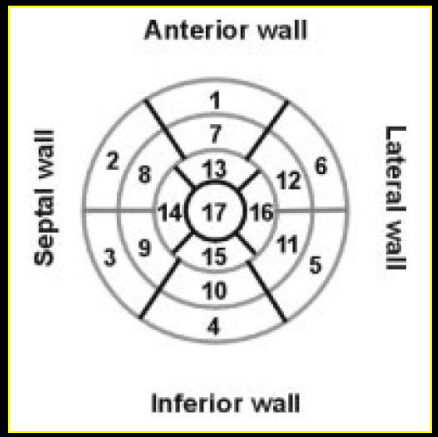
2-Chamber View



3-Chamber View



Short-Axis Views



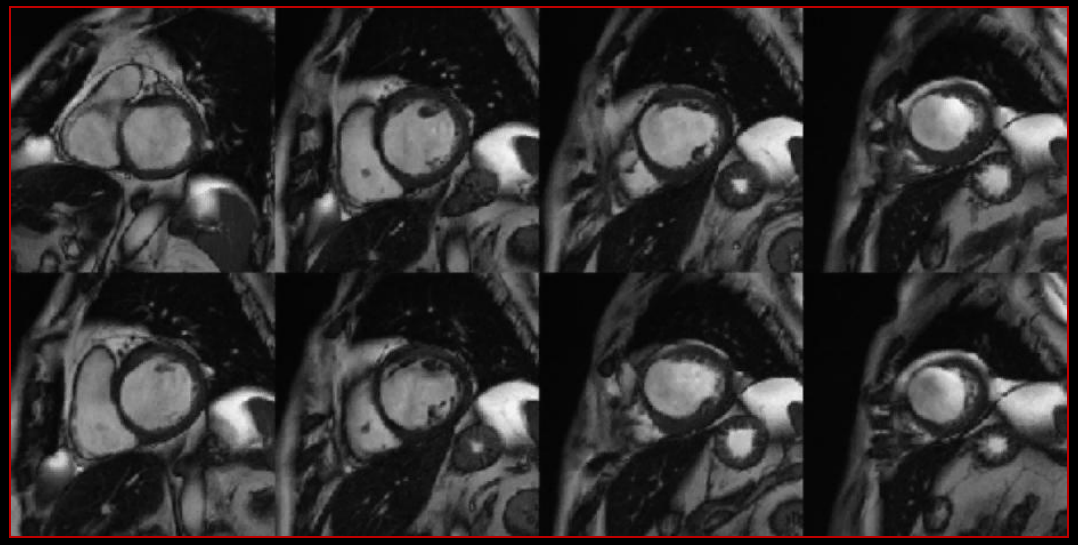
AHA Scientific Statement.
Circulation 2002

Wall Motion Score Index

0: Normal wall motion
1: Mild/moderate hypokinesia
2: Severe hypokinesia
3: Akinesia
4: Dyskinesia

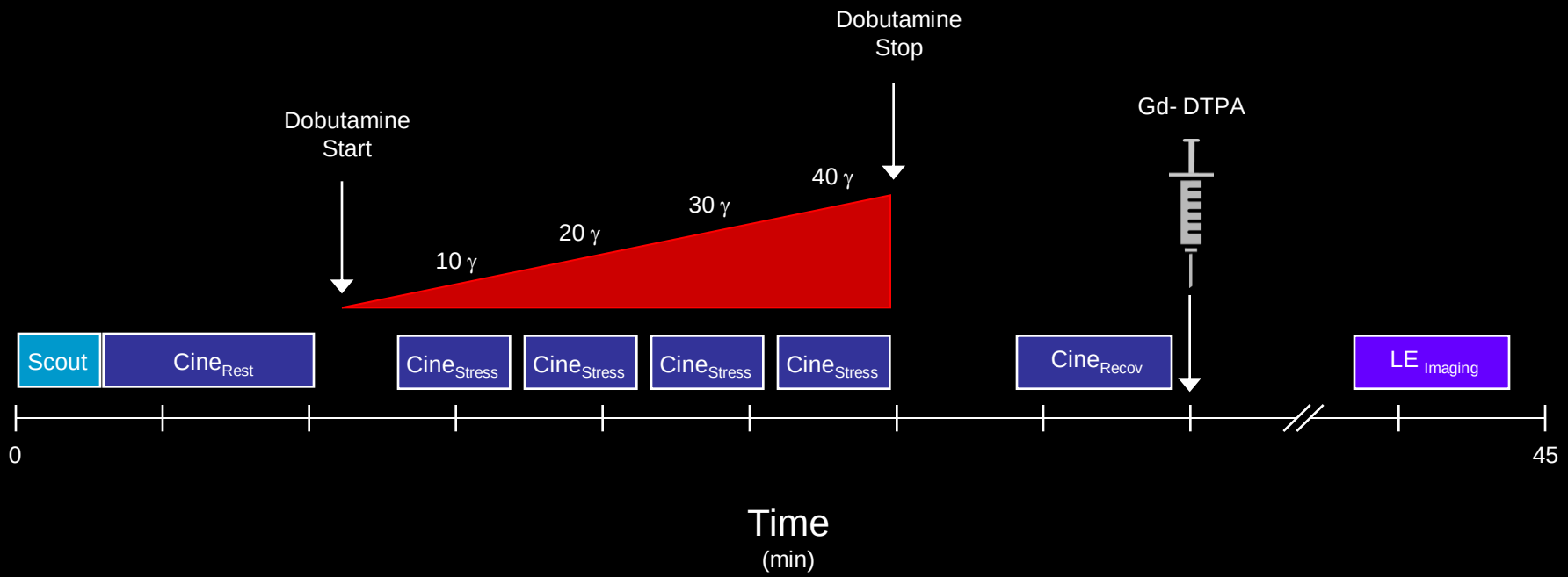
Evaluation of Ventricular Function in Patients with Myocardial Infarction

B.A.
55-year-old
Male
Anterior MI



A.C.
48-year-old
Male
Inferior MI

High-Dose Dobutamine Stress CMR Protocol: Wall-Motion Analysis




Basal


10 µg/kg/min

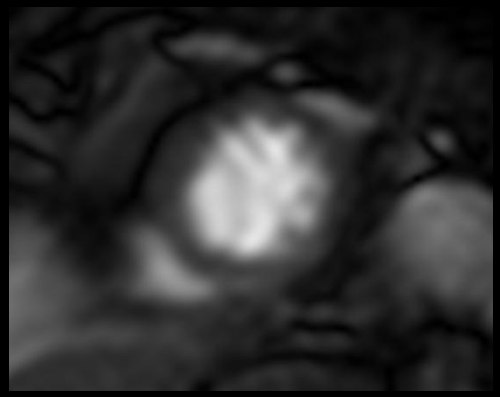

20 µg/kg/min

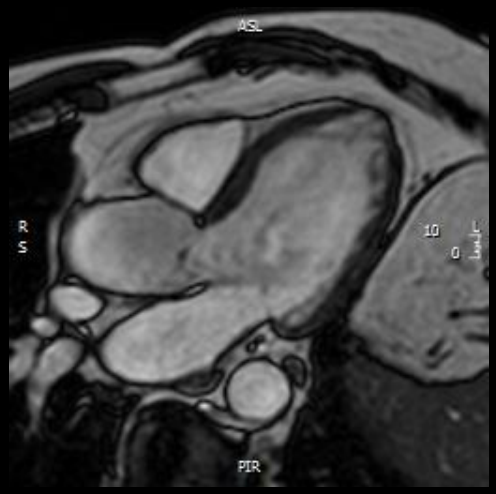

30 µg/kg/min


40 µg/kg/min

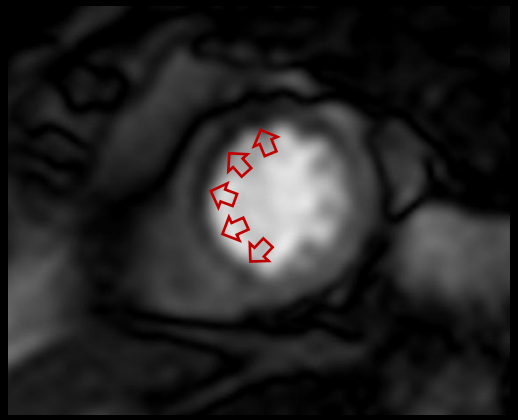
D. T.
67-yer old male
CTO mid LAD
Asymptomatic with max Rx

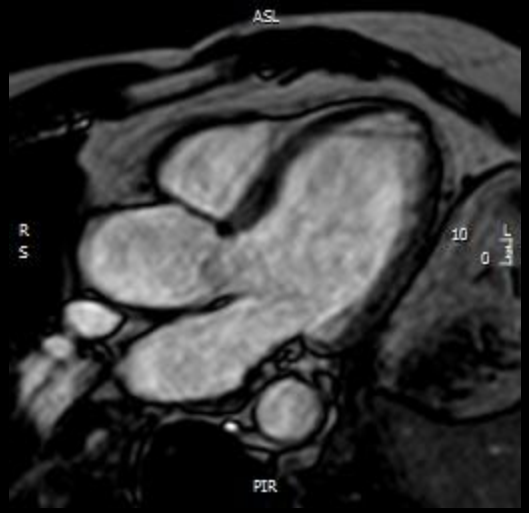
Rest



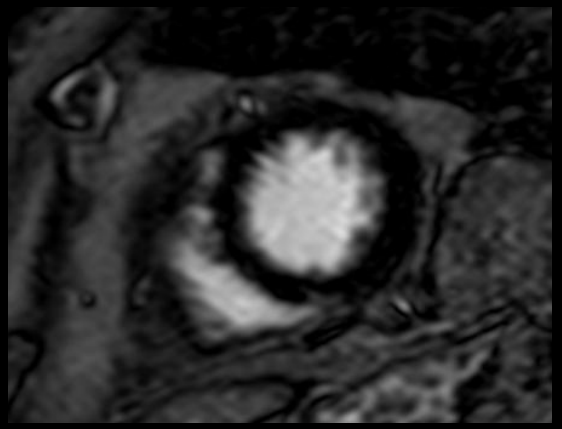


Adenosine





Late Post-Gd Enhancement



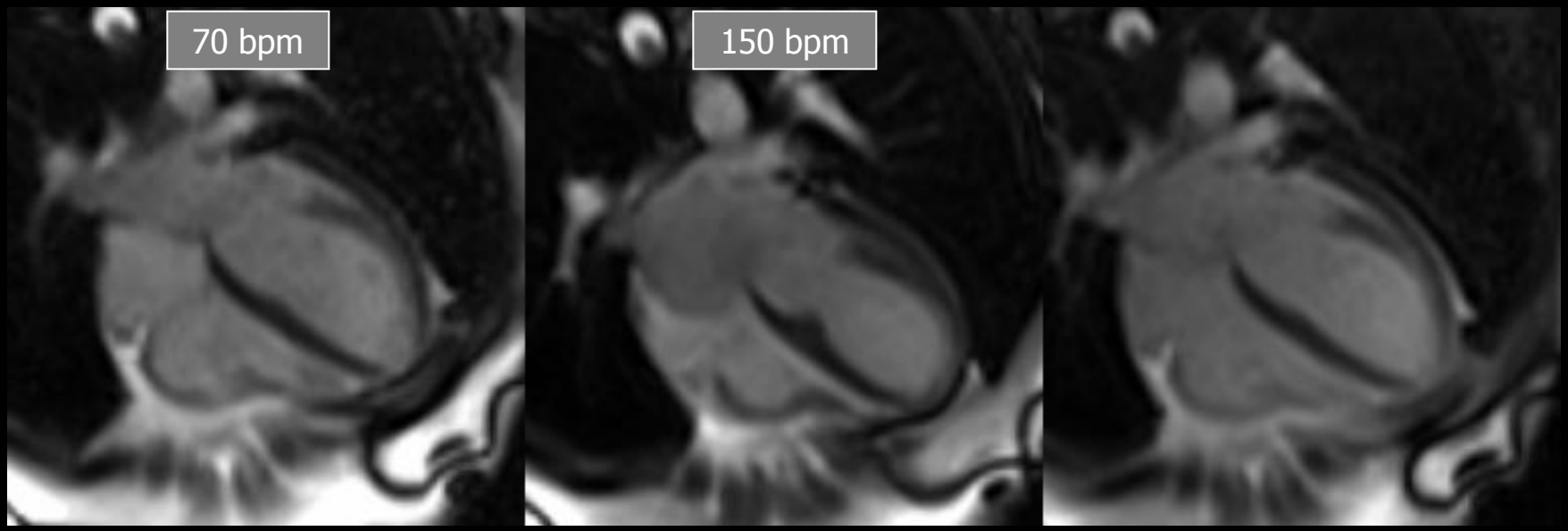
Subject Transfer

Vacuum cushions used to rapidly reposition patient
32-channel array to improve parallel imaging performance

Courtesy of Raman, Simonetti, Rajagopalan (Ohio State University, Columbus, OH)

Case #4: Positive CMR, Negative SPECT
42 y/o female, exertional chest pain
x-ray cath: non-obstructive LAD plaque

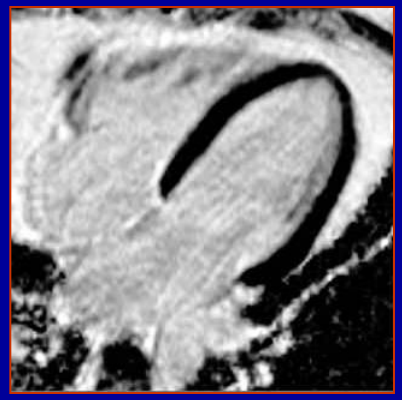
Rest | Exercise | Recovery

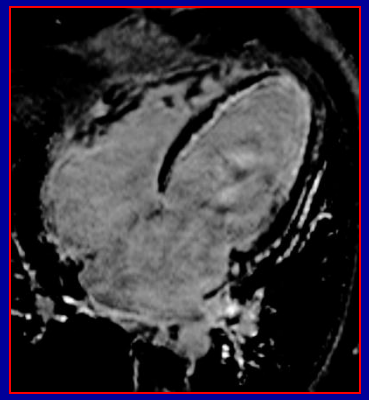


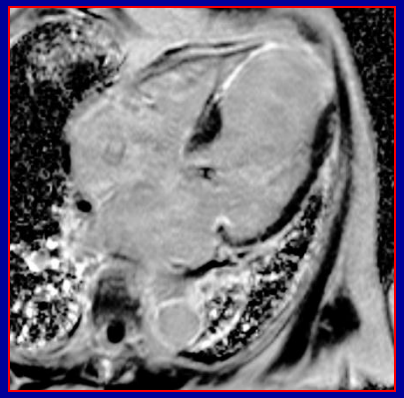
Normal cardiac function demonstrated at rest and following recovery.
Exercise stress real-time cine CMR shows apical wall motion defect.

Courtesy of Raman, Simonetti, Rajagopalan (Ohio State University, Columbus, OH)

LE-CMR: An Improved CMR Technique for the Visualization of Myocardial Infarction





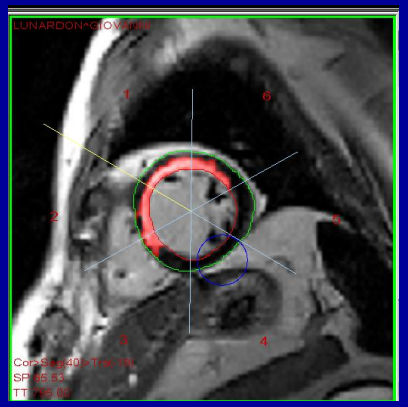


Segmented inversion-recovery turbo fast low-angle shot (FLASH)

Gd-based contrast agent injection (0.10-0.30 mmol/kg/min)

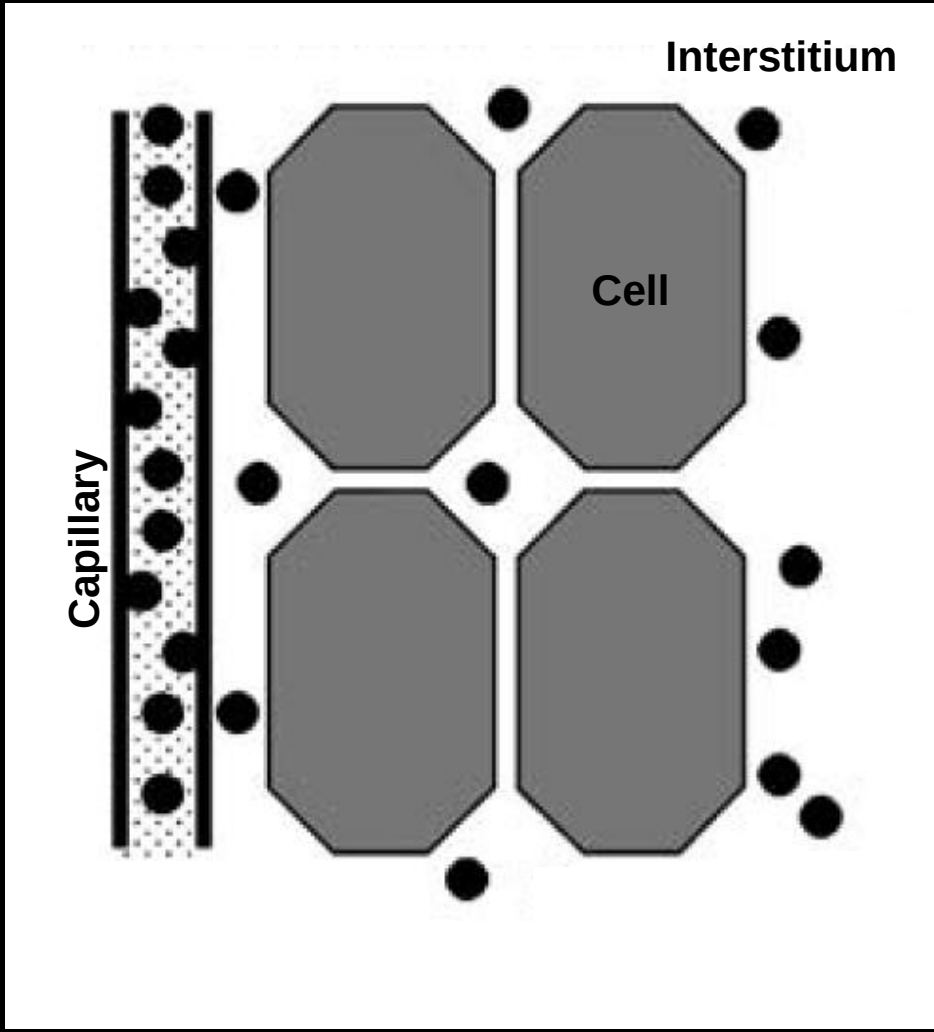
5-30 min

Image acquisition



Dellegrottaglie S et al. Fundamental Principles of MRI.
In: Mukherjee D, Rajagopalan S, Dellegrottaglie S eds.
CT and MR Angiography of the Peripheral Circulation. 1st edition.
Taylor & Francis Group, 2007

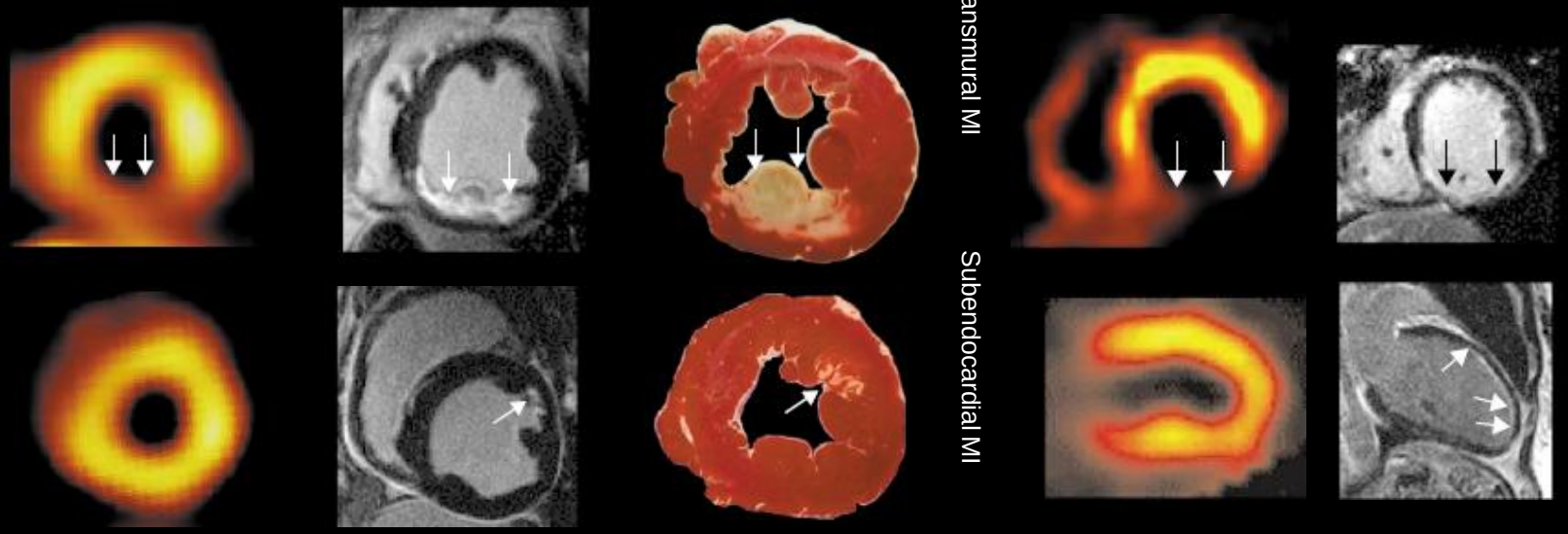
Extravascular/Extracellular Agents

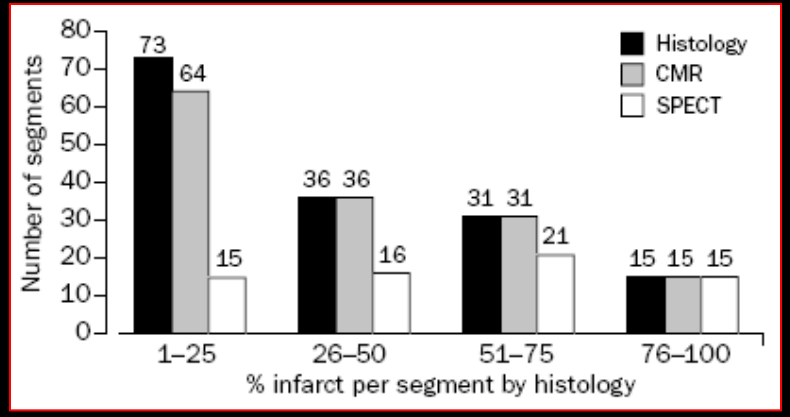


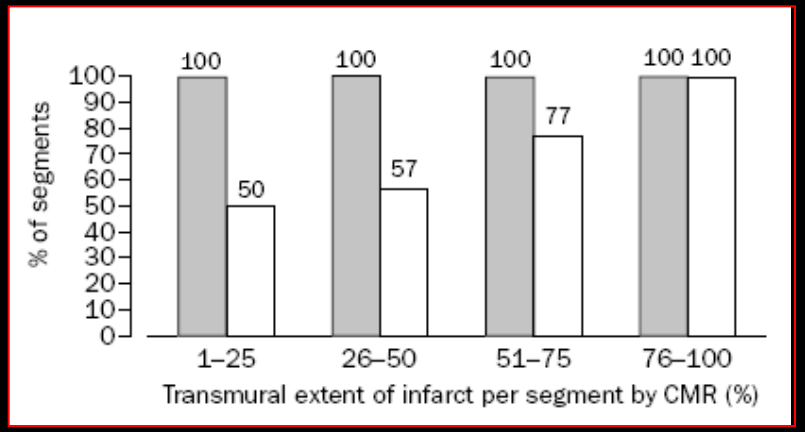
Contrast-enhanced MRI and Routine SPECT Perfusion Imaging for Detection of Subendocardial Myocardial Infarctions

Wagner A et al. *Lancet* 2003

N= 91 pts with suspected or known CAD
and 12 dogs with MI
CE CMR and ^{99m}Tc SPECT

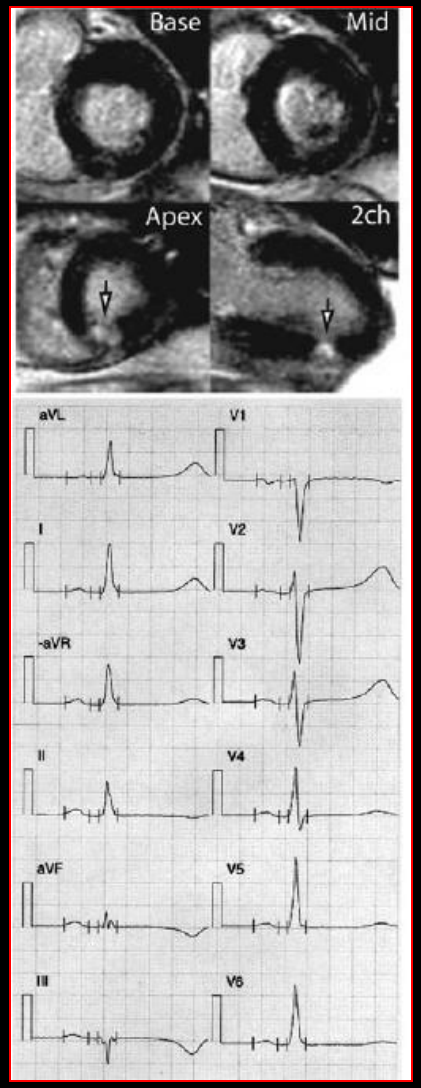


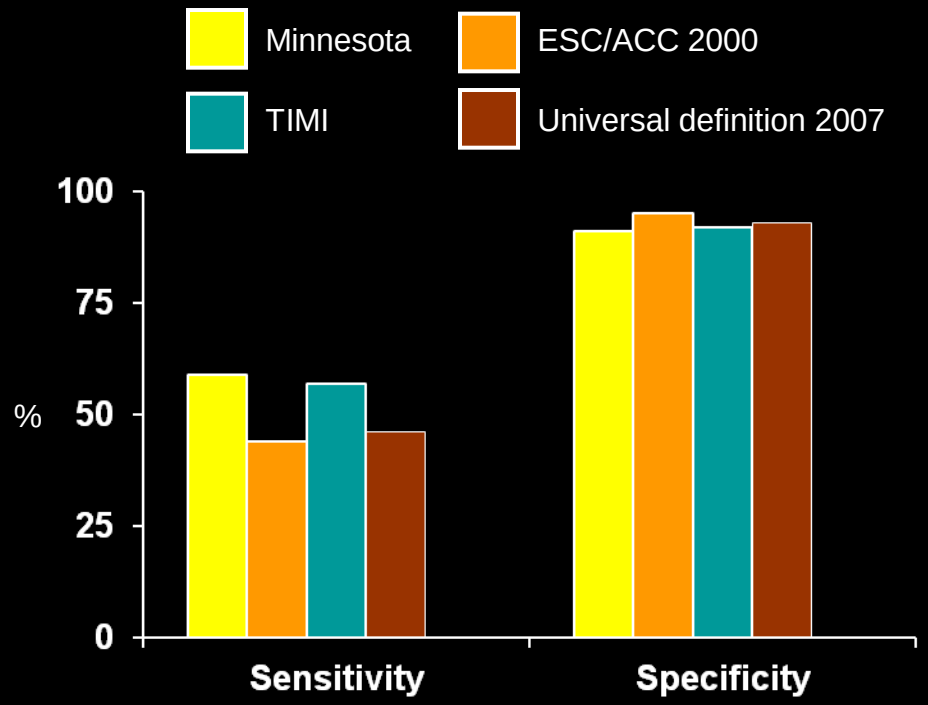




Limited Sensitivity of ECG Criteria for Healed MI in Comparison With Cardiovascular Magnetic Resonance

Krittayaphong R et al. *Am J Cardiol* 2009

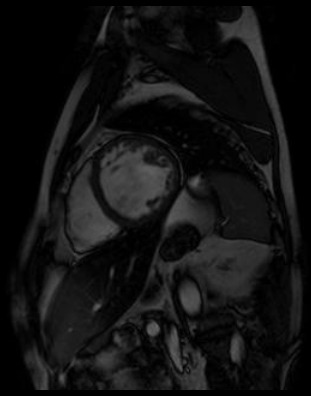


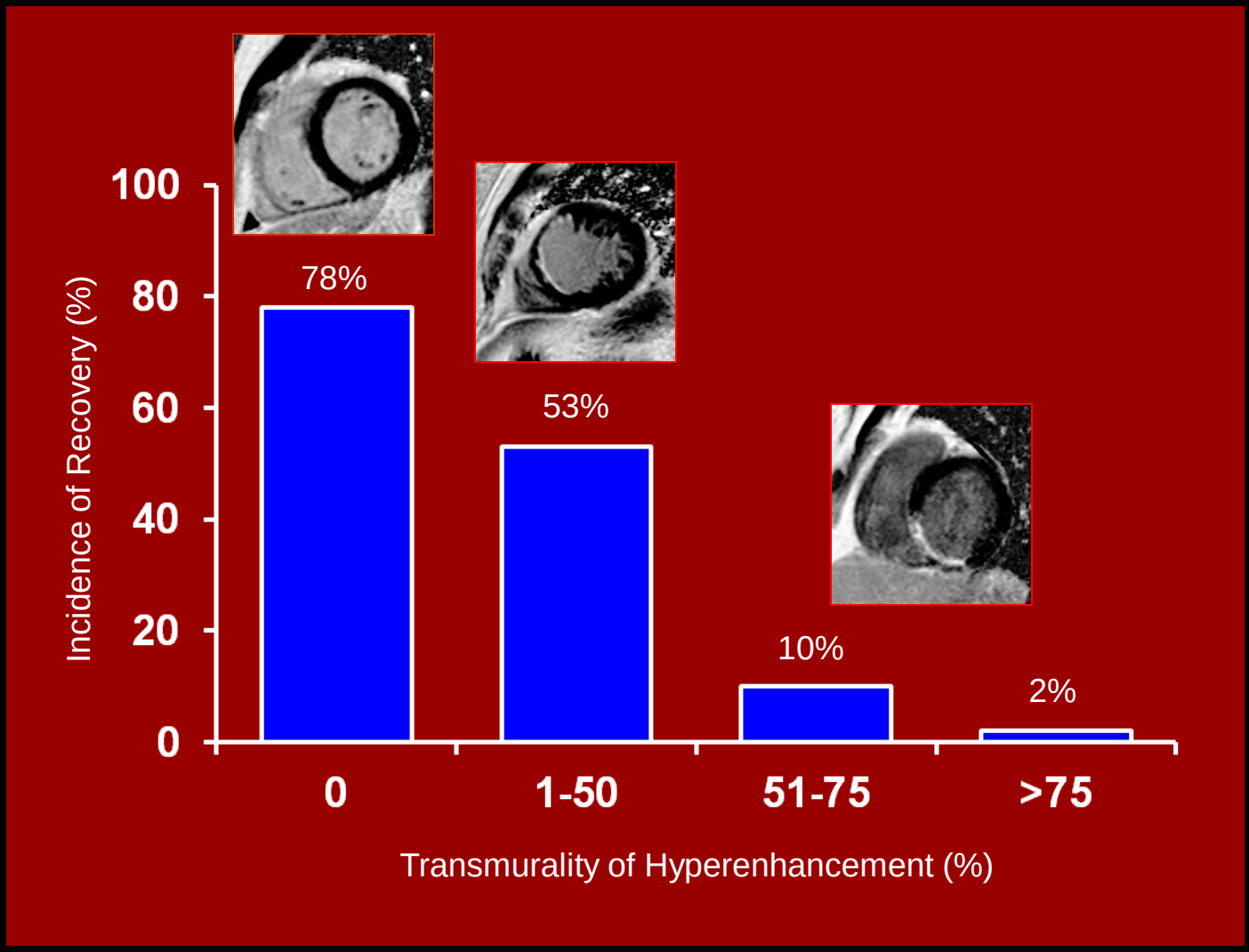


The Use of Contrast-Enhanced MRI to Identify Reversible Myocardial Dysfunction

Kim RJ et al. *N Engl J Med* 2000

N= 50 pts with CAD and LV dysfunction
Scheduled for revascularization
CE CMR before PTCI or CABG
Cine CMR 11 weeks after revascularization





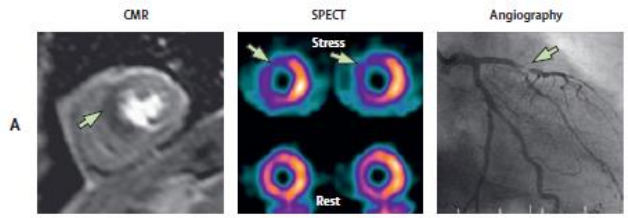
Cardiovascular magnetic resonance and single-photon emission computed tomography for diagnosis of coronary heart disease (CE-MARC): a prospective trial

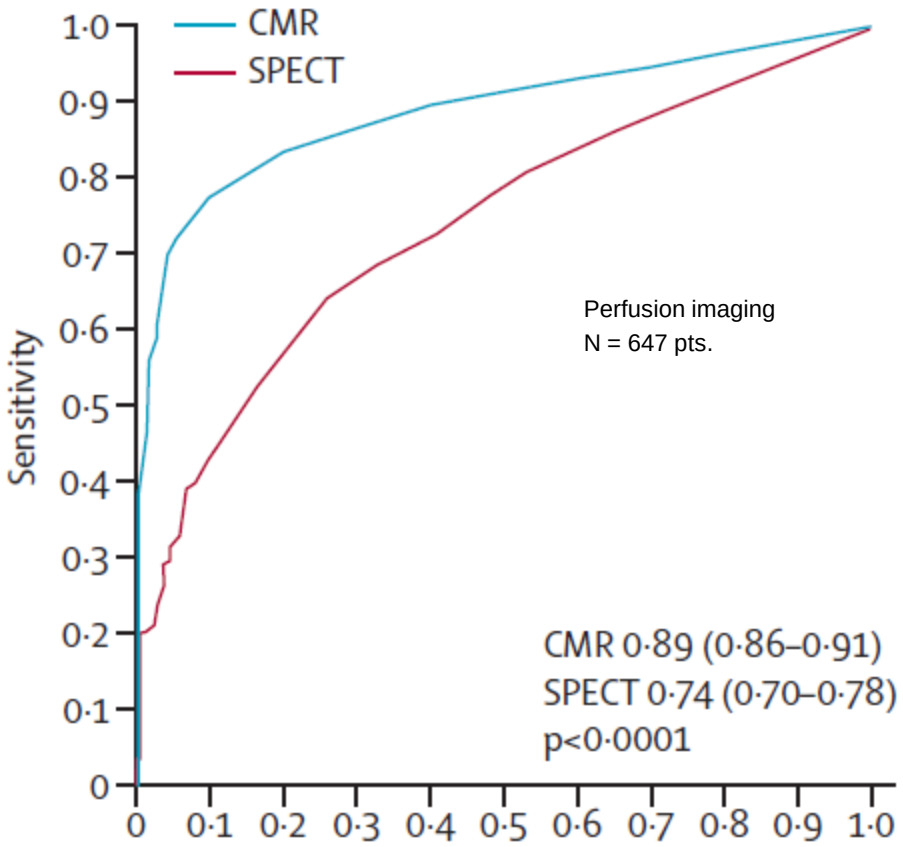
John P Greenwood, Neil Maredia, John F Younger, Julia M Brown, Jane Nixon, Colin C Everett, Petra Bijsterveld, John P Ridgway, Aleksandra Radjenovic, Catherine J Dickinson, Stephen G Ball, Sven Plein

Lancet. 2012 Feb 4;379(9814):453-60

Prospective design
N= 752 pts. with angina and ≥CV risk factor
MR, SPECT and coronary cath
CMR protocol: adenosine stress perfusion, cine imaging, LGE, coronary angio
Gated adenosine stress-rest ^{99}mTc tetrofosmin SPECT

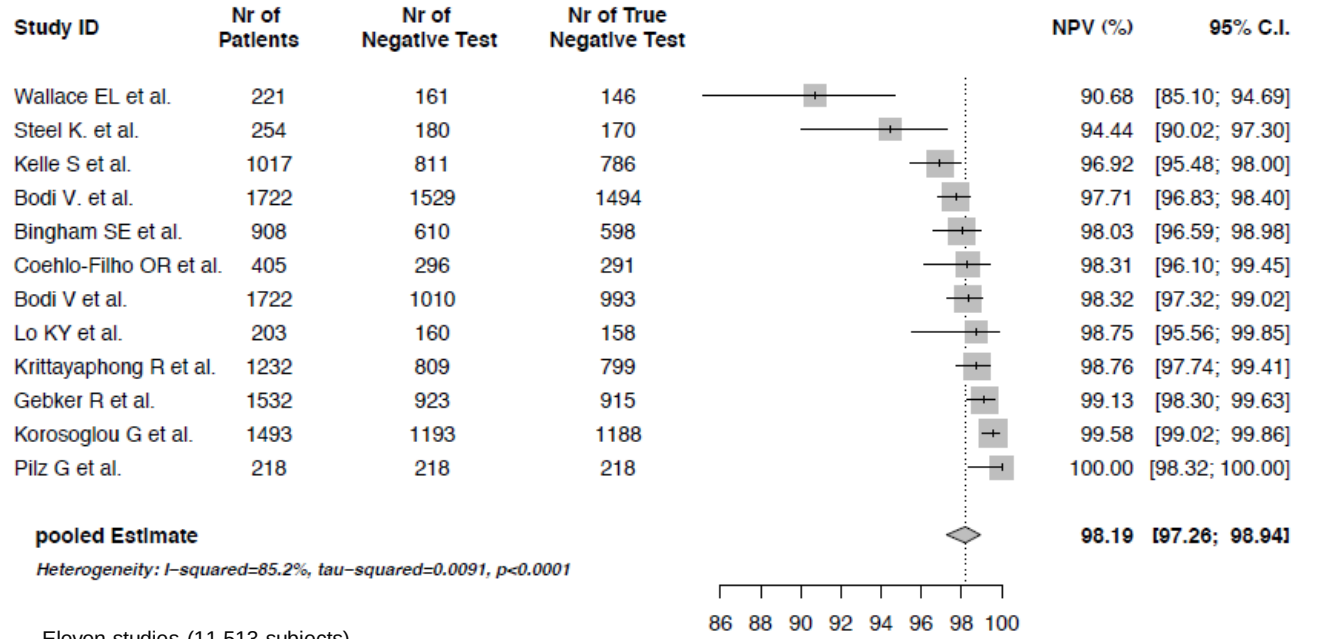
Multiparametric	Sens	Spec	PPV	NPV
CMR	86.3%*	83.2%	77.0%	90.3%*
SPECT	66.5%	82.6%	71.4%	79.1%





The Prognostic Value of Normal Stress CMR in Patients with Known or Suspected CAD: a Meta-analysis

Gargiulo P, Dellegrottaglie S, Bruzzese D,Scala O, Ruggiero D, D'Amore C,Savarese S, Paolillo S, Cuocolo A, Agostoni P, Trimarco B, Perrone Filardi P



VARIABLES	Nr of Studies	Nr of Patients	Mean follow Up months [min.; max.]	NPV %	95% C.I.
No inducible WMA	4	4492	27.11 [13;74]	97,02	[94,7 - 98,7]
No inducible PD	7	4942	24.37 [12;38]	98,47	[97,52 - 99,21]

Presented at the American Heart Association Scientic Sessions , November 2012

Guidelines on Myocardial Revascularization

The Task Force on Myocardial Revascularization of ESC and the EACTS
Eur Heart J 2010

Table 7 Indications of different imaging tests for the diagnosis of obstructive coronary artery disease and for the assessment of prognosis in subjects without known coronary artery disease[a]

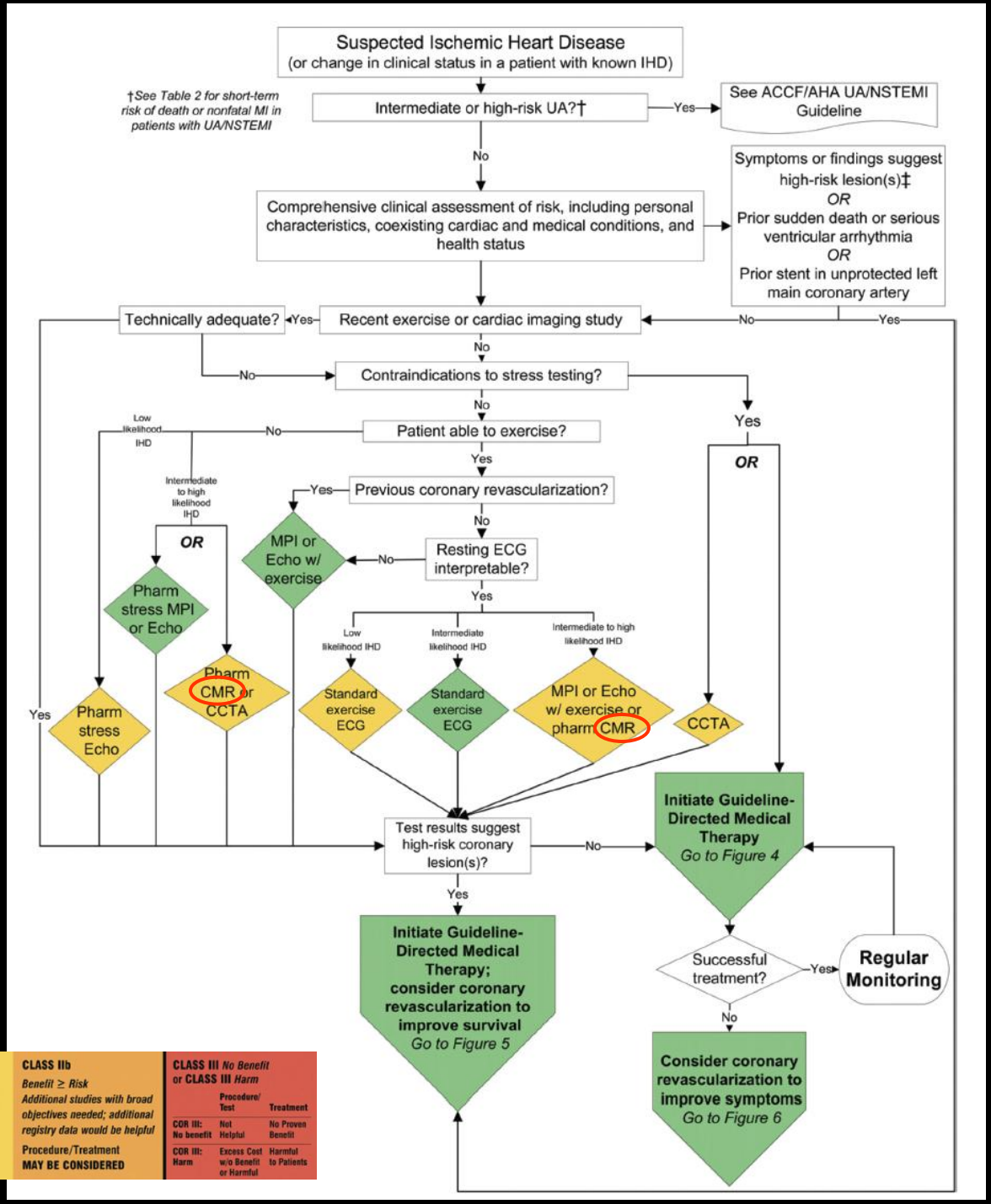
	Asymptomatic (screening)	Symptomatic			Prognostic value of positive result[a]	Prognostic value of negative result[a]	References
		Pretest likelihood[b] of obstructive disease					
		Low	Intermediate	High			
Anatomical test							
Invasive angiography	III A	III A	IIb A	I A	I A	I A	12
MDCT angiography	III B[c]	IIb B	IIa B	III B	IIb B	IIa B	17–20
MRI angiography	III B	III B	III B	III B	III C	III C	22
Functional test							
Stress echo	III A	III A	I A	III A[d]	I A	I A	12
Nuclear imaging	III A	III A	I A	III A[d]	I A	I A	12
Stress MRI	III B	III C	IIa B	III B[d]	IIa B	IIa B	12, 23–25
PET perfusion	III B	III C	IIa B	III B[d]	IIa B	IIa B	26

Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS Guideline for the Diagnosis and Management of Patients With Stable Ischemic Heart Disease: Executive Summary : A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, and the American College of Physicians, American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons

Stephan D. Fihn, Julius M. Gardin, Jonathan Abrams, Kathleen Berra, James C. Blankenship, Apostolos P. Dallas, Pamela S. Douglas, JoAnne M. Foody, Thomas C. Gerber, Alan L. Hinderliter, Spencer B. King III, Paul D. Kligfield, Harlan M. Krumholz, Raymond Y.K. Kwong, Michael J. Lim, Jane A. Linderbaum, Michael J. Mack, Mark A. Munger, Richard L. Prager, Joseph F. Sabik, Leslee J. Shaw, Joanna D. Sikkema, Craig R. Smith, Jr, Sidney C. Smith, Jr, John A. Spertus and Sankey V. Williams

Circulation. published online November 19, 2012;


Suspected Ischemic Heart Disease
(or change in clinical status in a patient with known IHD)
†See Table 2 for short-term risk of death or nonfatal MI in patients with UA/NSTEMI
Intermediate or high-risk UA?†
Yes
See ACCF/AHA UA/NSTEMI Guideline
No
Comprehensive clinical assessment of risk, including personal characteristics, coexisting cardiac and medical conditions, and health status
Symptoms or findings suggest high-risk lesion(s)‡
OR
Prior sudden death or serious ventricular arrhythmia
OR
Prior stent in unprotected left main coronary artery
Technically adequate?
Yes
Recent exercise or cardiac imaging study
No
Yes
No
Contraindications to stress testing?
No
Yes
Low likelihood IHD
No
Patient able to exercise?
Yes
OR
Intermediate to high likelihood IHD
Yes
Previous coronary revascularization?
No
OR
MPI or Echo w/ exercise
No
Resting ECG interpretable?
Yes
Pharm stress MPI or Echo
Low likelihood IHD
Intermediate likelihood IHD
Intermediate to high likelihood IHD
Pharm CMR or CCTA
Standard exercise ECG
Standard exercise ECG
MPI or Echo w/ exercise or pharm CMR
CCTA
Yes
Pharm stress Echo
Test results suggest high-risk coronary lesion(s)?
No
Initiate Guideline-Directed Medical Therapy
Go to Figure 4
Yes
Initiate Guideline-Directed Medical Therapy; consider coronary revascularization to improve survival
Go to Figure 5
Successful treatment?
Yes
Regular Monitoring
No
Consider coronary revascularization to improve symptoms
Go to Figure 6
CLASS I
Benefit >>> Risk
Procedure/Treatment SHOULD be performed/ administered
CLASS IIa
Benefit >> Risk
Additional studies with focused objectives needed
IT IS REASONABLE to perform procedure/administer treatment
CLASS IIb
Benefit ≥ Risk
Additional studies with broad objectives needed; additional registry data would be helpful
Procedure/Treatment MAY BE CONSIDERED
CLASS III No Benefit or CLASS III Harm
Procedure/ Test
Treatment
COR III: No benefit
Not Helpful
No Proven Benefit
COR III: Harm
Excess Cost w/o Benefit or Harmful
Harmful to Patients

Risonanza Magnetica Cardiaca

Come funziona?

A cosa serve?

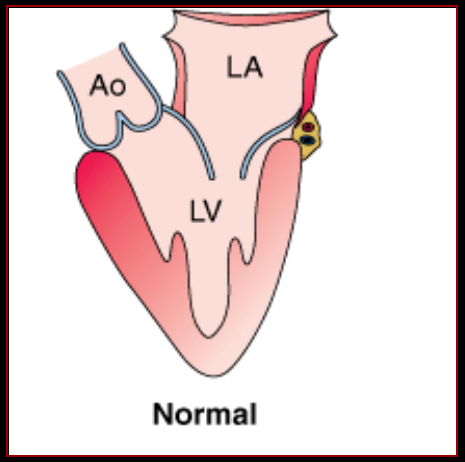
DOMANDE?

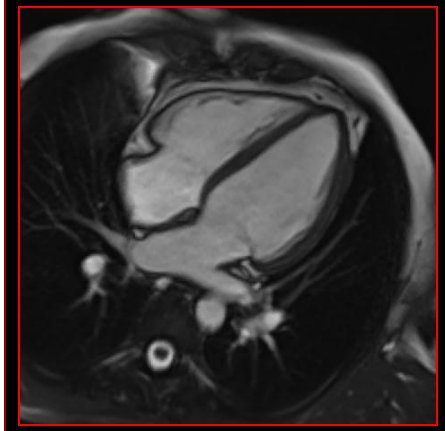
ESC Classification of Cardiomyopathies

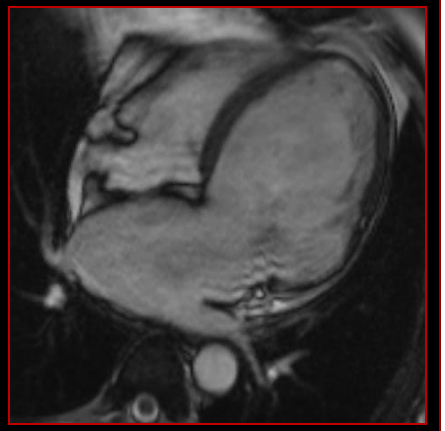
Elliott P, Andersson B, Arbustini E, et al. *Eur Heart J* 2007

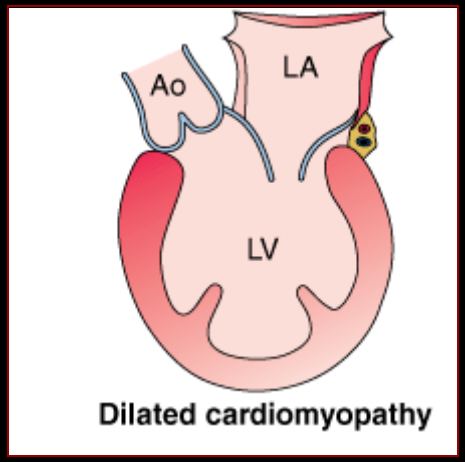
	Hypertrophic Cardiomyopathy	Dilated Cardiomyopathy	ARVC	Restrictive Cardiomyopathy	Unclassified
Familial	Familial, unknown gene Sarcomeric protein mutations ß myosin heavy chain Cardiac myosin binding protein C Cardiac troponin I Troponin-T α-tropomyosin Essential myosin light chain Regulatory myosin light chain Cardiac actin α-myosin heavy chain Titin Troponin C Muscle LIM protein Glycogen storage disease (e.g. Pompe; PRKAG2, Forbes', Danon) Lysosomal storage diseases (e.g. Anderson–Fabry, Hurler's) Disorders of fatty acid metabolism Carnitine deficiency Phosphorylase B kinase deficiency Mitochondrial cytopathies Syndromic HCM Noonan's syndrome LEOPARD syndrome Friedreich's ataxia Beckwith–Wiedermann syndrome Swyer's syndrome Other Phospholamban promoter Familial amyloid	Familial, unknown gene Sarcomeric protein mutations (see HCM) Z-band Muscle LIM protein TCAP Cytoskeletal genes Dystrophin Desmin Metavinculin Sarcoglycan complex CRYAB Epicardin Nuclear membrane Lamin A/C Emerin Mildly dilated CM Intercalated disc protein mutations (see ARVC) Mitochondrial cytopathy	Familial, unknown gene Intercalated disc protein mutations Plakoglobin Desmoplakin Plakophilin 2 Desmoglein 2 Desmocollin 2 Cardiac ryanodine receptor (RyR2) Transforming growth factor-β3 (TGFβ3)	Familial, unknown gene Sarcomeric protein mutations Troponin I (RCM +/− HCM) Essential light chain of myosin Familial amyloidosis Transthyretin (RCM + neuropathy) Apolipoprotein (RCM + nephropathy) Desminopathy Pseuxanthoma elasticum Haemochromatosis Anderson–Fabry disease Glycogen storage disease	Left ventricular non-compaction Barth syndrome Lamin A/C ZASP α-dystrobrevin
Non-familial	Obesity Infants of diabetic mothers Athletic training Amyloid (AL/prealbumin)	Myocarditis (infective/toxic/immune) Kawasaki disease Eosinophilic (Churg Strauss syndrome) Viral persistence Drugs Pregnancy Endocrine Nutritional — thiamine, carnitine, selenium, hypophosphataemia, hypocalcaemia Alcohol Tachycardiomyopathy	Inflammation?	Amyloid (AL/prealbumin) Scleroderma Endomyocardial fibrosis Hypereosinophilic syndrome Idiopathic Chromosomal cause Drugs (serotonin, methysergide, ergotamine, mercurial agents, busulfan) Carcinoid heart disease Metastatic cancers Radiation Drugs (anthracyclines)	Tako Tsubo cardiomyopathy

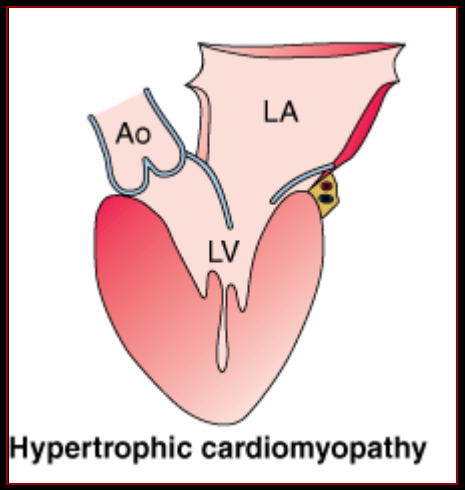
Evaluation of Cardiac Morphology and Function

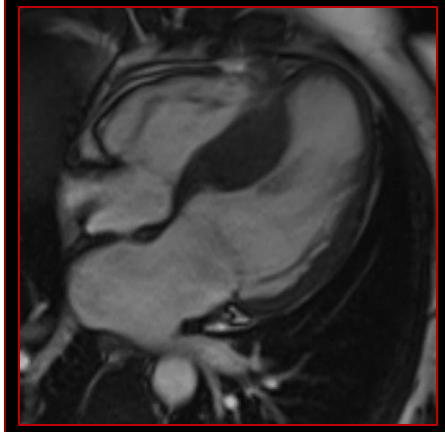


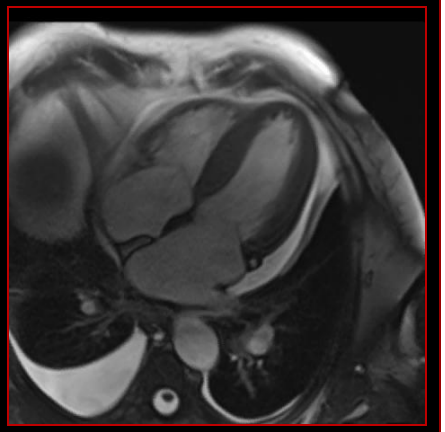


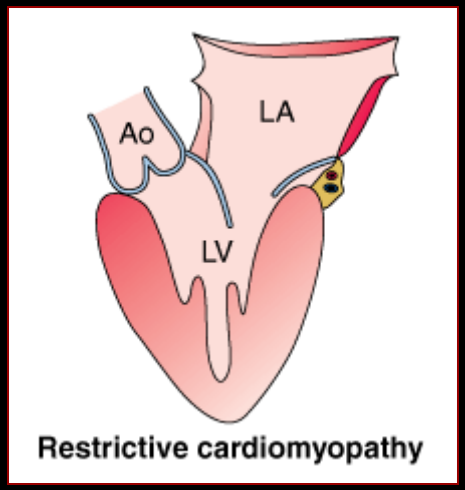




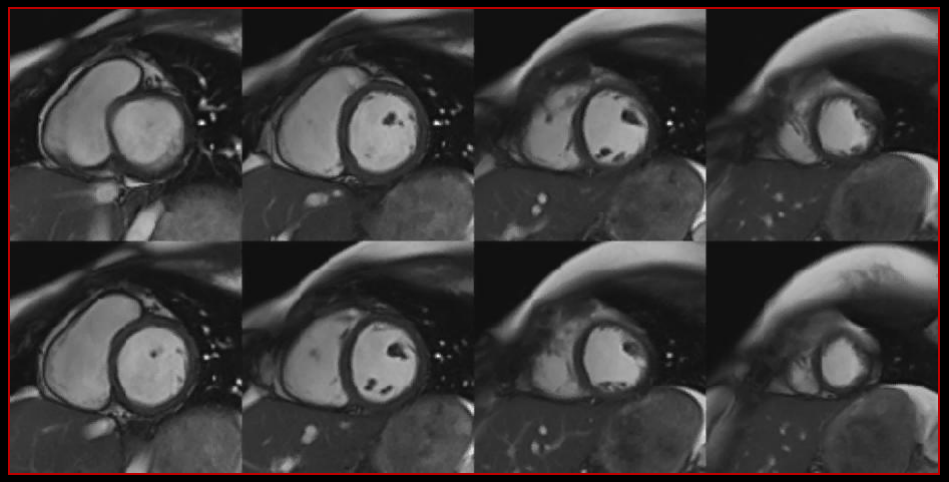




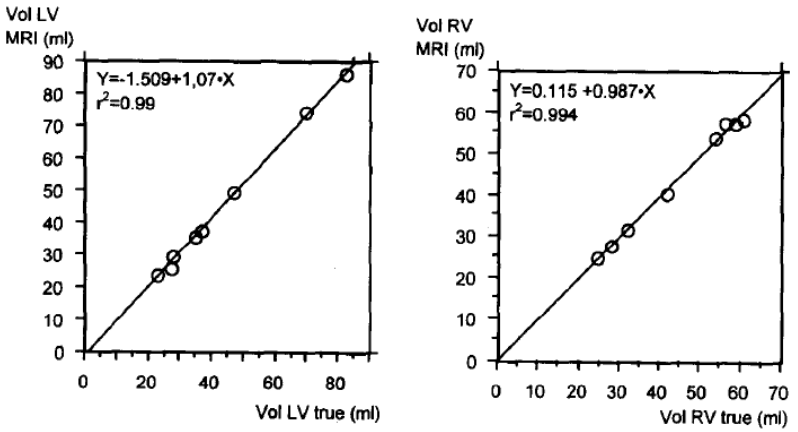




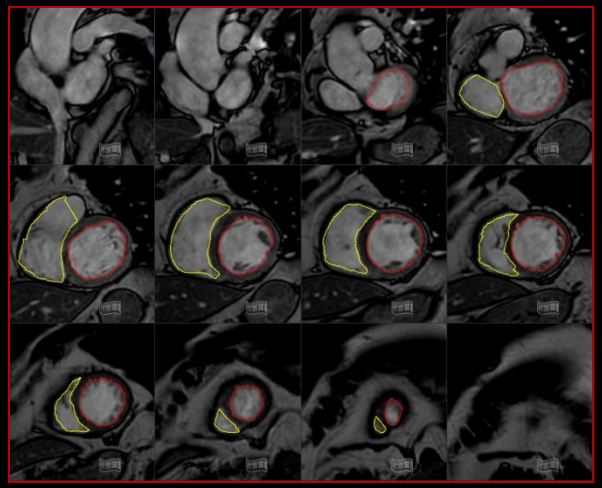
Volumetric Analysis of the Right and Left Ventricle with MRI



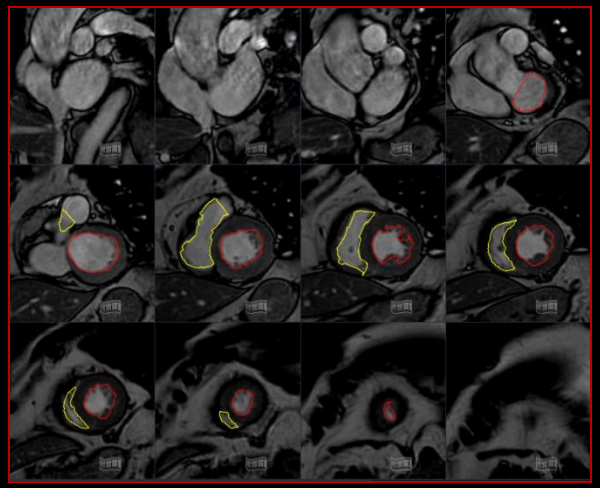
N = 8 explanted porcine hearts



Heusch A et al. *Eur J Ultrasound 1999*



End-diastole

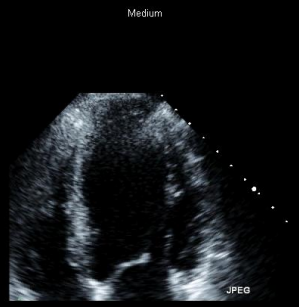


End-systole

Image Segmentation:

isolation of ventricular blood pool from myocardial wall

Noninvasive Determination of Left Ventricular Volumes and Ejection Fraction: The Issue of Feasibility and Reproducibility



2D Simpson's biplane analysis is not feasible in up to 30% pts. with CHF

Bellenger NG et al. *Eur Heart J* 2000

	Volumetric MRI	Volumetric Echocardiography	Biplane Echocardiography
Interobserver			
Variability (%)	3.6	8.3	17.8
Mean ± SD (%)	0.5 ± 1.5	−0.1 ± 3.8	1.3 ± 8.8
SEE	1.6	3.7	9.2
r^2	0.99	0.96	0.82
Intraobserver			
Variability (%)	5.1	6.9	13.4
Mean ± SD (%)	−1.1 ± 2.1	−0.4 ± 3.1	−0.9 ± 6.8
SEE	2.1	3.3	6.7
r^2	0.99	0.97	0.90

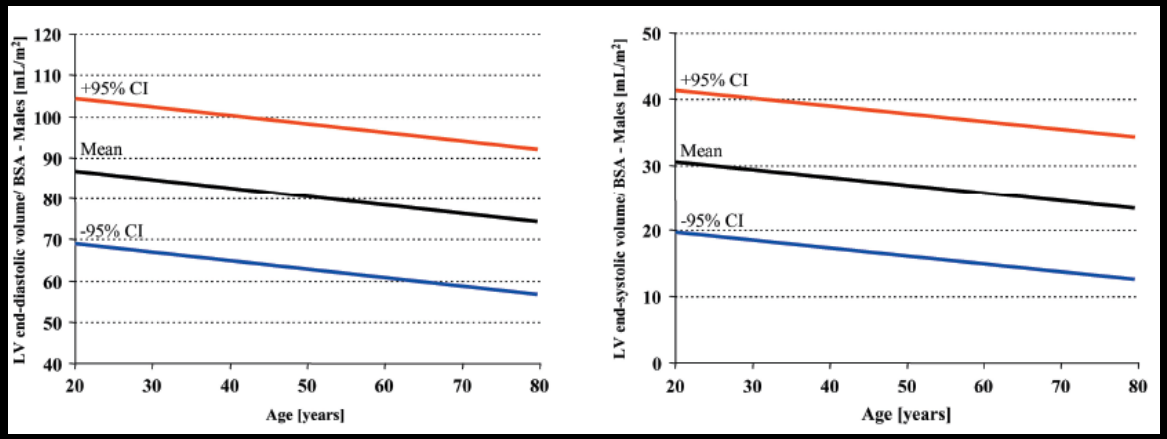
Chuang ML et al. *J Am Coll Cardiol* 2000

Comparison of LV Ejection Fraction and Volumes in Heart Failure by 2D Echocardiography and Cardiovascular Magnetic Resonance

Bellenger NG et al. *Eur Heart J* 2000

N = 52 pts. with systolic CHF
2D Echo and CMR within 4 weeks

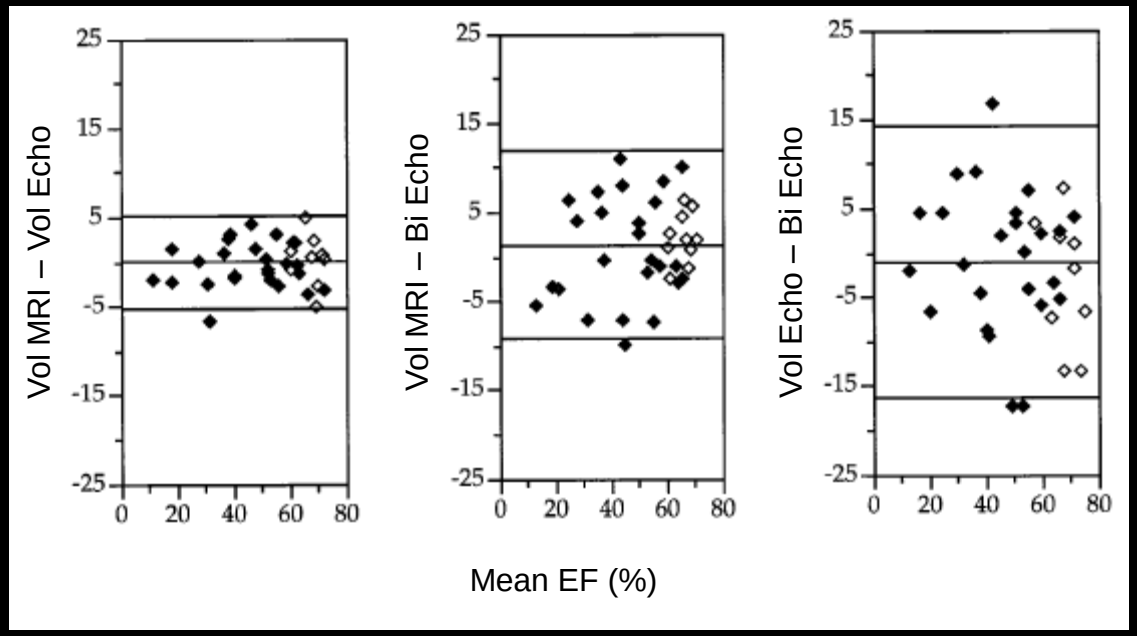
	EDV CMR – 2D Echo	ESV CMR – 2D Echo	EF CMR – 2D Echo
Mean diff ± SD	133 ± 42 ml	99 ± 45 ml	– 2 ± 11
Corr coef, *r*	0.83	0.80	0.41
P	<0.0001	<0.0001	n.s.
Limits	52 to 216	11 to 188	– 24 to 20



Noninvasive Determination of Left Ventricular Volumes and Ejection Fraction Assessment by Two- and Three-Dimensional Echocardiography and Magnetic Resonance Imaging

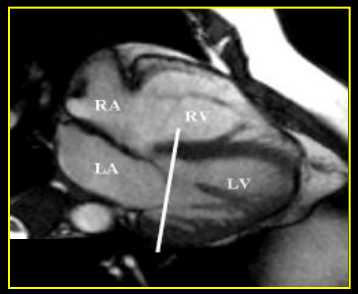
Chuang ML et al. *J Am Coll Cardiol* 2000

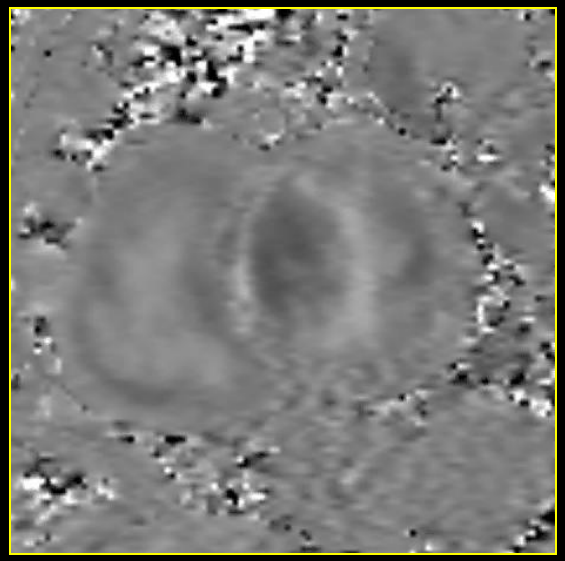
25 pts. with DCM
10 healthy volunteers

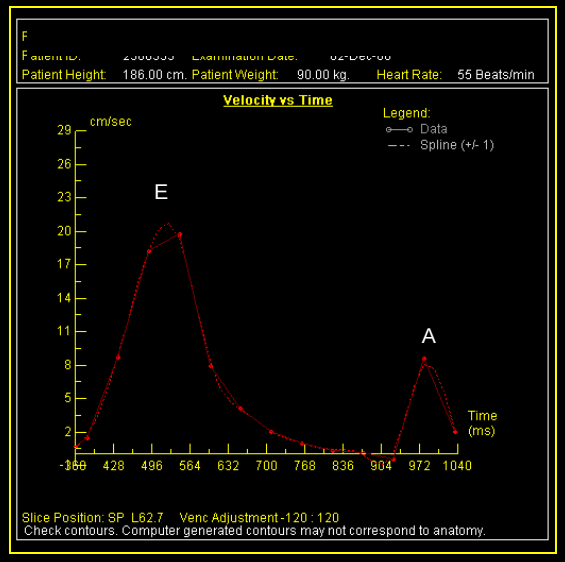


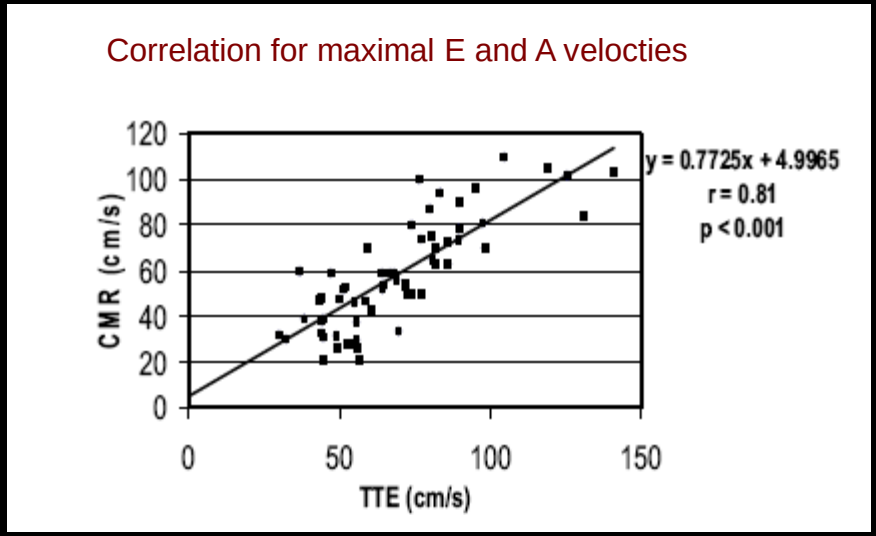
	LV Ejection Fraction			
	Normal → Mild/Mod Depressed	Mild/Mod Depressed → Sev Depressed	Normal → Sev Depressed	Total changes
Vol MRI vs Vol Echo	2	0	0	2
Vol MRI vs Bi Echo	6	5	0	11
Vol Echo vs Bi Echo	4	5	0	9

Evaluation of Transmitral Flow by Phase-Contrast MRI

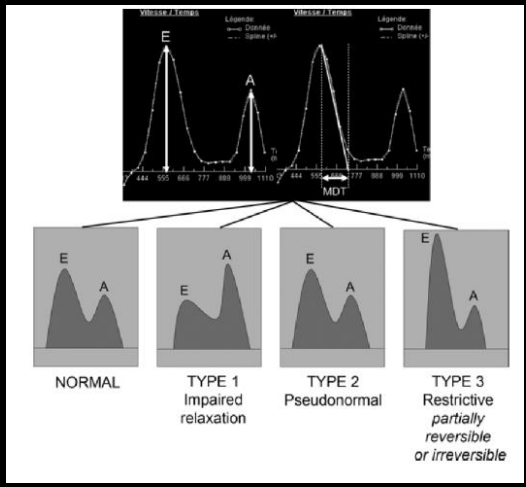








Rathi VK et al. *J Cardiovasc Magn Res* 2008

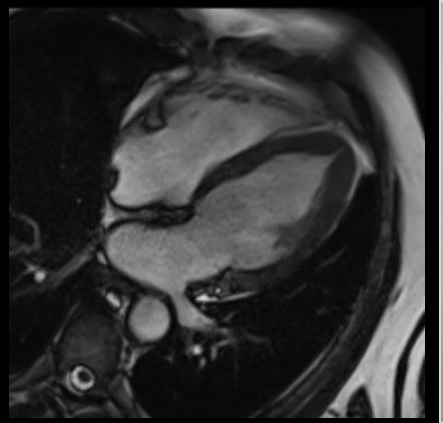


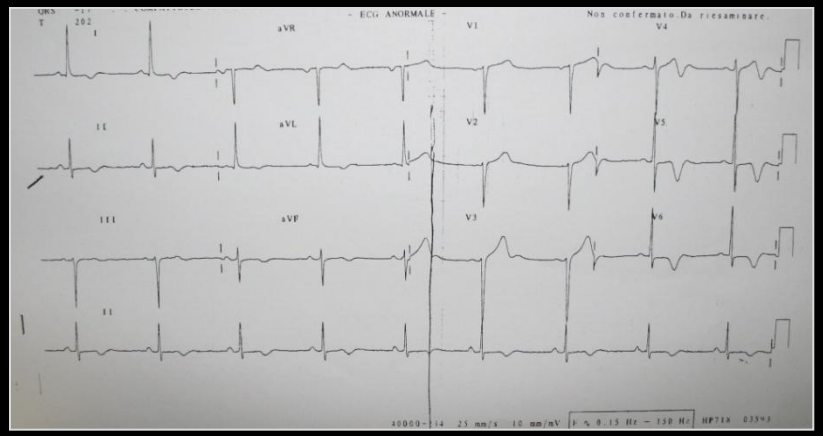
Caudron J et al. *Radiographics* 2011

Hypertrophic Cardiomyopathy Phenotype Revisited After 50 Years With Cardiovascular MR

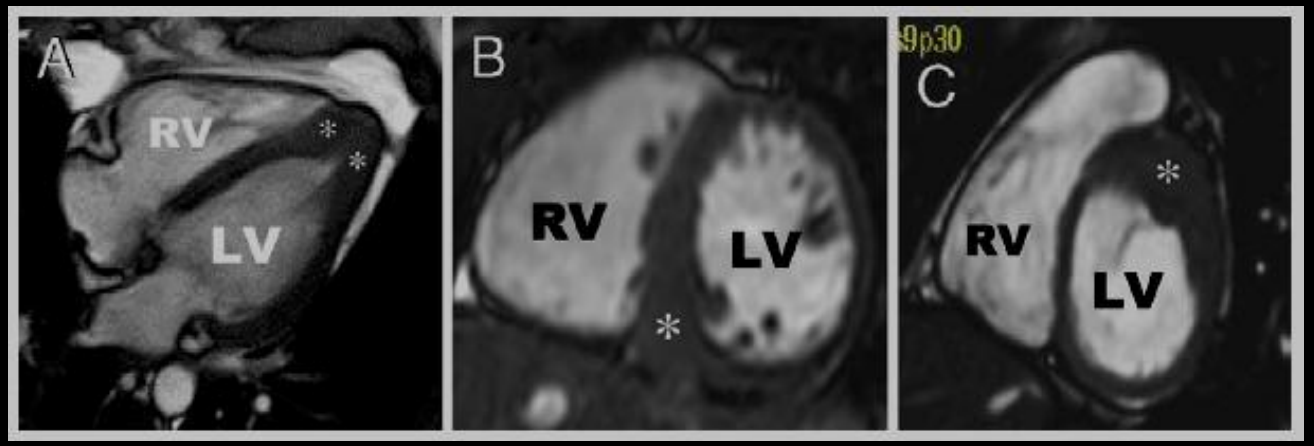
Maron MS et al. *J Am Coll Cardiol* 2009

N= 333 pts with HCM evaluated by CMR





The most common pattern
(256, 77%)



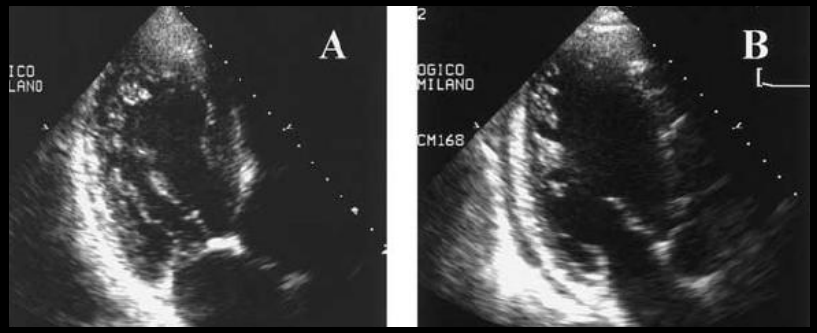
LVH patterns recognized by CMR, but not reliably with 2-D echocardiography
(40, 12%)

Incidence and Characteristics of LV Trabeculations in the Normal and Pathologic Heart

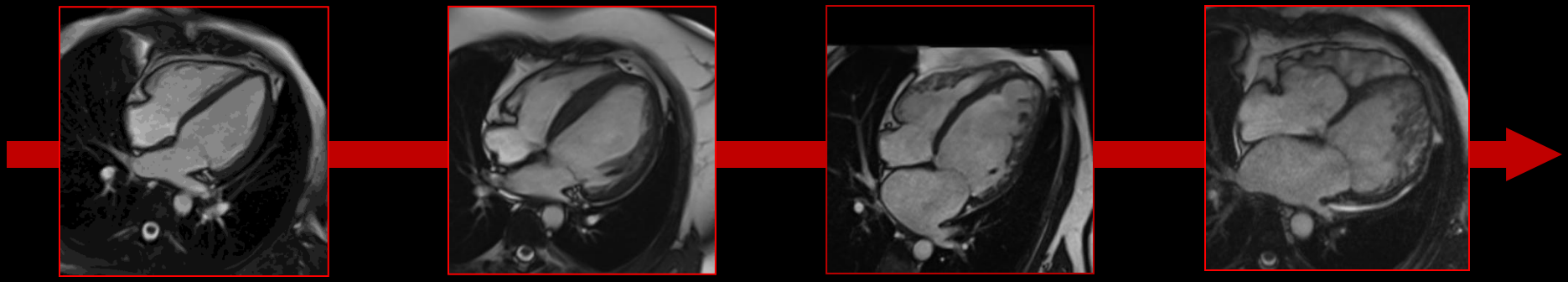
Prominent LV trabeculations may be observed in ~2/3 of autopsy specimens from subjects with normal heart.

Boyd MT et al. *J Am Coll Cardiol* 1987

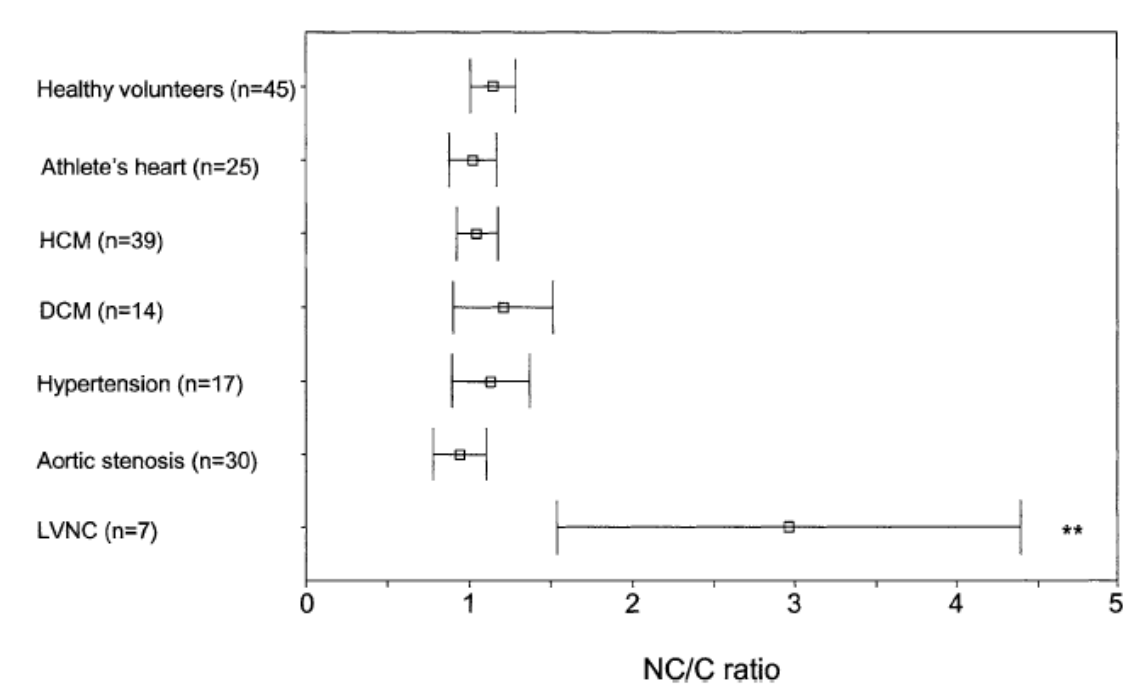
N= 1580 pts.	Trabeculations	(%)
Normal ventricle	38	8.9
Pathologic ventricle	163	14.3
Anteroapical infarction	24	15.1
Inferobasal infarction	19	11.2
Dilated cardiomyopathy	35	22.7
Left ventricular hypertrophy	33	14.9
Valvular or congenital disease	52	12

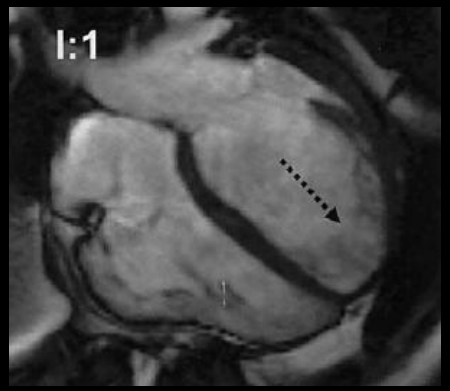


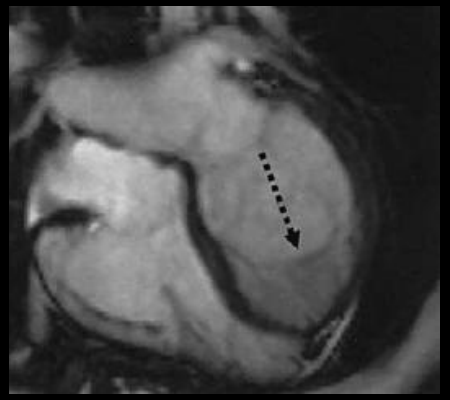
Tamborini G. et al., *JASE* 2004



Left Ventricular Non-Compaction
Insights From Cardiovascular Magnetic Resonance Imaging



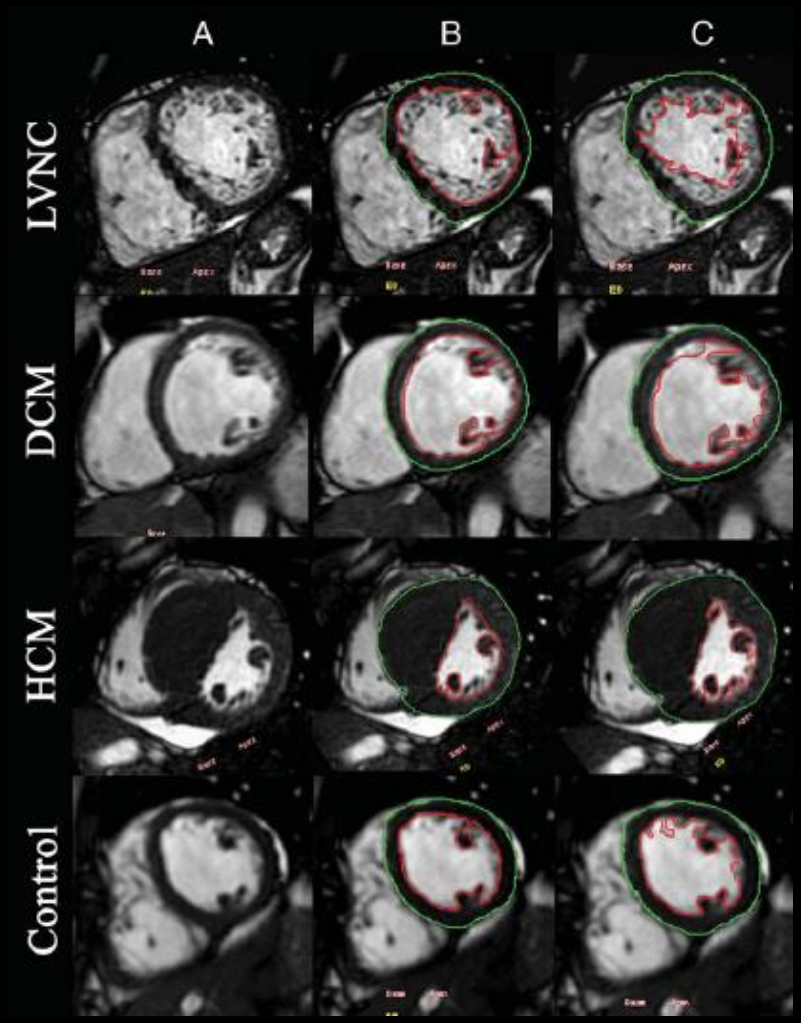


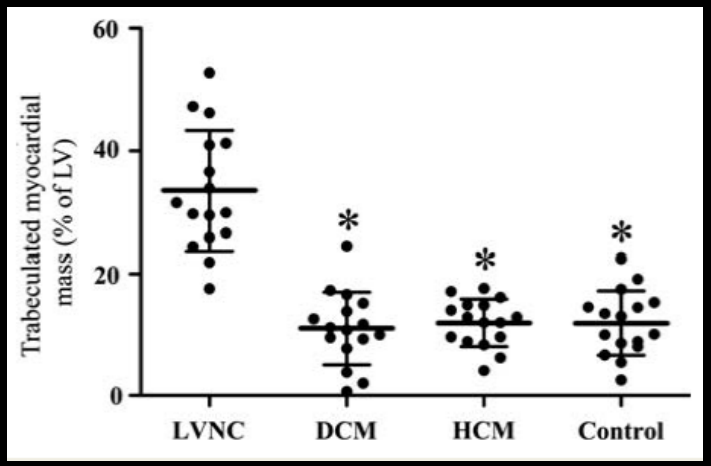


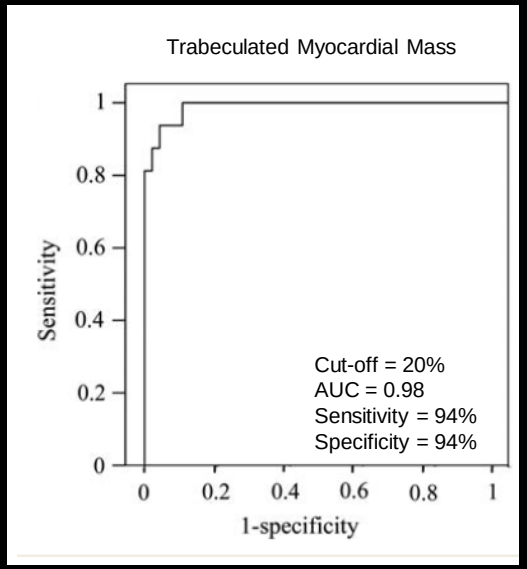
NC/C ratio>2.3	
Sensitivity	86%
Specificity	99%
PPV	75%
NPV	99%

Petersen SE et al. *J Am Coll Cardiol* 2005

Measurement of Trabeculated LV Mass Using CMR Imaging in the Diagnosis of Left Ventricular Non-Compaction



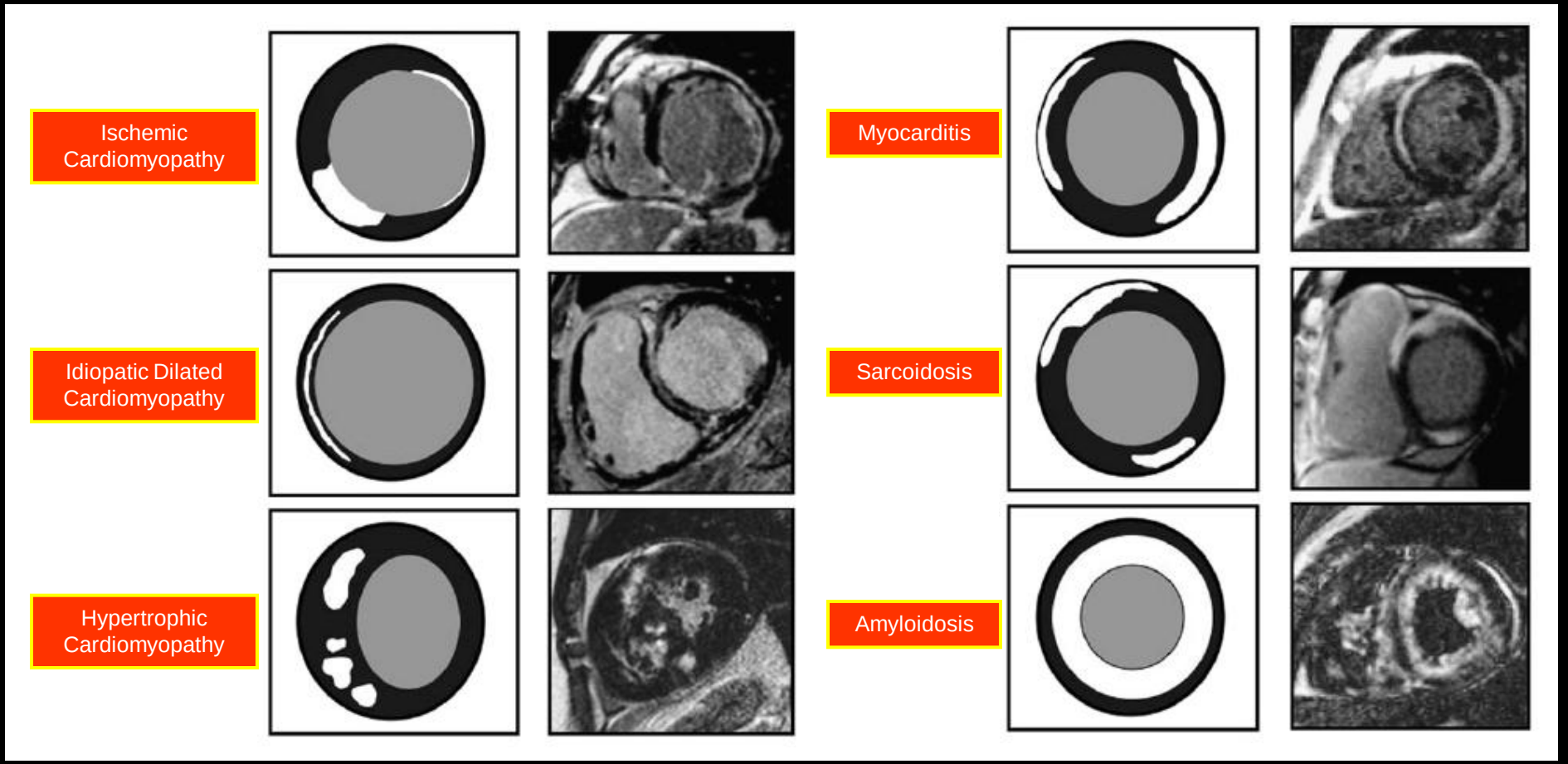




Jacquier A et al. Eur Heart J 2010

Characteristic Patterns of Late Enhancement in Specific Cardiomyopathies

White JA and Patel MR. *Cardio Clin* 2007

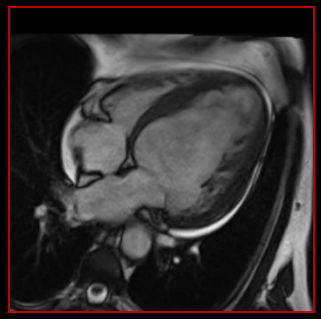


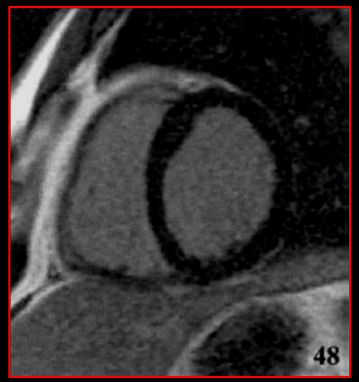
Differentiation of Heart Failure Related to Dilated Cardiomyopathy and CAD Using CE-CMR

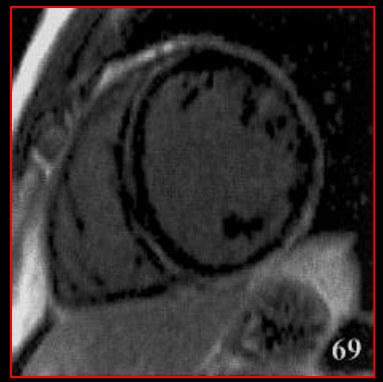
McCrohon JA et al. *Circulation 2003*

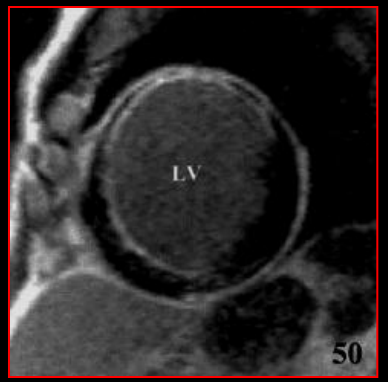
N= 90 pts with CHF and LV dysfunction
CE-CMR and coronary cath
CAD +: >50% stenosis in ≥1 coronary arteries + history of MI

	LE –	LE + (non-Ischemic)	LE + (Ischemic)
CAD + (n=27 pts)	0	0	27 (100%)
CAD – (n=63 pts)	37 (59%)	18 (28%)	8 (13%)





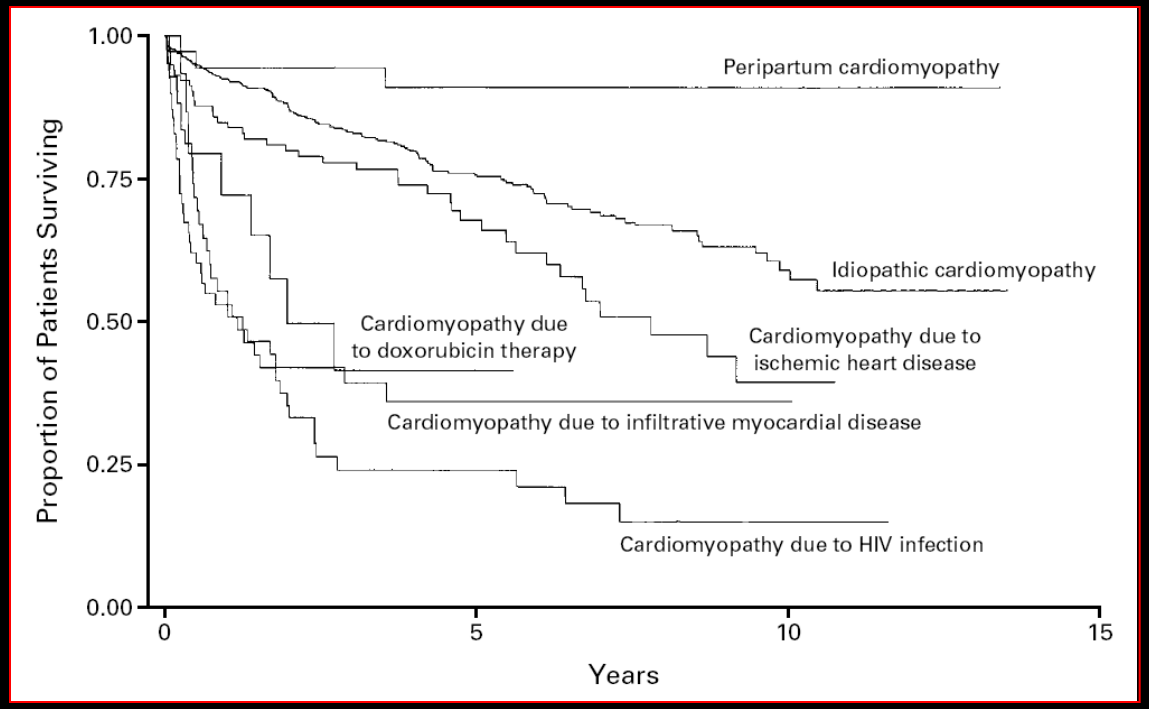




The Prognostic Value of Identifying Underlying Causes of Cardiomyopathy

Felker GM et al. *N Engl J Med* 2000

N= 1230 pts with cardiomyopathy and CHF
Endomyocardial biopsy
Mean follow-up = 4.4 years
Hard events = death or heart transplant

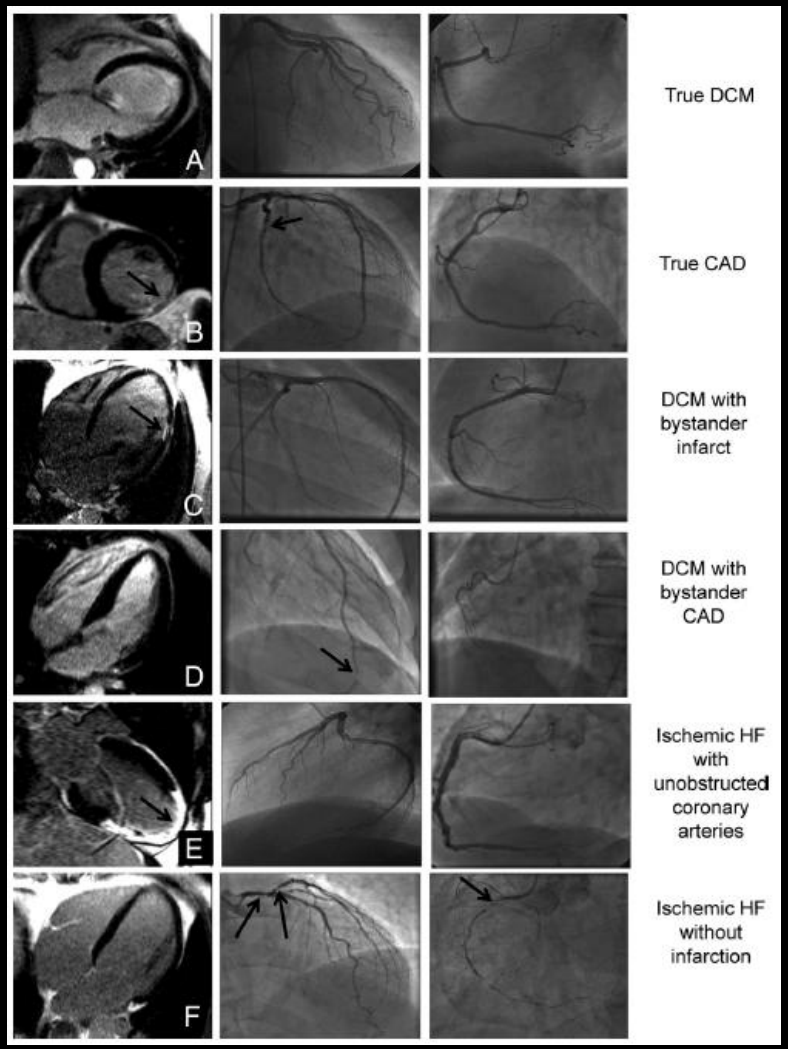


Cause	HR for death (95% CI)	p
Idiopathic	1.00	
Ischemic	1.51 (1.07-2.17)	0.02
Infiltrative	4.40 (3.04-6.39)	<0.001

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

Assomull RG et al. *Circulation 2011*

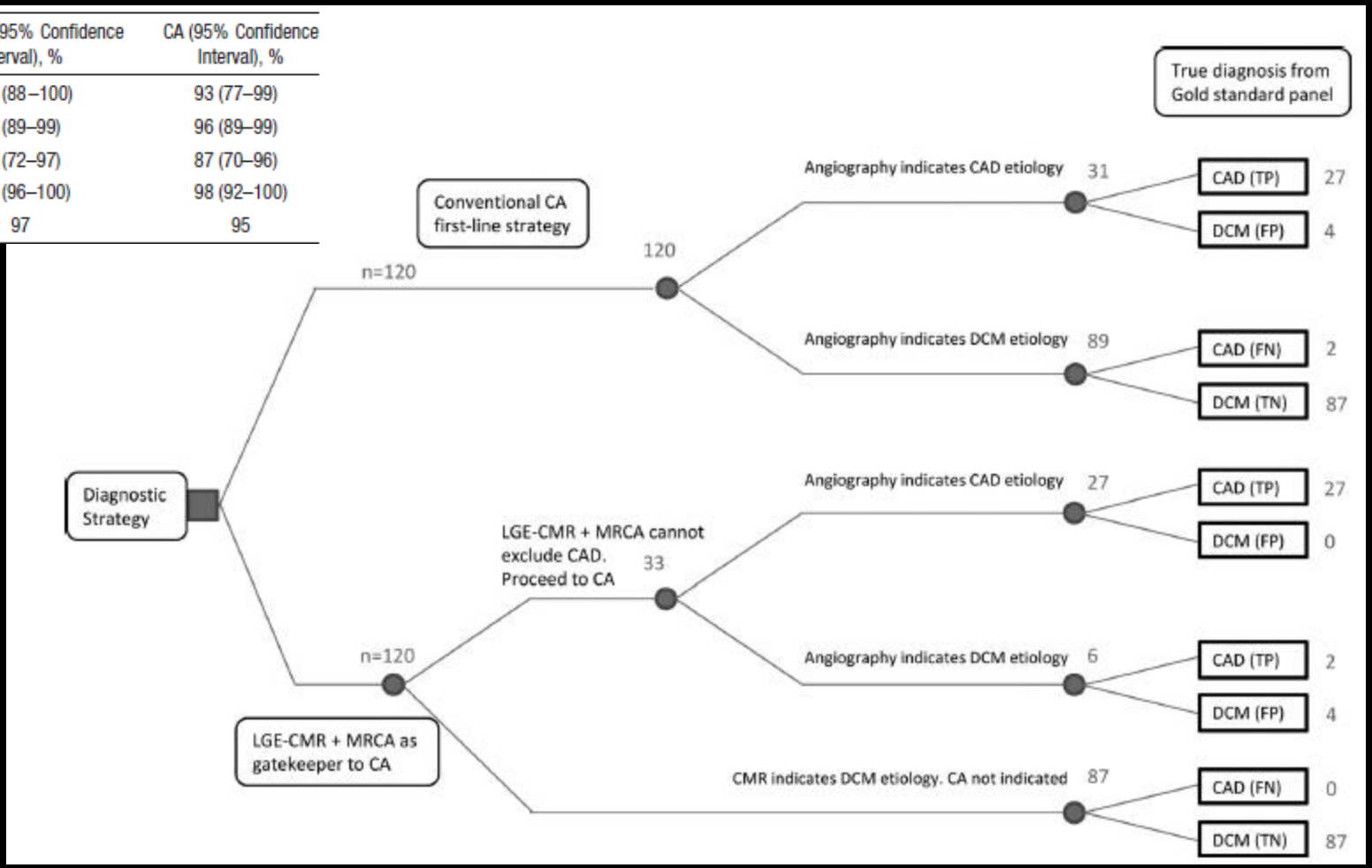
N= 120 pts with recently diagnosed HF and LV dysfunction
CMR and coronary angiography
CMR-based consensus panel
CA-based consensus panel
Gold-standard consensus panel



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

Assomull RG et al. *Circulation 2011*

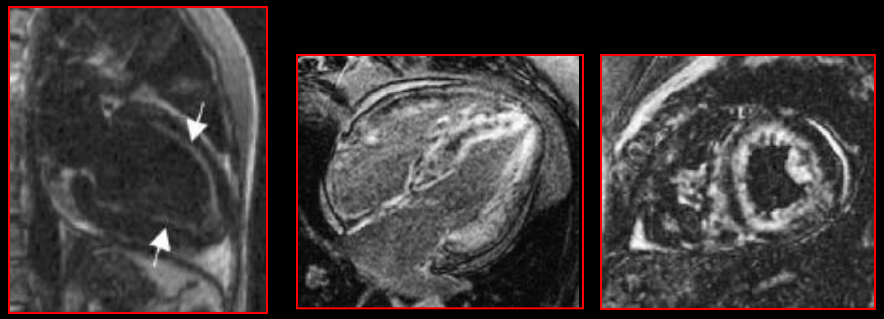
	LGE-CMR (95% Confidence Interval), %	CA (95% Confidence Interval), %
Sensitivity	100 (88–100)	93 (77–99)
Specificity	96 (89–99)	96 (89–99)
PPV	88 (72–97)	87 (70–96)
NPV	100 (96–100)	98 (92–100)
Diagnostic accuracy	97	95



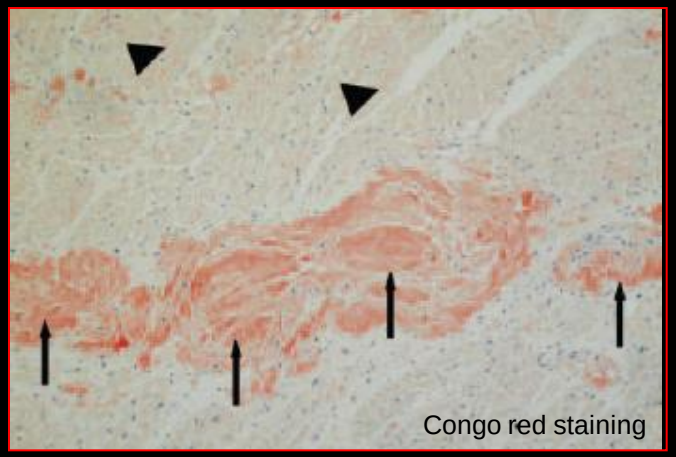
LE-CMR in Cardiac Amyloidosis

Maceira AM, Joshi J, Prasad SK, et al. *Circulation* 2005

N= 30 pts with cardiac amyloidosis
(non-cardiac biopsy + echocardiography)

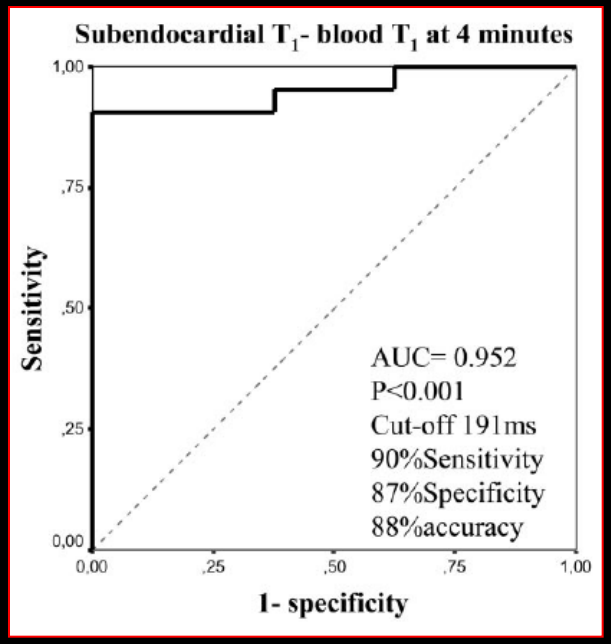


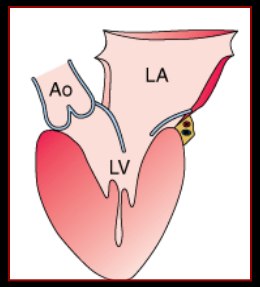
Diffuse subendocardial LGE in 2/3 of pts!!!



Cardiac Amyloidosis:

- Usually as part of systemic AL amyloidosis (2000-2500 cases/year in USA)
- AL amyloid: monoclonal Ig light chain (malign or benign monoclonal gammopathies)
- Multiorgan infiltration
- Very poor prognosis at the clinical diagnosis
- Heart failure or arrhytmias as cause of death in ~50%





Infiltrative Cardiovascular Diseases

Cardiomyopathies That Look Alike

Seward JB and Casaclang-Verzosa G. *J Am Coll Cardiol* 2010

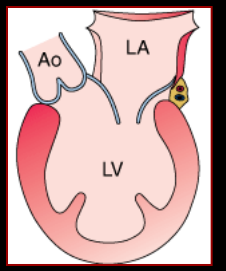
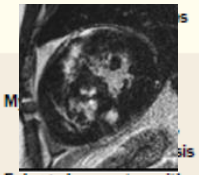
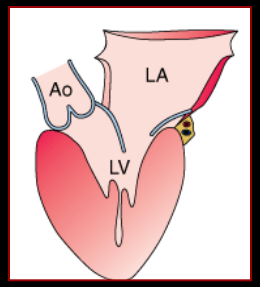


Table 1 Conditions Presenting With Increased LV Mass and Thick Ventricular Walls

Condition	Age at Presentation	History and Clinical Presentation	Echocardiography	ECG Profile	CMR LGE	Biopsy
Cardiac amyloid	>30 yrs	Heart failure symptoms, nephrotic syndrome, idiopathic peripheral neuropathy, unexplained hepatomegaly	Symmetrical increase in LV and RV wall thickness, dilated LA and RA, granular appearance of myocardium, pericardial effusion, decreased EF in advanced cases	Decreased or normal QRS complex voltage, pseudoinfarction in inferolateral leads	Global, diffuse, pronounced in subendocardium; RV and LV walls	M…  …oid
Fabry disease	Male: 11 ± 7 yrs; female: 23 ± 16 yrs	Neuropathic pain, impaired sweating, skin rashes	Symmetrical increase in LV and RV wall thickness, normal EF	Increased or normal QRS complex voltage, short or prolonged PR interval	Focal, midwall, inferolateral wall	Enlarged myocytes with clusters of concentric glycolipid (myelinoid bodies) within lysosomes
Danon disease	<20 yrs	Heart failure, skeletal myopathy, mental retardation	Very thick LV (20–60 mm), RV may or may not be thick, decreased EF	Increased or normal QRS complex voltage, short PR interval (delta wave)	Subendocardial, does not correspond to perfusion territory	Sarcoplasmic vacuolization, focal storage of PAS-positive material, myofibrillar disarray
Friedreich ataxia	25 yrs (range 2–51 yrs)	Gait abnormality	Increase in LV septal and posterior wall thickness, normal EF	Normal QRS complex voltage, ventricular tachycardia		Nonspecific
Cardiac oxalosis	>20 yrs	Juvenile urolithiasis and nephrocalcinosis	Symmetrical increase in LV and RV wall thickness; patchy, echodense speckled reflection; normal EF	Increased or normal QRS complex voltage, complete heart block	Increased myocardium attenuation on CT	Intra- and extracellular deposition of oxalate crystals without concomitant inflammation and necrosis
Mucopolysaccharidoses	1–24 yrs (median, 10 yrs)	Variable depending on subtype, coarse facial features, delayed mental development, skeletal deformities, corneal clouding, hepatosplenomegaly	Asymmetrical septal hypertrophy, mitral and/or aortic valve stenosis or insufficiency, normal EF	Increased or decreased QRS complex voltage, malignant arrhythmia		Swollen myocytes with clear cytoplasm due to accumulation of …  …s
Differential diagnosis						
Hypertrophic cardiomyopathy	17–18 yrs	Maybe asymptomatic, dyspnea, angina, syncope, sudden death	Asymmetrical hypertrophy, small LV cavity, LVOT obstruction, normal EF	Increased QRS complex voltage, pseudo–delta wave, giant T-wave inversion	Patchy, midwall, junctions of the ventricular septum and RV	M… …sis
Hypertensive heart disease	Adults	History of hypertension	Symmetrical increase in LV wall thickness, mild LV dilation, normal EF	Increased QRS complex, nonspecific ST-T-wave changes	No pattern, predominantly subendocardial	Enlarged myocytes with enlarged or replicated nuclei



Infiltrative Cardiovascular Diseases

Cardiomyopathies That Look Alike

Seward JB and Casaclang-Verzosa G. *J Am Coll Cardiol* 2010

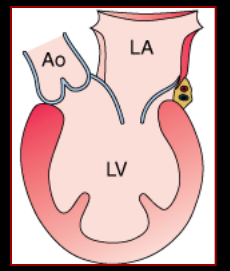
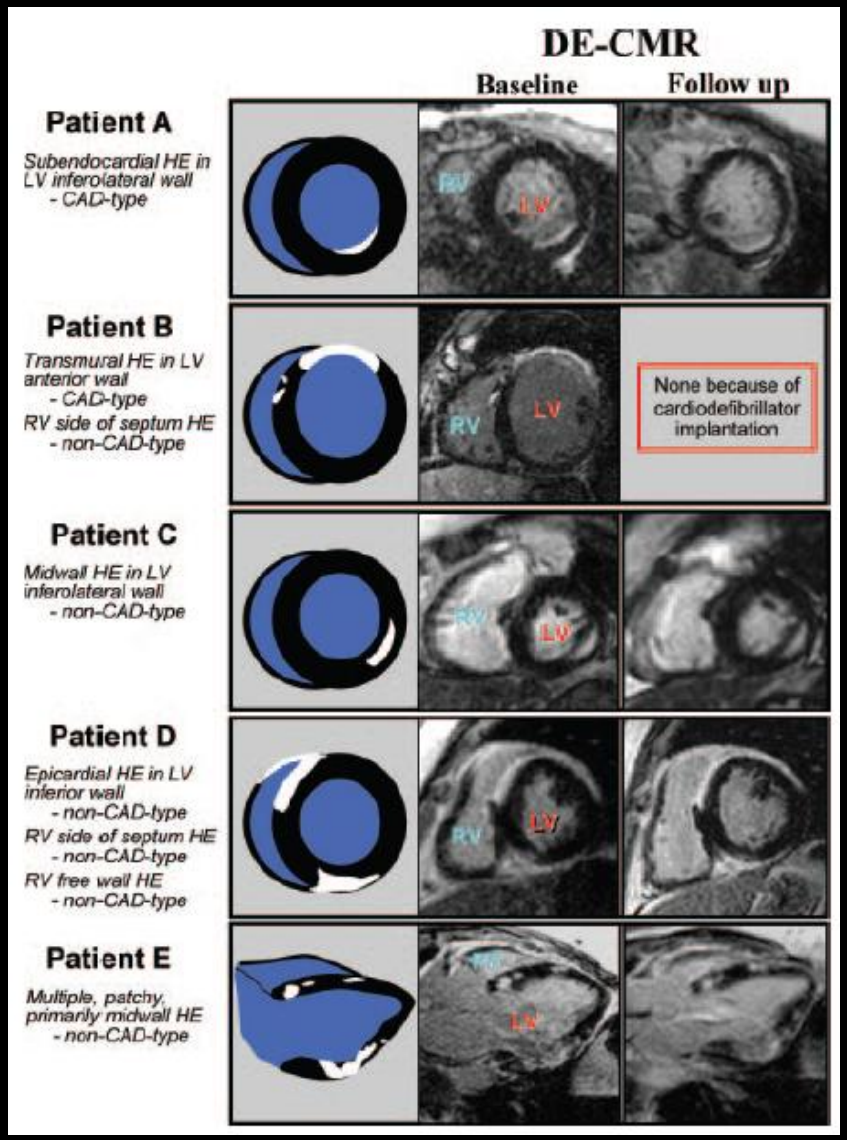


Table 2 Conditions With Dilated LV and Infarct Pattern

Condition	Age at Presentation	History	Echocardiography	ECG	CMR LGE	Cardiac Biopsy
Sarcoidosis	Young adults	Congestive heart failure	Variable wall thickness, focal or global hypokinesis, LV aneurysm	Infrahisian block, atypical infarction pattern	Patchy, basal and lateral LV walls	Noncas… …eated gian… surr… …f dens…
Wegener disease	Young adults	Chronic upper and lower respiratory tract infections	Regional hypokinesis, pericardial effusion, mild MR, LV systolic dysfunction	Atrial fibrillation, atrioventricular block, atypical infarction pattern	Diffuse, midwall	Vasculitis with necrotizing granulomatous inflammation
Hemochromatosis	Hereditary hemochromatosis: >30 yrs in men, older in women; secondary hemochromatosis: any age	Hereditary hemochromatosis: liver function abnormalities, weakness and lethargy, skin hyperpigmentation, diabetes mellitus, arthralgia, impotence in men; secondary hemochromatosis: hemolytic anemia, multiple blood transfusions	Dilated LV with global systolic dysfunction	Supraventricular arrhythmia, ventricular conduction abnormality is rare		Iron deposits within the myocyte
Differential diagnoses						
Ischemic cardiomyopathy	Adult	Coronary artery disease, congestive heart failure	Dilated LV, regional hypokinesis corresponding to perfusion territory, decreased systolic function	Multiform premature ventricular complexes, nonsustained ventricular tachycardia	Subendocardial, different degrees of transmural extension, corresponds to perfusion territory	
Idiopathic dilated cardiomyopathy	Adult	Congestive heart failure, no known cardiovascular disease	Dilated LV with global systolic dysfunction	Atrial fibrillation	No LGE, or if present, midwall and patchy	

Detection of Myocardial Damage in Patients With Sarcoidosis



N= 58 biopsy-proven pulmonary sarcoidosis
Clinically-defined cardiac sarcoidosis in 12 (21%) pts.
LE (+) = 19 (33%) pts.

Diagnostic Performance of LGE	-
Sensitivity	100%
Specificity	78%
Positive Predictive Value	55%
Negative Predictive Value	100%
Accuracy	83%

LGE in 100% of pts with clinical cardiac sarcoidosis!!!

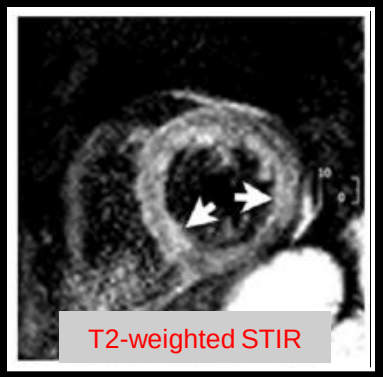
Smedema JP et al. J Am Coll Cardiol 2005
Patel MR et al. Circulation 2009

Cardiovascular Magnetic Resonance in Myocarditis

Friedrich M.G. et al. for the International Consensus Group on CMR in Myocarditis, *J Am Coll Cardiol* 2009

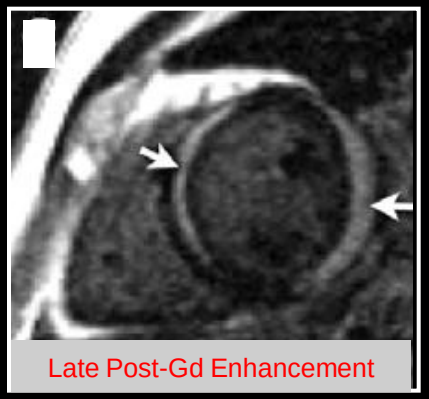
Tissue pathology in active myocarditis

- Edema/inflammation



- Hyperemia/capillary leakage

- Necrosis/fibrosis



Diagnostic Accuracy of CMR Tissue Criteria in Detecting Myocarditis

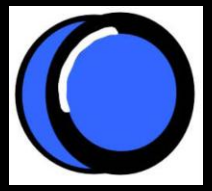
Friedrich M.G. et al. for the International Consensus Group on CMR in Myocarditis, *J Am Coll Cardiol* 2009

	Sensitivity (%)	Specificity (%)	Accuracy (%)	PPV (%)	NPV (%)
T2W STIR	70	71	70	77	63
Early Post-Gd Enhancement	74	83	78	86	70
Late Post-Gd Enhancement	59	86	68	89	53
Combination (any 2 of 3)	**67**	**91**	**78**	**91**	**69**

Proposed Diagnostic CMR Criteria for Myocarditis

(≥2 criteria need to be satisfied)

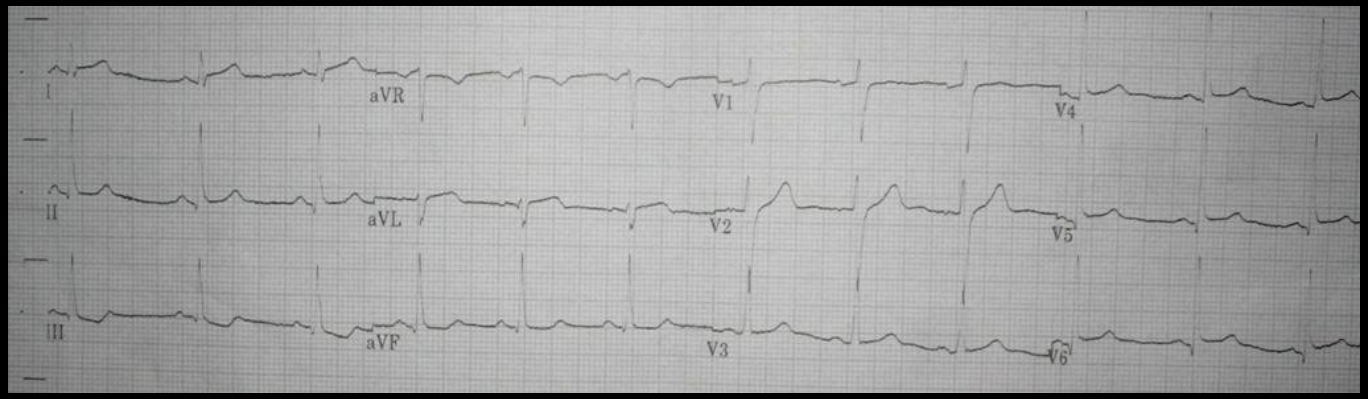
1. Regional or global ↑ SI in T2W STIR images
2. ↑ myocardium/skeletal muscle SI ratio in early post-Gd T1W images
3. ≥1 focal area of nonischemic enhancement in late post-Gd T1W images

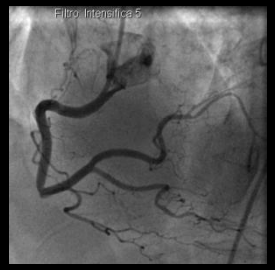


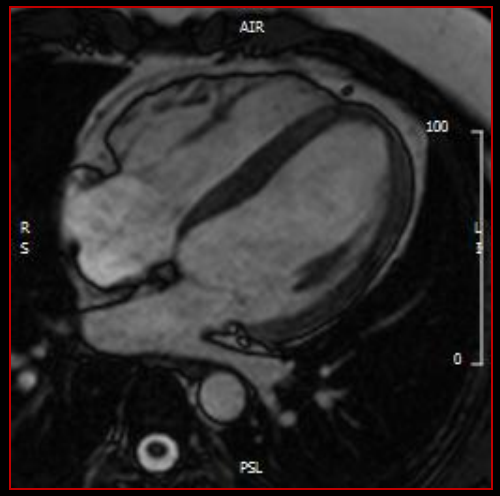
Ischemia

Myocarditis

T.R.
36 year-old male
Intense chest pain after 3 days with fever (zenith = 39.1° C)
No CV risk factors
TnI = 5.18 ng/dl
Echo unremarkable
Coronary angiography –

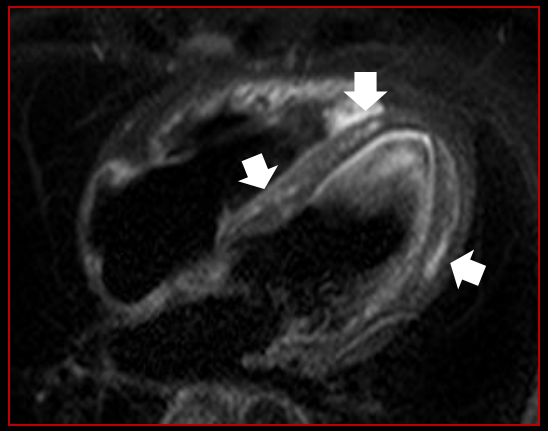






Cine

(Function)



T2 STIR

(Edema/Inflammation)

Late Enhancement

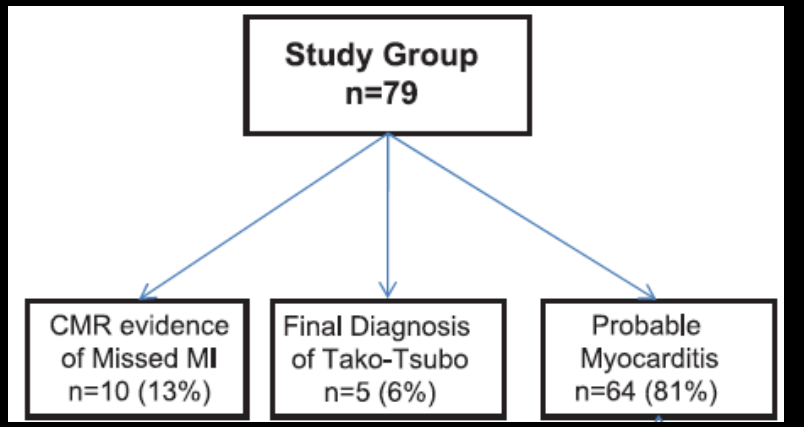
(Necrosis/Fibrosis)

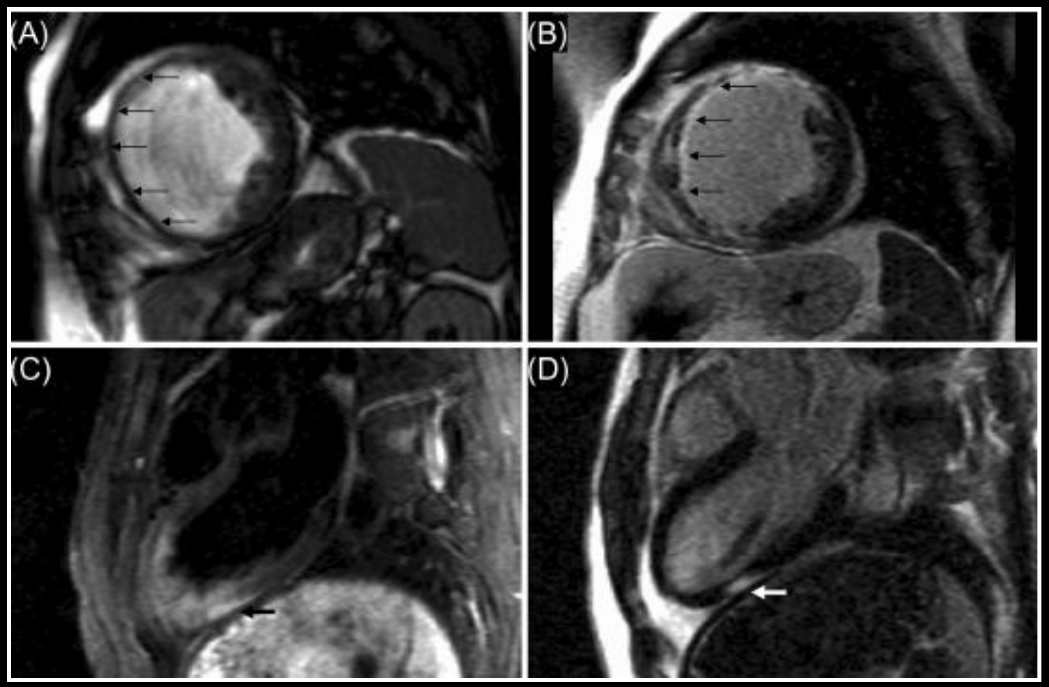
Role of CMR in Patients Presenting with Chest Pain, Raised Troponin, and Unobstructed Coronary Arteries

N= 79 pts resting chest pain, ↑ Tn and CAD (–) by cath

92% with abnormal ECG on presentation (40% with ↑ST)

Median symptoms-CMR interval = 15 days



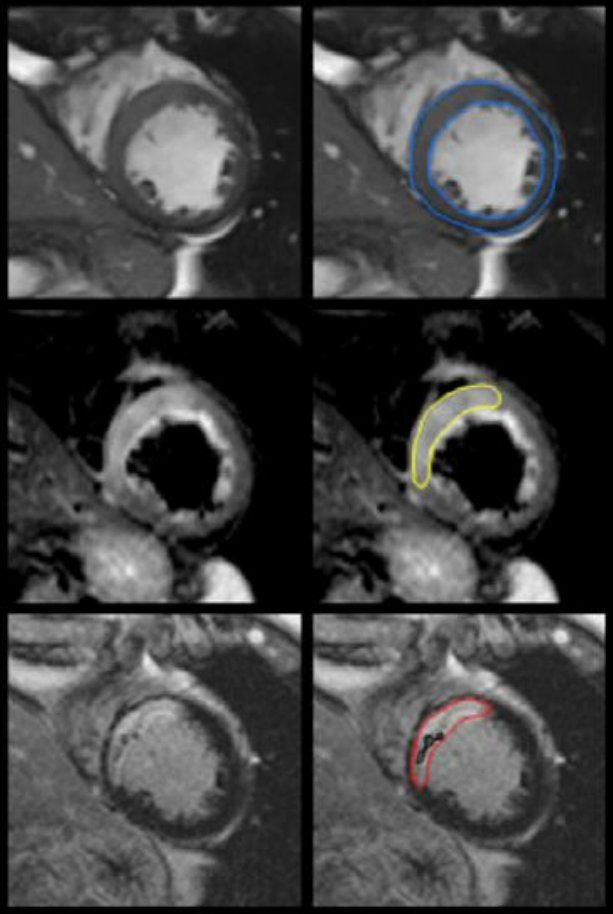


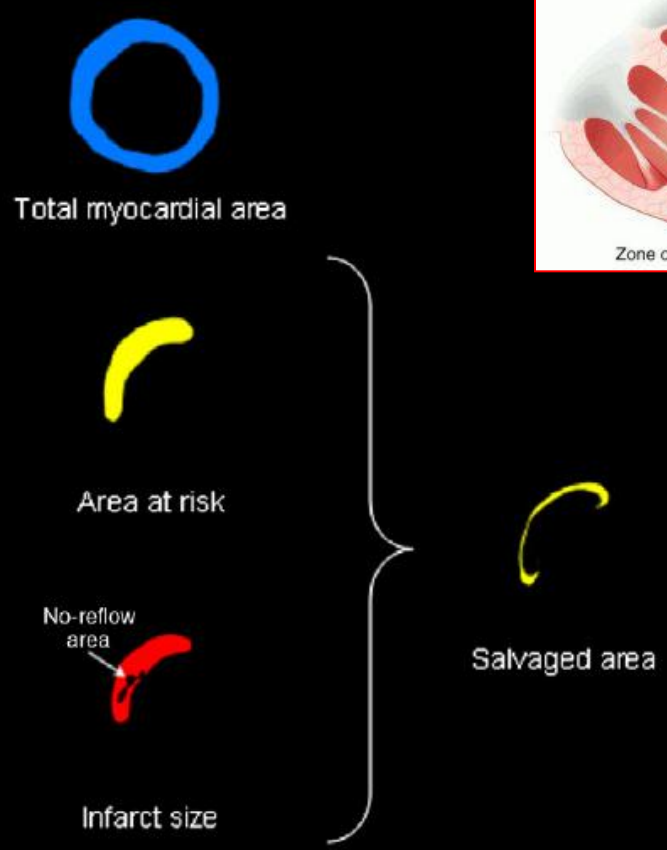
Assomull RG et al. *Eur Heart J* 2007

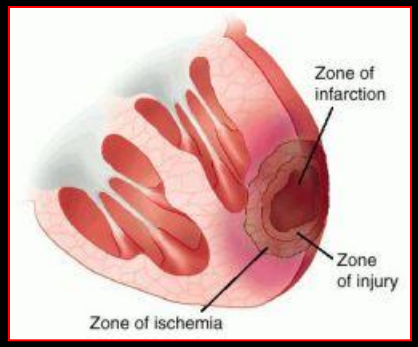
Monney PA et al. *Heart* 2010

MRI for Infarct Sizing and Characterization of Ischemic Myocardial Damage

Esposito G, Dellegrottaglie S, Chiariello M. *Am Heart J Suppl* 2010





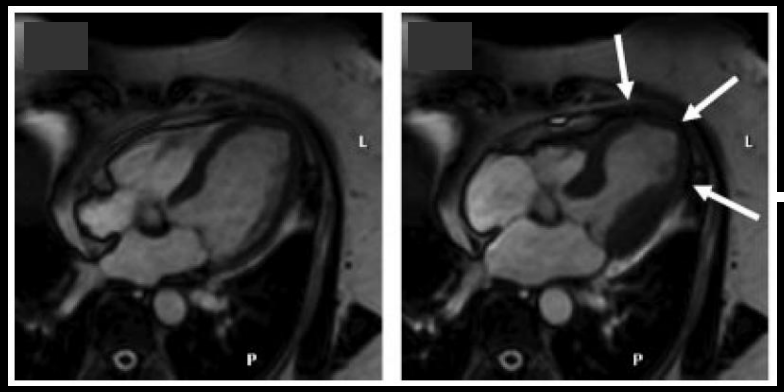


Salvaged myocardium correlated inversely with the time-to-reperfusion (r= -0.37; p< 0.0001) (Friedrich et al. JACC 2008)

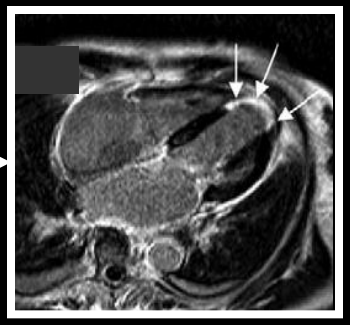
Differential Diagnosis of Suspected Apical Ballooning Syndrome Using Contrast-Enhanced MRI

Eitel I. et al. *Eur Heart J* 2008

N= 59 ACS pts with normal coronary vessels and apical ballooning by cath
(suspected Tako-Tsubo based on Mayo Clinic Criteria)

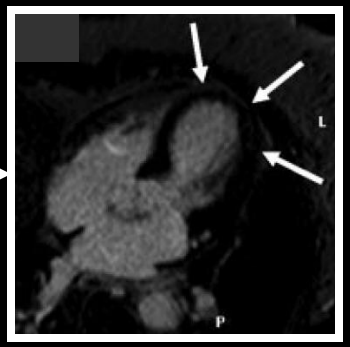


End-diastole End-systole



MI (13, 22%)

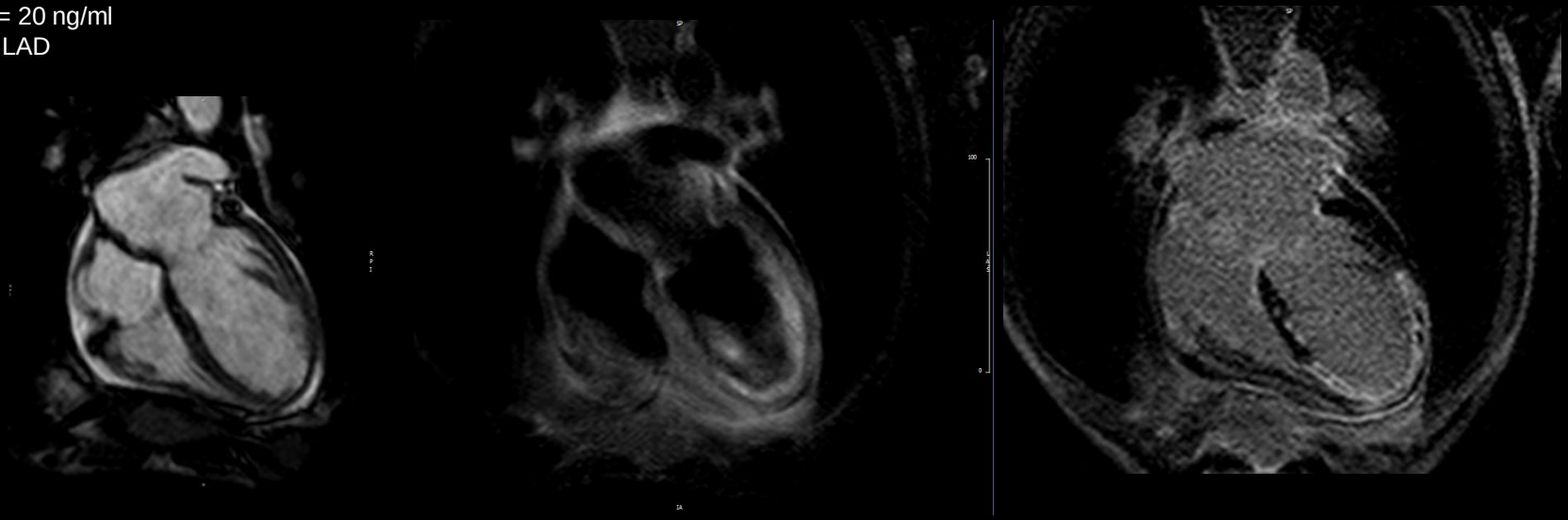
Myocarditis (8, 14%)



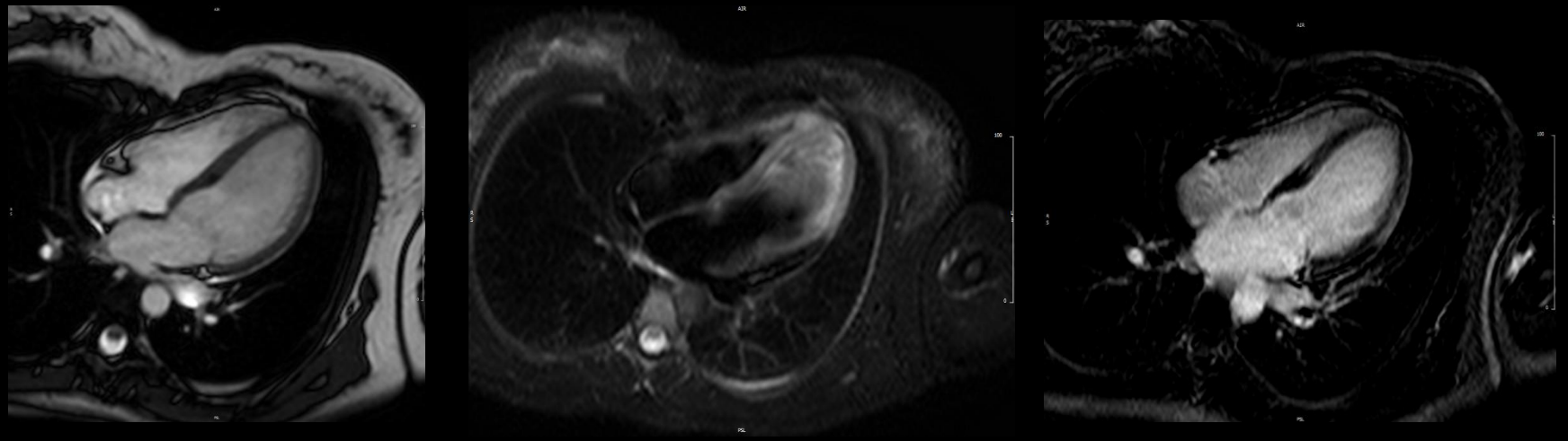
Takotsubo (38, 64%)

Left Ventricular Apical Ballooning: CMR Characterization

69-year-old man with acute chest pain
Significant ST elevation
Peak TnI = 20 ng/ml
Occluded LAD



34-year-old female with acute chest pain (intense emotional stress)
Significant ST elevation
Peak TnI = 1.06 ng/ml
Normal coronary arteries



Arrhythmogenic Right Ventricular Dysplasia (ARVD)

1994 Task Force Criteria

Major Criteria

- Right ventricular dysfunction
  - Severe dilatation and reduction of RV ejection fraction with little or no LV impairment
  - Localized RV aneurysms
  - Severe segmental dilatation of the RV
- Tissue characterization
  - Fibrofatty replacement of myocardium
- Conduction abnormalities
  - Epsilon waves in V1 - V3.
  - Localized prolongation (>110 ms) of QRS in V1 - V3
- Family history
  - Familial disease confirmed on autopsy or surgery

2010 Revised Task Force Criteria

By MRI:

- Regional RV akinesia or dyskinesia

+ 1 of the following:

- Index RV volume >110 ml/m^2 (male) or >100 ml/m^2 (female)
- RV EF <40%

Minor Criteria

- Right ventricular dysfunction
  - Mild global RV dilatation and/or reduced ejection fraction with normal LV.
  - Mild segmental dilatation of the RV
  - Regional RV hypokinesis
- Conduction abnormalities
  - Inverted T waves in V2 and V3 in an individual over 12 years old, in the absence of a
  - Late potentials on signal averaged EKG.
  - Ventricular tachycardia with a LBBB morphology
  - Frequent PVCs (> 1000 PVCs / 24 hours)
- Family history
  - Family history of sudden cardiac death before age 35
  - Family history of ARVD

2010 Revised Task Force Criteria

By MRI:

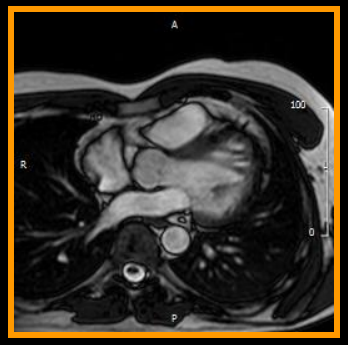
- Regional RV akinesia or dyskinesia

+ 1 of the following:

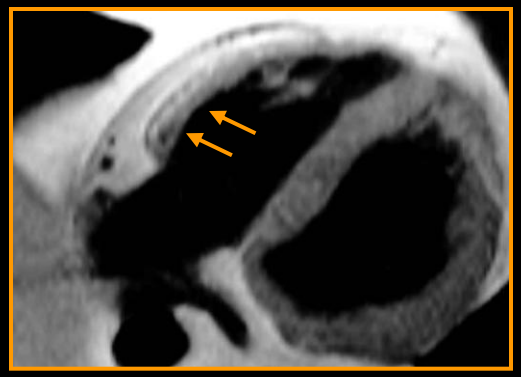
- Index RV volume = 100-110 ml/m^2 (male) or 90-100 ml/m^2 (female)
- RV EF = 40-45%

ARVC: Role of Cardiac MRI

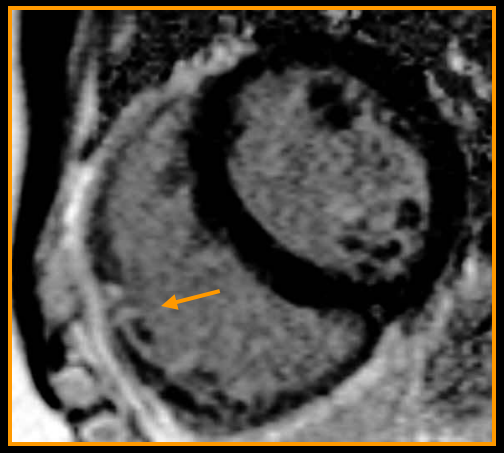
Regional and global RV dysfunction



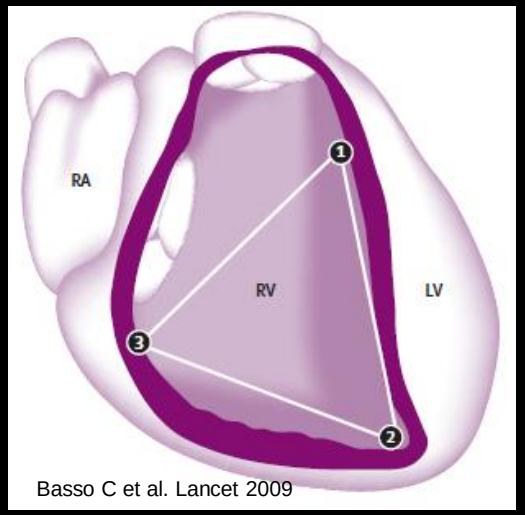
Fatty infiltration



Myocardial fibrosis

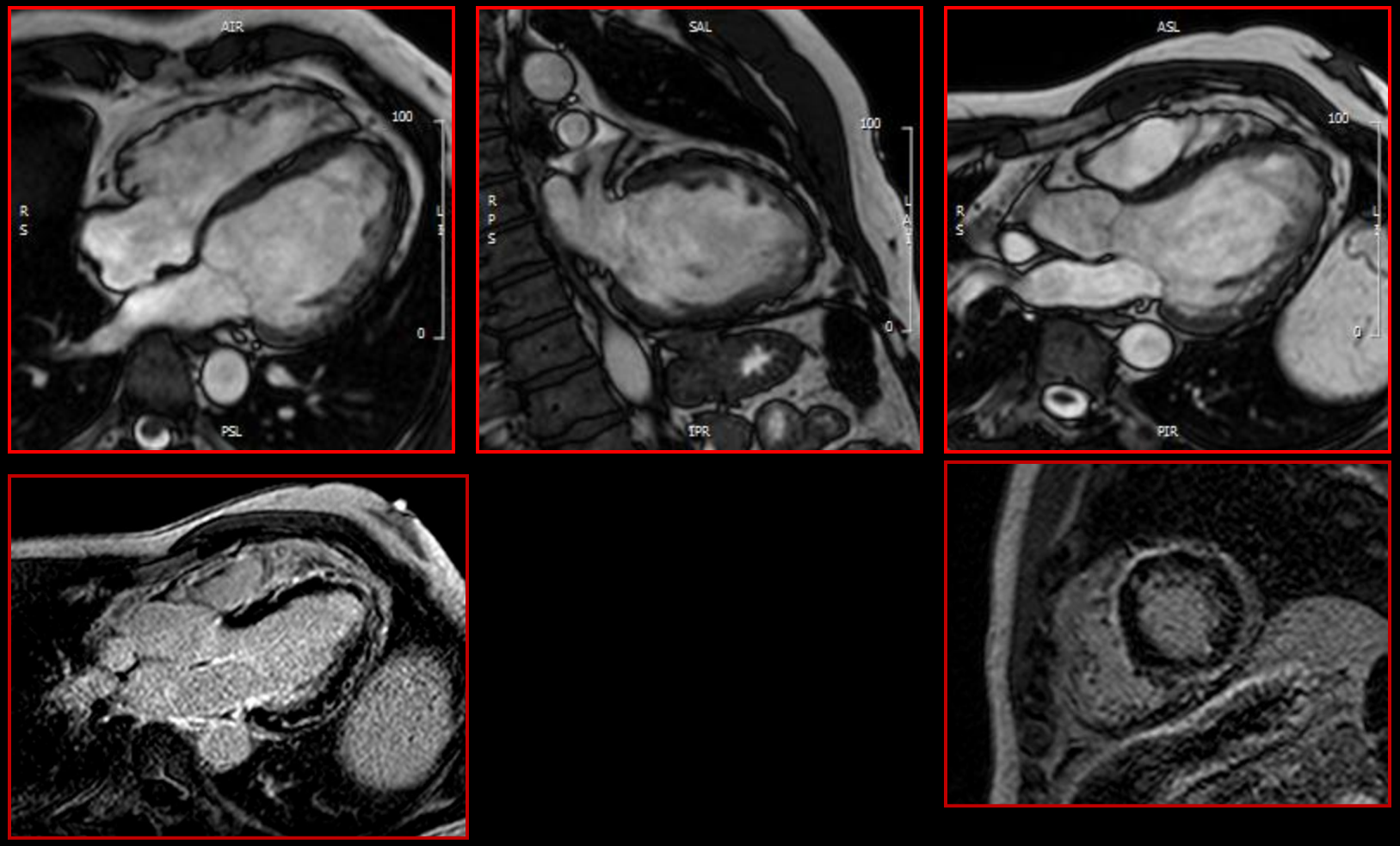


Triangle of Dysplasia



Basso C et al. Lancet 2009

P.G.
33 year-old male
Positive family history for SCD
Previous episode of NSVT
Negative T waves in V1-V6



Biventricular Arrhythmogenic Cardiomyopathy

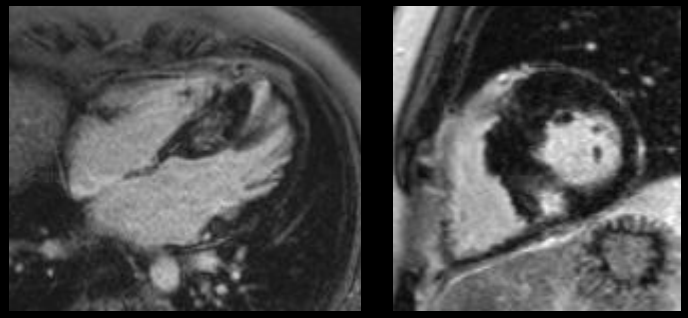
The Prognostic Implications of Cardiovascular Magnetic Resonance

Flett AS et al. *Circ Cardiovasc Imaging* 2009

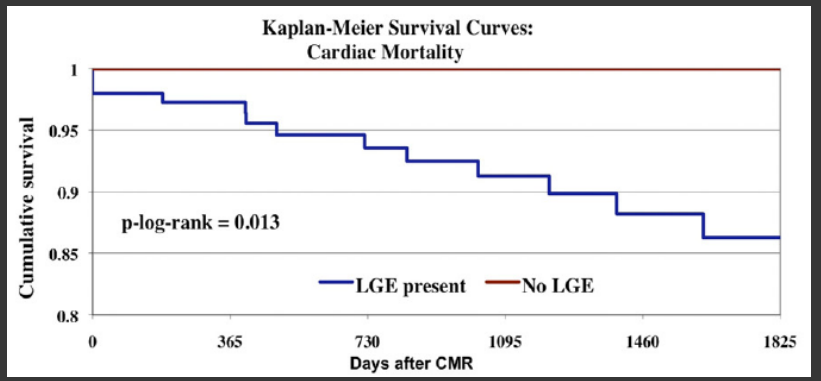
Table. Prognostic Evidence Base of CMR

Disease	Technique	Studies	End Point, n, (Patient-Years)	Reference
ACS chest pain	Adenosine stress	1	MACE, 131, (168)	Ingkanisorn et al, 2006[7]
Infarction	Infarct size	1	MACE/mortality, 122, (244)	Wu et al, 2007[10]
	MVO	4	MACE, 405, (378)	Wu et al, 1998[13], Hombach et al, 2005[14], Cochet et al, 2008[15]*, Bruder et al, 2008[16]
	Peri-infarct zone	1	Mortality, 144, (346)	Yan et al, 2006[20]
	Silent MI	3	MACE/mortality, 682, (1210)	Kwong et al, 2006[28], Kwong et al, 2008[29], Valle et al, 2008[48]*
Chronic IHD	Extent of LGE	2	MACE/mortality, 1486, (3801)	Cao et al, 2008[25], Chan et al, 2008[24]
Postsurgical	New LGE	1	MACE/mortality, 152, (441)	Rahimi et al, 2008[31]*
Normal LV	Dobutamine stress	2	MACE/mortality, 578, (1063)	Hundley et al, 2002[37], Kuijpers et al, 2004[39]
	Mixed stress	1	MI/mortality, 513, (1180)	Jahnke et al, 2007[41]
	Adenosine stress	2	Mortality, 1220, (2823)	Bingham and Hachamovitch, 2008[44], Pilz et al, 2008[42]
	Dipyridamole stress	1	MACE/mortality, 420, (483)	Bodi et al, 2007[43]
Impaired LV	Dobutamine stress	1	MI/mortality, 200, (1000)	Dall'Armellina et al, 2008[40]
	LGE	2	MACE, mortality, 435, (1050)	Yokota et al, 2008[32], Kwon et al, 2009[33]
	LGE pre-CRT	1	Heart failure, nonresponse, mortality, 62, (126)	Chalil et al, 2007[34]
	CMR TSI pre-CRT	1	MACE/mortality, 77, (161)	Chalil et al, 2007[35]
DCM	LGE	2	MACE/mortality, 166, (274)	Assomull et al, 2006[46], Wu et al, 2008[47]
HCM	LGE	1	Mortality, 424, (1201)	Rubinshtein et al, 2008[56]
	Apical aneurysms	1	MACE, mortality, 1299, (5326)	Maron et al, 2008[50]†
Amyloid	Gd kinetics	1	Mortality, 29, (49)	Maceira et al, 2008[62]
PAH	Volumes	1	Mortality, 64, (64)	Van Wolferen et al, 2007[63]
Congenital	RV morphology	1	MACE, 88, (370)	Knauth et al, 2008[69]
Stroke	Carotid plaque	1	Stroke, 154, (490)	Takaya et al, 2006[71]

Prognostic Value of Myocardial Fibrosis by MRI in Hyperthophic Cardiomyopathy

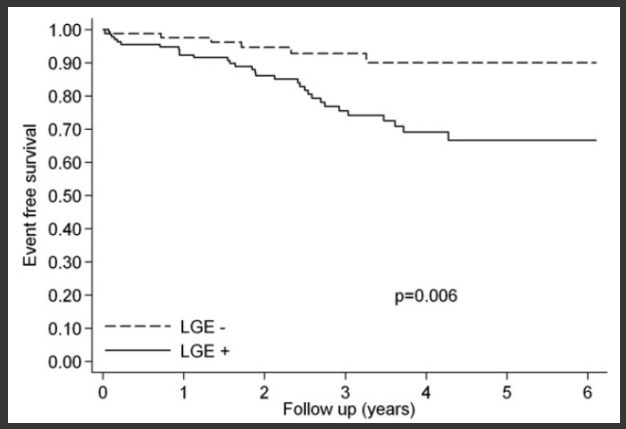


N= 220
End point: sudden cardiac death, aborted sudden cardiac death



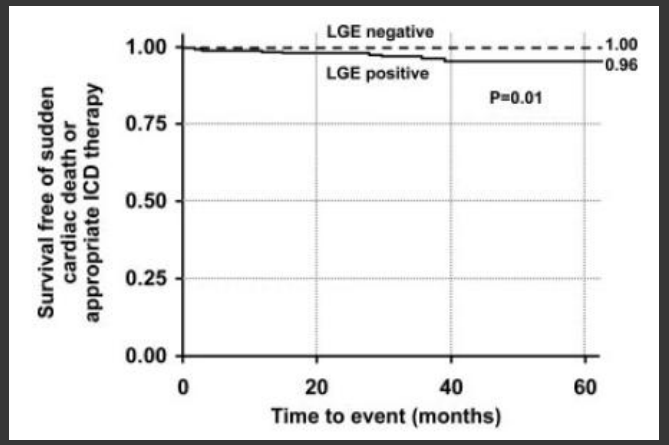
Bruder O et al. *J Am Coll Cardiol* 2010

N= 217
End point: CV death, unplanned CV admission, sustained VT or VF, appropriate ICD discharge



O'Hanlon R et al. *J Am Coll Cardiol* 2010

N= 434
End point: sudden cardiac death, appropriate ICD discharge

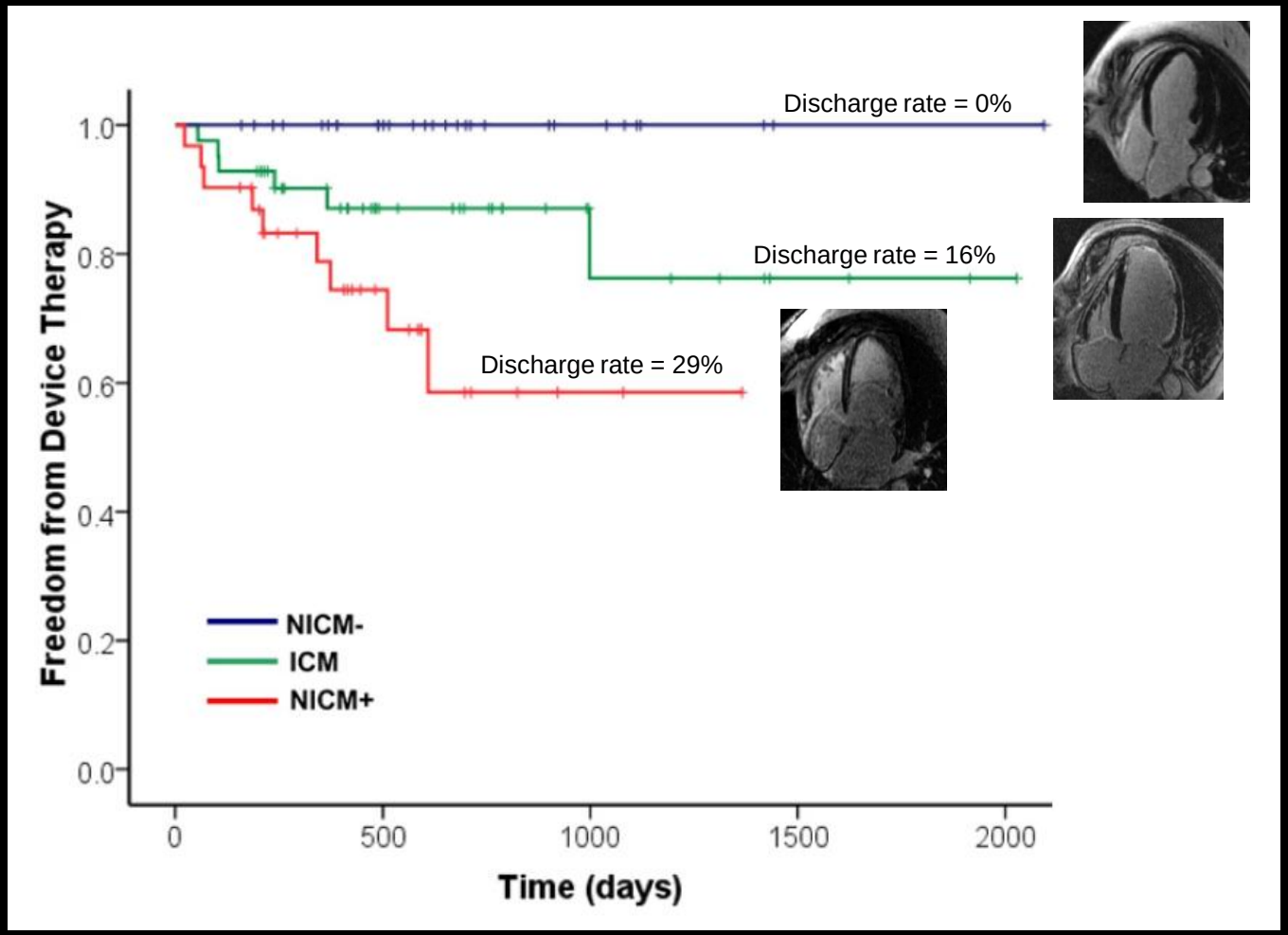


Rubinshtein R et al. *Circ Heart Fail* 2010

Myocardial Fibrosis Predicts Appropriate Device Therapy in Patients With ICDs for Primary Prevention of Sudden Cardiac Death

Iles L et al. *J Am Coll Cardiol* 2011

N= 103 pts. with indication to ICD implantation



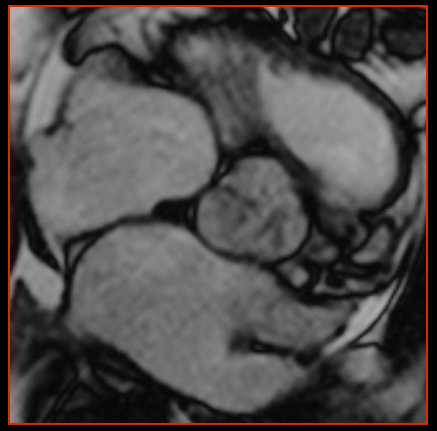
Evaluation of Valvular Function and Morphology

Appropriate

- Characterization of native and prosthetic valves
- Patients with technically limited images from TT or TE echo

3-Leaflets Aortic Valve

2-Leaflets Aortic Valve



Aortic Stenosis

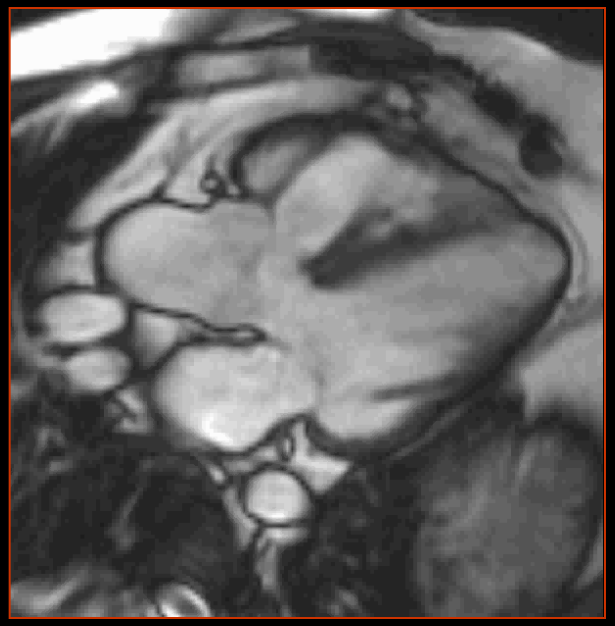
Aortic Regurgitation

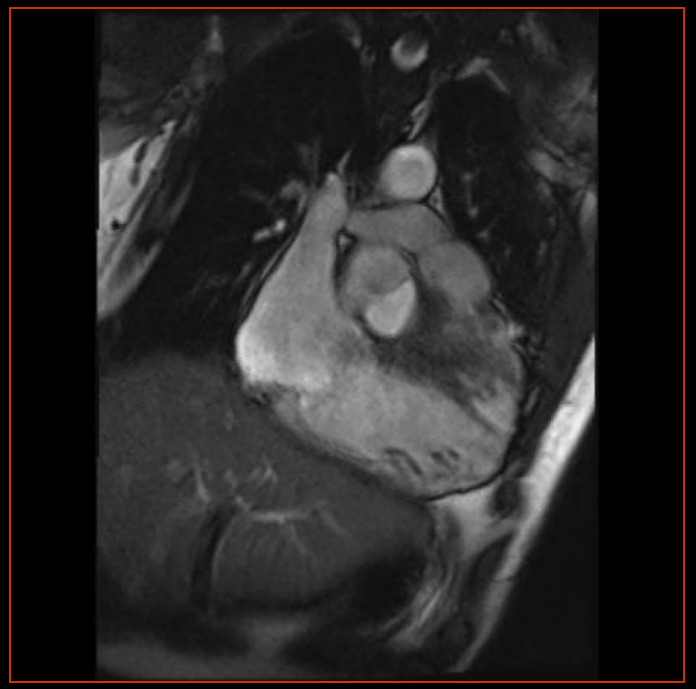
Assessment of Complex Congenital Heart Disease

Appropriate

- Characterization of anomalies of coronary circulation, great vessels, and cardiac chambers and valves

Unrepaired Fallot Tetralogy





Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association

ACC/AHA 2008 Guidelines for the Management of Adults With Congenital Heart Disease : A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Develop Guidelines on the Management of Adults With Congenital Heart Disease): Developed in Collaboration With the American Society of Echocardiography, Heart Rhythm Society, International Society for Adult Congenital Heart Disease, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons

Carole A. Warnes, Roberta G. Williams, Thomas M. Bashore, John S. Child, Heidi M. Connolly, Joseph A. Dearani, Pedro del Nido, James W. Fasules, Thomas P. Graham, Jr, Ziyad M. Hijazi, Sharon A. Hunt, Mary Etta King, Michael J. Landzberg, Pamela D. Miner, Martha J. Radford, Edward P. Walsh and Gary D. Webb

Circulation. 2008;118:e714-e833; originally published online November 7, 2008;

EUROPEAN SOCIETY OF CARDIOLOGY®

European Heart Journal (2010) **31**, 794–805
doi:10.1093/eurheartj/ehp586

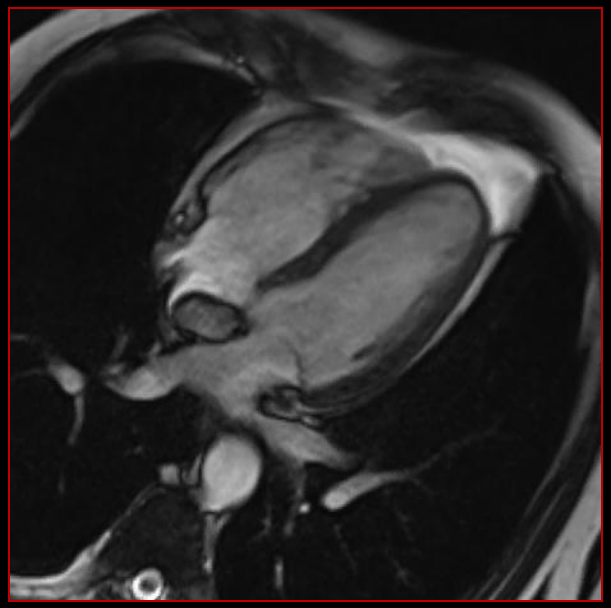
SPECIAL ARTICLE

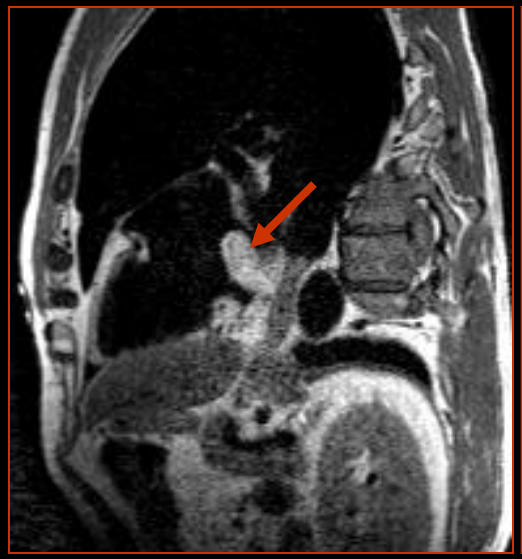
Recommendations for cardiovascular magnetic resonance in adults with congenital heart disease from the respective working groups of the European Society of Cardiology

Philip J. Kilner[1*†], Tal Geva[2], Harald Kaemmerer[3‡], Pedro T. Trindade[4‡], Juerg Schwitter[5†], and Gary D. Webb[6‡]

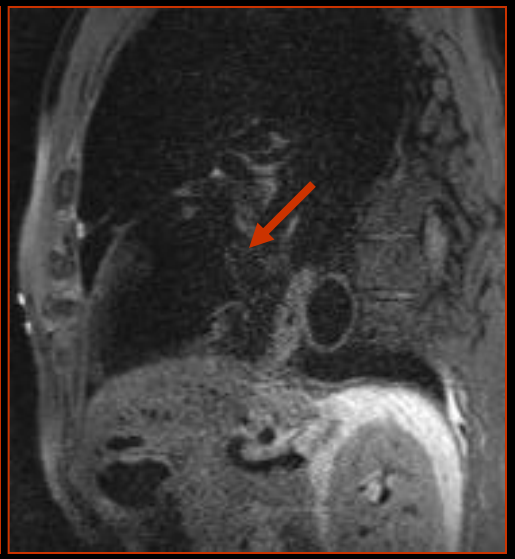
MR Imaging in the Evaluation of a Cardiac Mass

D.M.
61 year-old male
Arterial hypertension
Smoker
Echo: suspected mixoma
in right atrium





Fat Saturation -



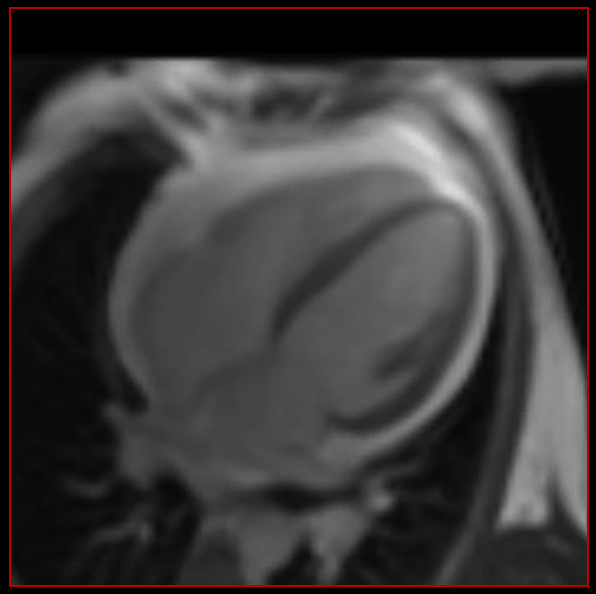
Fat Saturation +

Cardiac MR Evaluation of Pericardial Diseases

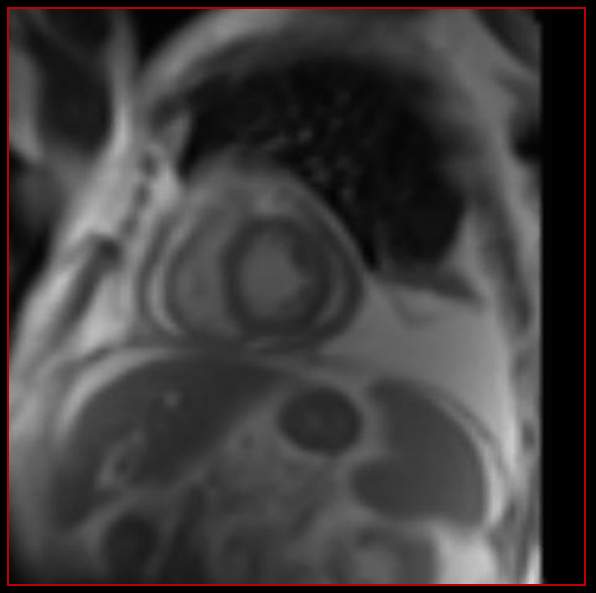
Appropriate

- Evaluation of pericardial effusion and of constrictive pericarditis

Real-Time Cine Imaging



Pericardial Effusion



Constrictive Pericarditis

RM Cardiaca

Vantaggi:

- Elevata risoluzione spaziale, temporale e di contrasto
- Assenza di “cattiva finestra”
- Orientamento spaziale illimitato
- Ampio campo di osservazione
- Versatilità (“one-stop-shop”)
- Accuratezza e riproducibilità
- Basso impatto biologico

Svantaggi:

- Costi elevati
- Scarsa diffusione
- Complessità tecnica
- Limitata esperienza
- Immobilità
- Intensi campi magnetici

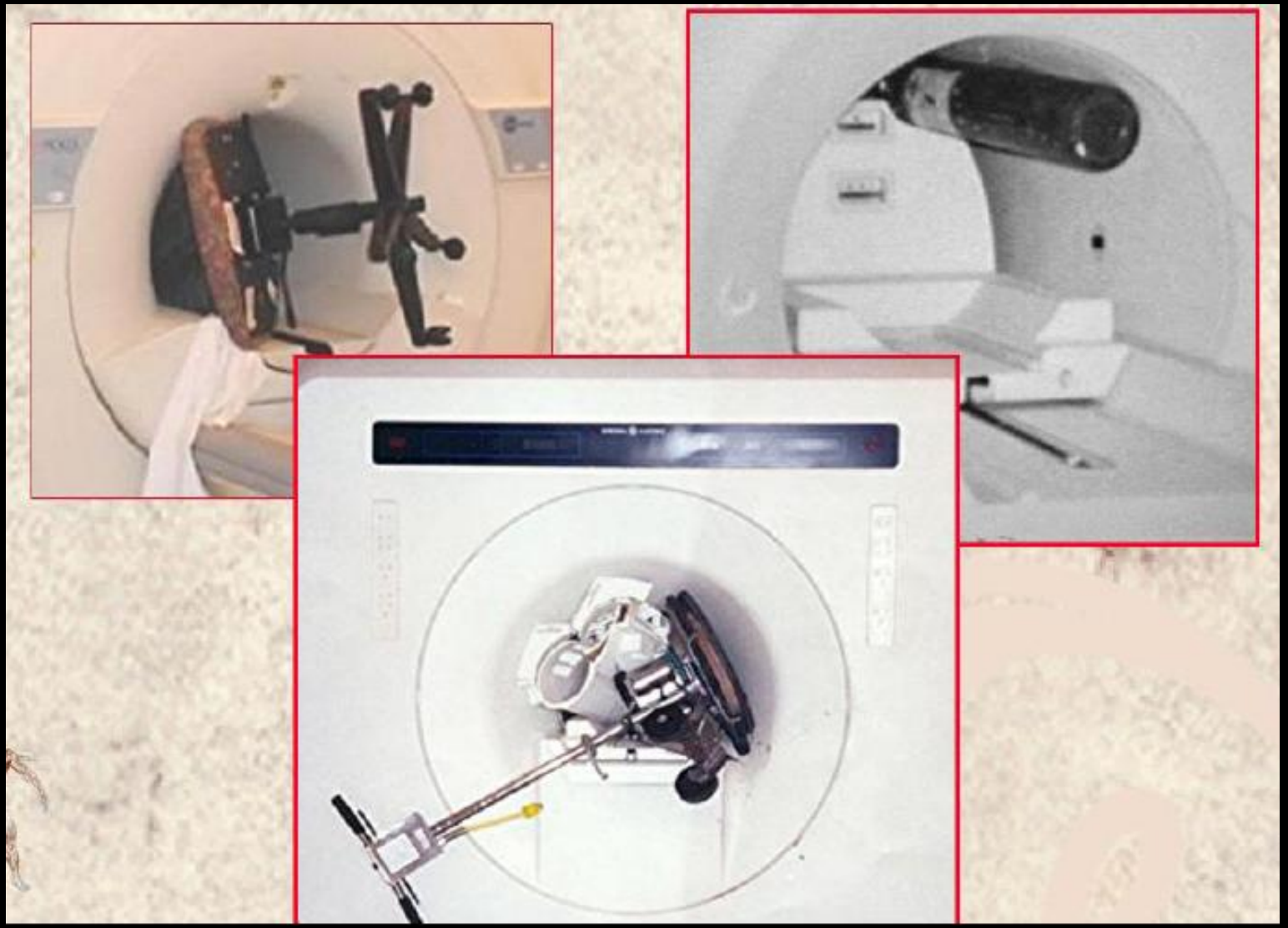
  (impianti metallici)

Controindicazioni in MRI

- **Assolute:**
  - **Clips vascolari cerebrali**
  - **Oggetti metallici intraoculari**
  - **Pompe di infusione**
  - **Neurostimolatori**
  - **Corpi estranei metallici**

  - **Pacemakers**
  - **Defibrillatori**
- **Relative:**
  - **Obesità**
  - **Claustrofobia**
  - **Gravidanza**
  - **Instabilità clinica**
  - **Insufficienza renale (mdc)**

MRI Safety: Missile effect



AHA Scientific Statement

Safety of Magnetic Resonance Imaging in Patients With Cardiovascular Devices

An American Heart Association Scientific Statement From the Committee on Diagnostic and Interventional Cardiac Catheterization, Council on Clinical Cardiology, and the Council on Cardiovascular Radiology and Intervention

Endorsed by the American College of Cardiology Foundation, the North American Society for Cardiac Imaging, and the Society for Cardiovascular Magnetic Resonance

Glenn N. Levine, MD, FAHA; Antoinette S. Gomes, MD, FAHA; Andrew E. Arai, MD, FAHA; David A. Bluemke, MD, FAHA; Scott D. Flamm, MD; Emanuel Kanal, MD; Warren J. Manning, MD, FAHA; Edward T. Martin, MD, FAHA; J. Michael Smith, MD; Norbert Wilke, MD; Frank S. Shellock, PhD

***Circulation*. 2007;116:2878-2891**

Terminology for labeling implanted devices

MR safe	An item that poses no known hazards in any MR environment. Using the new terminology, "MR safe" items include nonconducting, nonmetallic, nonmagnetic items, such as a plastic Petri dish.
MR conditional	An item that has been demonstrated to pose no known hazards in a specified MR imaging environment with specified conditions of use. Conditions that define the MR environment include static magnetic field strength, spatial magnetic gradient, dB/dt (time-varying magnetic fields), RF fields, and SAR. Additional conditions, including specific configurations of the item (eg, the routing of leads used for a neurostimulation system), may be required.
MR unsafe	An item that is known to pose hazards in all MR environments. "MR unsafe" items include magnetic items such as a pair of ferromagnetic scissors.

Performing MR Examinations in Patients With Pacemakers or ICDs

Potential risks:

- Movement of the device
- Programming changes
- Asynchronous pacing
- Activation of tachyarrhythmia therapies
- Inhibition of pacing output
- Induction of lead currents
  (heating and cardiac stimulation)

Potential clinical sequelae:

- Changes in pacing/defibrillation thresholds
- Pacemaker/ICD dysfunction or damage (including battery depletion)
- Arrhythmias
- Death

Data:
martedì 02.12.2008

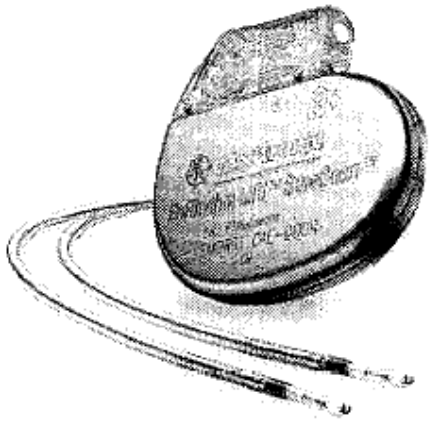
CORRIERE DELLA SERA

Estratto da Pagina:
26

MEDICINA

Impiantato un nuovo pacemaker compatibile con la risonanza

L'ultimo modello di pacemaker *(nella foto)* per il cuore è a prova di campi magnetici. Superate le sperimentazioni in Gran Bretagna e in Germania, nei giorni scorsi è stato impiantato anche in Italia. In tre pazienti che, a differenza dei 300 mila portatori di pacemaker normali, potranno sottoporsi a esami come la risonanza magnetica e passare tranquillamente i metal detector di aeroporti, banche, supermercati. Nessun rischio di tilt. Ideato dall'americano



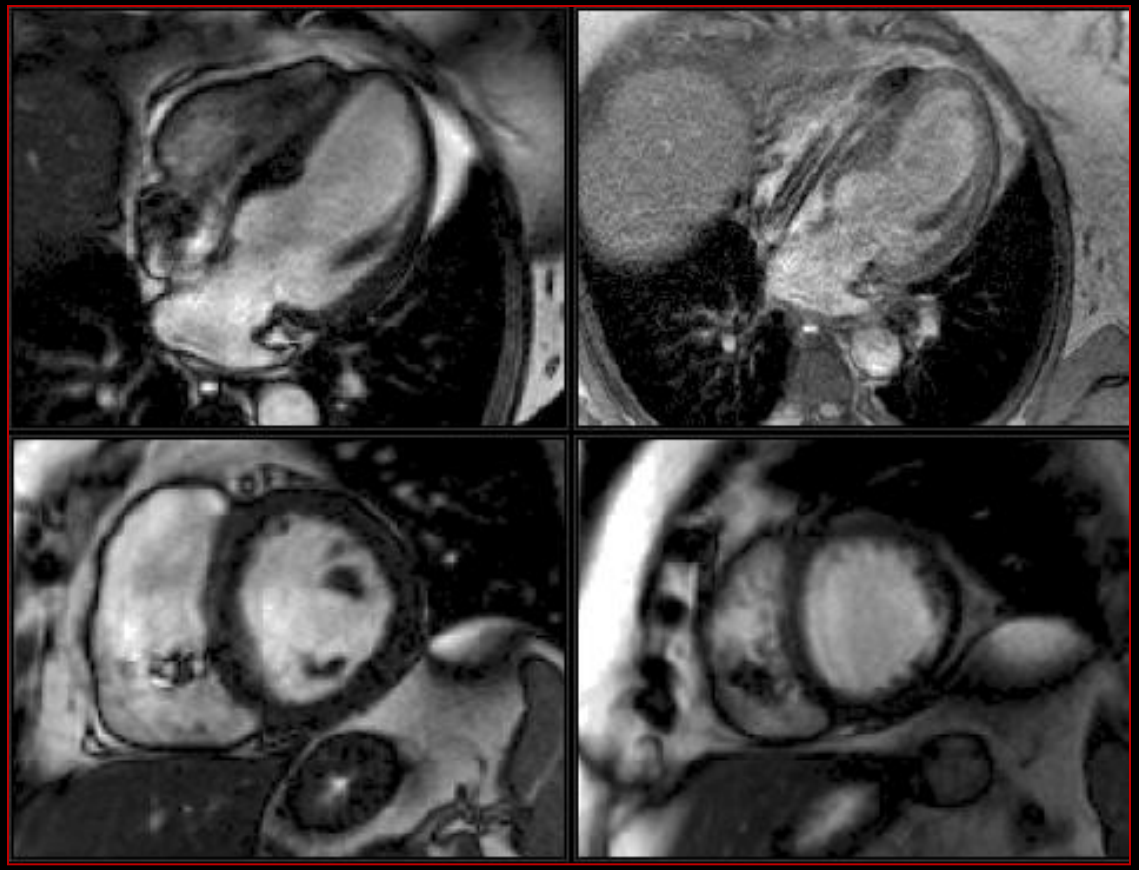
Earl Bakken, il primo pacemaker (una valigetta portatile) fu impiantato nel 1958 al Karolinska di Stoccolma. Oggi, diventati micro e super intelligenti, sono applicati ogni anno a oltre un milione di pazienti nel mondo. A 60 mila in Italia.

Cardiovascular Magnetic Resonance in Cardiac Sarcoidosis with MR Conditional Pacemaker in Situ

Quarta G. et al. *J Cardiov Magn Res* 2011

53-year-old woman with neuro-sarcoidosis

MRI-conditional dual chamber pacemaker and leads



Safety of Magnetic Resonance Imaging in Patients With Cardiovascular Devices

AHA Scientific Statement, *Circulation* 2007

Device	Recommendations		
			
Pacemakers/ICDs		X	X
Temporary pacing			X
Swan-Ganz catheters			X
Intra-aortic balloon pumps			X
Aortic stent grafts	X	X	Zenith AAA
Coronary stents	X	X	
Peripheral stents	X	X	
Prosthetic heart valves	X	X	
Inferior vena cava filters	X		
Cardiac closure/occluder devices	X		

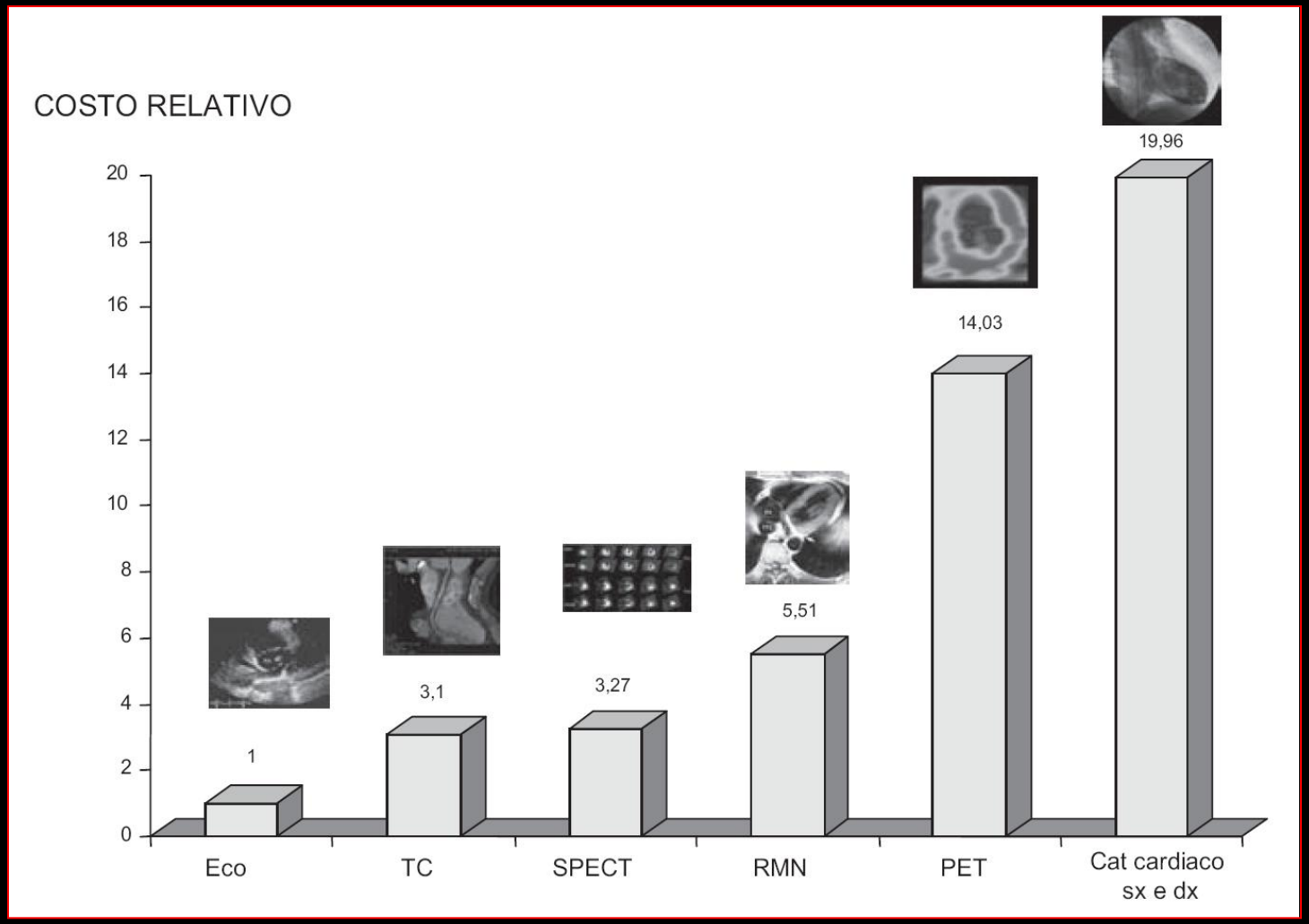
MR Safe

MR Conditional

MR Unsafe

Costo Relativo delle Metodiche di Imaging in Cardiologia

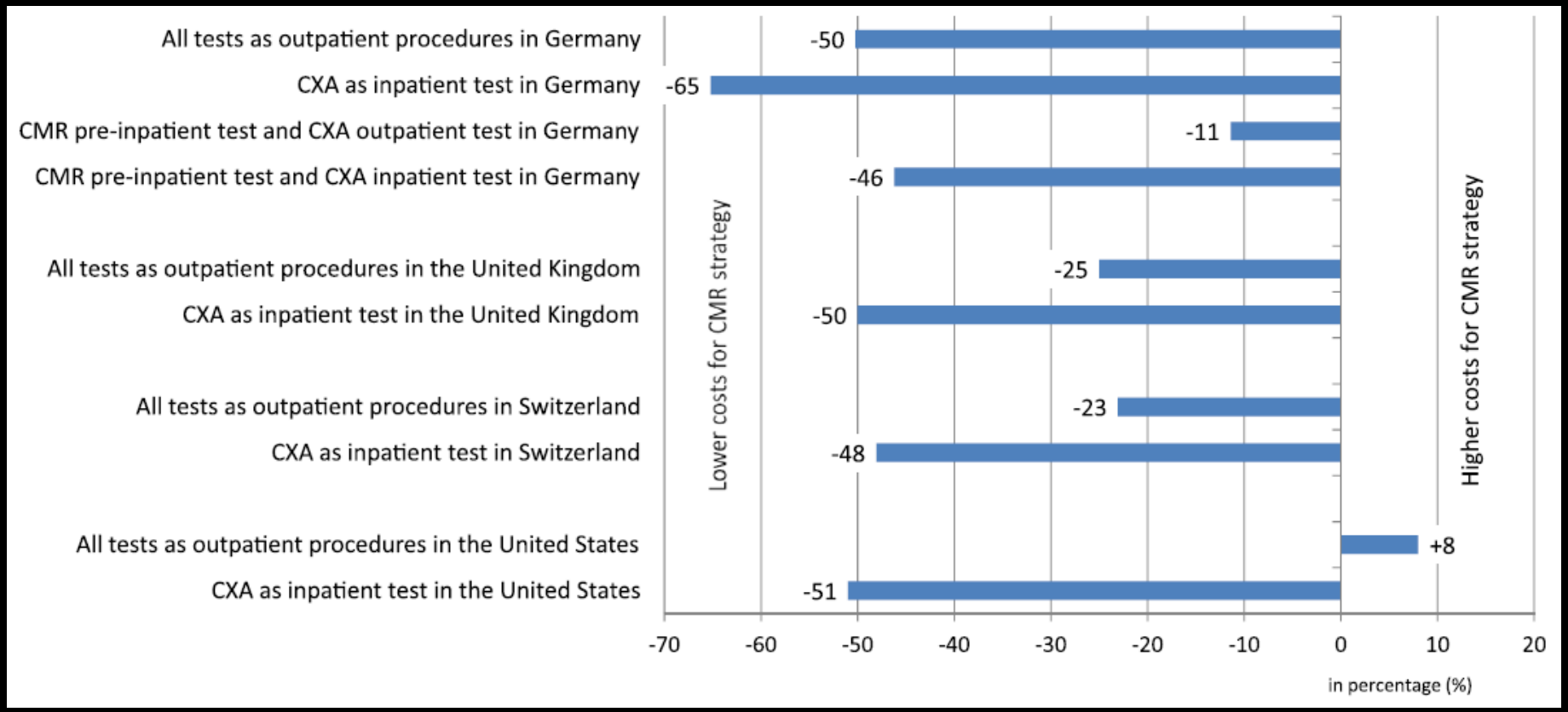
Picano E. *G Ital Cardiol* 2009



Cost Evaluation of CMR versus Coronary Angiography for the Diagnostic Work-up of CAD: Application of the European CMR Registry

Moschetti K et al., *J Cardiov Magn Res* 2012

Percentage of cost variation between CMR strategy and CXA strategy.



Portable Echo

Portable MRI

	Ecocardiografia	Cardio-RM
Disponibilità	++++	++
Portabilità	++++	-
Costo/beneficio	+++	++
Rapidità di esecuzione	+++	++
Fattibilità	++	+++ (PM)
Complessità delle informazioni	++	++++
Risoluzione spaziale e di contrasto	++	++++
Riproducibilità	++	++++
Impatto biologico	+	+

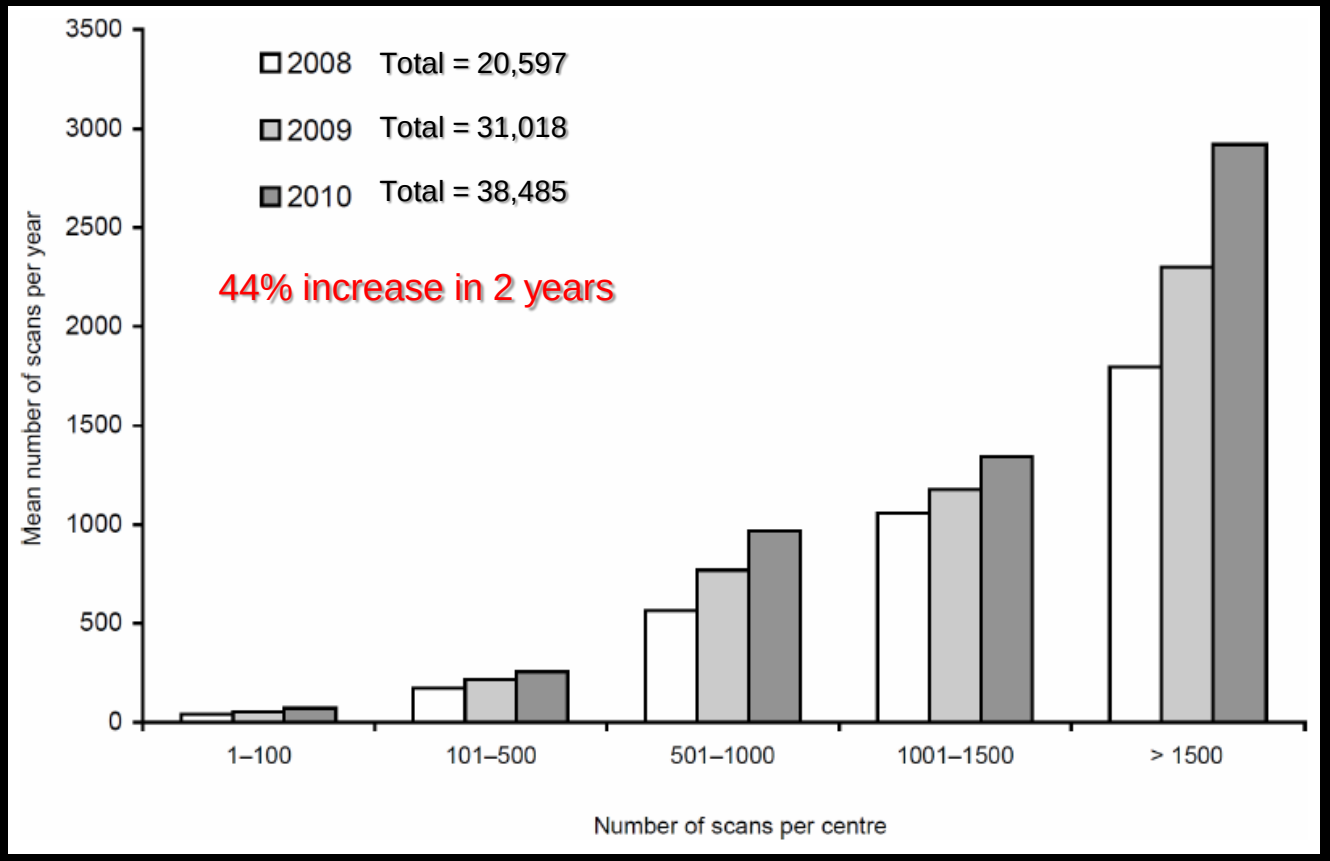
Cardiovascular Magnetic Resonance Activity in the UK: a Survey on Behalf of the British Society of CMR

Antony R. et al. *J Cardiov Magn Res* 2011

N= 60 Centers with CMR facilities from the national UK hospital database

Led by cardiologists alone (33%), by radiologists alone (33%) of by both specialities (33%)

1.5T in 86%



EuroCMR Registry

Results of the German Pilot Phase

Bruder O. et al. *J Am Coll Cardiol* 2009

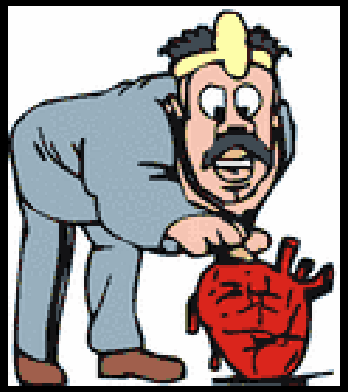
Baseline Characteristics	N= 11,040 from 20 Centers
All	100 (11,040)
Male	63.7% (7,020/11,017)
Female	36.3% (3,997/11,017)
Age (yrs)	60 (47–70)
BMI (kg/m^2)	26.2 (23.7–29.4)
Field	
1.0-T	1.1% (116/11,002)
1.5-T	98.2% (10,801)
3.0-T	0.8% (85)
Stress	
No stress	68.5% (7,565/11,040)
Adenosine	20.9% (2,309)
Dobutamine	10.6% (1,166)
Reader	
Cardiologist	78.2% (8,619)
Team of cardiologist and radiologist	20.1% (2,215)
Radiologist	1.7% (187)
Primary indication for CMR	
Myocarditis/cardiomyopathies	31.9% (3,511/11,026)
Suspected CAD/ischemia in known CAD	30.8% (3,399)
Myocardial viability	14.7% (1,626)
Valvular heart disease	4.8% (531)
Aortic disease	3.4% (372)
Congenital heart disease	1.6% (181)
Ventricular thrombus	1.4% (154)
Cardiac masses	1.2% (129)
Pulmonary vessels	1.1% (126)
Coronary vessels	0.2% (25)
Other than above	8.8% (972)

Impact of CMR on Patient Management by Indication

	Suspected CAD/Ischemia
All (from n = 11,040)	30.8%
Completely new diagnosis not suspected before	19.6%
Therapeutic consequences	
Change in medication	25.9%
Intervention/surgery	6.7%
Invasive angiography/biopsy	15.6%
Hospital discharge	3.6%
Hospital admission	0.2%
Impact on patient management (new diagnosis and/or therapeutic consequence)	71.2%

From April 2007 and January 2009

Limited Scanner/Operator Availability for Cardiac MRI



Cardiologist

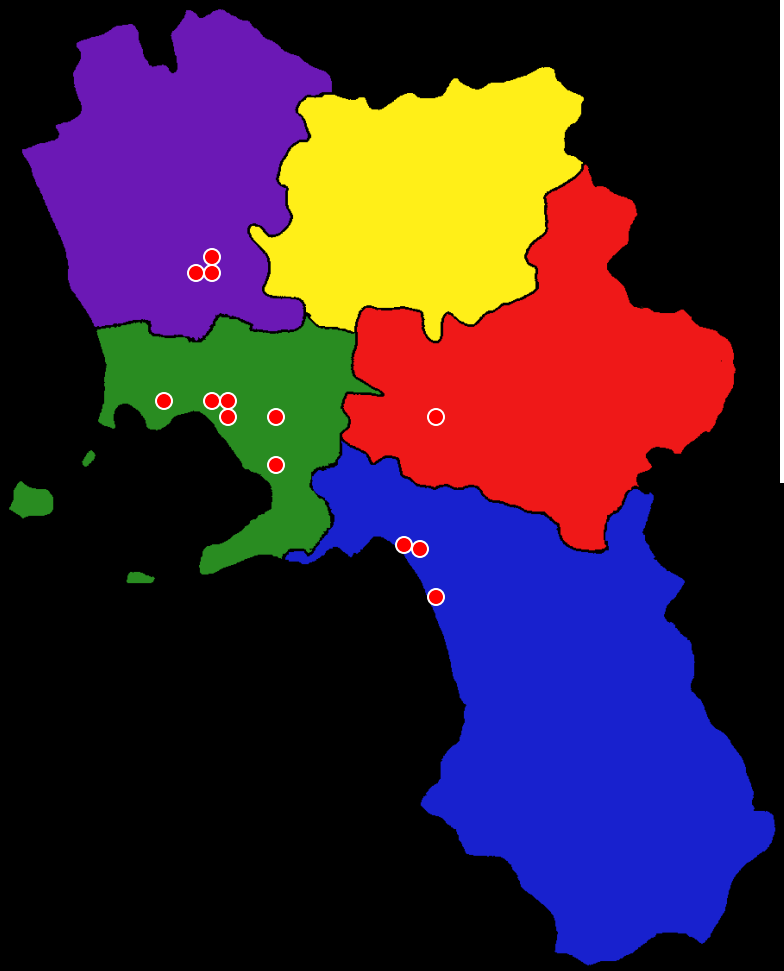
Radiology Oriented Imager

General Imaging Sessions

Cardiology Oriented Imager

Dedicated Imaging Sessions

RM Cardiaca in Campania



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CURRENT OPINION

Training and accreditation in cardiovascular magnetic resonance in Europe: a position statement of the working group on cardiovascular magnetic resonance of the European Society of Cardiology

Sven Plein[1,2*], Jeanette Schulz-Menger[3], Ana Almeida[4], Heiko Mahrholdt[5], Frank Rademakers[6], Dudley Pennell[7], Eike Nagel[2], Juerg Schwitter[8], and Massimo Lombardi[9], on behalf of the Working Group on Cardiovascular Magnetic Resonance of the European Society of Cardiology

Accreditated site:

- >400 exams/year
- Case mix
- Qualified supervisor (level 3 SCMR or ESC)
- Structured training programme
- Quality control (EuroCMR Registry)
- Multi-modality imaging environment (echocardiography, invasive angiography, nuclear cardiology, cardiac computed tomography)

Position Paper

Formazione e accreditamento in risonanza magnetica cardiovascolare: Documento del Gruppo di Studio per le Applicazioni della Risonanza Magnetica della Società Italiana di Cardiologia (SIC) e dell'Area CardioImaging dell'Associazione Nazionale Medici Cardiologi Ospedalieri (ANMCO)

Alberto Roghi[1], Santo Dellegrottaglie[1], Gian Piero Perna[2]

[1] per il Nucleo del Gruppo di Studio per le Applicazioni della Risonanza Magnetica della Società Italiana di Cardiologia (SIC)
[2] per il Comitato di Coordinamento dell'Area CardioImaging dell'Associazione Nazionale Medici Cardiologi Ospedalieri (ANMCO)

G Ital Cardiol 2012; 00: 00-00

Livello	Durata Training	Casi	Esame RMC	ECM (h)	Altro
1	1 mese	50+	No	20	-
2	3 mesi	150+	Si	50	BLS+ACLS
3	12 mesi	300+	Si	50	BLS+ACLS

il Gruppo di Studio per le Applicazioni della RM della Società Italiana di Cardiologia (SIC) e l'Area CardioImaging dell'Associazione Nazionale Medici Cardiologi Ospedalieri (ANMCO) hanno ritenuto di affrontare in un documento le criticità di ordine logistico, culturale e formativo che ostacolano la diffusione delle applicazioni della metodica. Si propone: 1) l'integrazione della formazione in RM cardiaca nel curriculum formativo delle Scuole di Specialità di Cardiologia così come previsto dal curriculum formativo europeo; 2) che il percorso di formazione e certificazione degli operatori preveda competenze cardiovascolari e radiologiche secondo quanto previsto dagli standard europei; 3) che l'accreditamento dei Centri di formazione rispetti gli standard previsti dall'ESC per volumi, *case-mix*, attività di training e di ricerca e per la sicurezza delle procedure.


THE
M.R.I. of Love

CORSO AVANZATO DI ECOCARDIOGRAFIA DI "ECOCARDIOCHIRURGIA"

con uno sguardo all'imaging integrato

La Risonanza Magnetica Presentata agli Ecocardiografisti

Santo Dellegrottaglie, MD – PhD

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Divisione di Cardiologia
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