I Problemi della Valvola: la Diagnosi

Stenosi Valvolare Aortica
La Diagnosi con RM

EUROPEAN SOCIETY OF CARDIOLOGY®

European Heart Journal (2012) **33**, 2451–2496
doi:10.1093/eurheartj/ehs109

ESC/EACTS GUIDELINES

Guidelines on the management of valvular heart disease (version 2012)

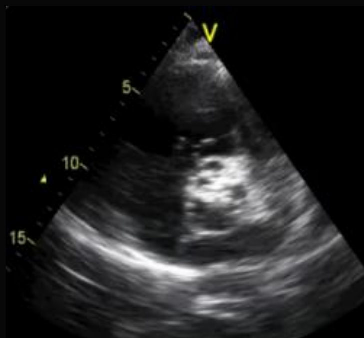
The Joint Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS)

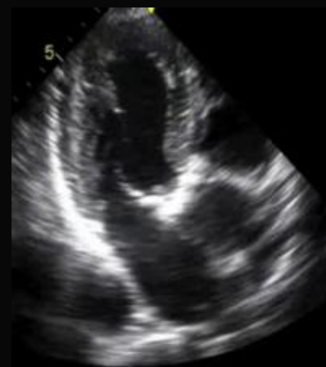
3.1.3.2 Cardiac magnetic resonance

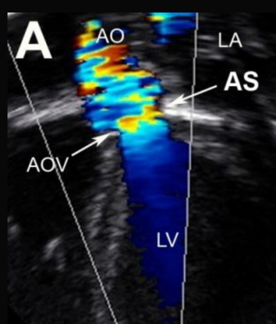
In patients with inadequate echocardiographic quality or discrepant results, cardiac magnetic resonance (CMR) should be used to assess the severity of valvular lesions—particularly regurgitant lesions—and to assess ventricular volumes and systolic function, as CMR assesses these parameters with higher reproducibility than echocardiography.[2,3]

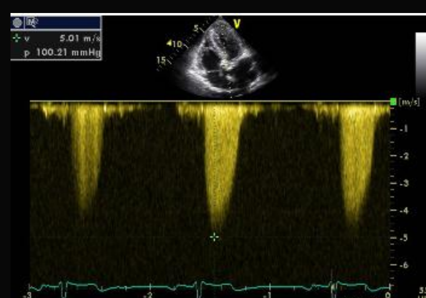
CMR is the reference method for the evaluation of RV volumes and function and is therefore useful to evaluate the consequences of tricuspid regurgitation (TR). In practice, the routine use of CMR is limited because of its limited availability, compared with echocardiography.

Heart Valve Disease: Investigation by Cardiovascular Magnetic Resonance









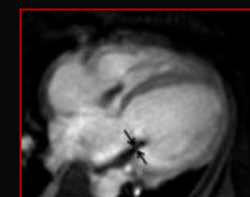
Kang D et al. Circulation 2009

Echocardiography remains the major imaging modality for assessing valve disease

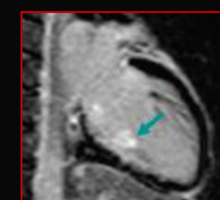
Cardiovascular MR

Morphology assessment

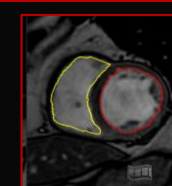
Functional assessment



Aetiology assessment



Impact on ventricular dimension/function



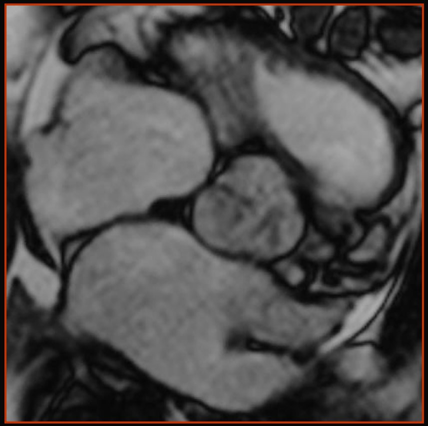
Associated great vessel disease

Evaluation of Valvular Function and Morphology

Advantage: unlimited imaging planes

Tri-Leaflets
Aortic Valve

Bi-Leaflets
Aortic Valve



Aortic
Stenosis

Aortic
Regurgitation

CMR in Heart Valve Disease: Functional Assessment

Qualitative:
visual assessment of turbulent flow in stenotic jets

Visualization of signal voids due to spin dephasing in moving protons

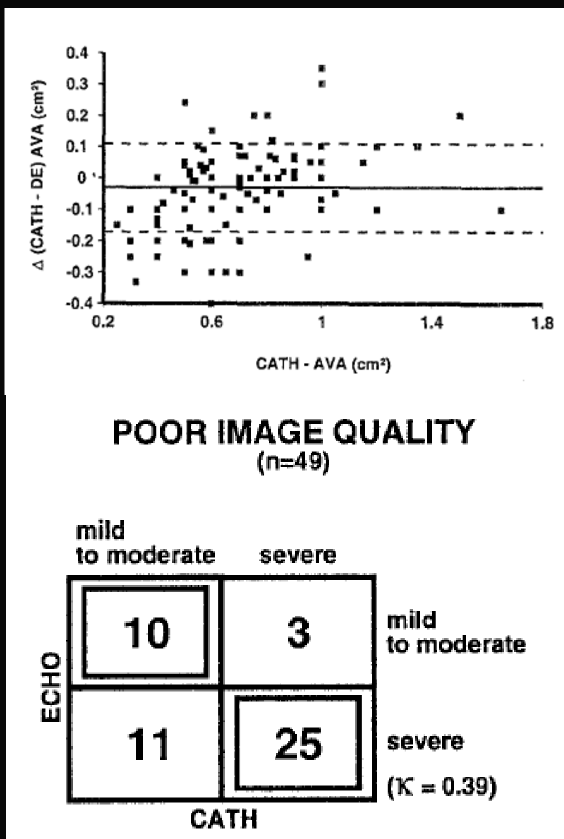
Assessing the severity of a valvular defect with visual assessment of cine images requires caution as the technique is subject to slice positioning, partial volume effects, the insensitivity of SSFP sequences and to other sequence parameters.

Quantification of Aortic Stenosis: Inadequacy of Traditional Methods

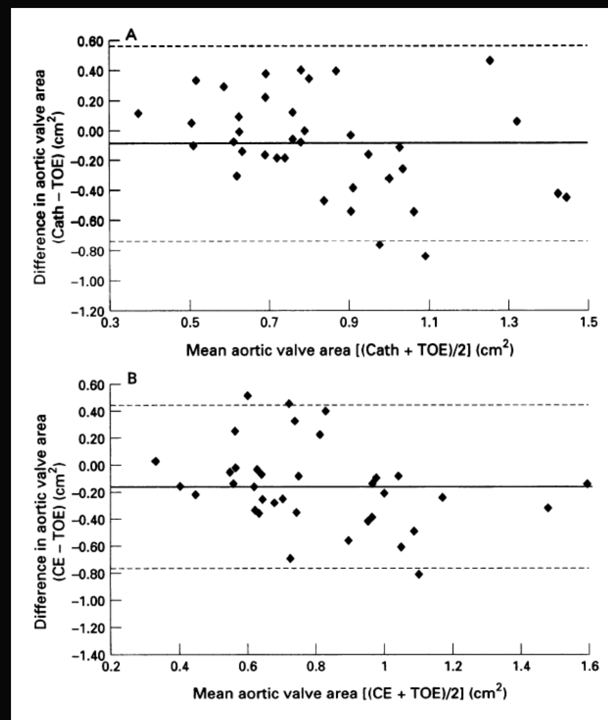
Transthoracic Echocardiography

Transoesophageal Echocardiography

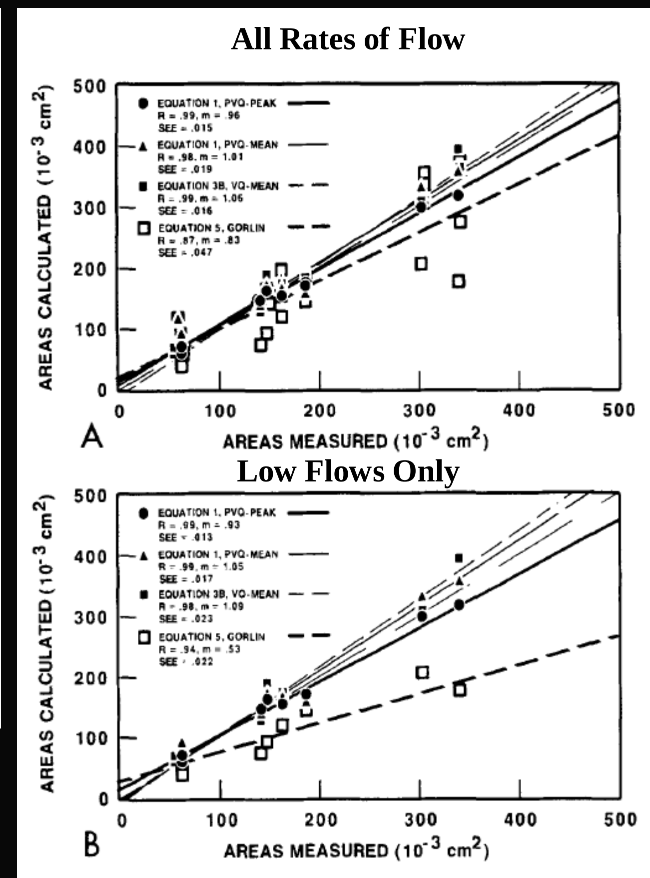
Invasive Catherization



Bartunek J et al. Int J Card Imaging 1995



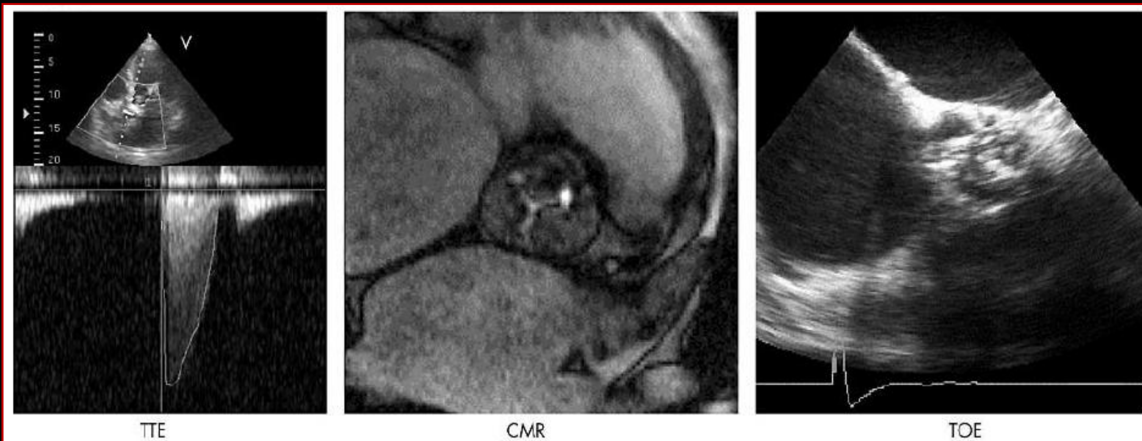
Bernard Y et al. Heart 1997



Segal J et al. J Am Coll Cardiol 1987

Evaluation of Aortic Stenosis by CMR Imaging: Comparison with Established Routine Clinical Techniques

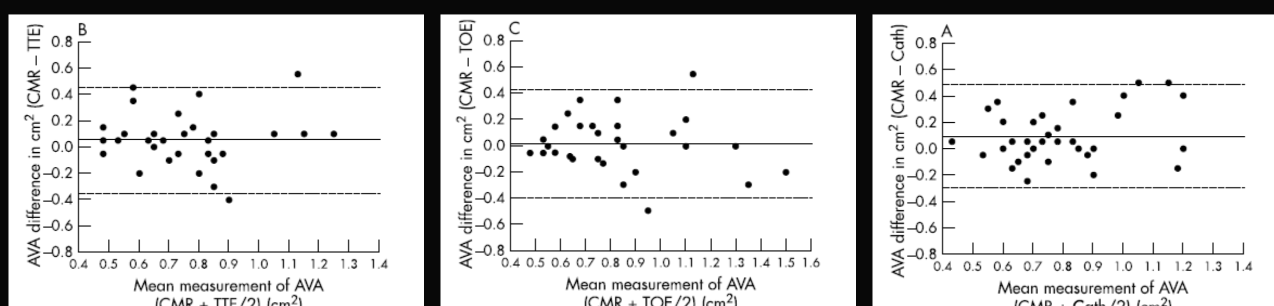
Kupfahl C et al. *Heart 2004*



In this example, the valve could not be assessed by TTE due to poor acoustic window and LVOT calcification as well as by TOE due to commissural calcification

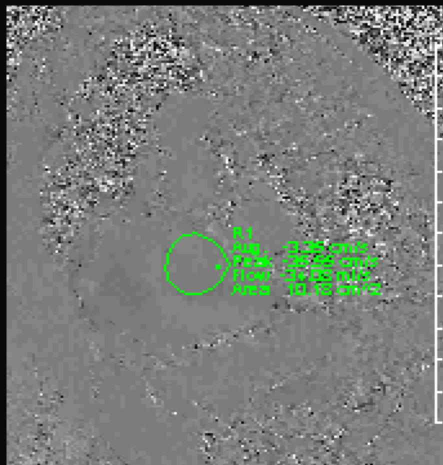
44 symptomatic pts. with severe AoSt
AVA by continuity equation from TTE
AVA by planimetry from TOE
AVA by planimetry from cine-CMR
AVA by Gorlin equation from catheterization

CMR planimetry had the best accuracy of all non-invasive methods for detecting severe AoSt in comparison with cardiac cath

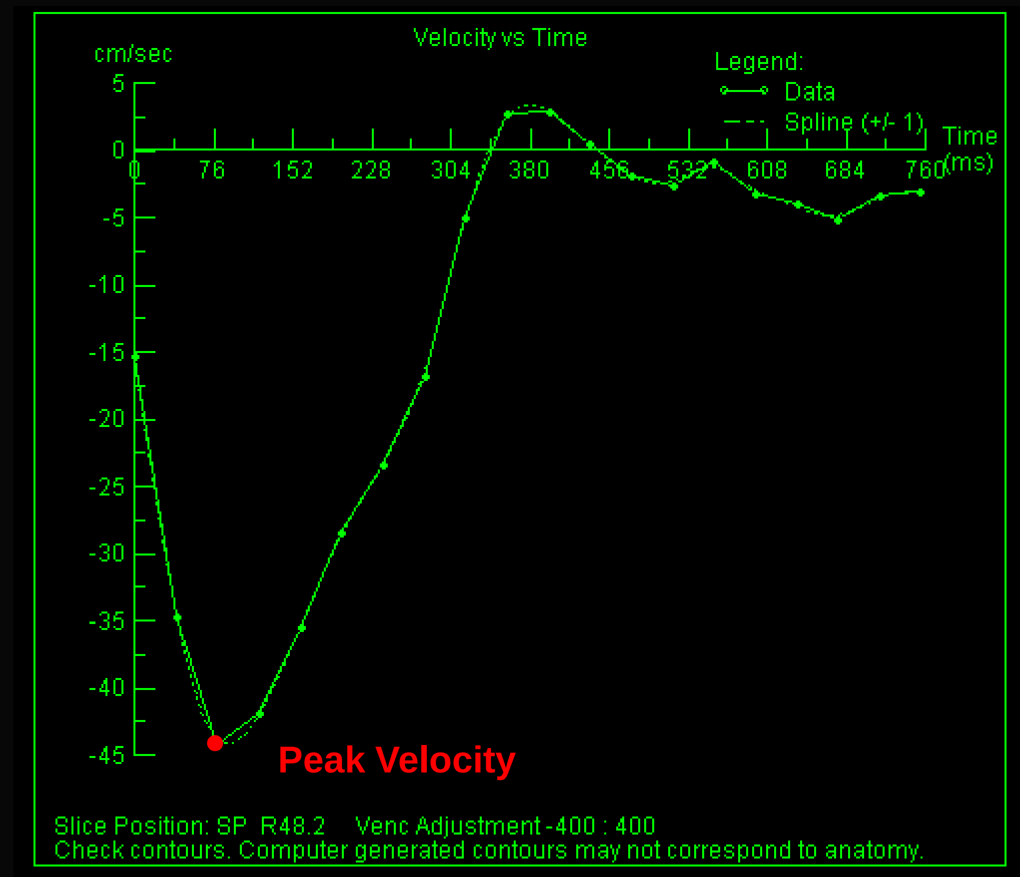


Intra-observer bias = -0.016
Inter-observer bias = 0.019

Quantification of Aortic Stenosis by Phase-Contrast CMR



Velocity-Time Curve



Modificed Bernulli Equation

$$\Delta P = 4\ V^2$$

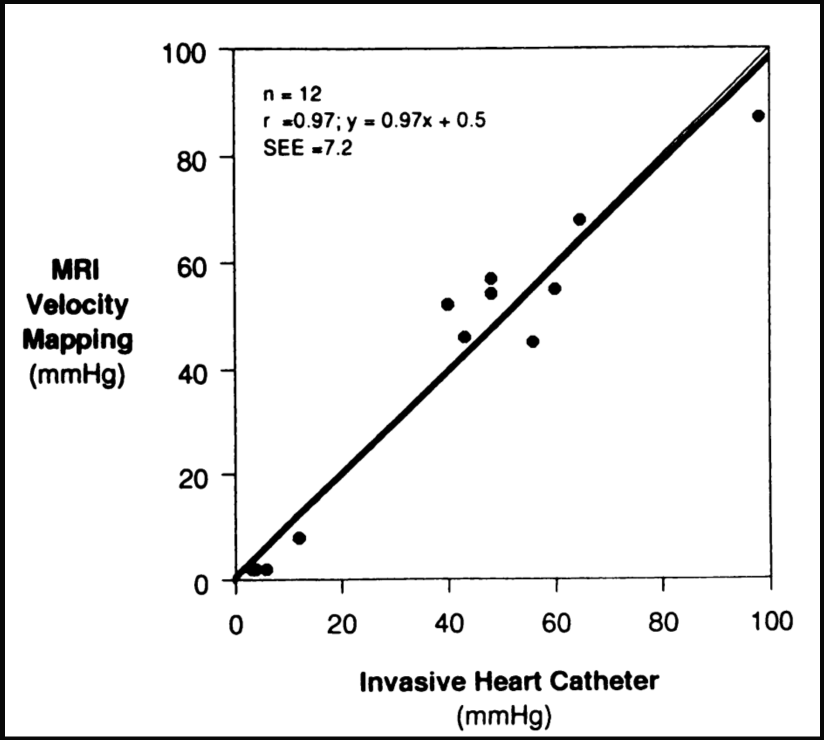
Advantages

- Evaluation of pts. with angulated roots

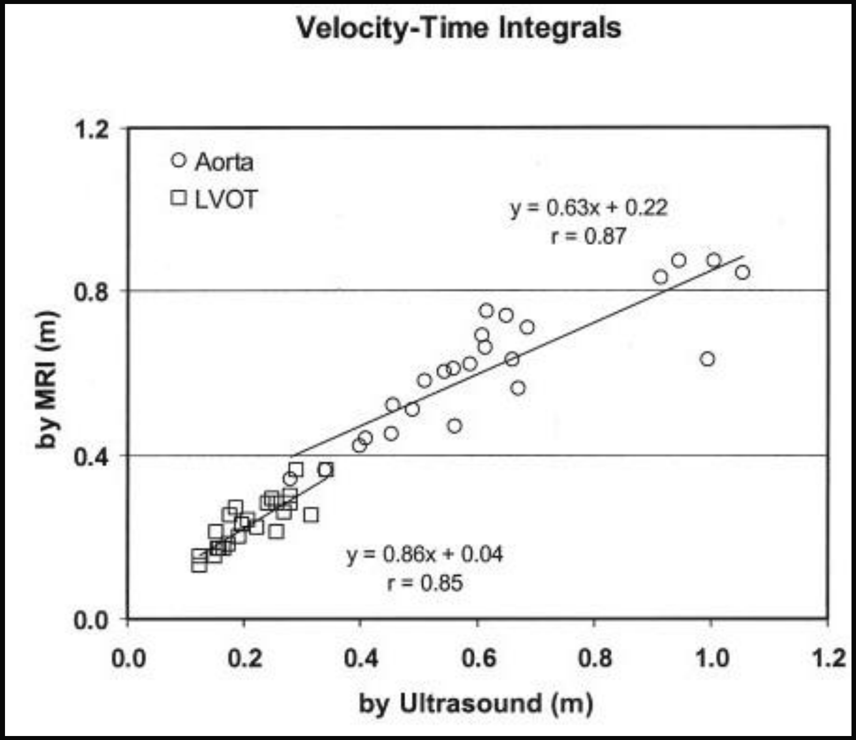
(correct echo beam alignment is difficult)

- Ability to differentiate sub-valvar and supra-valvar stenosis
- Possibility to assess the ascending aorta which may be dilated

Quantification of Aortic Stenosis by Phase-Contrast CMR



Eichenberger AC et al. Am J Roentgenol 1993



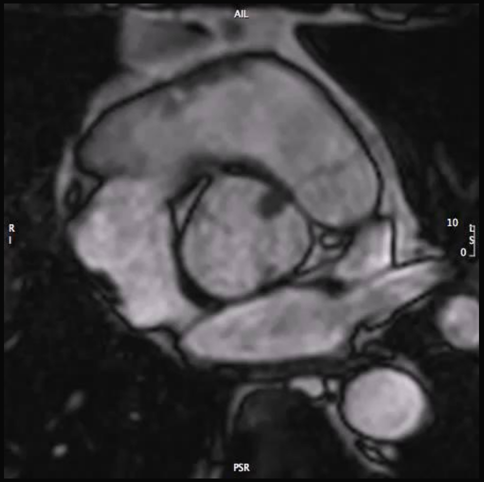
Caruthers SD et al. Circulation 2003

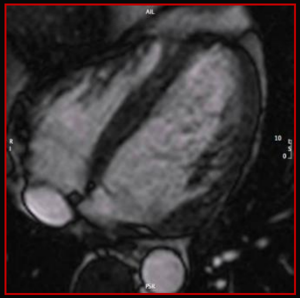
Disadvantages

Less accurate (modest underestimation) compared to continuous-wave Doppler echo for higher velocities (partial volume effects, lower temporal resolution, and artefacts from turbulent jets)

Flow-Gradient Patterns in Severe Aortic Stenosis

- **Severe AoSt** (AVA <1.0 cm^2)
  - **High Gradient** (Mean Gradient >40 mmHg)
    - **Normal Flow** (SVi >35 ml/m^2)
    - **Low Flow** (SVi <35 ml/m^2)
  - **Low Gradient** (Mean Gradient <40 mmHg)
    - **Normal Flow** (SVi >35 ml/m^2)
    - **Low Flow** (SVi <35 ml/m^2) — **Low Flow-Low Gradient Aortic Stenosis**
      - **Low EF** (EF <40%) — **Classical**
      - **Preserved EF** (EF >40%) — **Paradoxical**



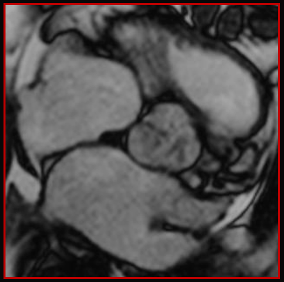


Paradoxical low flow-low-gradient pattern has been reported in up to 35% of patients with severe AS and seems to be consistent with a more advanced stage of the disease (increased global LV afterload, significant LV concentric remodeling, and intrinsic myocardial dysfunction)

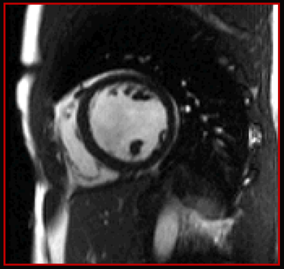
Hachicha Z et al., Circulation 2007

Low Flow-Low Gradient Ao St: Pontential Role of MRI

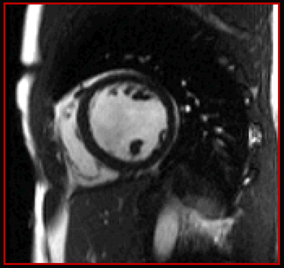
Planimertric AVA



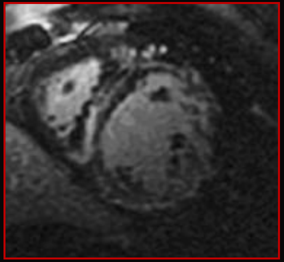
LV Ejection Fraction



LV Stroke Volume

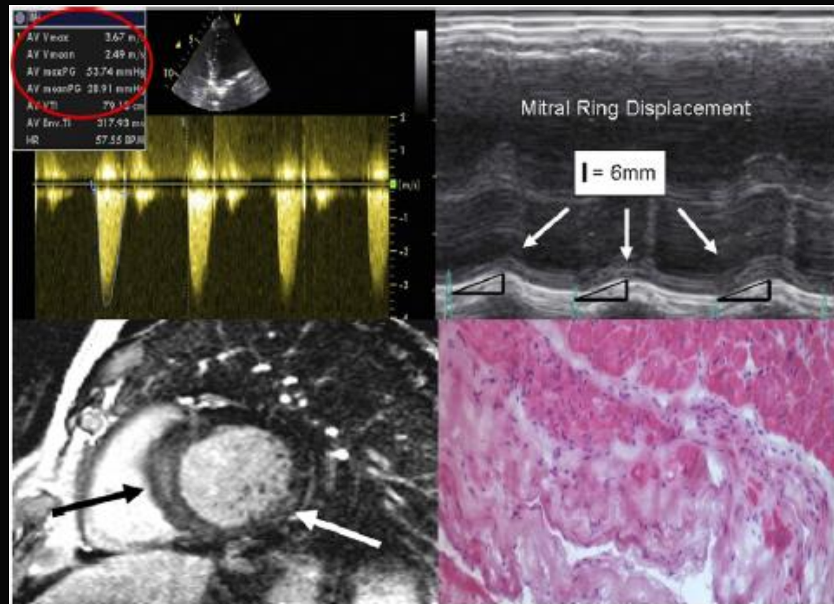


LV Myocardial Scar/Fibrosis



Myocardial Fibrosis in Low-Gradient Aortic Valve Stenosis

N = 69 pts with severe AoSt undergoing Echo + MRI + biopsy (at time of AVR surgery)

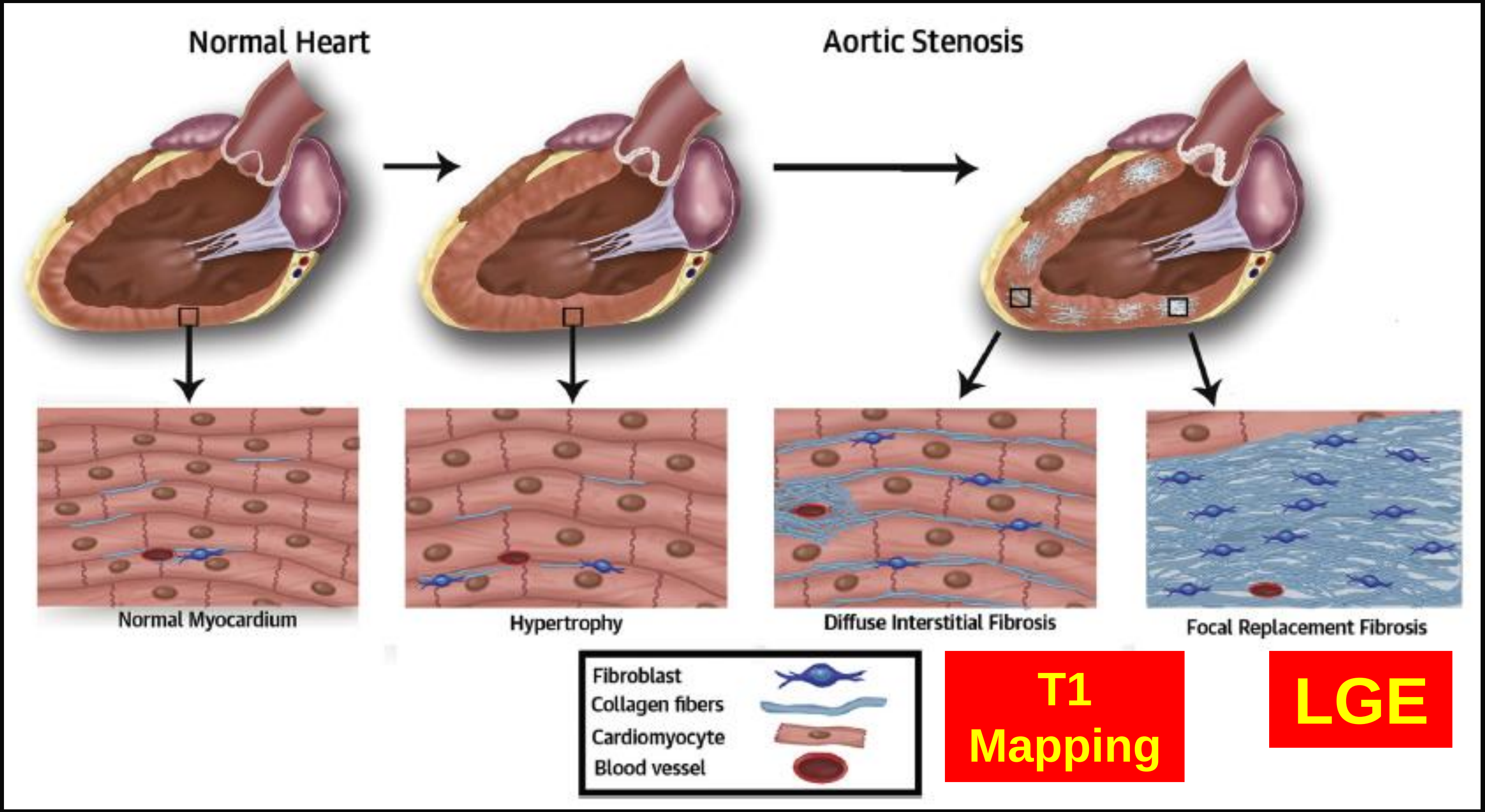


	Severe AS, High Gradient (n = 49)	Severe AS, Low Gradient, EF ≥50% (n = 11)	Severe AS, Low Gradient, EF <50% (n = 9)
cMRI			
Ejection fraction, %	55 ± 13	56 ± 12	38 ± 17*†
Late enhancement–positive segments: 0/1/>1, %	47/19/34	0/20/80	0/23/77
Myocardial histology			
Interstitial fibrosis, %	1.8 ± 0.8	3.9 ± 0.6*	4.8 ± 0.6*
Myocyte diameter, μm	12.2 ± 1.3	13.1 ± 1.5	13.7 ± 1.3*

Conclusions: In severe AoSt, a low gradient is associated with a higher degree of fibrosis

Herrmann S et al., J Am Coll Cardiol 2011

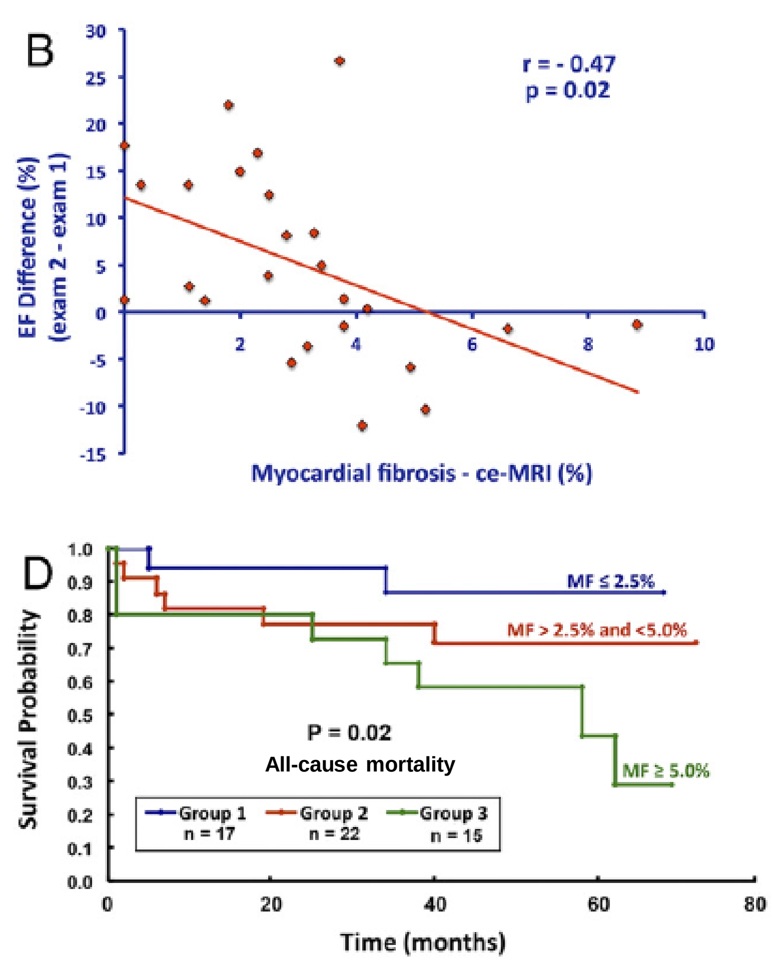
Pathophysiology of Myocardial Fibrosis in Aortic Stenosis



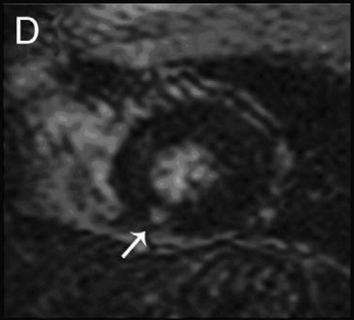
Barone –Rochette G et al., J Am Coll Cardiol 2014

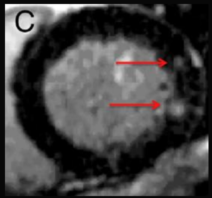
Prognostic Significance of Myocardial Fibrosis as detected by LGE MRI in Aortic Stenosis

N = 54 pts scheduled for surgical AVR

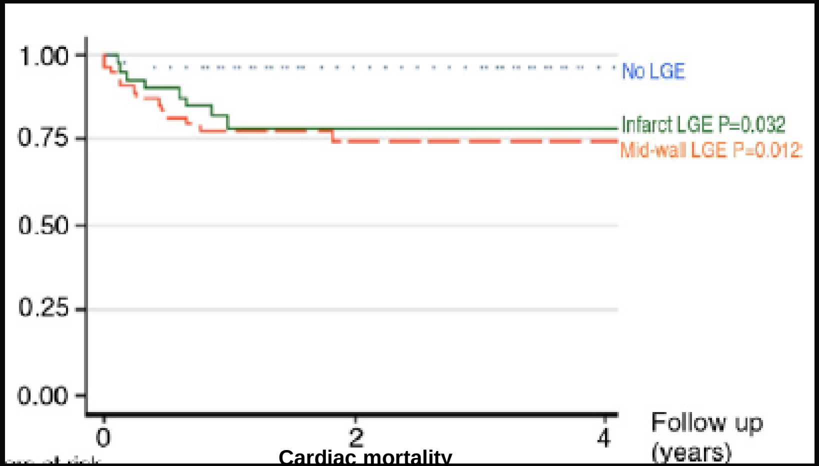


Azevedo CF et al., J Am Coll Cardiol 2010





N = 143 pts with moderate-severe AoSt



Dweck MR et al., J Am Coll Cardiol 2011

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Prognostic Significance of LGE by CMR in Aortic Stenosis Patients Undergoing Valve Replacement

Gilles Barone-Rochette, MD, Sophie Piérard, MD, Christophe De Meester de Ravenstein, MS, Stéphanie Seldrum, MD, Julie Melchior, MD, Frédéric Maes, MD, Anne-Catherine Pouleur, MD, PhD, David Vancraeynest, MD, PhD, Agnes Pasquet, MD, PhD, Jean-Louis Vanoverschelde, MD, PhD, Bernhard L. Gerber, MD, PhD

N = 154 consecutive AoSt pts. undergoing surgical AVR and 40 AoSt pts. undergoing TAVR

Coronary angiography in all pts. (No CAD in 110/CAD in 44 pts.)

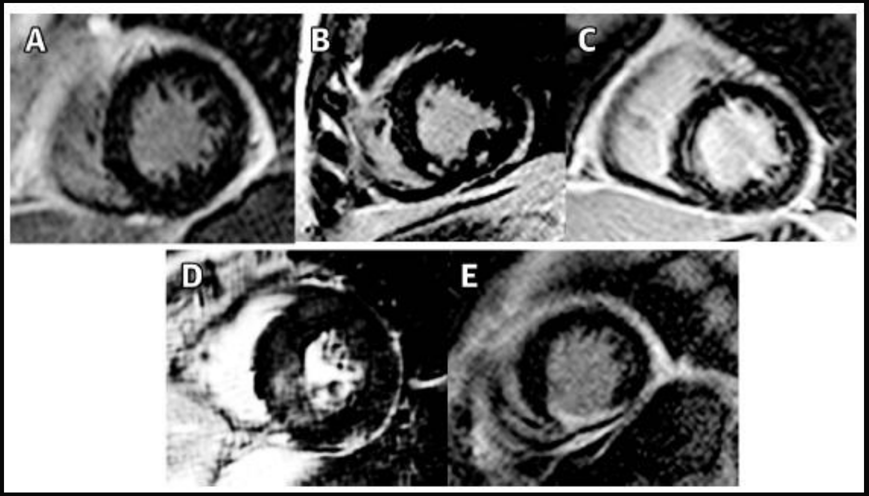
Endpoints: CV mortality (death from CHF, MI, SCD or post-AVR)

Median follow-up = 2.9 years

TABLE 2 Patterns of LGE

			Noninfarct LGE		
Group	No LGE	Infarct LGE*	Focal	Diffuse	Septal Stripe
All patients (n = 154)	110 (72)	14 (9)	20 (13)	7 (4)	3 (2)
No CAD (n = 110)	79 (72)	8 (7)	16 (14)	4 (4)	3 (3)
CAD (n = 44)	31 (71)	6 (14)	4 (9)	3 (7)	0 (0)

LGE in 29% of surgical AVR and 50% of TAVR



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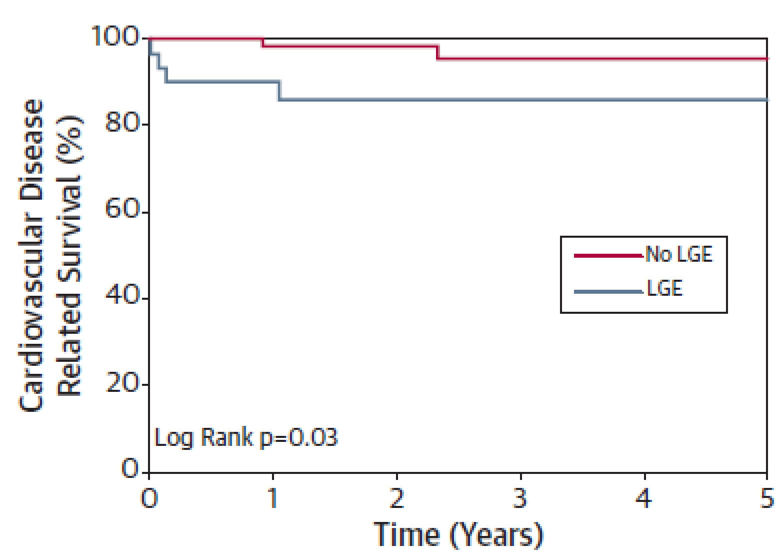
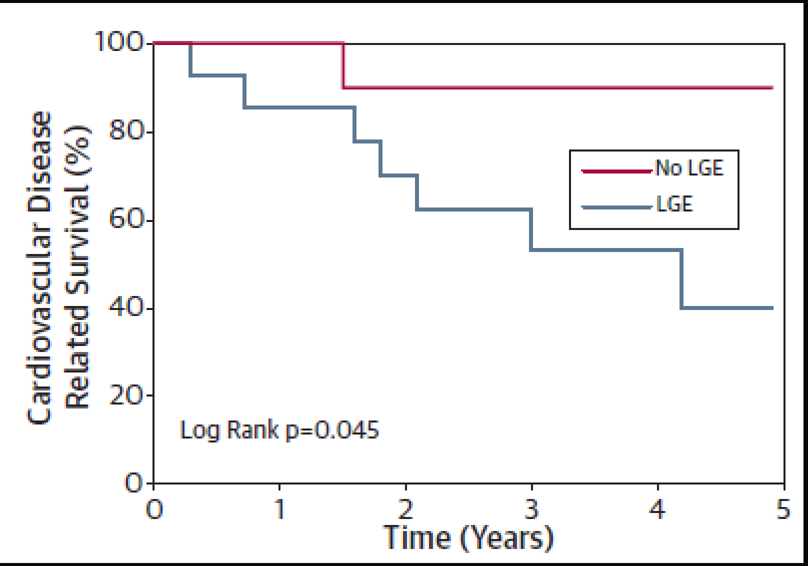
Surgical AVR

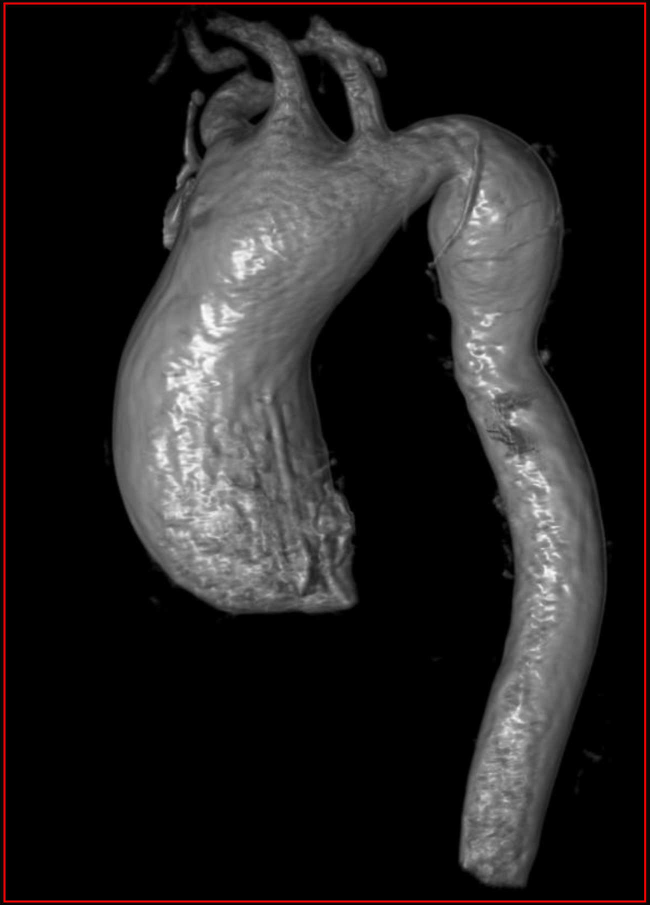


TAVR



CONCLUSIONS The presence of LGE indicating focal fibrosis or unrecognized infarct by CMR is an independent predictor of mortality in patients with AS undergoing AVR and could provide additional information in the pre-operative evaluation of risk in these patients. (J Am Coll Cardiol 2014;64:144–54)

MR Angiograhy of the Thoracic Aorta



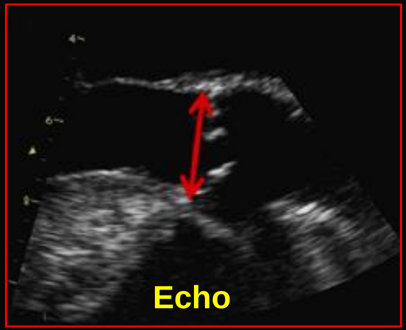
Aneurysm

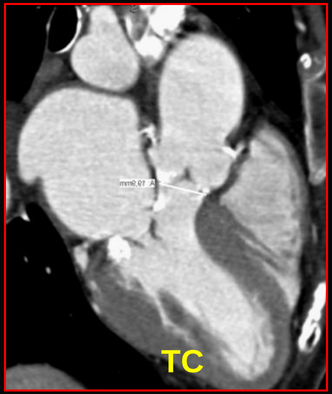
Dissection

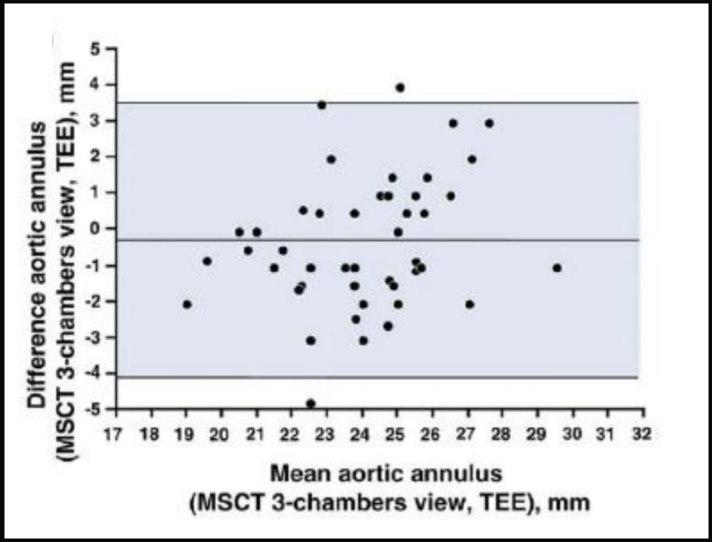
Coarctation

Assessment of Aortic Annulus Diameter

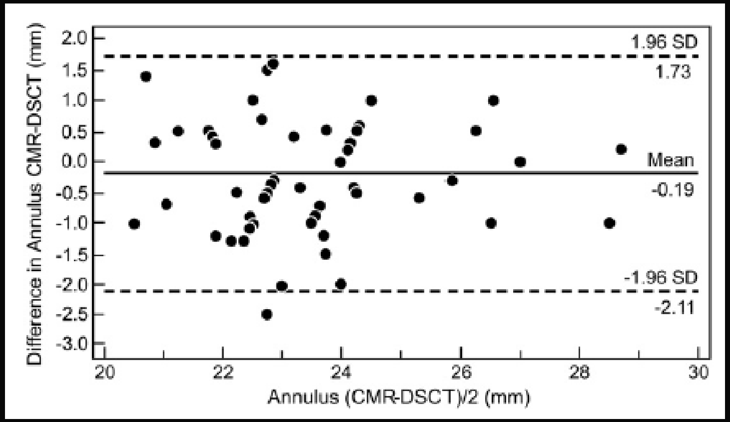
Are the Noninvasive Imaging Modalities Interchangeable?







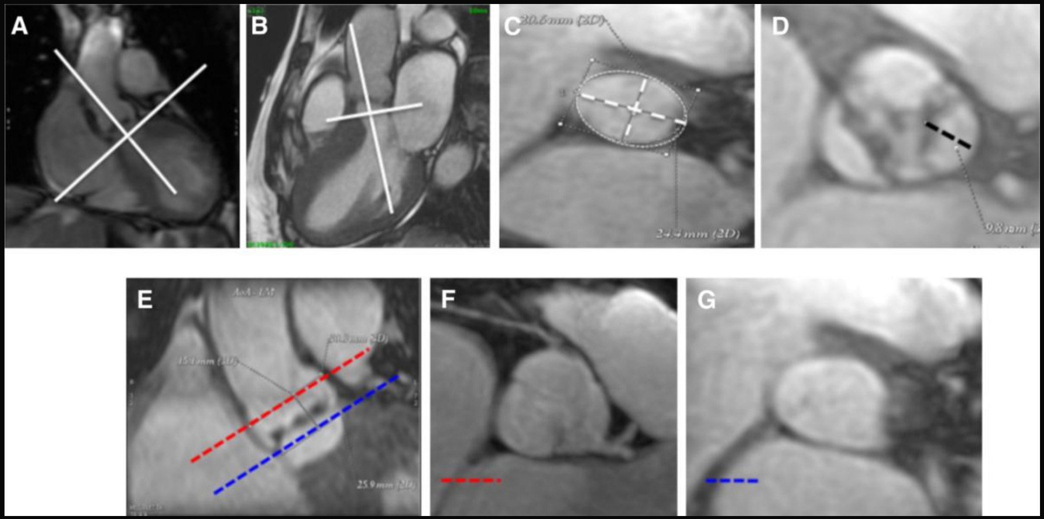
Messika-Zeitoun D et al., J Am Coll Cardiol 2010

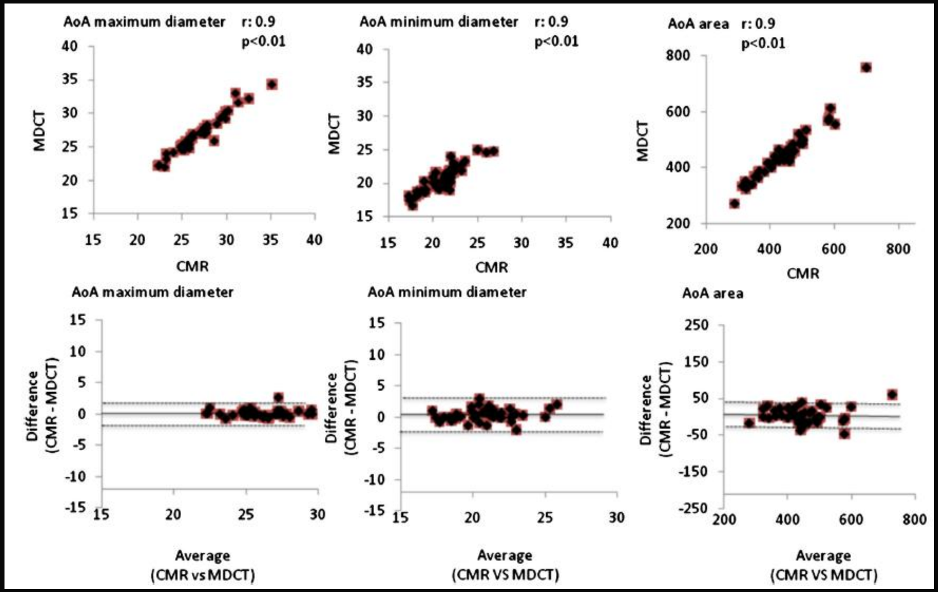


Koos R et al., Int J Cardiol 2011

Aortic Root Annulus Assessment With CMR vs. Echo and MDCT in Patients Referred for TAVI

N = 50 consecutive pts. with severe AoSt referred for TAVI with SAPIEN valve
(no severe CKD, no atrial fibrillation, no PM/ICD)





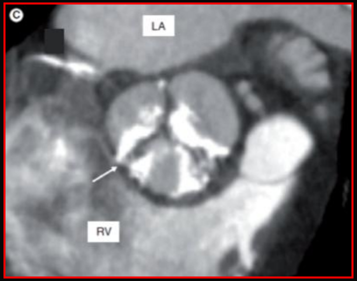
Conclusions: Aortic root assessment with CMR including AoA size, aortic leaflet length, and coronary artery ostia height (but not aortic leaflet calcification) is accurate compared with MDCT.
CMR may be a valid imaging alternative in patients unsuitable for MDCT.

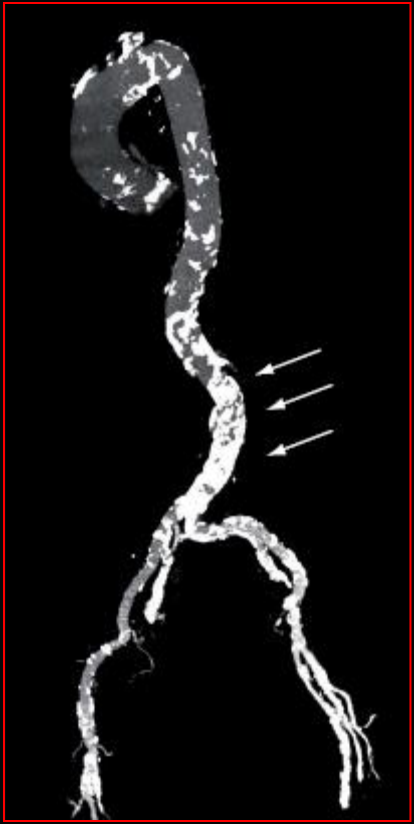
Pontone G et al., Am J Cardiol 2013

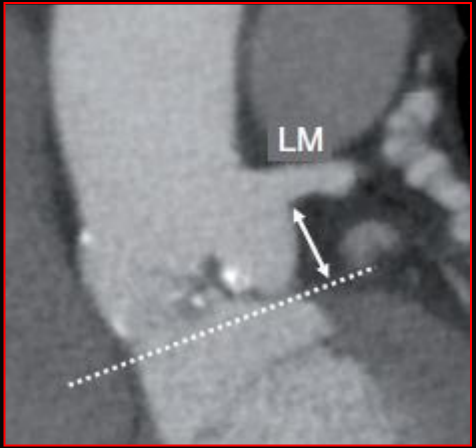
Trancatheter Aortic Valve Implantation (TAVI)
Morphologic Selection Criteria

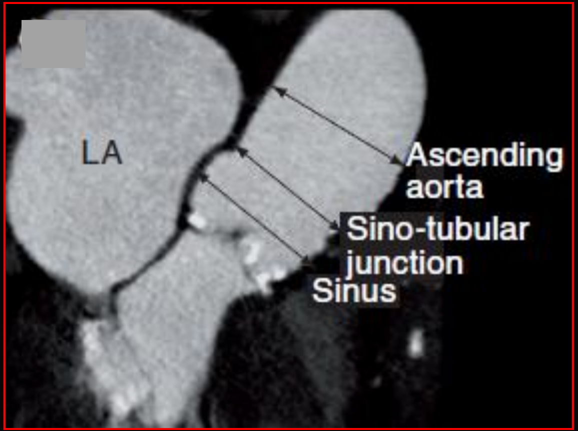
Feasibility assessment:

- Left ventricular function
- Coronary artery anatomy/disease severity
- Coronary ostia position (take-off)
- Aortic valve calcification
- Size of aortic annulus
- Size, calcification, tortuosity of aorta/ilio-femoral arteries





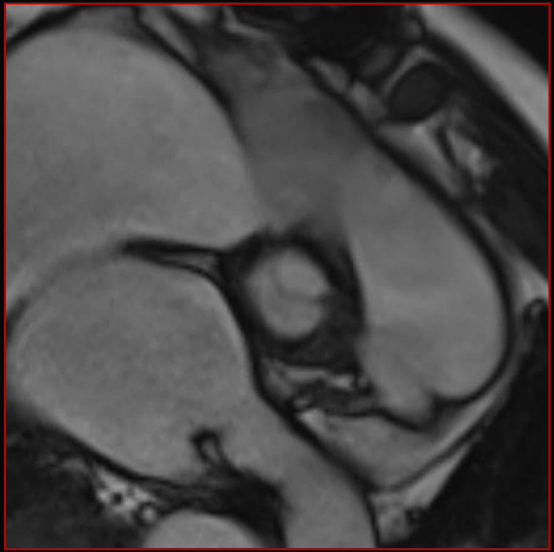




Delgado V et al., Expert Rev Cardiovasc Ther 2010

Cardiovascular MR: Post-Surgical AVR Evluation

Biological

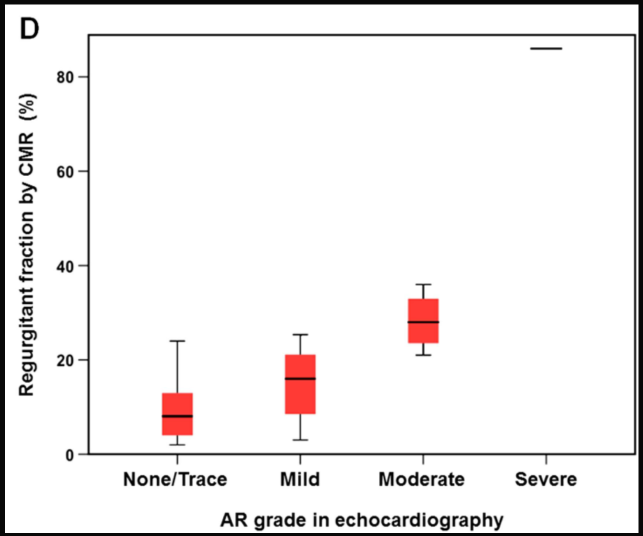


Mechanical

Aortic Regurgitation Severity after TAVI is Underestimated by Echocardiography Compared with MRI

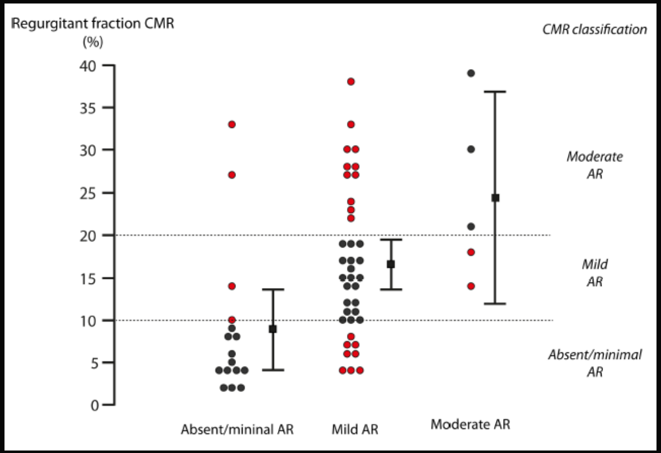
N = 71 post-TAVI pts. (Edwards SAPIEN)

N = 42 post-TAVI pts. (Edwards SAPIEN)

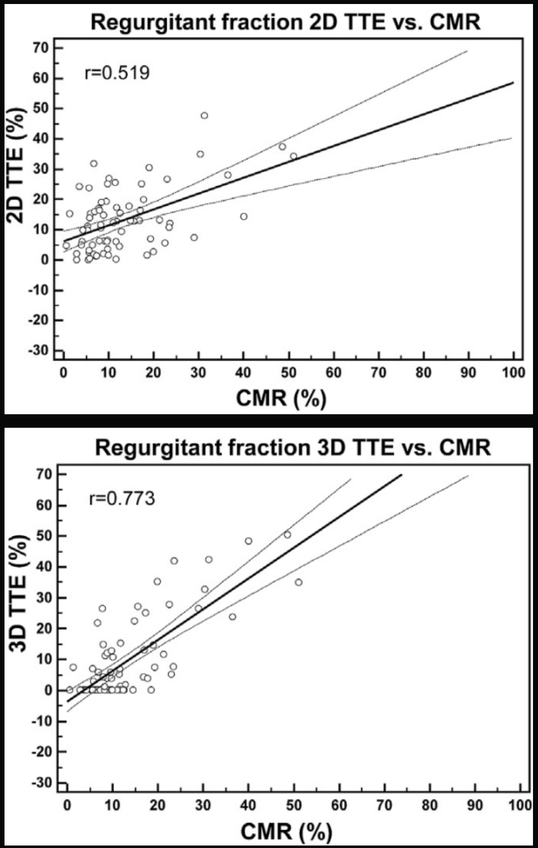


Ribeiro HB et al., Heart 2014

N = 65 post-TAVI pts. (Edwards SAPIEN)



Orwat S et al., Heart 2014



Altiok E et al., Am Heart J 2014

Conclusions: The correlation between the prosthetic AR severity assessed by 2D TTE and by CMR is only modest, with a strong tendency of TTE to underestimate AR compared with CMR
When CMR imaging is used for comparison, 3D TTE allows quantification of AR with greater accuracy than 2D TTE

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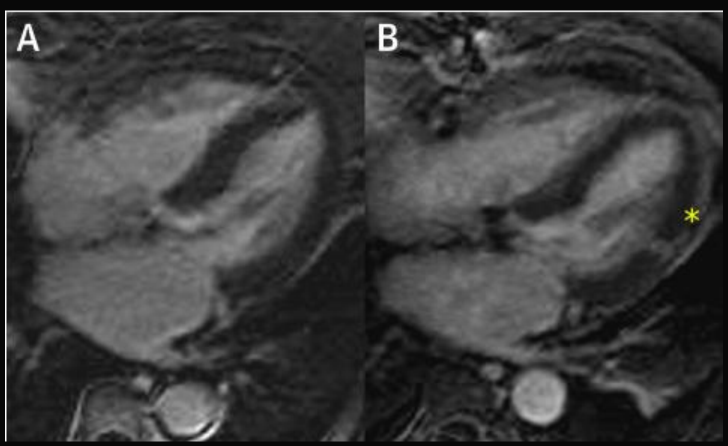
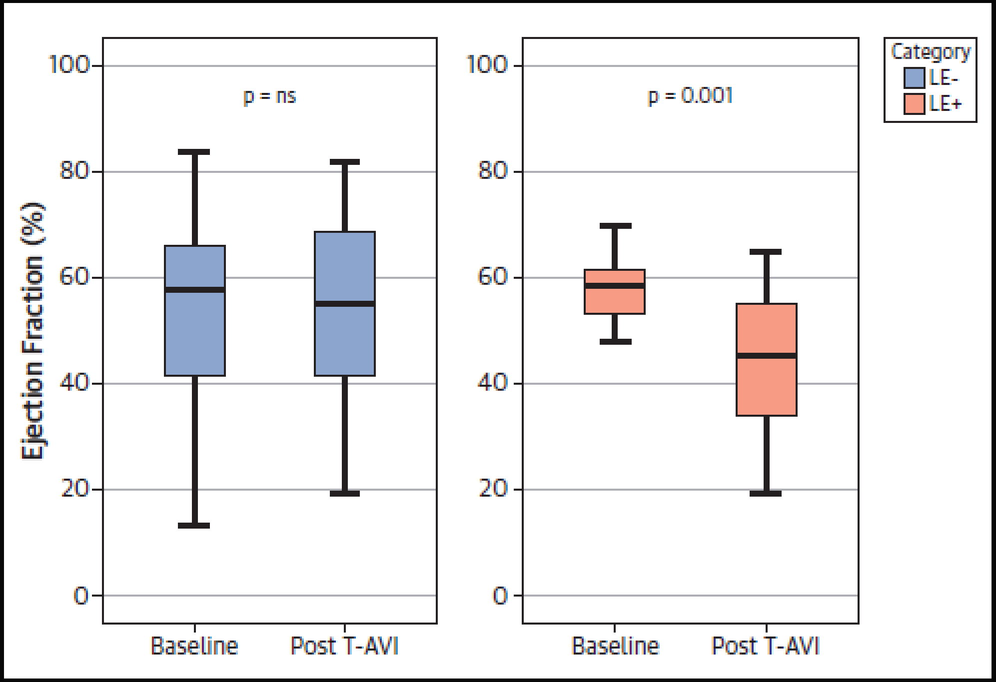
Detection of Myocardial Injury by CMR After Transcatheter Aortic Valve Replacement

Won-Keun Kim, MD,*† Andreas Rolf, MD,*‡ Christoph Liebetrau, MD,* Arnaud Van Linden, MD,* Johannes Blumenstein, MD,* Jörg Kempfert, MD,† Georg Bachmann, MD,§ Holger Nef, MD,‡ Christian Hamm, MD,*‡ Thomas Walther, MD,† Helge Möllmann, MD*

N = 61 pts. with severe AoSt
LGE MRI before and after TAVR

New ischemic LGE in 18% (mean mass 3.7 g)





CONCLUSIONS New ischemic-type myocardial LE after TAVR can be observed in a notable proportion of patients and is assumed to be of embolic origin. Patients with new LE feature a significant decrease in left ventricular function at discharge. (J Am Coll Cardiol 2014;64:349–57) © 2014 by the American College of Cardiology Foundation

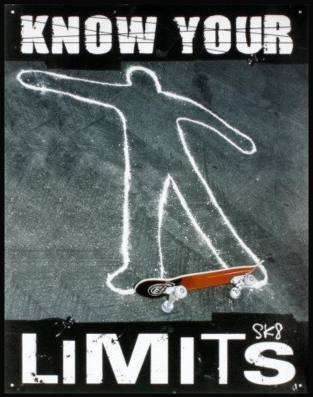
Heart Valve Disease: Investigation by Cardiovascular MRI

- Limitations -

Spatial Resolution
(valve thickness = 1-2 mm; slice thickness = 5-6 mm) → **Partial volume effect**

Temporal Resolution
(30-50 ms) → **Underestimation of functional significance of valve disease**

Multisegment acquisition
(signal overage from multiple cardiac cycles) → **Suboptimal visualization of small/chaotically mobile structures (i.e. vegetations)**

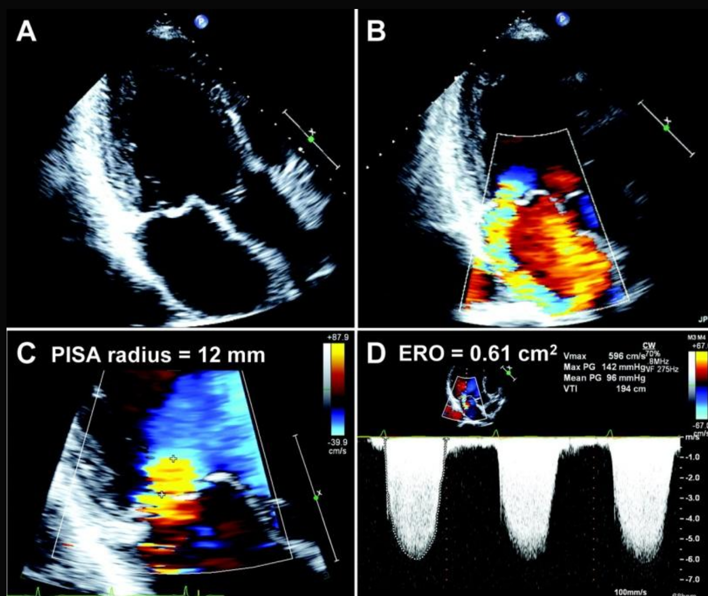


Very irregular rhythms (e.g. uncontrolled AF, multiple VEs) can present a challenge

I Problemi della Valvola: la Diagnosi

Insufficienza Valvolare Mitralica
La Diagnosi con RM

Heart Valve Disease: Investigation by Cardiovascular Magnetic Resonance



Kang D et al. Circulation 2009

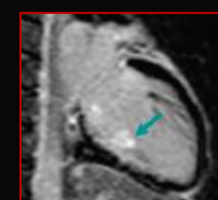
Echocardiography remains the major imaging modality for assessing valve disease

Cardiovascular MR

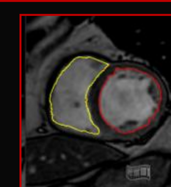
Morphology assessment

Functional assessment

Aetiology assessment



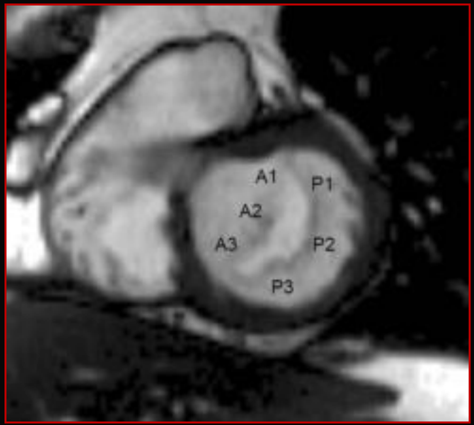
Impact on ventricular dimension/function

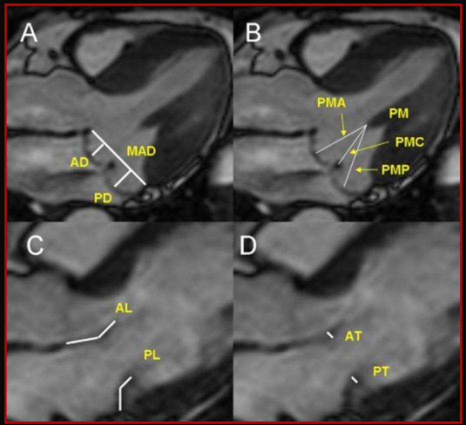


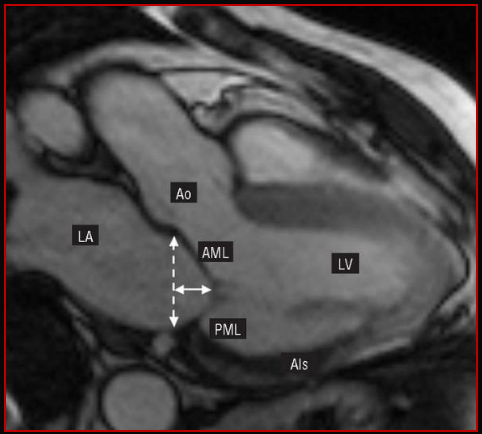
Associated great vessel disease

Comprehensive Assessment of Mitral Regurgitation Using Cardiac Magnetic Resonance

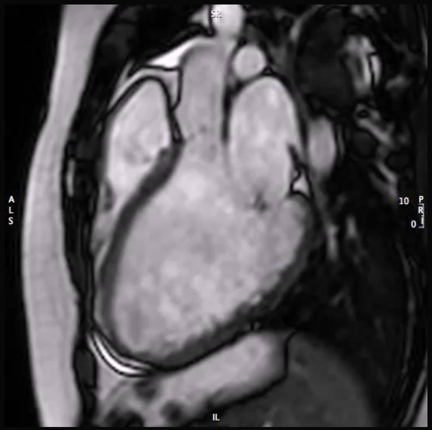
Mitral Valve Morphology



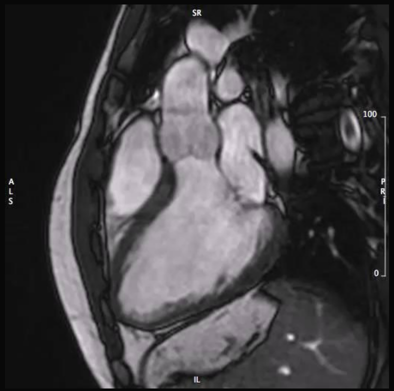




Mitral Regurgitation: Surgical Classification by Carpentier



Type I – Normal Leaflet Motion (Annular Dilatation)



Type II – Increased Leaflet Motion (Mitral Valve Prolapse)

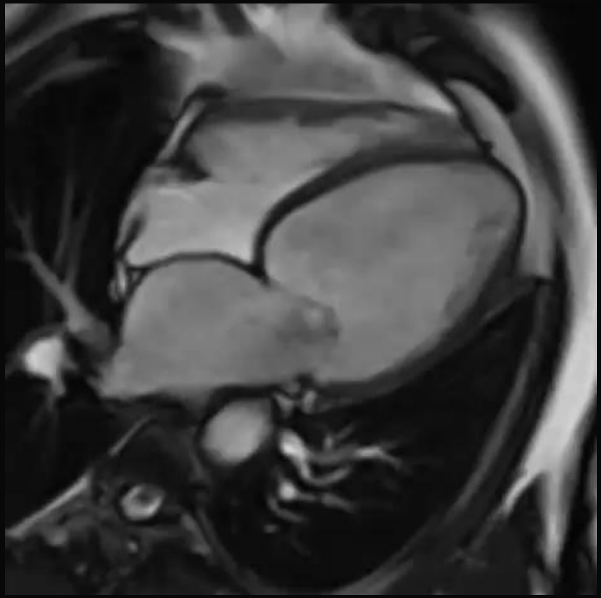
Type IIIa – Restricted Leaflet Motion (Rheumatic Valve Disease)

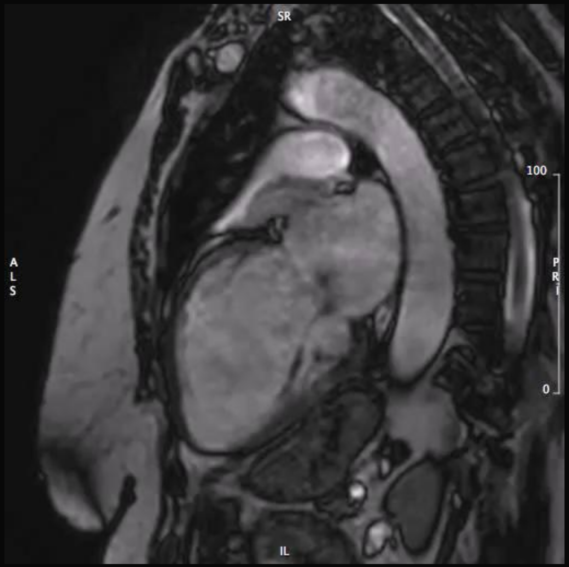
Type IIIb – Restricted Leaflet Motion (Functional MI from Tethering)

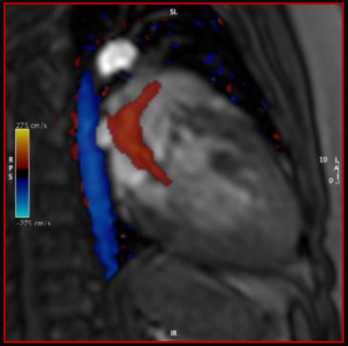
CMR in Heart Valve Disease: Functional Assessment

Qualitative:
visual assessment of turbulent flow in regurgitant jets

Visualization of signal voids due to spin dephasing in moving protons



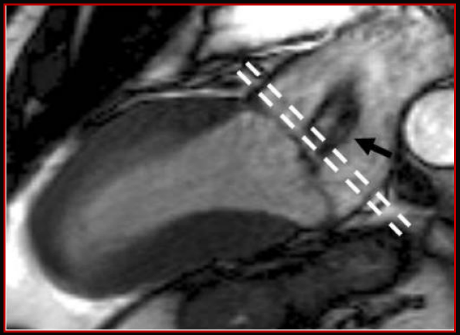


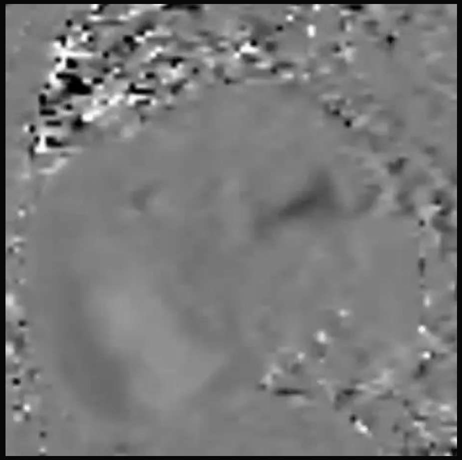


Assessing the severity of a valvular defect with visual assessment of cine images requires caution as the technique is subject to slice positioning, partial volume effects, the insensitivity of SSFP sequences and to other sequence parameters.

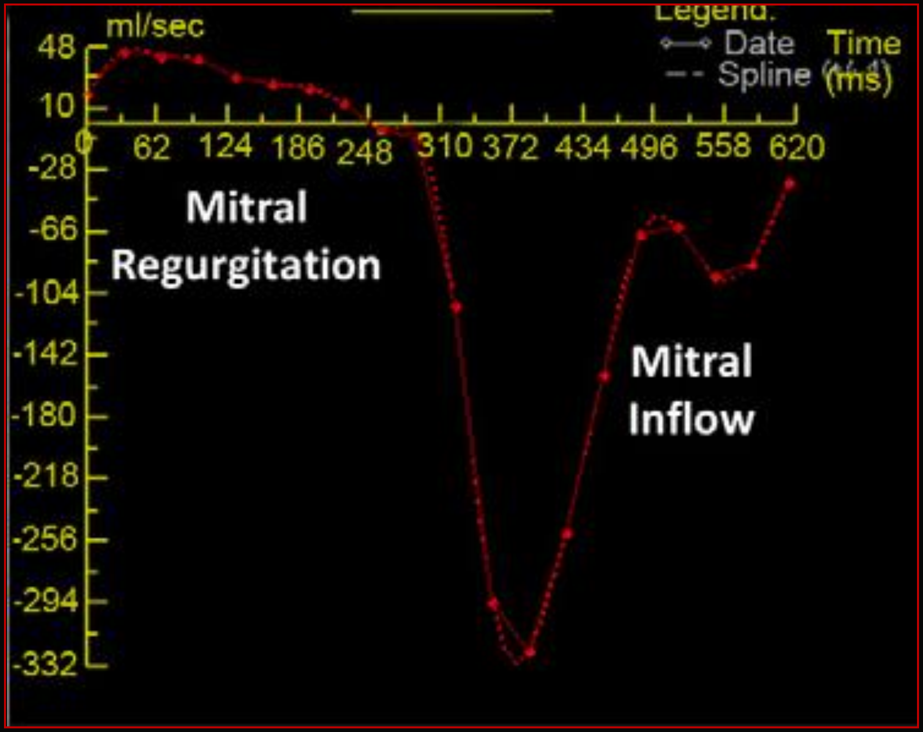
Quantification of Mitral Regurgitation by Phase-Contrast CMR

Direct Method



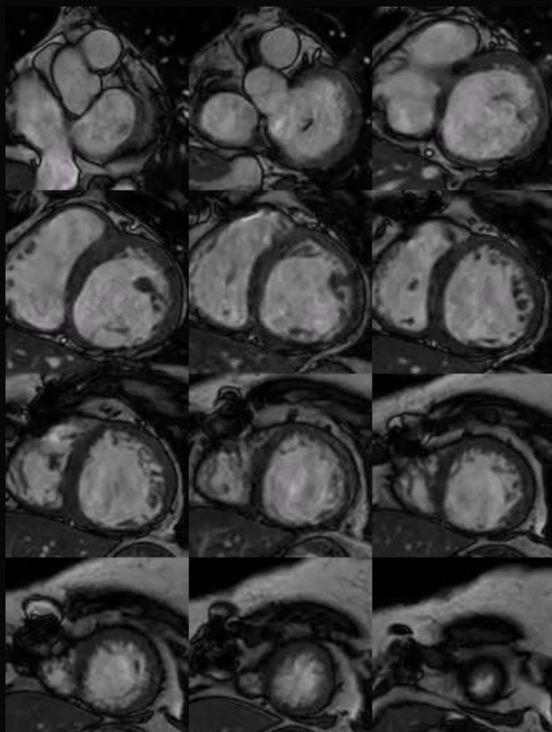


Velocity-Time Curve



Quantification of Mitral Regurgitation by Phase-Contrast CMR

Indirect Method



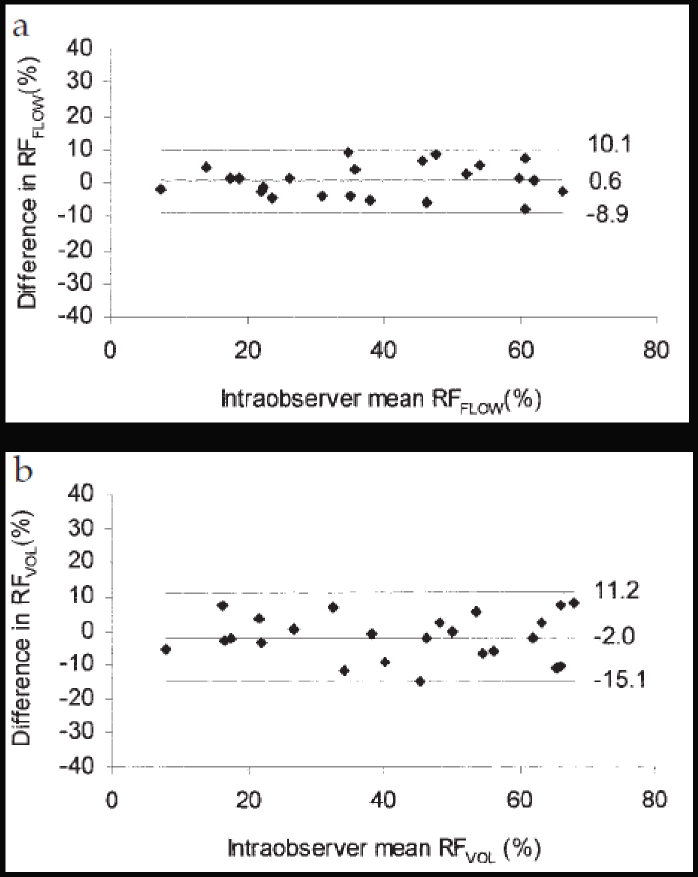
LV Stroke Volume – Aortic Systolic Flow

=

Mitral Regurgitant Volume

Kon MW et al. J Heart Valve Dis 2004

Quantification of Mitral Regurgitation by Phase-Contrast CMR



Conclusions: Compared with the volumetric method (LVSV – RVSV), the flussimetric method (LVSV – Ao Systolic Flow) is more reproducible and enables correction for Ao regurgitation

Kon MW et al. J Heart Valve Dis 2004

Currently the only work that provides RF categories to grade MR severity using CMR is based on the indirect flussimetric technique

Grade	Regurgitant Volume
Mild	≤15%
Moderate	16-24%
Mod-severe	25-42%
Severe	>42%

Gelfand EV et al. J Cardiov Magn Res 2006

Quantification of Mitral Regurgitation by Phase-Contrast CMR
- Advantages and Limitations -

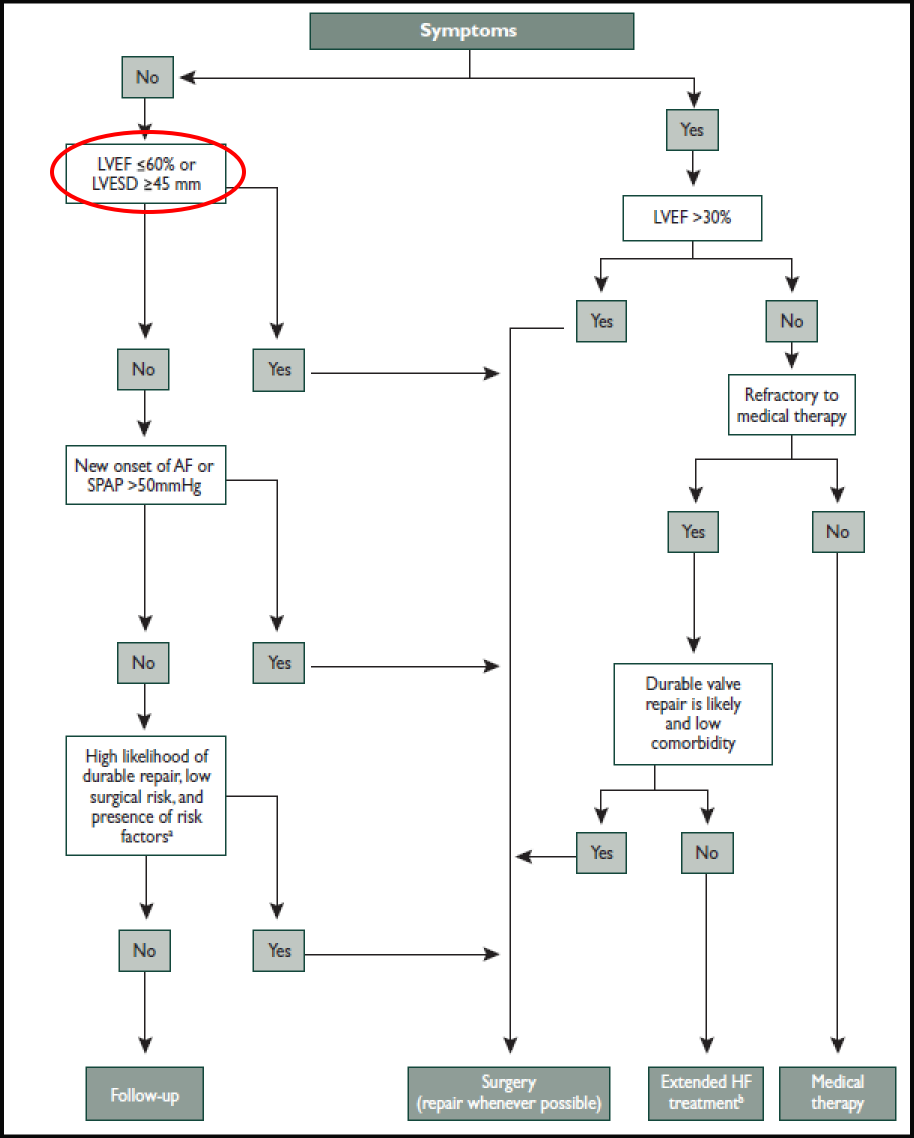
Advantages (over Echo)

- CMR is considered the reference standard for the assessment of ventricular volumes (no need for geometric assumptions)
- Regurgitant volumes are calculated without any hemodynamic or shape assumptions and are not affected by the direction of the MR jet or the orifice geometry
- The comparable spatial resolution, but superior signal- and contrast-noise resolution of CMR make measurements highly reproducible

Limitations

- There are few validation data against reference modalities
- Indirect quantification methods can be challenging and time-consuming
- It is unclear if the cut-offs suggested in the echo guidelines can be applied to the CMR measurements to classify MR severity (typically lower cutoffs should be used with CMR)

Management of Severe Chronic Primary Mitral Regurgitation



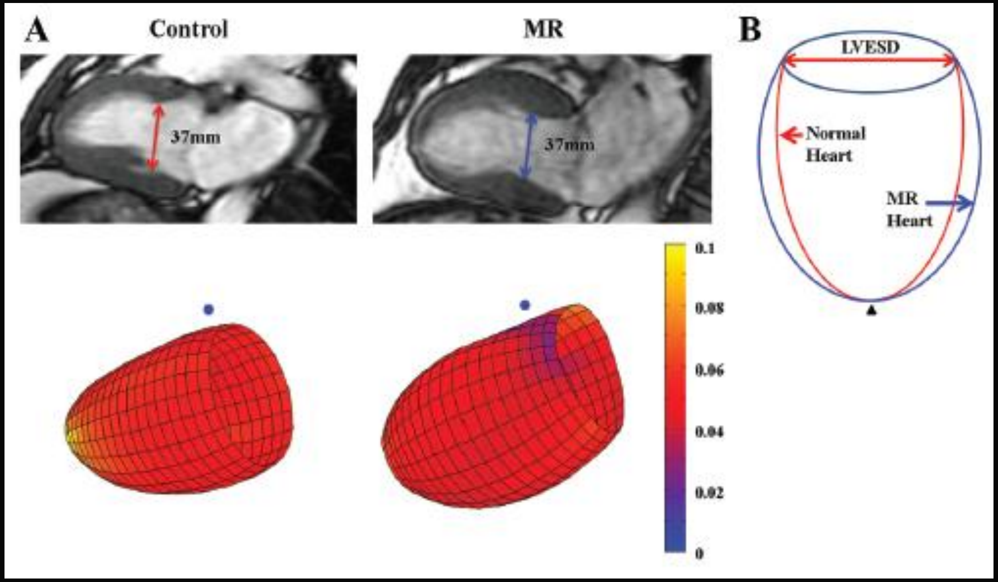
ESC Guidelines on the Management of Valvular Heart Disease (Version 2012)

MRI Definition of LV Remodeling in Isolated Mitral Regurgitation

N = 95 pts. with degenerative isolated MR

Cine magnetic resonance imaging (LV diameter and volume calculation)

34 pts. underwent mitral valve repair per current guideline recommendations



	Control (n=51)	MR Preoperative (n=35)	MR Postoperative (n=35)
Age, y	44±14	53±11*	54±11*
Female, %	53	20*	20*
Body surface area, m^2	1.9±0.24	2.00±0.24	1.98±0.23
Heart rate, bpm	67±12	71±11	69±10
Systolic BP, mm Hg‡	118±13	124±15	121±11
Diastolic BP, mm Hg	75±10	78±8	76±10
LVED volume index, mL/m^2‡	69±10	112±24*	80±18*†
LVES volume index, mL/m^2‡	25±7	45±13*	38±14*†
LVSV volume index, mL/m^2‡	44±7	67±16*	42±8†
LVEF, %	64±7	61±7*	54±8*†
LVED dimension, mm‡	49±4	60±7*	51±6*†
LVES dimension, mm‡	32±4	39±6*	36±7*†
LVED mass index, g/m^2	50±10	67±14*	57±13*†
LVED volume/mass, ml/g	1.45±0.38	1.70±0.35*	1.45±0.38†
LVES R/T ratio‡	1.48±0.40	1.84±0.60*	1.78±0.68*
Peak early filling rate, mL/s‡	378±110	632±270*	285±96*†

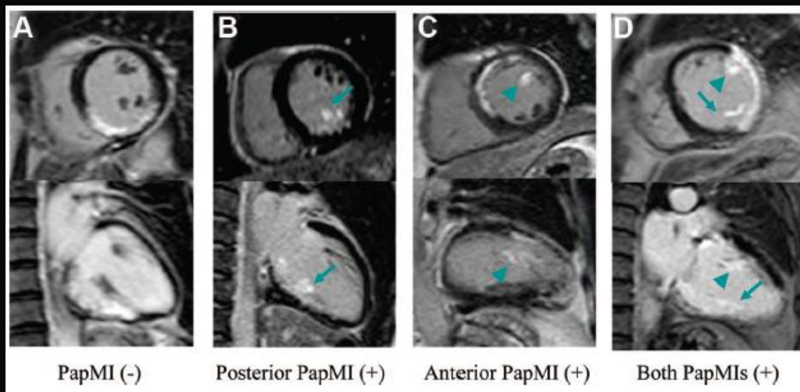
Conclusions: Despite apparently preserved LVES dimension, MR patients demonstrate significant spherical mid-to-apical LVES remodeling that contributes to higher LVESV than predicted by standard geometry-based calculations.

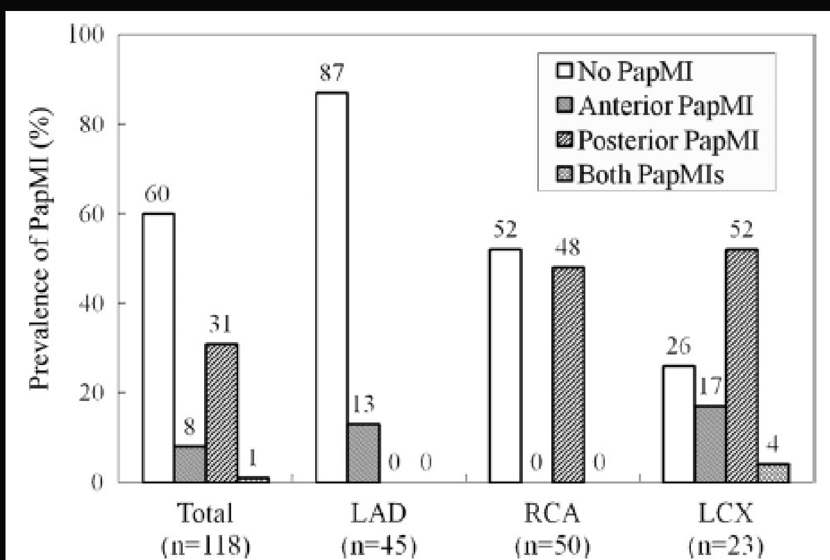
Decreased LV systolic function after surgery suggests that a volumetric analysis of LV remodeling and function may be preferred to evaluate disease progression in isolated MR.

Schiros CG et al., Circulation 2012

Prevalence and Clinical Significance of Papillary Muscle Infarction Detected by LGE MRI in Patients With STEMI

Tanimoto T et al. *Circulation 2010*





N= 118 STEMI with primary PCI
PapMI in 40%

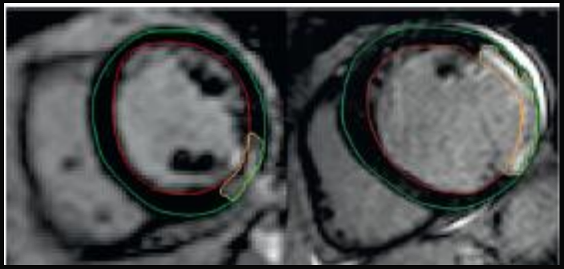
	MR		
	Yes (n=34)	No (n=84)	*P*
Maximum total CK, IU/L	3229±2487	2509±1747	0.08
Maximum CK-MB, IU/L	301±123	209±150	<0.01
Infarct-related artery, n			0.44
LAD	11	34	
LCx	9	14	
RCA	14	36	
Time to reperfusion, h	5.3±3.1	5.0±3.3	0.65
LVEDV, mL	130±33	116±29	0.20
LVESV, mL	71±28	60±25	0.04
LVEF, %	47±10	50±10	0.14
Infarct size, %	21±8	16±11	0.02
MVO, n (%)	11 (32)	27 (32)	1.00
Sphericity index	0.61±0.06	0.57±0.07	0.04
Mitral annular diameter, mm	34.9±2.7	34.4±2.8	0.29
Coaptation height, mm	6.7±1.6	3.6±1.5	<0.01
LA diameter, mm	32.7±6.1	31.1±5.7	0.18
PapMI, n (%)			0.32
None	18 (53)	53 (63)	
Anterior	2 (6)	8 (10)	
Posterior	14 (41)	23 (27)	

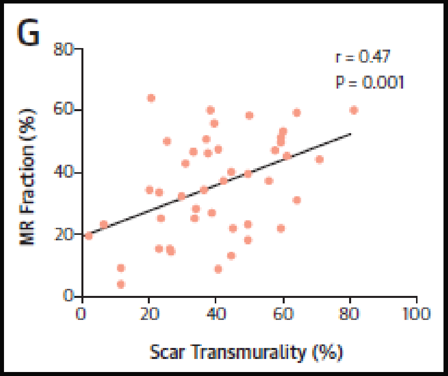
Conclusions: PapMI is more frequent than previously thought yet appears to have significant clinical latency. The size of the myocardial infarction, rather than the presence of PapMI, seems to affect left ventricular remodeling, and PapMI is not obligatorily associated with MR.

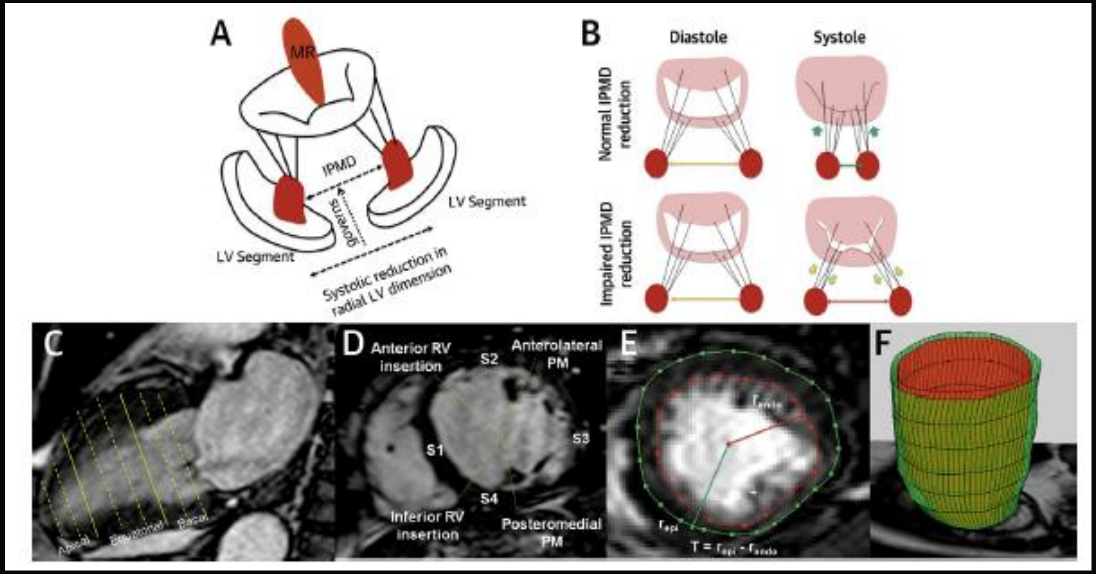
Temporal Changes in Interpapillary Muscle Dynamics as an Active Indicator of Mitral Valve and LV Interaction in Ischemic Mitral Regurgitation

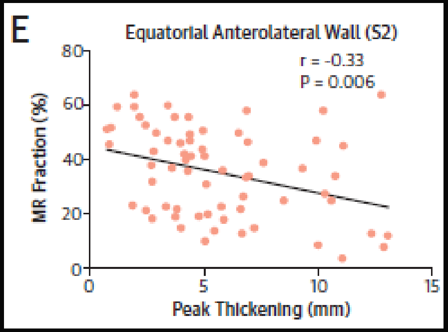
N = 67 pts. with ischemic MR

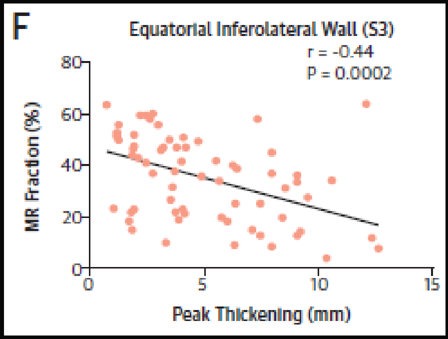
Cine + LGE magnetic resonance imaging



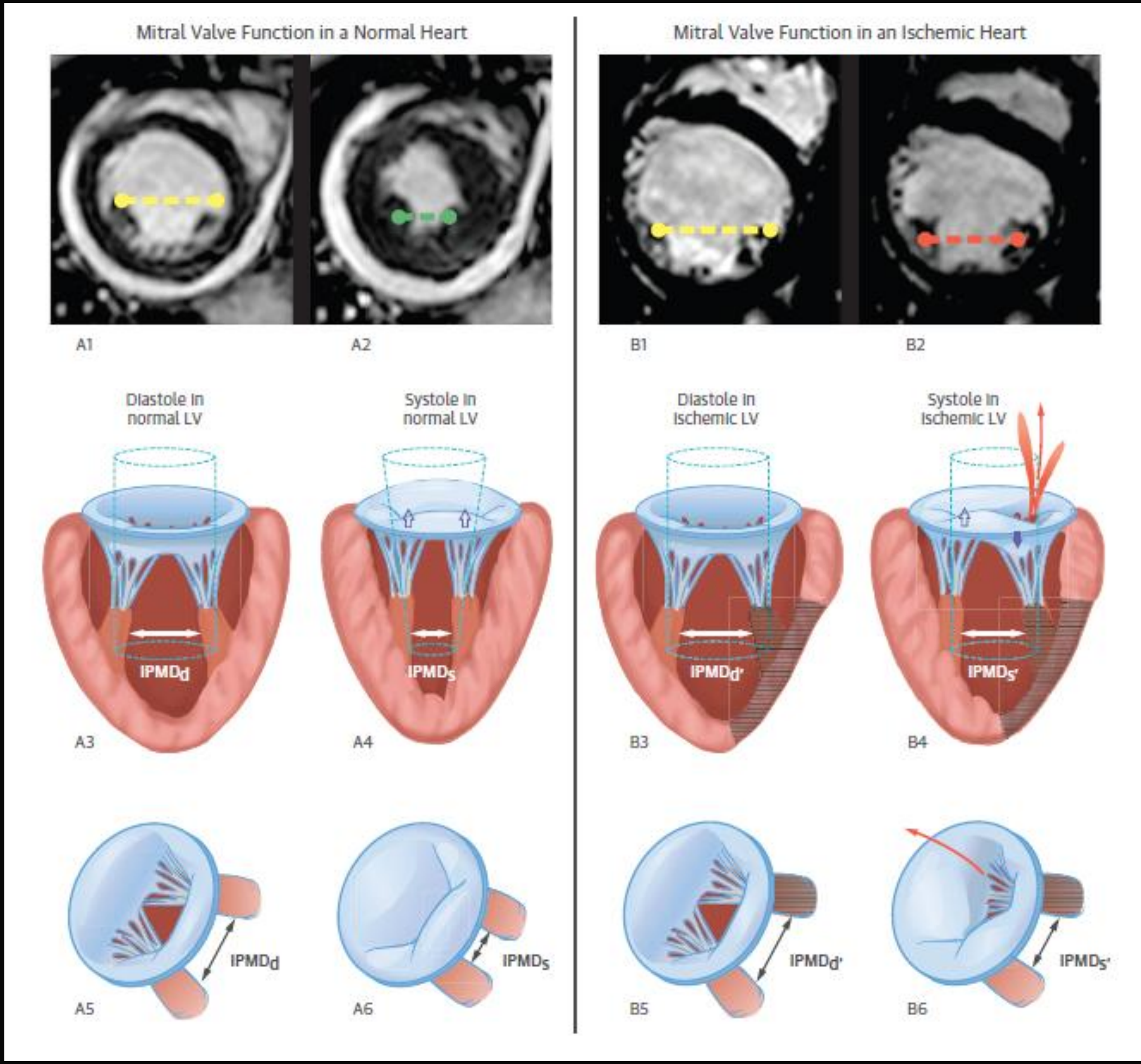








Kalra K et al., J Am Coll Cardiol 2014



Conclusions: It is the impairment of lateral shortening between the papillary muscles, and not passive ventricular size, that governs the severity of ischemic mitral regurgitation.

Loss of lateral shortening of inter-papillary muscle distance (IPMD) tethers the leaflet edges and impairs their systolic closure, resulting in mitral regurgitation, even in small ventricles.

Kalra K et al., J Am Coll Cardiol 2014

Prognostic Value of Delayed Enhancement Cardiac Magnetic Resonance Imaging in Mitral Valve Repair

N = 48 consecutive patients with chronic mitral regurgitation scheduled for surgical repair

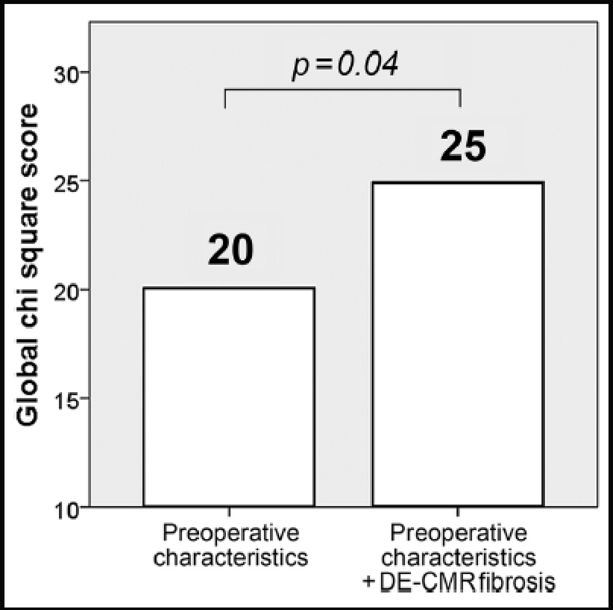
Mean follow-up = 11 months

Endpoints events: ICU readmission, needs of permanent cardiac PMK and rehospitalization for cardiac reasons

40% of pts with myocardial fibrosis (median LGE mass = 4%)

Ischemic pattern in 53% of LGE +

Preoperative CMR Variables	All Patients (n = 48)	No Fibrosis (n = 29)	With Fibrosis (n = 19)	*p* Value
Secondary MR, n (%)	10 (20.8)	3 (10.3)	7 (36.8)	0.03
Mean LAVI (mL/m^2)	79 ± 26	79 ± 27	79 ± 26	0.97
Mean LVEF	0.63 ± 0.12	0.63 ± 0.12	0.63 ± 0.11	0.85
Mean LVSV (mL)	125 ± 35	122 ± 35	131 ± 35	0.43
Mean LVEDV (mL)	199 ± 61	199 ± 58	198 ± 68	0.95
Mean LVESV (mL)	76 ± 41	76 ± 40	77 ± 43	0.94
Mean LVMI (g/m^2)	82 ± 41	70 ± 37	103 ± 42	0.02
Mean RVEF	0.51 ± 0.10	0.53 ± 0.11	0.49 ± 0.10	0.18
Mean RVSV (mL)	79 ± 20	82 ± 18	72 ± 21	0.13
Mean RVEDV (mL)	122 ± 72	124 ± 63	118 ± 86	0.78
Mean RVESV (mL)	73 ± 30	65 ± 22	88 ± 36	0.02



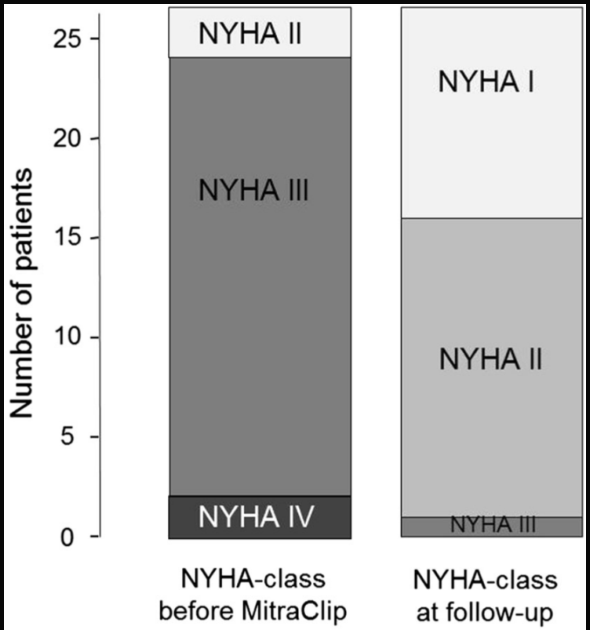
Conclusions: The presence of preoperative myocardial fibrosis assessed with delayed-enhancement CMR is an independent predictor of increased adverse clinical outcomes in patients with chronic mitral regurgitation undergoing mitral valve repair

Chaikriangkrai K et al., Ann Thorac Surg 2014

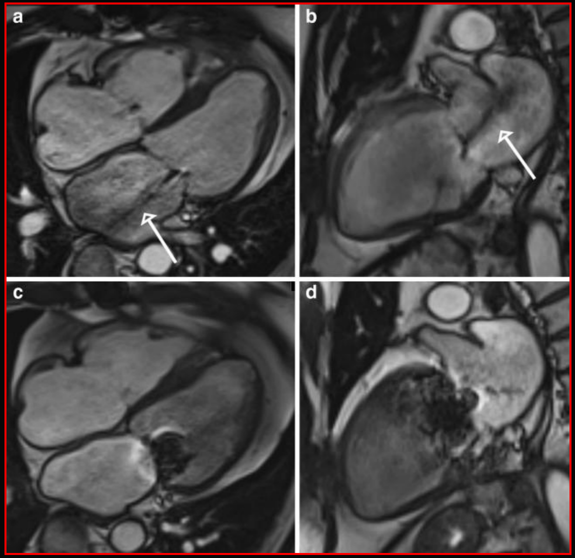
Cardiac Magnetic Resonance Imaging in Patients Undergoing Percutaneous Mitral Valve Repair with the MitraClip System

N = 27 consecutive patients with symptomatic moderate-severe MR

Cardiac MRI before and 3-month after MitraClip



MitraClip System
Cobalt/chromium with a polyester cover (approved for cardiac MRI)



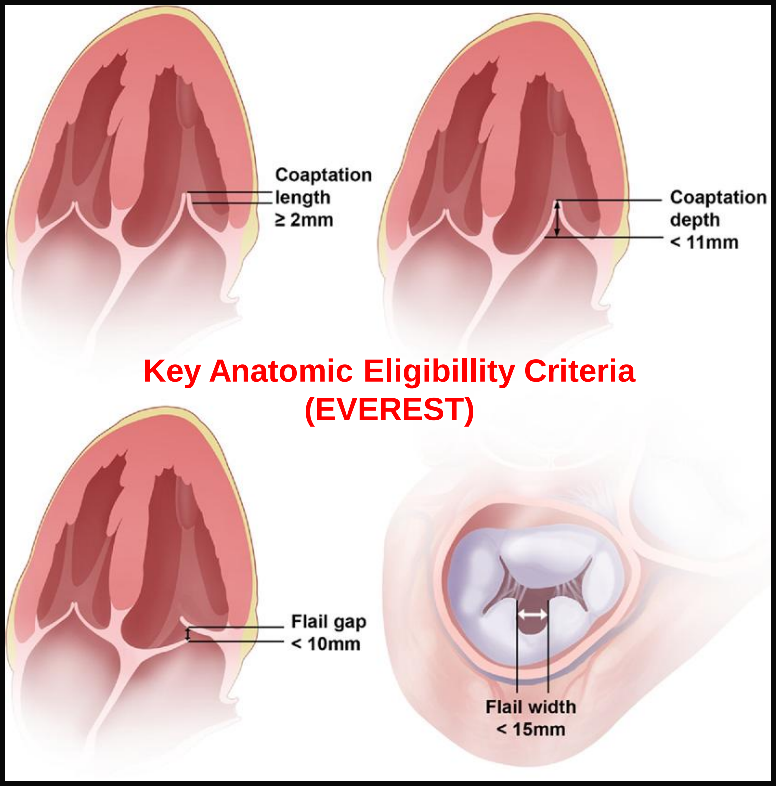
Conclusions: Cardiac MRI is feasible in patients with MitraClips

Chaikriangkrai K et al., Ann Thorac Surg 2014

Utility of Cardiac MRI in Patients Undergoing Percutaneous Mitral Valve Repair with the MitraClip System

Difficulties

1) Need to provide accurate pre-procedure morphologic parameters



2) Need to guide the procedure (intra-operative assessment)

3) Many suitable patients already treated with ICD/CRT

3) Many patients with conditions potentially affecting feasibility and/or image quality (i.e. III/IV NYHA class, atrial fibrillation, severe renal failure, etc.)

Clinical characteristics before MitraClip	All patients, $n = 27$
Age, years	77.5 ± 7.6
Gender, female	15 (56 %)
Atrial fibrillation	24 (88.9 %)
Ischemic cardiomyopathy	16 (59.3 %)
Arterial hypertension	23 (85.2 %)
Renal insufficiency	10 (37.0 %)
Diabetes mellitus	7 (25.9 %)
NYHA class I	0 (0 %)
NYHA class II	2 (7.4 %)
NYHA class III	23 (85.2 %)
NYHA class IV	2 (7.4 %)
Mitral regurgitation	
Functional mitral regurgitation	14 (51.9 %)
Organic mitral regurgitation	13 (48.1 %)
Implantation of one clip	11 (40.7 %)
Implantation of two clips	16 (59.3 %)

Chaikriangkrai K et al., Ann Thorac Surg 2014

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	
All	100% (11,040)
Completely new diagnosis not suspected before	16.4% (1,748/10,672)
Therapeutic consequences	
Change in medication	23.5% (2,462/10,464)
Intervention/surgery	8.7% (912)
Invasive angiography/biopsy	8.7% (909)
Hospital discharge	2.2% (231)
Hospital admission	0.3% (36)
Impact on patient management (new diagnosis and/or therapeutic consequence)	61.8% (6,589)
Noninvasive imaging ordered after CMR	
Transthoracic echocardiography	11.9% (1,228/10,346)
Transesophageal echocardiography	0.9% (97)
Computed tomography	0.9% (96)

From April 2007 and January 2009

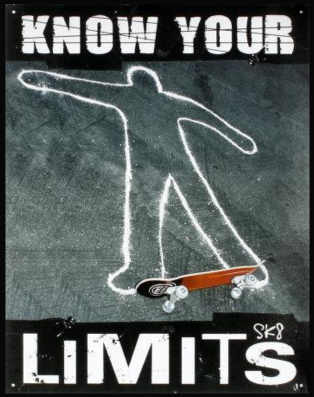
Heart Valve Disease: Investigation by Cardiovascular MRI

- Limitations -

Spatial Resolution
(valve thickness = 1-2 mm; slice thickness = 5-6 mm) → **Partial volume effect**

Temporal Resolution
(30-50 ms) → **Underestimation of functional significance of valve disease**

Multisegment acquisition
(signal overage from multiple cardiac cycles) → **Suboptimal visualization of small/chaotically mobile structures (i.e. vegetations)**



Very irregular rhythms (e.g. uncontrolled AF, multiple VEs) can present a challenge