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)

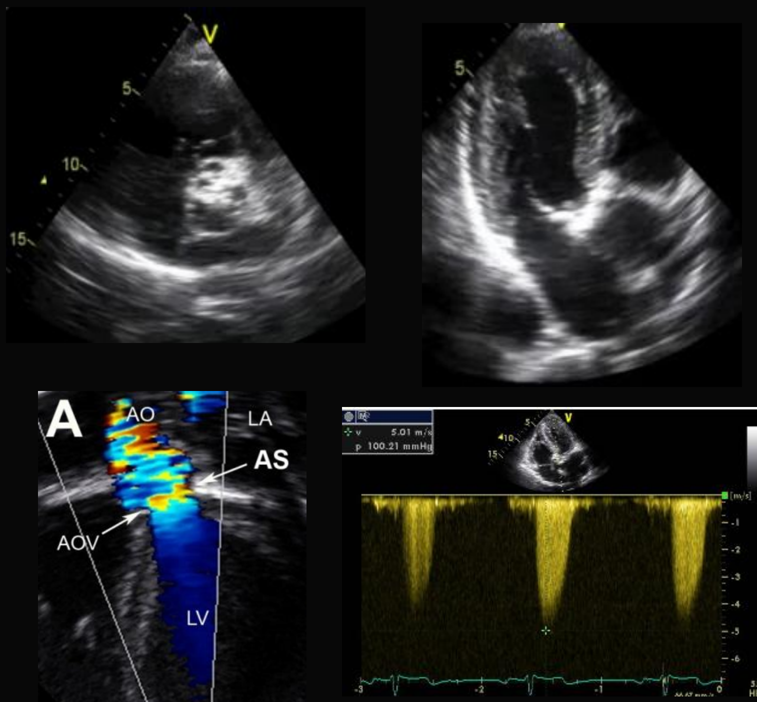
The Joint Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS)

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



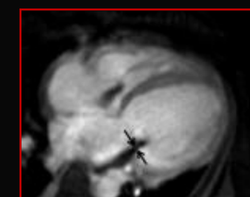
Kang D et al. Circulation 2009

Echocardiography remains the major imaging modality for assessing valve disease

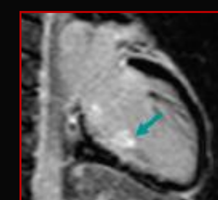
Cardiovascular MR

Morphology assessment

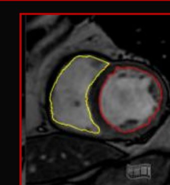
Functional assessment



Aetiology assessment



Impact on ventricular dimension/function



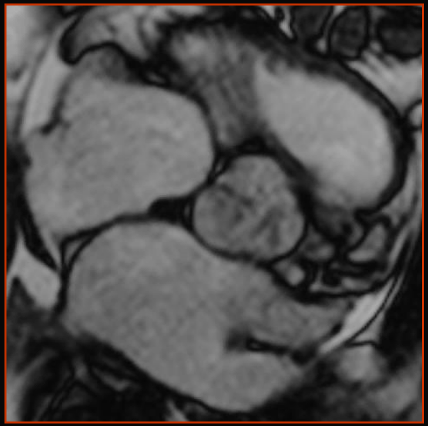
Associated great vessel disease

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

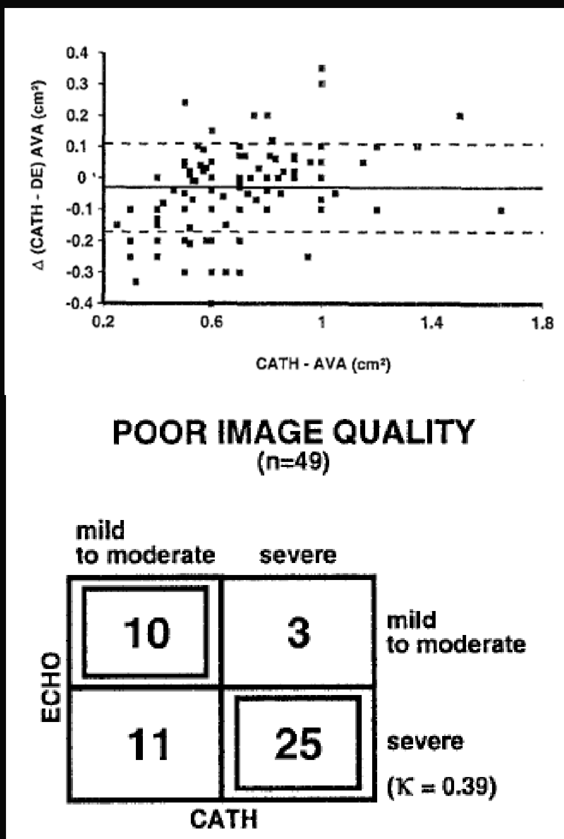
Qualitative:
visual assessment of turbulent flow in stenotic jets

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.

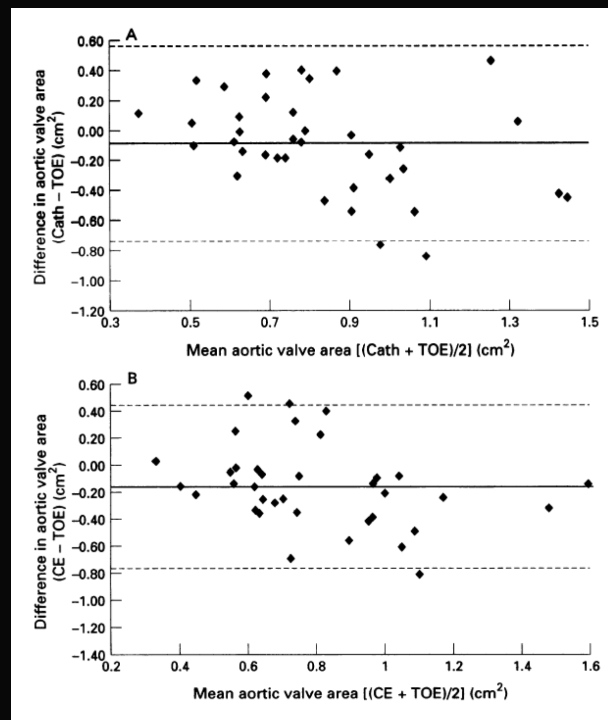
Quantification of Aortic Stenosis: Inadequacy of Traditional Methods

Transthoracic Echocardiography



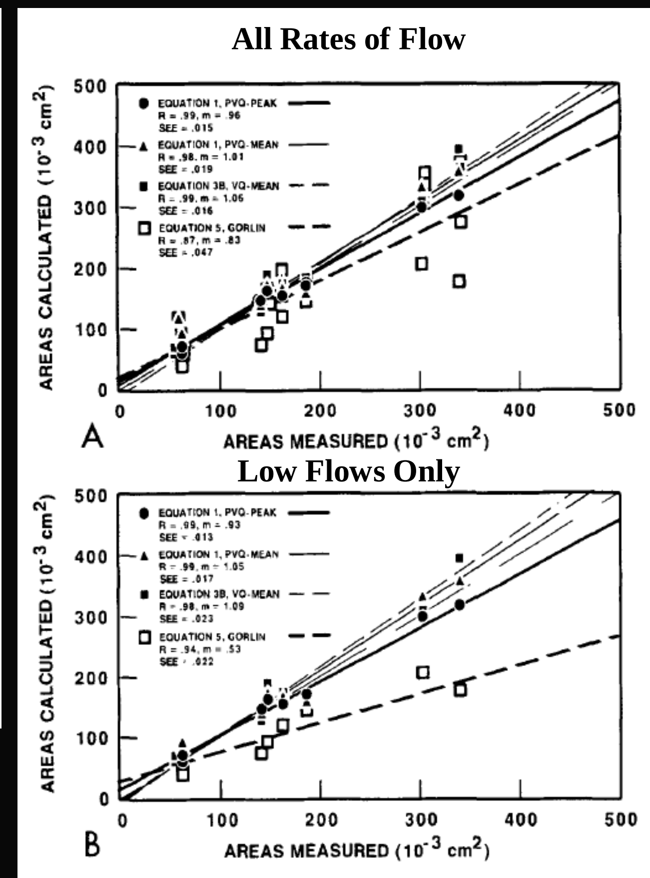
Bartunek J et al. Int J Card Imaging 1995

Transoesophageal Echocardiography



Bernard Y et al. Heart 1997

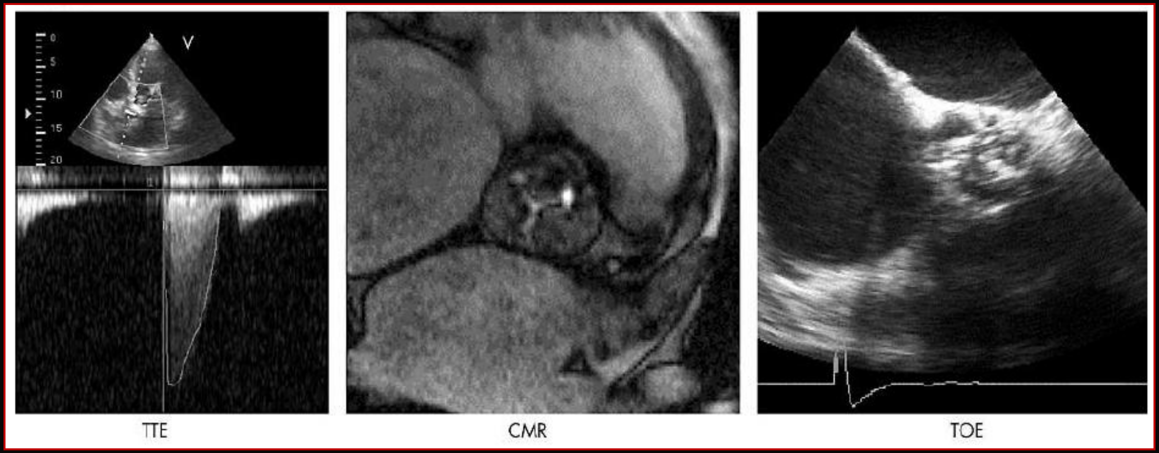
Invasive Catherization



Segal J et al. J Am Coll Cardiol 1987

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

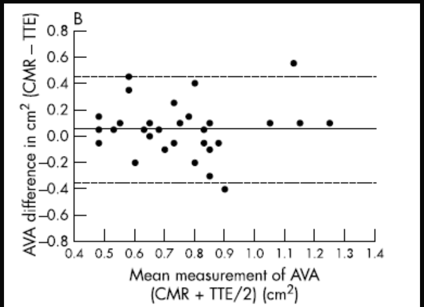
Kupfahl C et al. *Heart 2004*

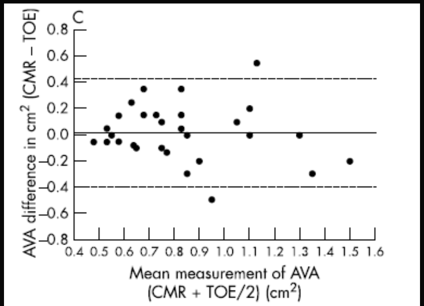


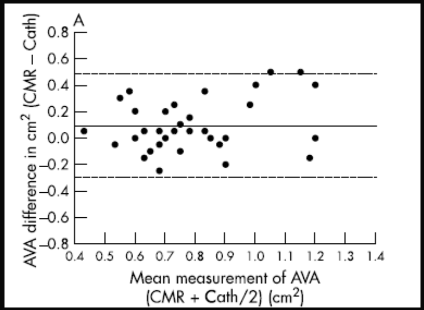
In this example, the valve could not be assessed by TTE due to poor acoustic window and LVOT calcification as well as by TOE due to commissural calcification

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



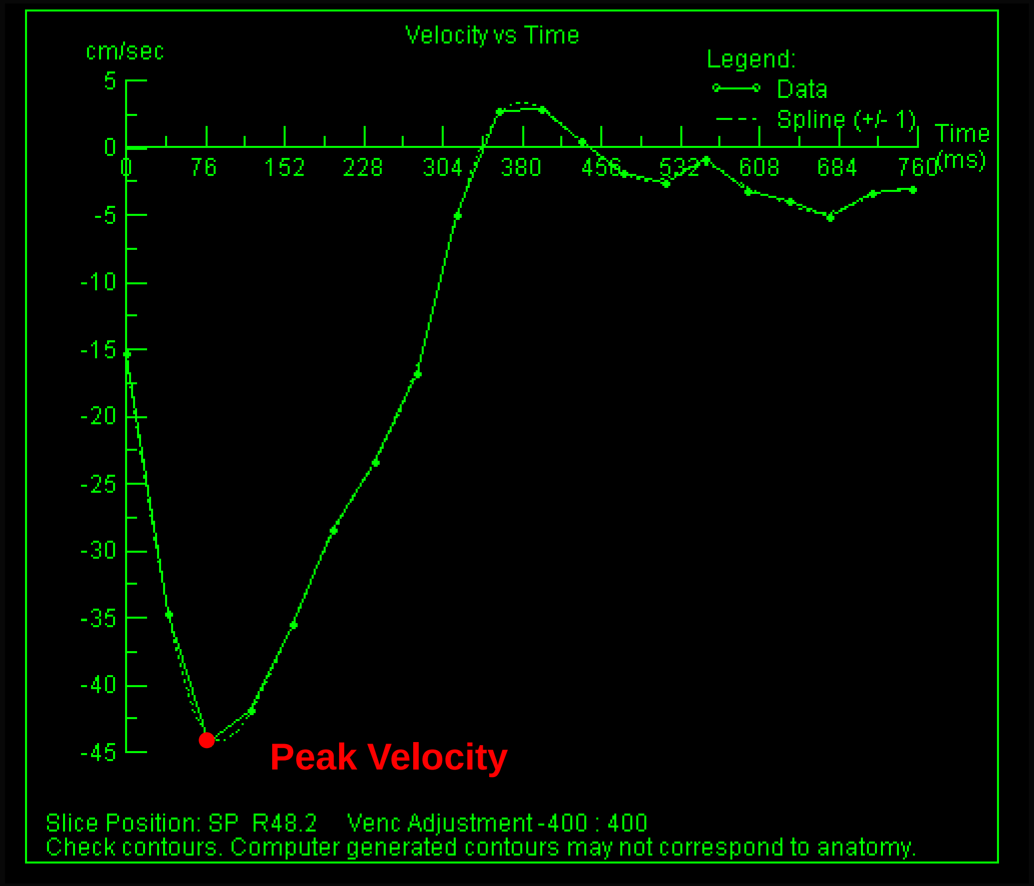




Intra-observer bias = -0.016
Inter-observer bias = 0.019

Quantification of Aortic Stenosis by Phase-Contrast CMR

Velocity-Time Curve



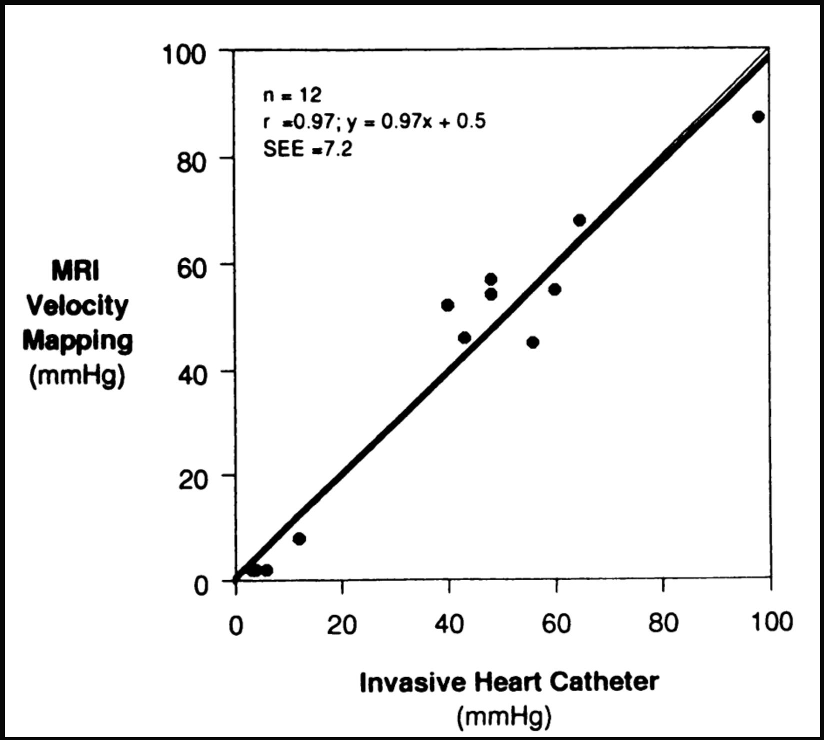
Modificed Bernulli Equation

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

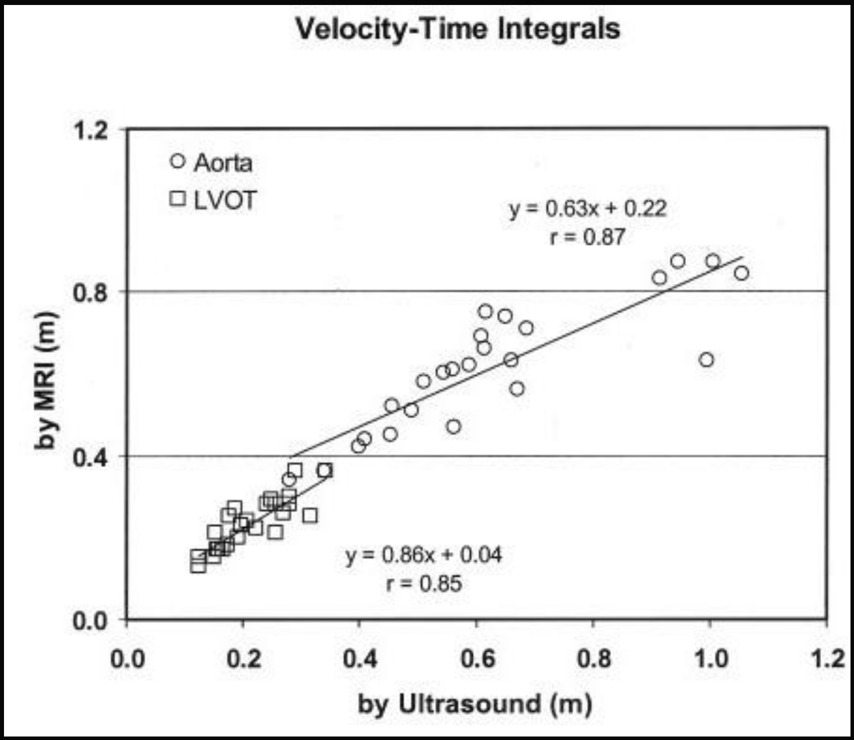
Advantages

- 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

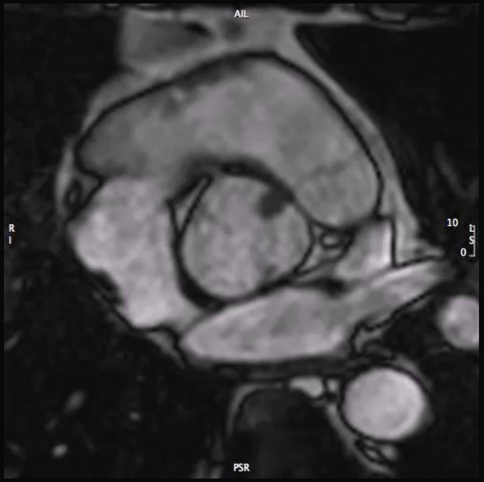
Disadvantages

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

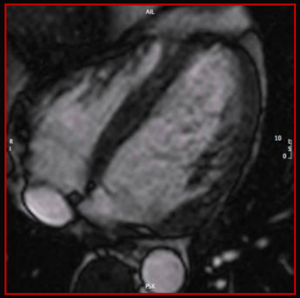
Flow-Gradient Patterns in Severe Aortic Stenosis

Severe AoSt
(AVA <1.0 cm²)

- **High Gradient** (Mean Gradient >40 mmHg)
  - **Normal Flow** (SVi >35 ml/m²)
  - **Low Flow** (SVi <35 ml/m²)
- **Low Gradient** (Mean Gradient <40 mmHg)
  - **Normal Flow** (SVi >35 ml/m²)
  - **Low Flow** (SVi <35 ml/m²)
    - **Low EF** (EF <40%) — **Classical**
    - **Preserved EF** (EF >40%) — **Paradoxical**



Low Flow-Low Gradient Aortic Stenosis

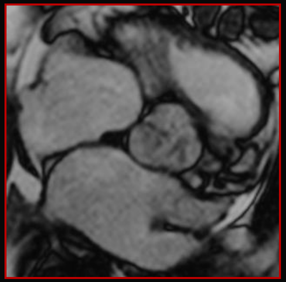


Paradoxical low flow-low-gradient pattern has been reported in up to 35% of patients with severe AS and seems to be consistent with a more advanced stage of the disease (increased global LV afterload, significant LV concentric remodeling, and intrinsic myocardial dysfunction)

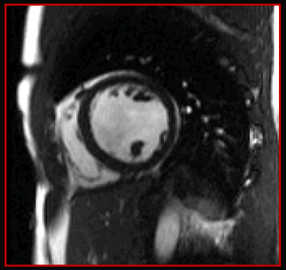
Hachicha Z et al., Circulation 2007

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

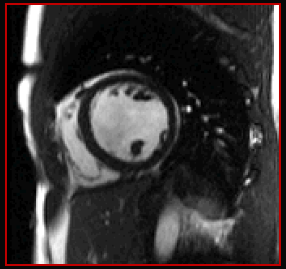
Planimertric AVA

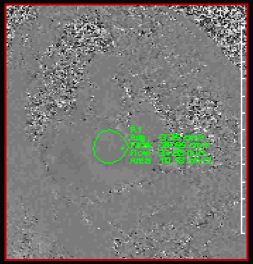


LV Ejection Fraction

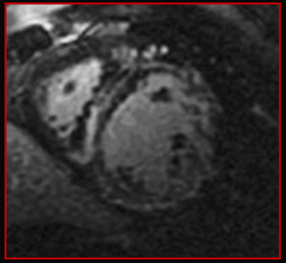


LV Stroke Volume



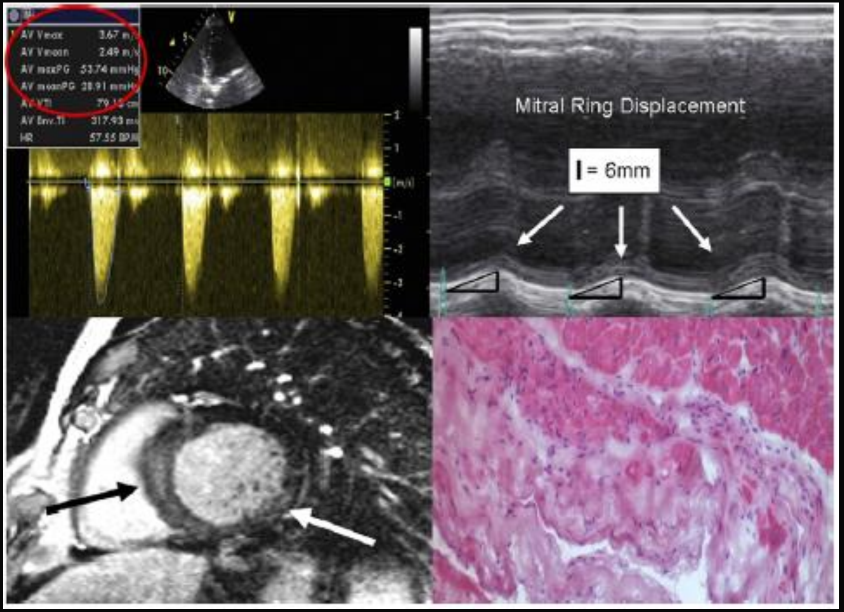


LV Myocardial Scar/Fibrosis



Myocardial Fibrosis in Low-Gradient Aortic Valve Stenosis

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

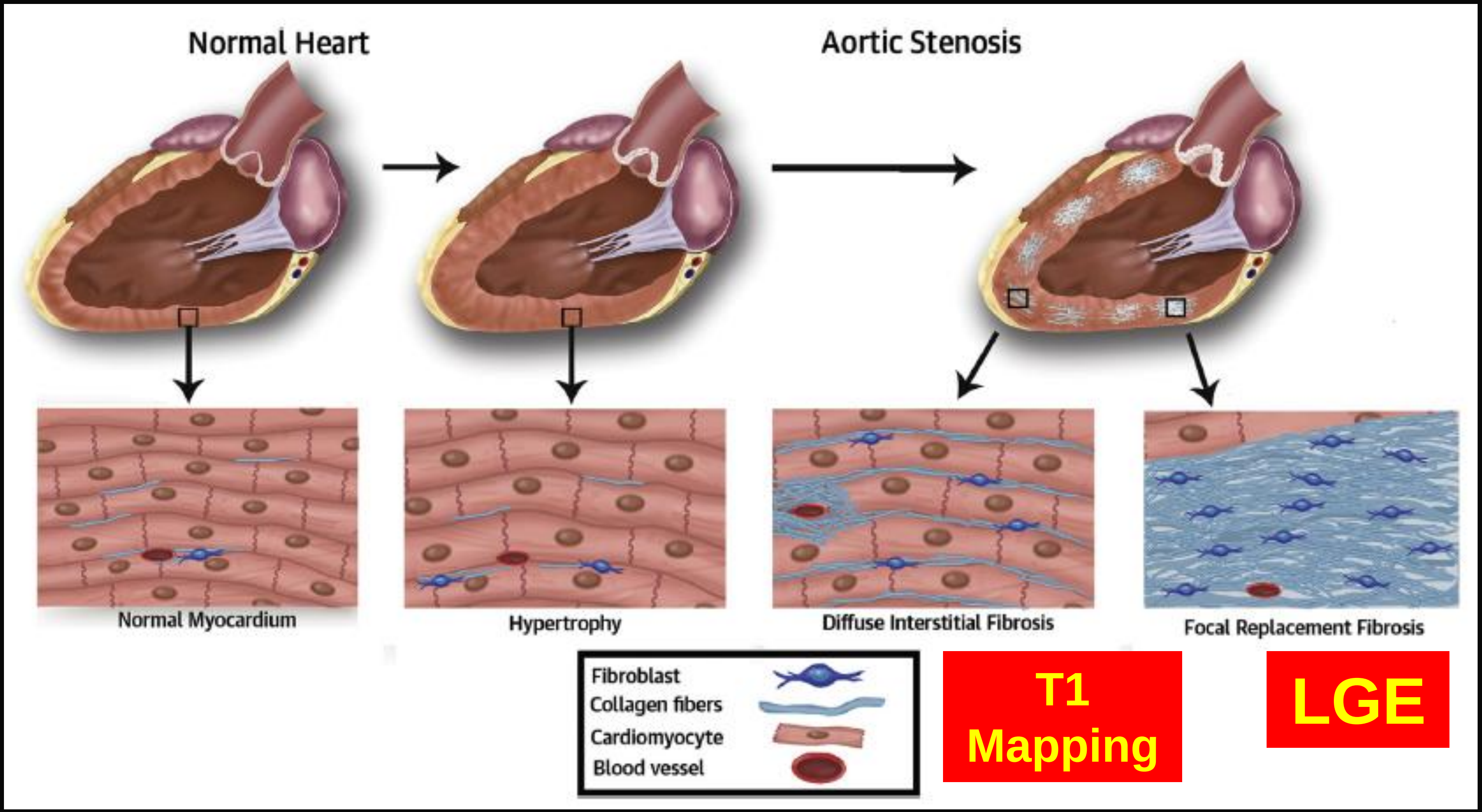


	Severe AS, High Gradient (n = 49)	Severe AS, Low Gradient, EF ≥50% (n = 11)	Severe AS, Low Gradient, EF <50% (n = 9)
cMRI			
Ejection fraction, %	55 ± 13	56 ± 12	38 ± 17*†
Late enhancement–positive segments: 0/1/>1, %	47/19/34	0/20/80	0/23/77
Myocardial histology			
Interstitial fibrosis, %	1.8 ± 0.8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

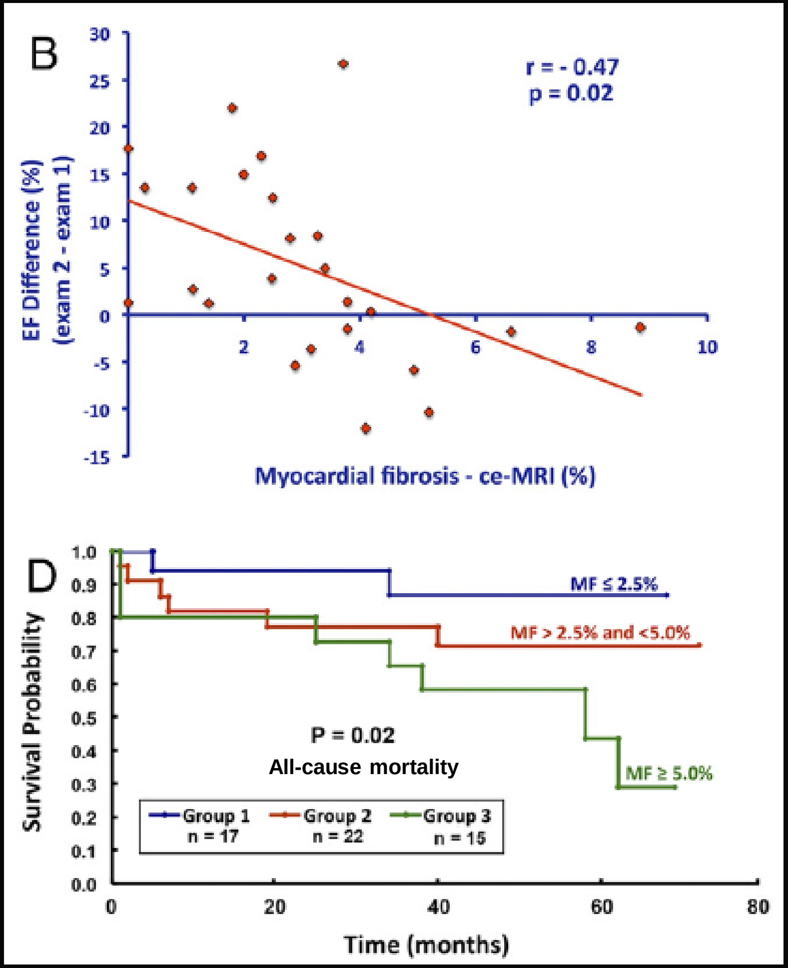
Pathophysiology of Myocardial Fibrosis in Aortic Stenosis



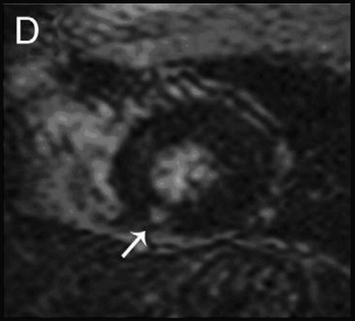
Barone –Rochette G et al., J Am Coll Cardiol 2014

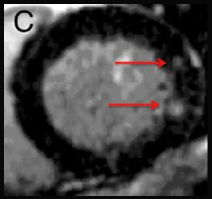
Prognostic Significance of Myocardial Fibrosis as detected by LGE MRI in Aortic Stenosis

N = 54 pts scheduled for surgical AVR

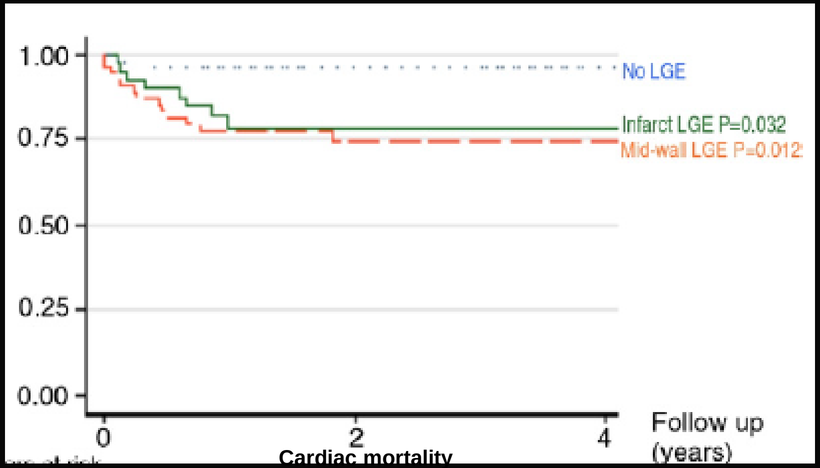


Azevedo CF et al., J Am Coll Cardiol 2010





N = 143 pts with moderate-severe AoSt



Dweck MR et al., J Am Coll Cardiol 2011

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
VOL. 64, NO. 2, 2014

ISSN 0735-1097/$36.00
PUBLISHED BY ELSEVIER INC.
http://dx.doi.org/10.1016/j.jacc.2014.02.612

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.)

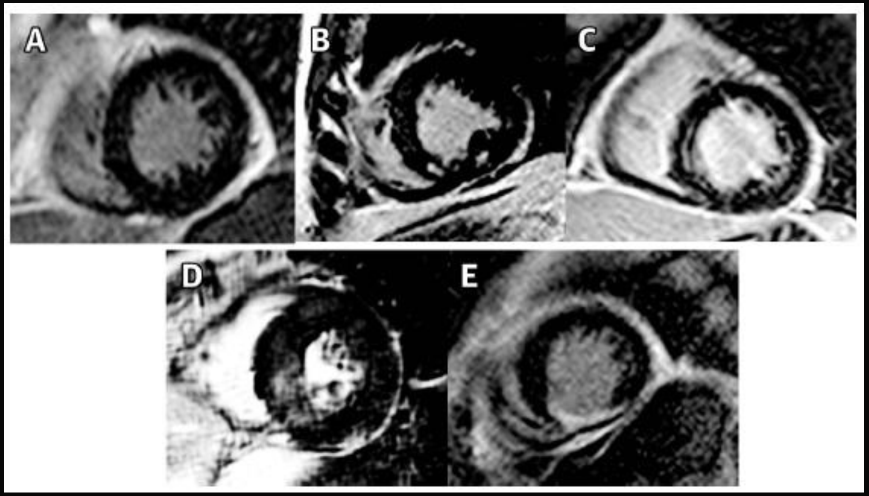
Endpoints: CV mortality (death from CHF, MI, SCD or post-AVR)

Median follow-up = 2.9 years

TABLE 2 Patterns of LGE

Group	No LGE	Infarct LGE*	Noninfarct 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



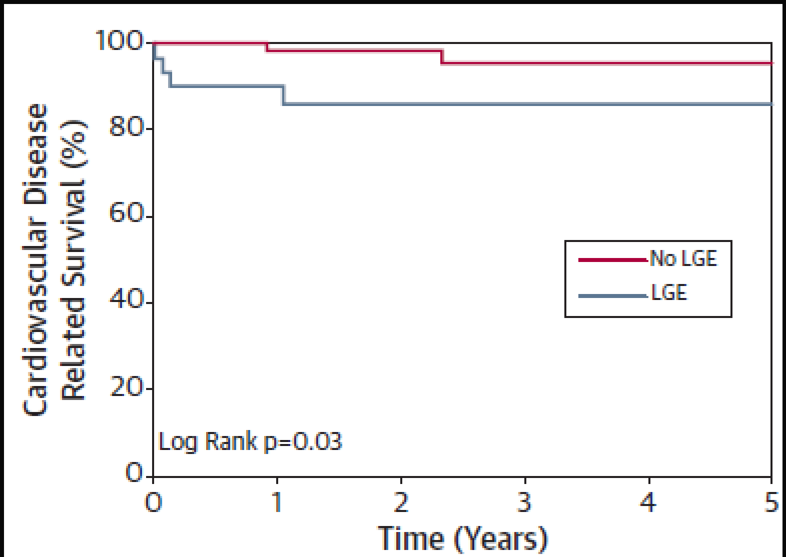
JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
VOL. 64, NO. 2, 2014

ISSN 0735-1097/$36.00
PUBLISHED BY ELSEVIER INC.
http://dx.doi.org/10.1016/j.jacc.2014.02.612

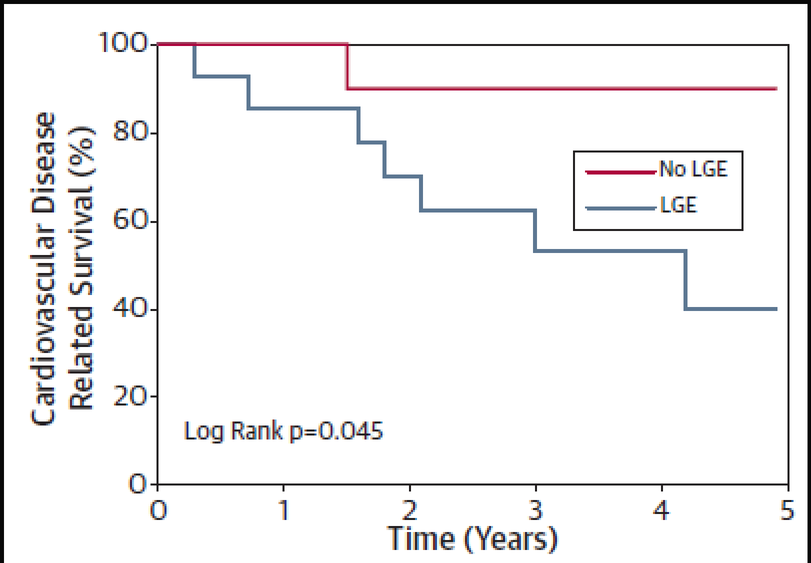
Prognostic Significance of LGE by CMR in Aortic Stenosis Patients Undergoing Valve Replacement

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

Surgical AVR

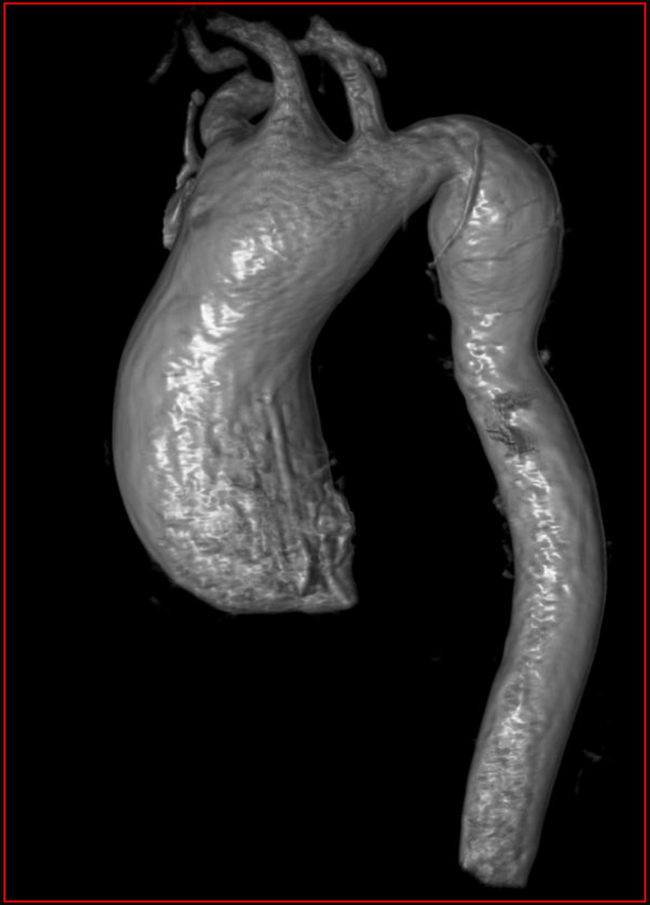


TAVR



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) © 2014 by the American College of Cardiology Foundation.

MR Angiograhy of the Thoracic Aorta



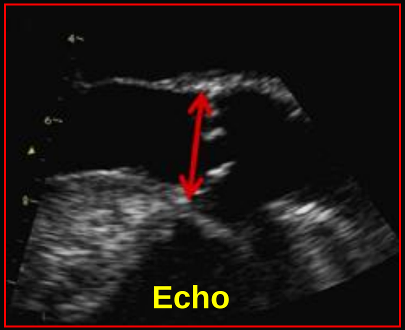
Aneurysm

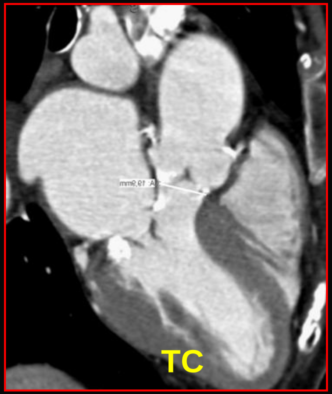
Dissection

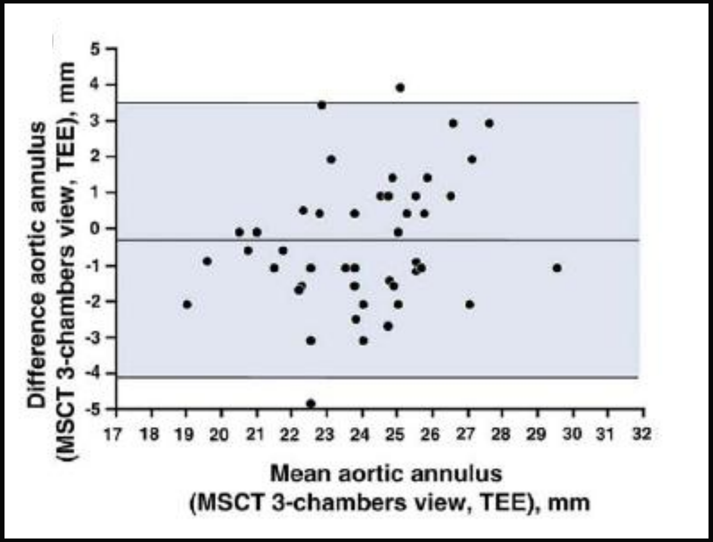
Coarctation

Assessment of Aortic Annulus Diameter

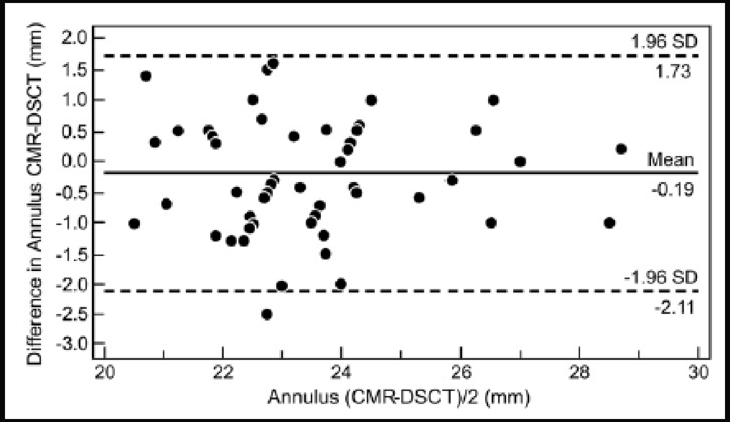
Are the Noninvasive Imaging Modalities Interchangeable?







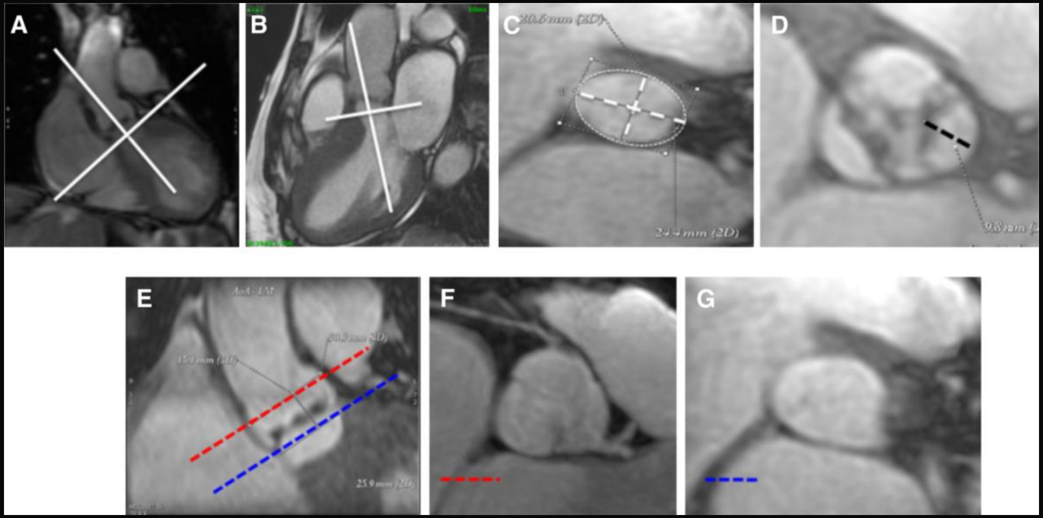
Messika-Zeitoun D et al., J Am Coll Cardiol 2010

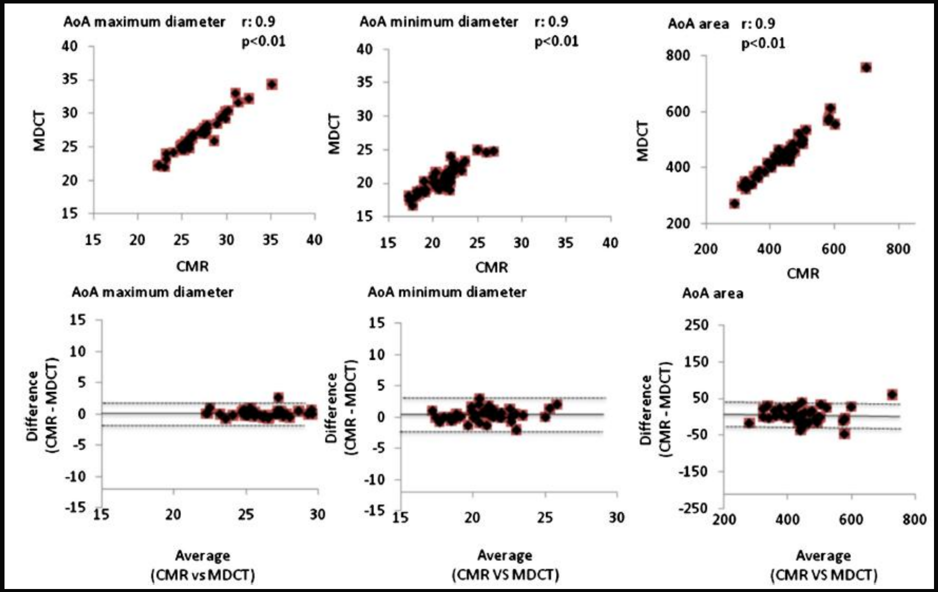


Koos R et al., Int J Cardiol 2011

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)





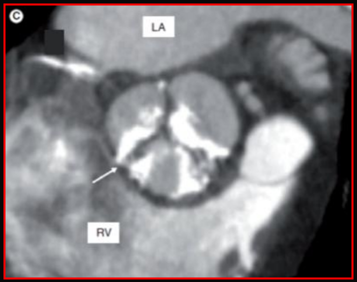
Conclusions: Aortic root assessment with CMR including AoA size, aortic leaflet length, and coronary artery ostia height (but not aortic leaflet calcification) is accurate compared with MDCT.
CMR may be a valid imaging alternative in patients unsuitable for MDCT.

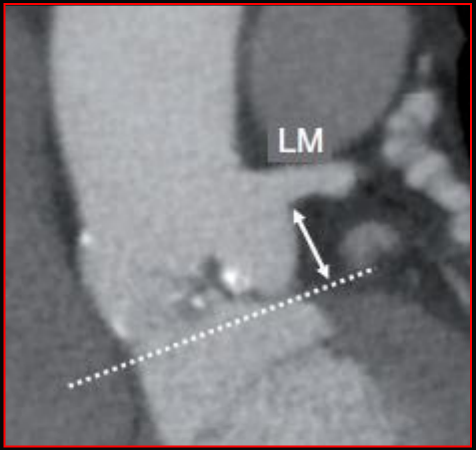
Pontone G et al., Am J Cardiol 2013

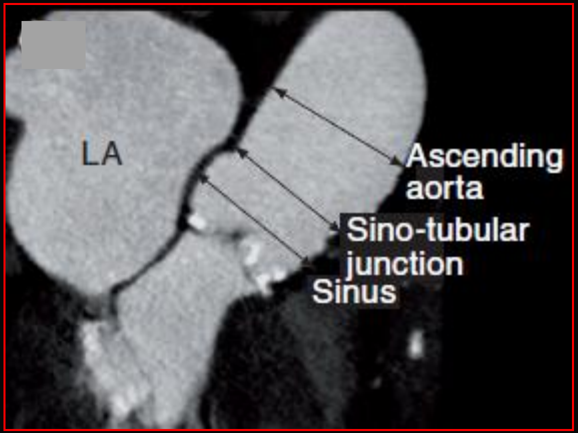
Trancatheter Aortic Valve Implantation (TAVI)
Morphologic Selection Criteria

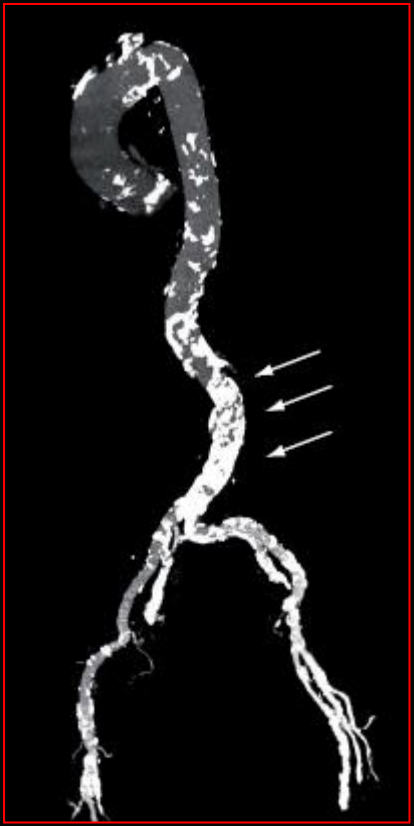
<u>Feasibility assessment</u>:

- **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**





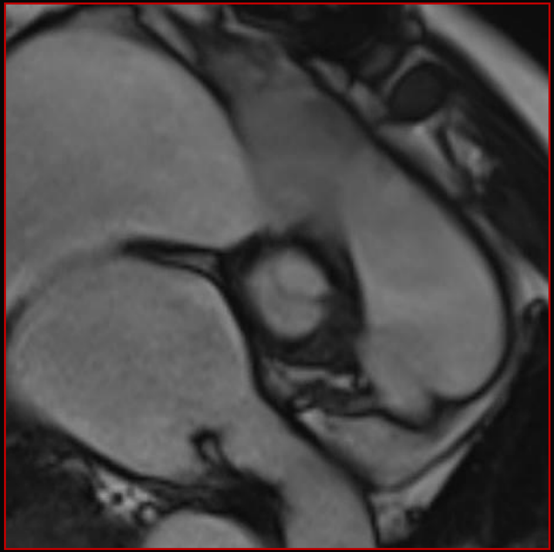




Delgado V et al., Expert Rev Cardiovasc Ther 2010

Cardiovascular MR: Post-Surgical AVR Evluation

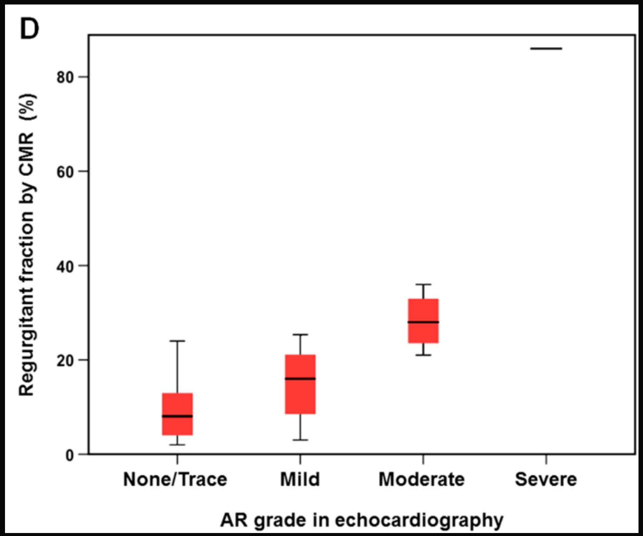
Biological



Mechanical

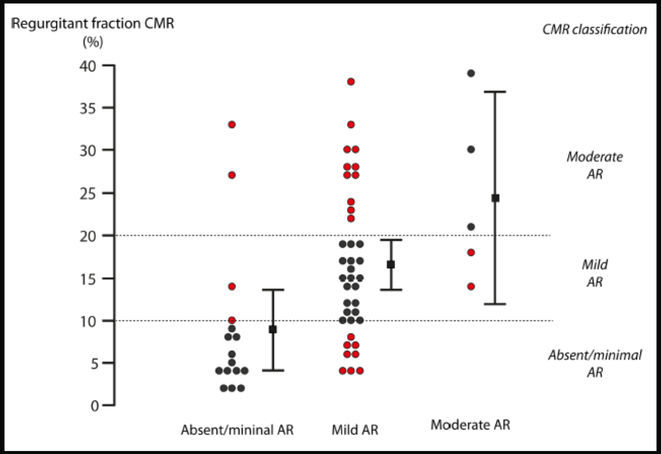
Aortic Regurgitation Severity after TAVI is Underestimated by Echocardiography Compared with MRI

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



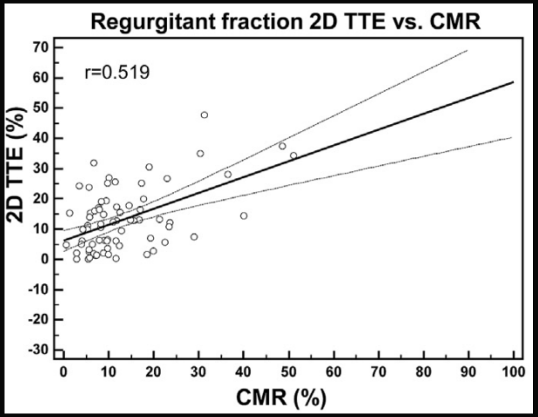
Ribeiro HB et al., Heart 2014

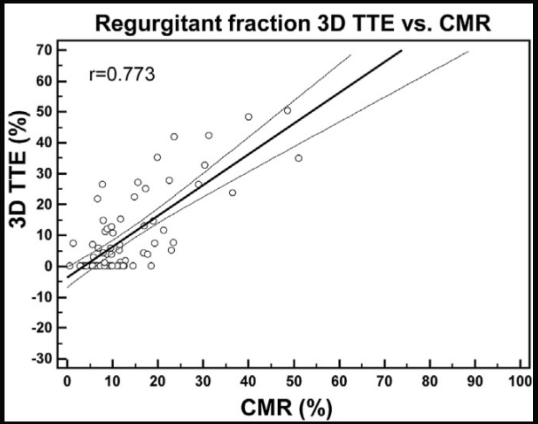
N = 65 post-TAVI pts. (Edwards SAPIEN)



Orwat S et al., Heart 2014

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





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

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
VOL. 64, NO. 4, 2014

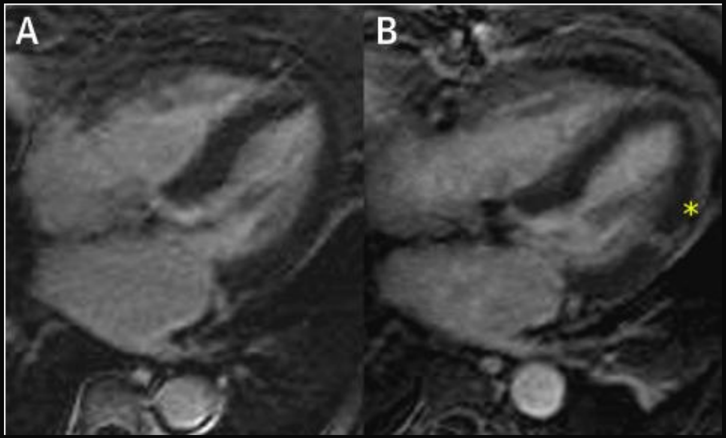
ISSN 0735-1097/$36.00
PUBLISHED BY ELSEVIER INC.
http://dx.doi.org/10.1016/j.jacc.2014.03.052

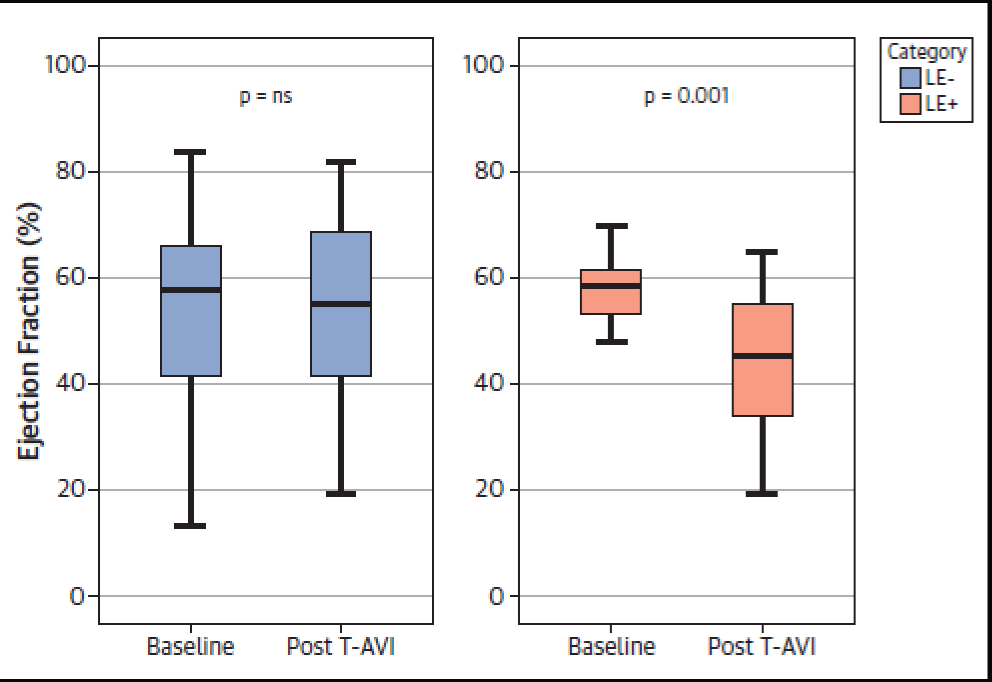
Detection of Myocardial Injury by CMR After Transcatheter Aortic Valve Replacement

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)



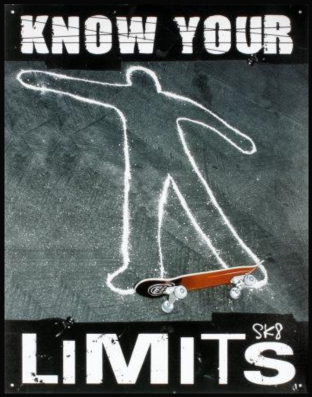


CONCLUSIONS New ischemic-type myocardial LE after TAVR can be observed in a notable proportion of patients and is assumed to be of embolic origin. Patients with new LE feature a significant decrease in left ventricular function at discharge. (J Am Coll Cardiol 2014;64:349–57) © 2014 by the American College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