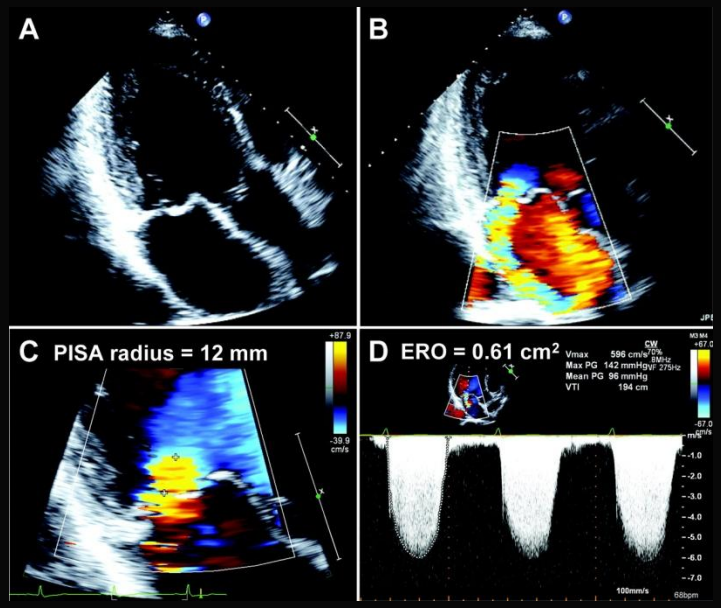
I Problemi della Valvola: la Diagnosi

Insufficienza Valvolare Mitralica
La Diagnosi con RM

Heart Valve Disease: Investigation by Cardiovascular Magnetic Resonance

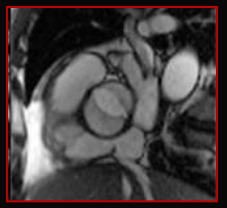


Kang D et al. Circulation 2009

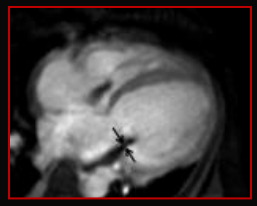
Echocardiography remains the major imaging modality for assessing valve disease

Cardiovascular MR

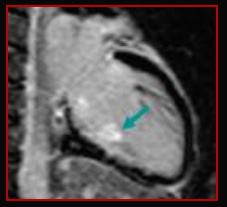
Morphology assessment



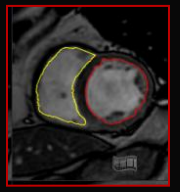
Functional assessment



Aetiology assessment



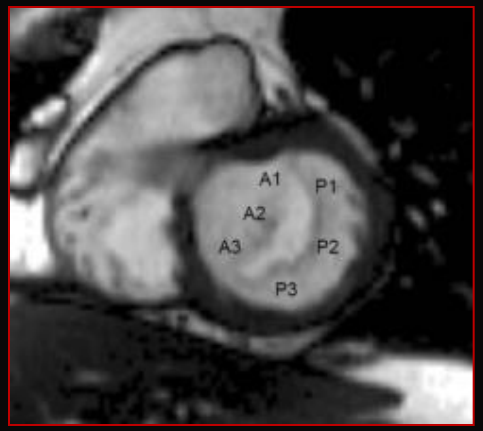
Impact on ventricular dimension/function

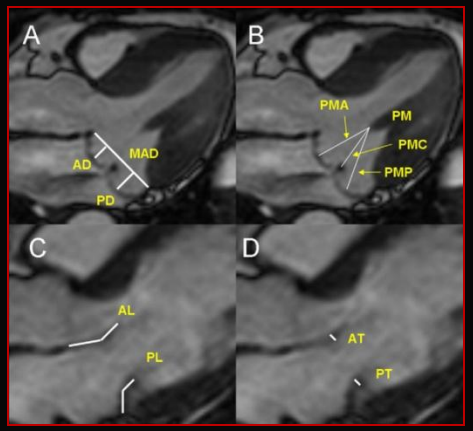


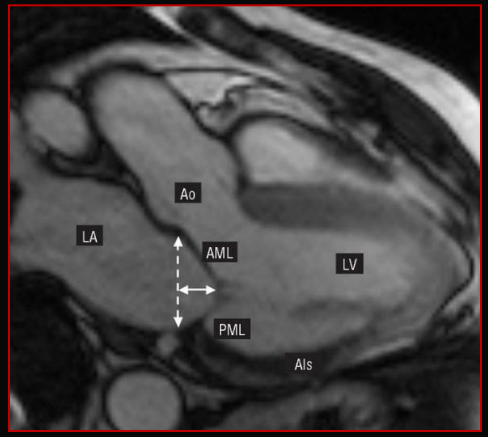
Associated great vessel disease

Comprehensive Assessment of Mitral Regurgitation Using Cardiac Magnetic Resonance

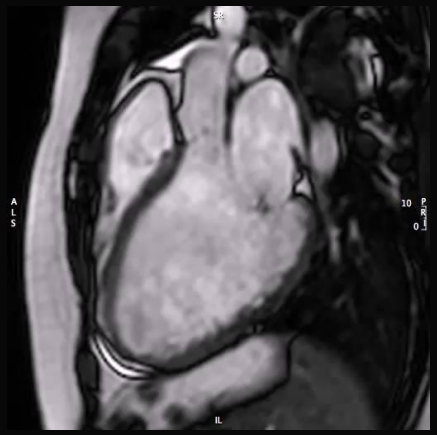
Mitral Valve Morphology



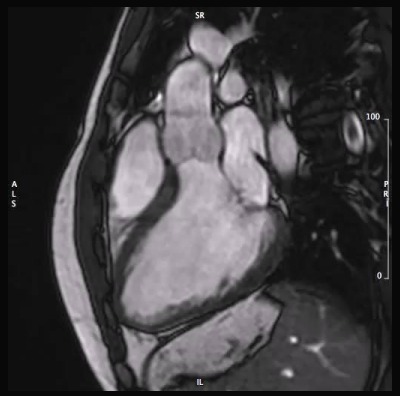




Mitral Regurgitation: Surgical Classification by Carpentier



Type I – Normal Leaflet Motion
(Annular Dilatation)



Type II – Increased Leaflet Motion
(Mitral Valve Prolapse)

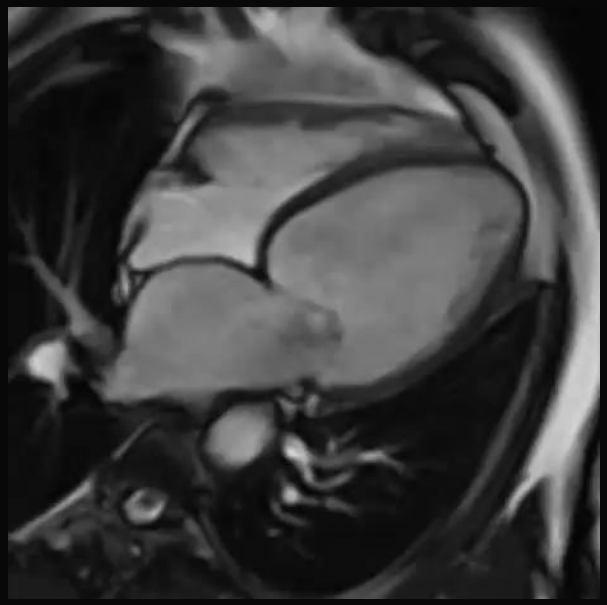
Type IIIa – Restricted Leaflet Motion
(Rheumatic Valve Disease)

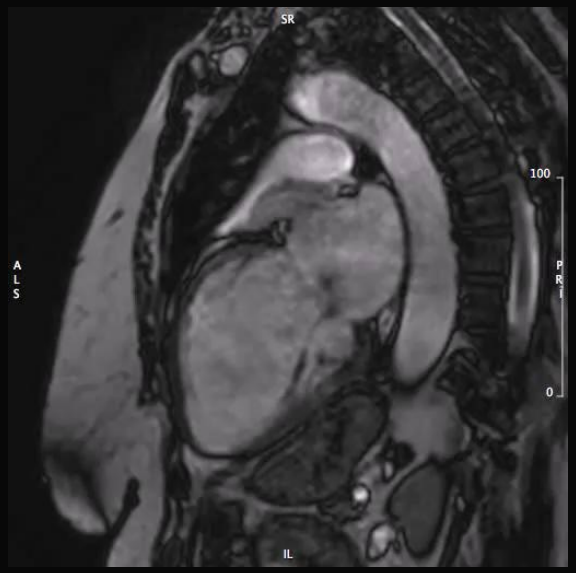
Type IIIb – Restricted Leaflet Motion
(Functional MI from Tethering)

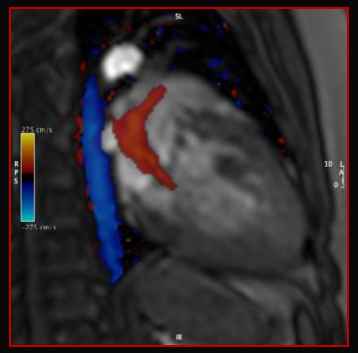
CMR in Heart Valve Disease: Functional Assessment

Qualitative:
visual assessment of turbulent flow in regurgitant jets

Visualization of signal voids due to spin dephasing in moving protons



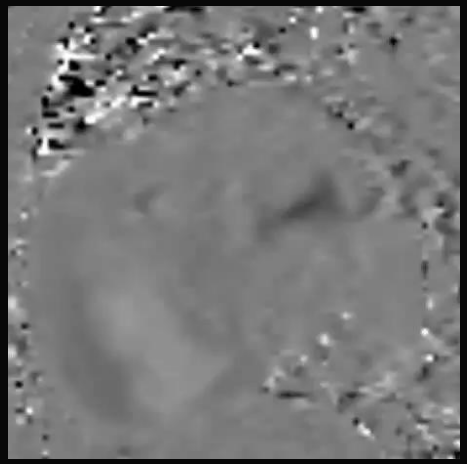




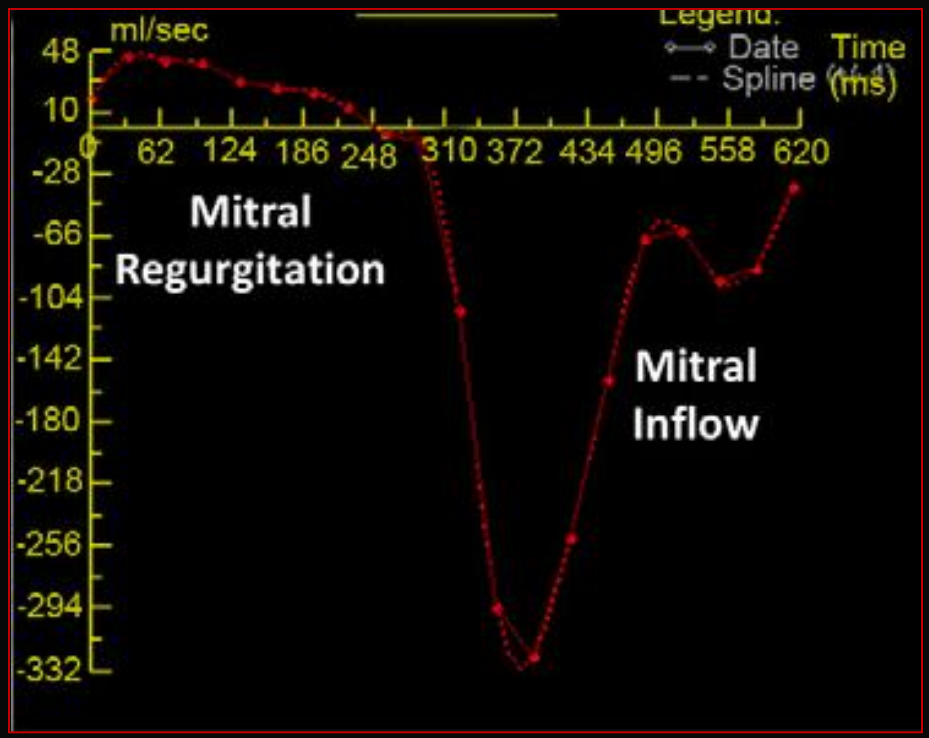
Assessing the severity of a valvular defect with visual assessment of cine images requires caution as the technique is subject to slice positioning, partial volume effects, the insensitivity of SSFP sequences and to other sequence parameters.

Quantification of Mitral Regurgitation by Phase-Contrast CMR

Direct Method

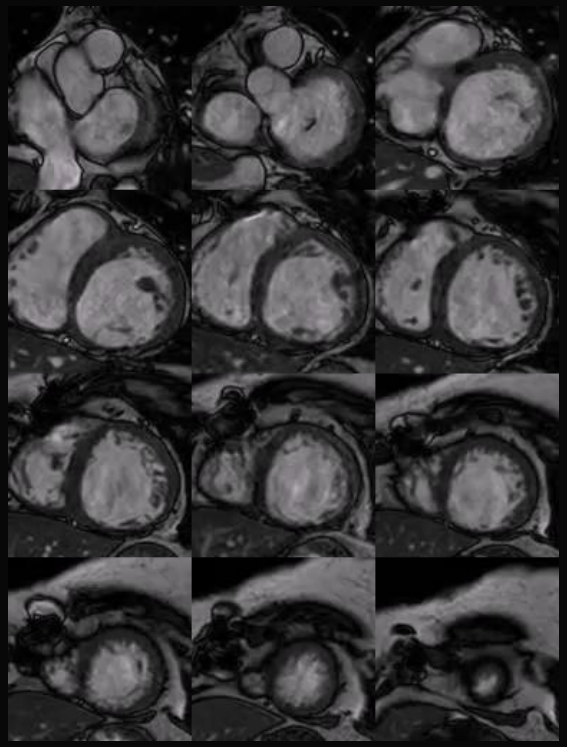


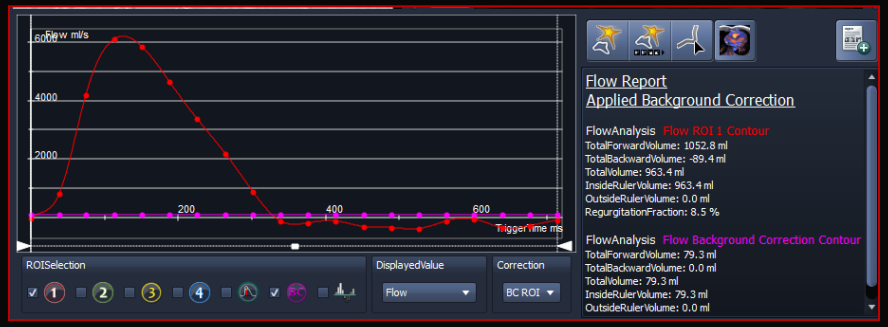
Velocity-Time Curve



Quantification of Mitral Regurgitation by Phase-Contrast CMR

Indirect Method





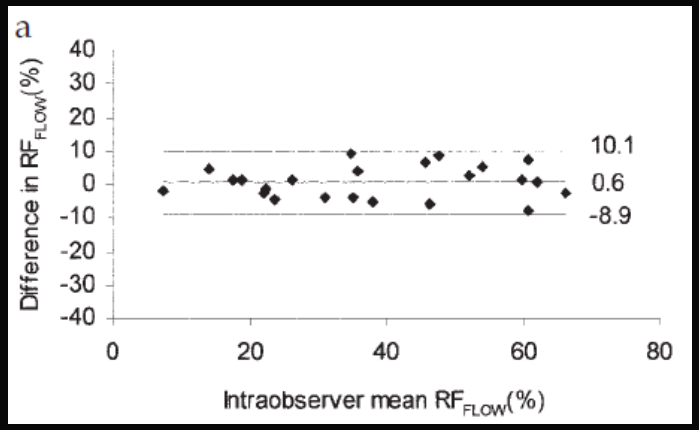
LV Stroke Volume – Aortic Systolic Flow

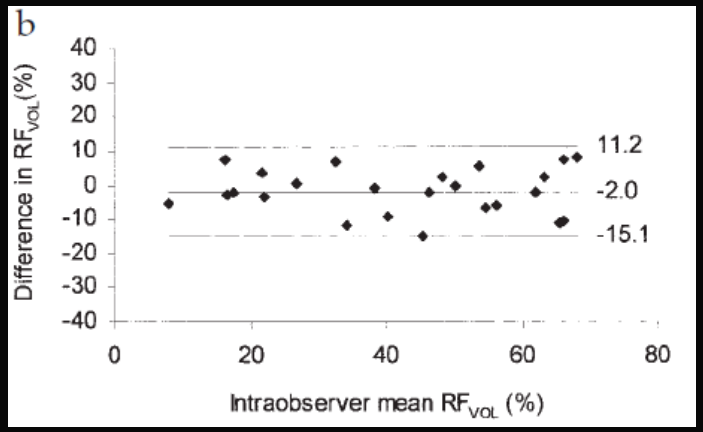
=

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 -

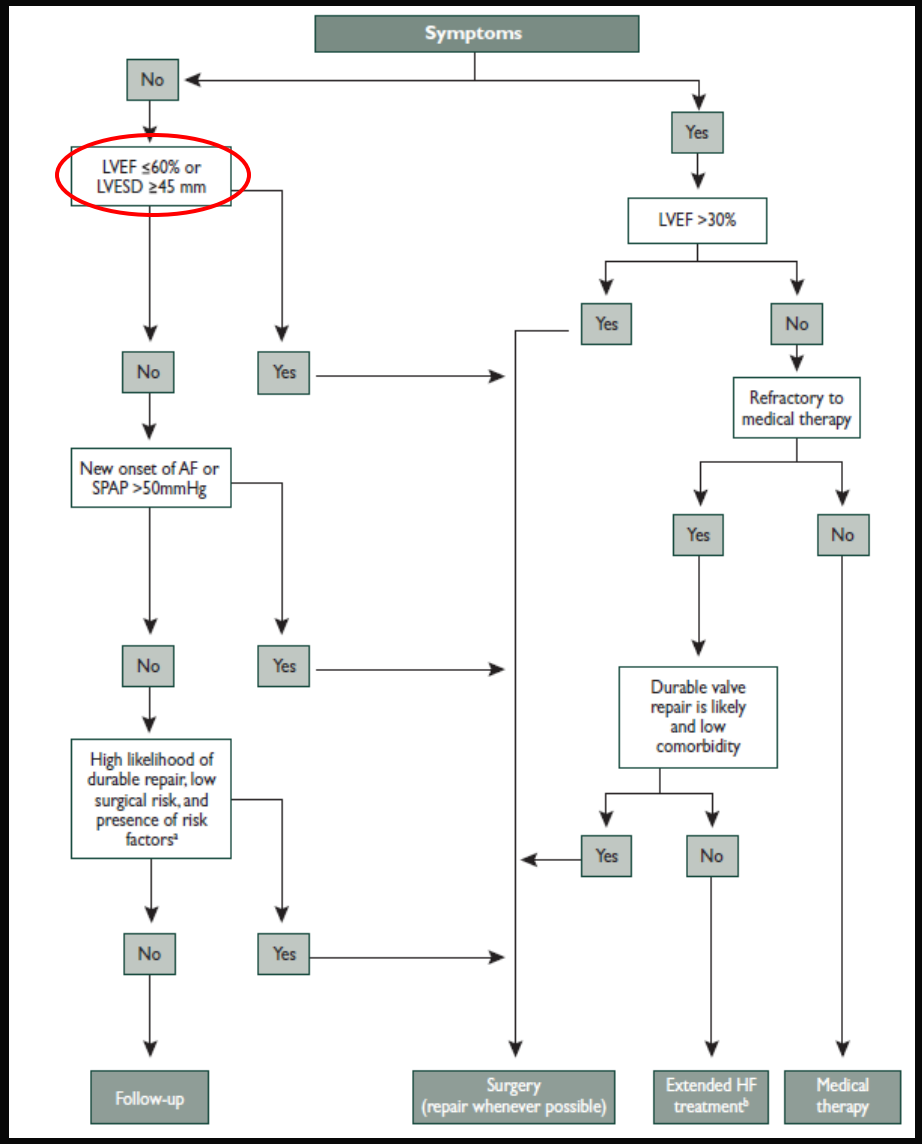
Advantages (over Echo)

- 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



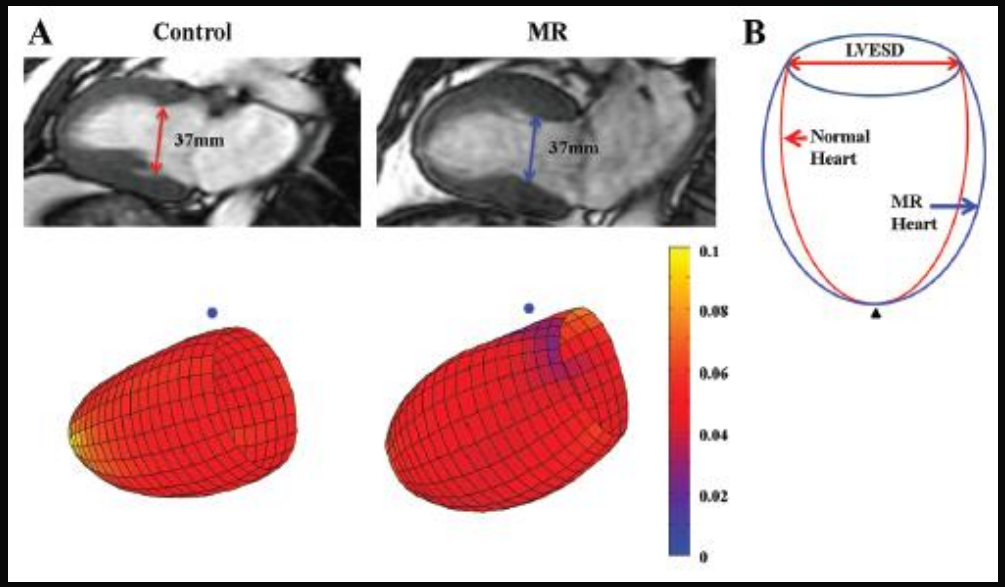
ESC Guidelines on the Management of Valvular Heart Disease (Version 2012)

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



		MR	
	Control (n=51)	Preoperative (n=35)	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*†

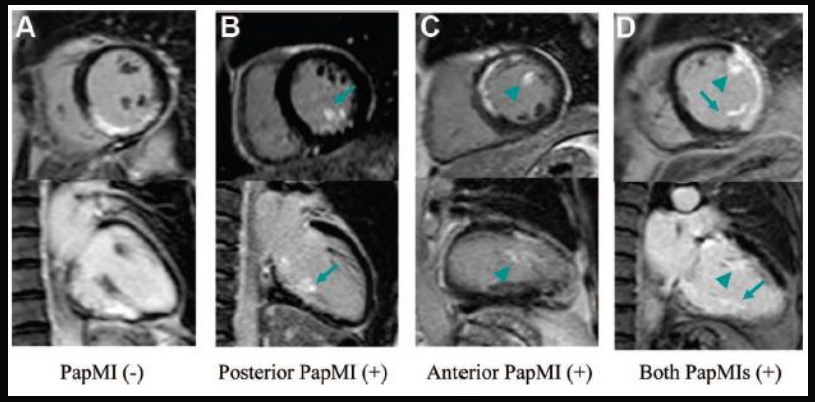
Conclusions: Despite apparently preserved LVES dimension, MR patients demonstrate significant spherical mid-to-apical LVES remodeling that contributes to higher LVESV than predicted by standard geometry-based calculations.

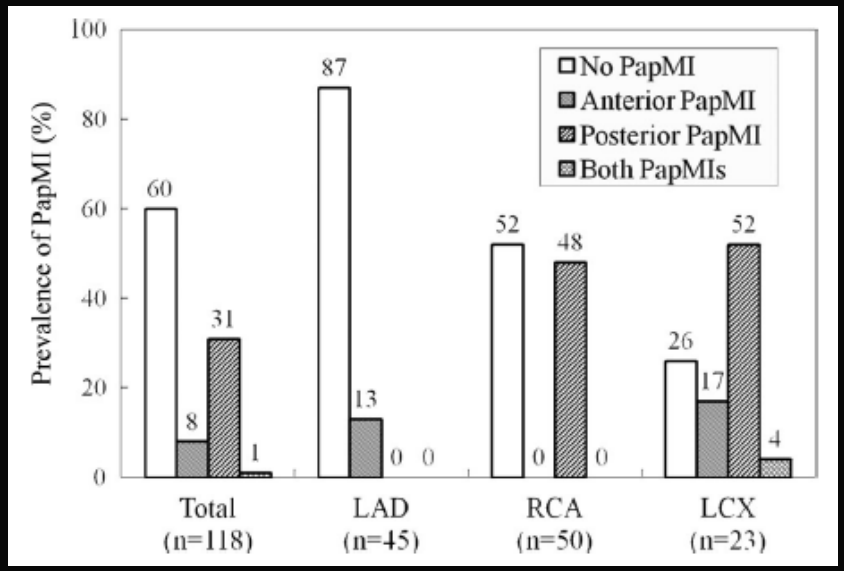
Decreased LV systolic function after surgery suggests that a volumetric analysis of LV remodeling and function may be preferred to evaluate disease progression in isolated MR.

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%

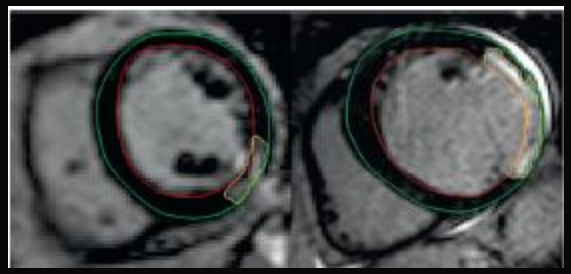
	MR		
	Yes (n=34)	No (n=84)	*P*
Maximum total CK, IU/L	3229±2487	2509±1747	0.08
Maximum CK-MB, IU/L	301±123	209±150	<0.01
Infarct-related artery, n			0.44
LAD	11	34	
LCx	9	14	
RCA	14	36	
Time to reperfusion, h	5.3±3.1	5.0±3.3	0.65
LVEDV, mL	130±33	116±29	0.20
LVESV, mL	71±28	60±25	0.04
LVEF, %	47±10	50±10	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)	

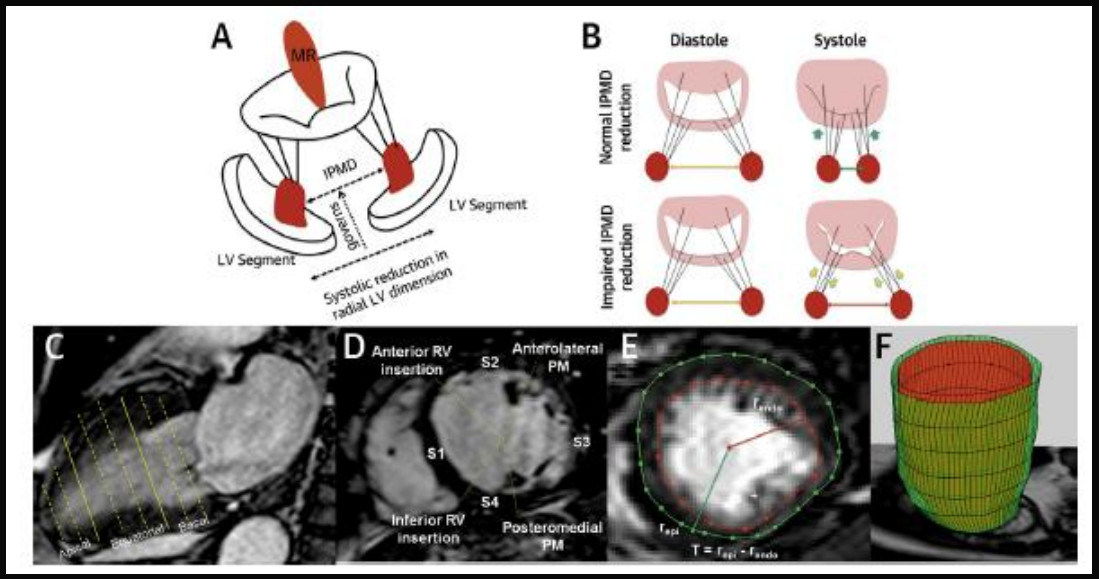
Conclusions: PapMI is more frequent than previously thought yet appears to have significant clinical latency.
The size of the myocardial infarction, rather than the presence of PapMI, seems to affect left ventricular remodeling, and PapMI is not obligatorily associated with MR.

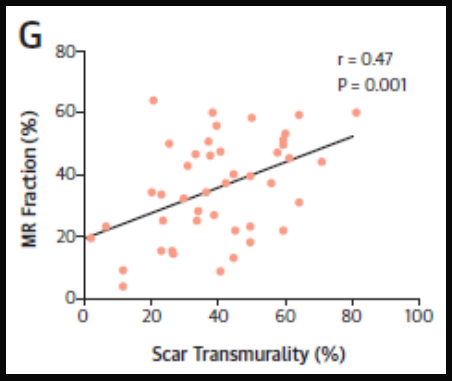
Temporal Changes in Interpapillary Muscle Dynamics as an Active Indicator of Mitral Valve and LV Interaction in Ischemic Mitral Regurgitation

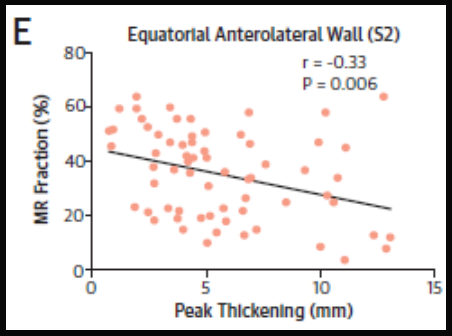
N = 67 pts. with ischemic MR

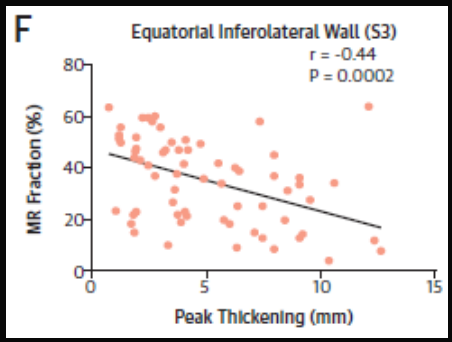
Cine + LGE magnetic resonance imaging



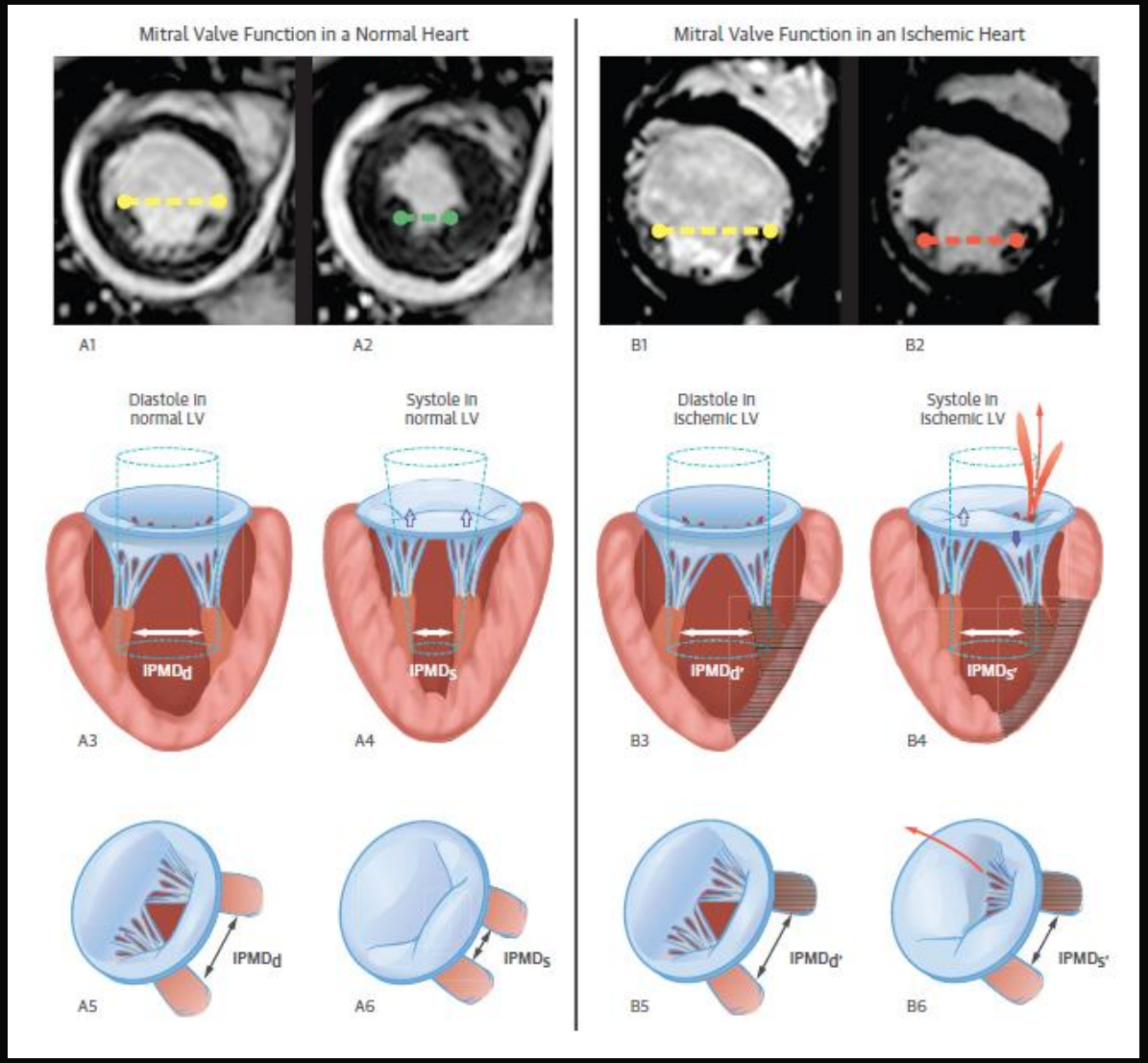








Kalra K et al., J Am Coll Cardiol 2014



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

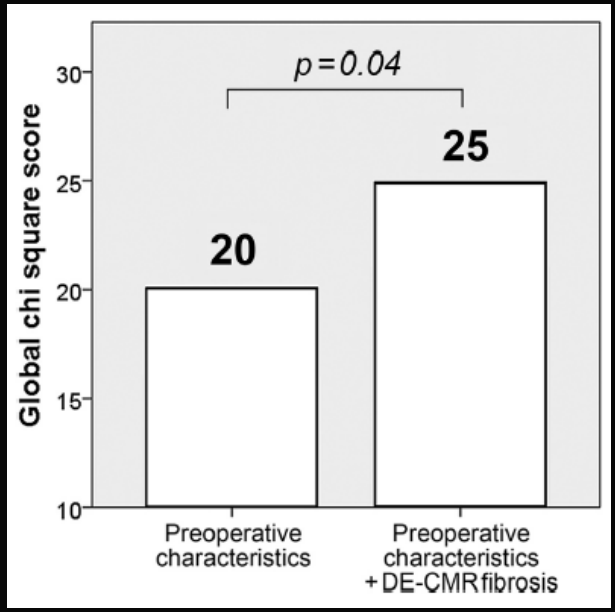
Mean follow-up = 11 months

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



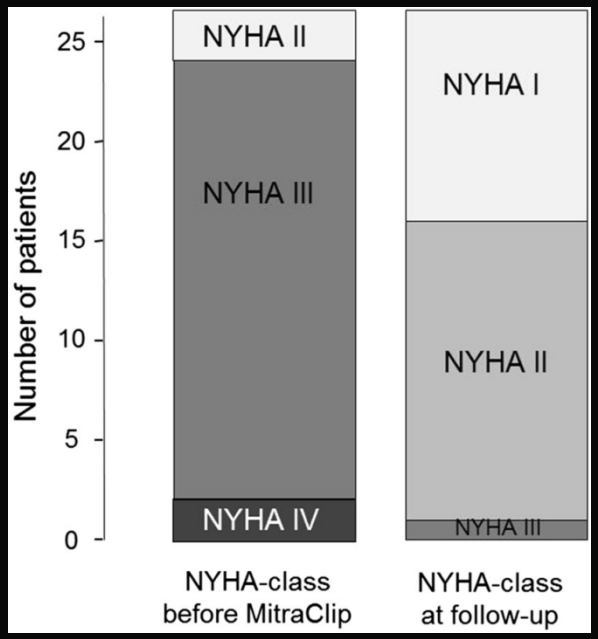
Conclusions: The presence of preoperative myocardial fibrosis assessed with delayed-enhancement CMR is an independent predictor of increased adverse clinical outcomes in patients with chronic mitral regurgitation undergoing mitral valve repair

Chaikriangkrai K et al., Ann Thorac Surg 2014

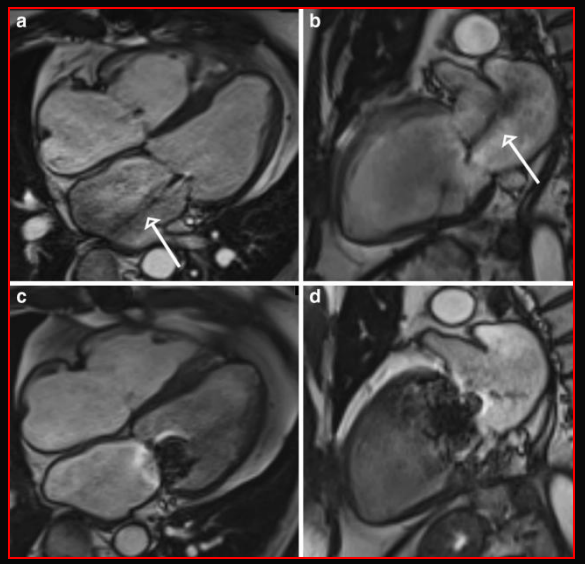
Cardiac Magnetic Resonance Imaging in Patients Undergoing Percutaneous Mitral Valve Repair with the MitraClip System

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)



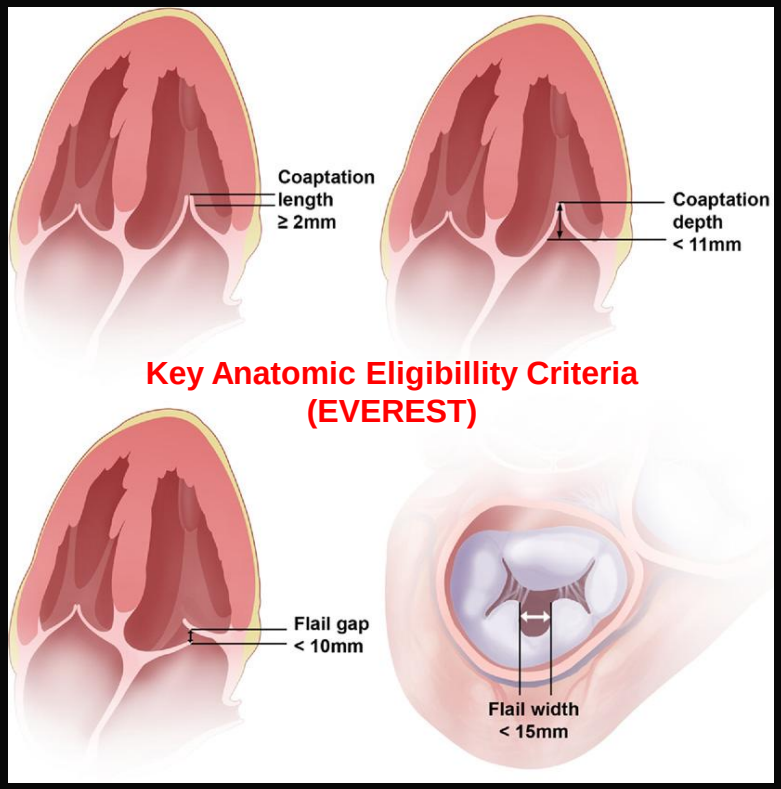
Conclusions: Cardiac MRI is feasible in patients with MitraClips

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