RUOLO DELLA DELLA CMR NELLA GESTIONE DEI PAZIENTI CON VALVULOPATIE … QUALE RUOLO NELLA TAVI ?

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VII CONGRESSO DI **ECOCARDIOCHIRURGIA**

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MILAN, MAY 7th 2014

DISCLOSURE

- SPEAKER BUREAU FOR GENERAL ELECTRIC
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- CONSULTANT FOR HEARTFLOW
- SPEAKER BUREAU FOR MEDTRONIC
- SPEAKER BUREAU FOR BAYER

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AGENDA

- ❑ EPIDEMIOLOGY OF VALVULAR HEART DISEASE (VHD)
- ❑ PIVOTAL ROLE OF CARDIAC IMAGING
- ❑ PITFALLS OF ECHOCARDIOGRAPHY
- ❑ ROLE OF CARDIAC MAGNETIC RESONANCE (CMR)
- ❑ ROLE OF CMR IN PATIENTS SELECTION FOR TAVI

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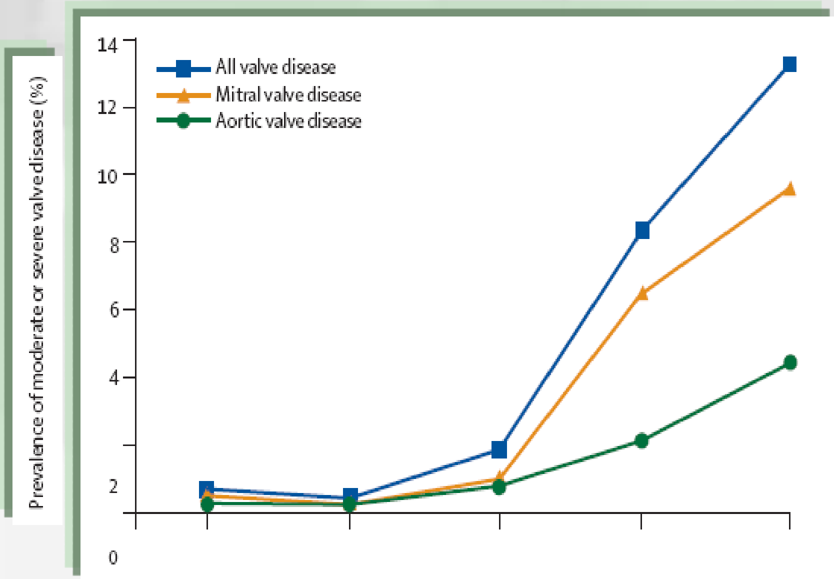
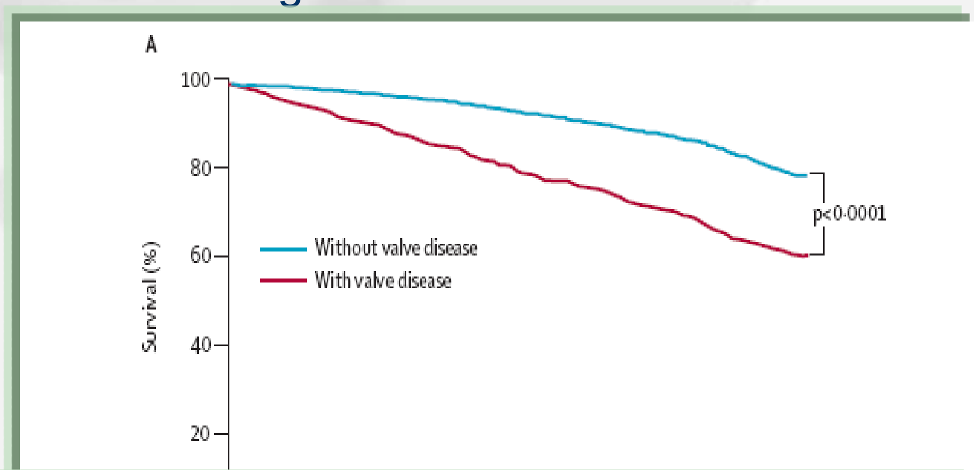
EPIDEMIOLOGY OF VHD

11911 randomly selected adults from the general population evaluated with echocardiography.



Data report the prevalence of moderate or severe valvular disease in the United States at 2.5%, increasing from 0.7% in those 18 to 44 years old, to 13.2% in those older than age 75



Survival among these individuals is significantly lower than in those without valvular disease. The

those without valvular disease. Therefore, identification of valvular heart disease and quantification of its severity remains an important public health goal. Any

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Nkomo VT, Lancet 2006

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PIVOTAL ROLE OF CARDIAC IMAGING

Any imaging modality must address particular aspects of the valvular disease process to be clinically useful. It must be able to:

- Defined the valve morphology
- Precisely and reproducibly quantify the severity of the valvular abnormality
- Assess the impact of the valvular abnormality on the surrounding cardiac structure and on cardiac function

Despite echocardiography remains the primary noninvasive imaging modality in patients with VHD, it has not negligible limitations.

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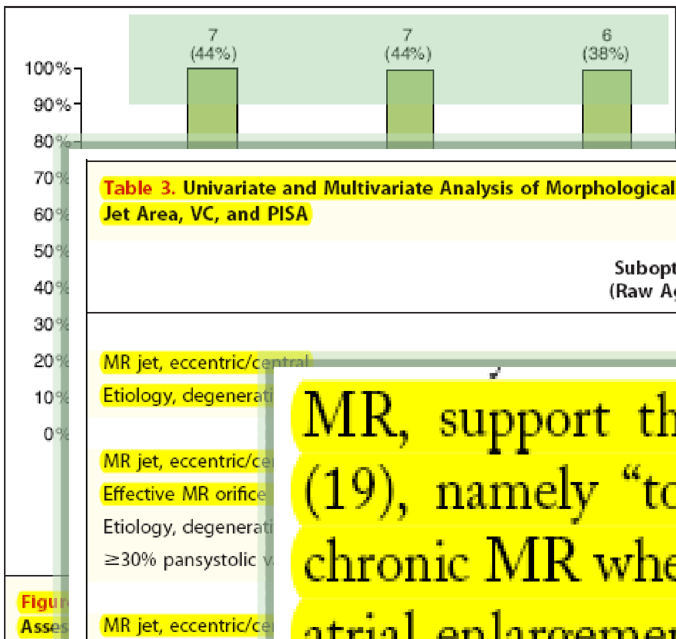
PITFALLS OF ECHOCARDIOGRAPHY

16 patients referred to Cedars Sinai Medical Center for MR surgical correction evaluated by TTE with images referred to 18 expert cardiologist expert in echicardiography



Figu…
Asses…

Substantial (raw agreement 80%), fair (raw agreement 60% to 79%), and poor (raw agreement <60%) interobserver agreements are … …ervers. …t was …itation … vena …fective …d on

Table 3. Univariate and Multivariate Analysis of Morphological and Etiologic Predictors of Substantial Interobserver Agreement for Jet Area, VC, and PISA

	Suboptimal Agreement (Raw Agreement <80%)	Substantial Agreement (Raw Agreement ≥80%)	Univariate p Value	Multivariate p Value
Jet Area				
MR jet, eccentric/central	50/50	17/83	0.074	NS
Etiology, degenerati…				
MR jet, eccentric/ce…				
Effective MR orifice…				
Etiology, degenerati…				
≥30% pansystolic v…				
MR jet, eccentric/ce…				
PISA spherical, yes/…				
Etiology, degenerative/functional	70/30	17/83	0.039	NS
≥30% pansystolic variation of PISA radius, yes/no	80/20	20/80	0.025	NS

EROA = effective regurgitant orifice area; other abbreviations as in Table 1.

MR, support the concept of Gaasch and Meyer (19), namely "to question the diagnosis of severe chronic MR when little or no left ventricular or left atrial enlargement is found."

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Biner S JACC CI 2010

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ROLE OF CMR: strenghts

- No or less operator dependency
- No need for good acoustic windows
- No use of ionizing radiation
- No use of contrast agent
- Most importantly, CMR offer a comprehensive, detailed, and quantitative examination inclusive of valvular morphology and function, ventricular volumes, systolic function, and anatomy of associated structures.

Morello A, **Current Heart Failure Reports 2009**

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ROLE OF CMR: protocol

Table 1. CMR Pulse Sequences for Valvular Heart Disease

Pulse Sequence	Indication
SSFP cine	Valve anatomy and motion
	Ventricular volumes and function
Gradient echo cine	Valve anatomy and motion
	Turbulent flow
Phase contrast	Velocity

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Cawley P Circulation 2009

ROLE OF CMR: protocol - SSFP

Clinical Change	Echo (SD/N)	MRI (SD/N)	Reduction in sample size (%)
EDV, 10 ml	23.8/121	7.4/12	90
ESV, 10 ml	15.8/53	6.5/10	81
EF, 3%	6.6/102	2.5/15	85
Mass, 10 gr	36.4/273	6.4/9	97

Bellinger NG J Cardiovasc Magn Reson 2000

ROLE OF CMR: protocol - PhC

Table 1. CMR Pulse Sequences for Valvular Heart Disease

Pulse Sequence	Indication
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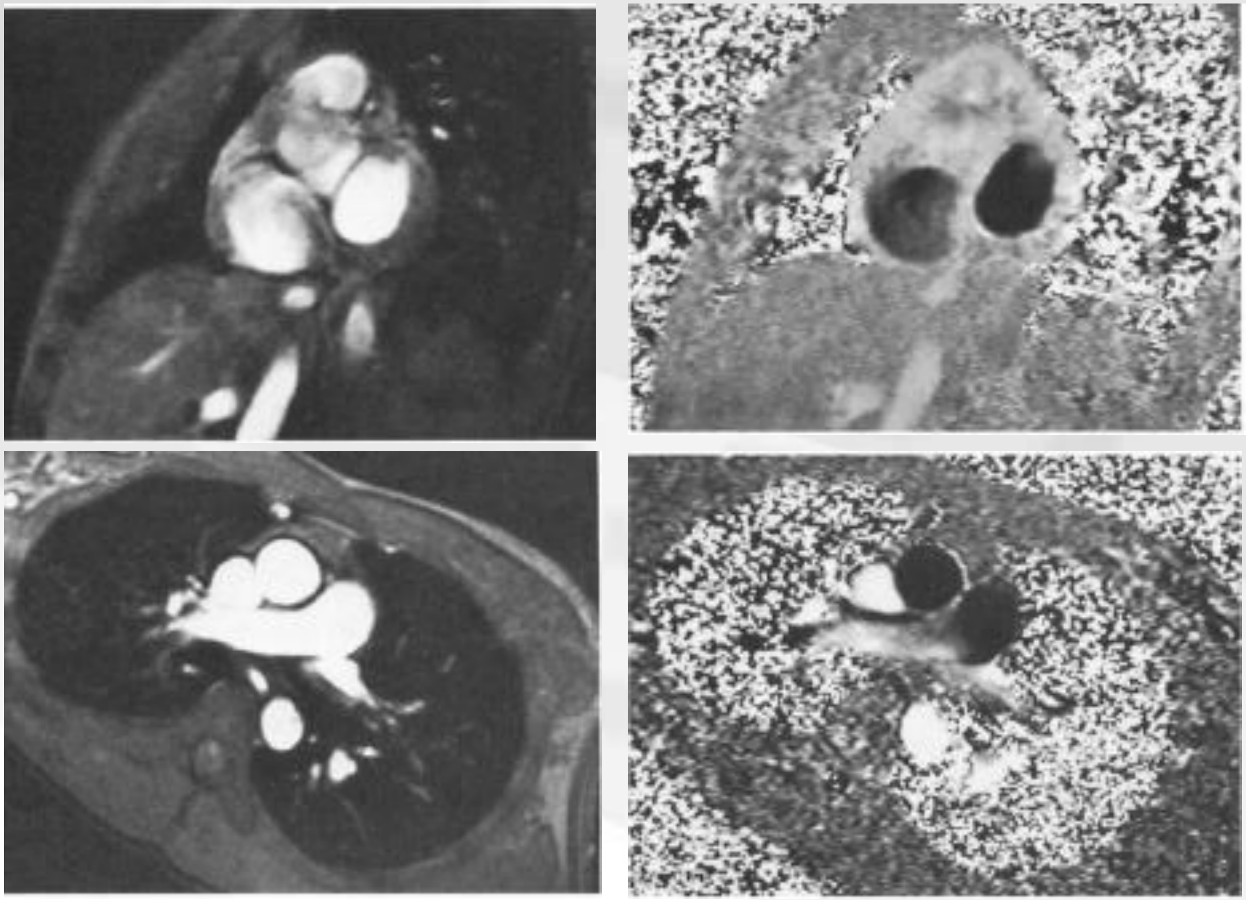
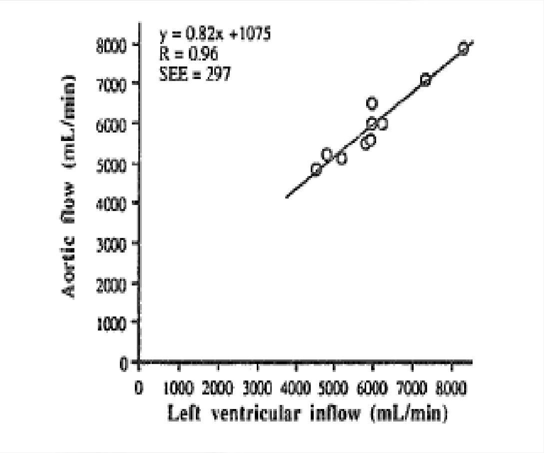
ROLE OF CMR: protocol - PhC





Typical left ventricular inflow and aortic flow velocity patterns in a normal. The normal velocity time integral for left ventricular inflow is the same as that for aortic flow over time . PhC imaging- determined left ventricular inflow and aortic flow volumes yielded a close correlation coefficient (r = 0 .96) .

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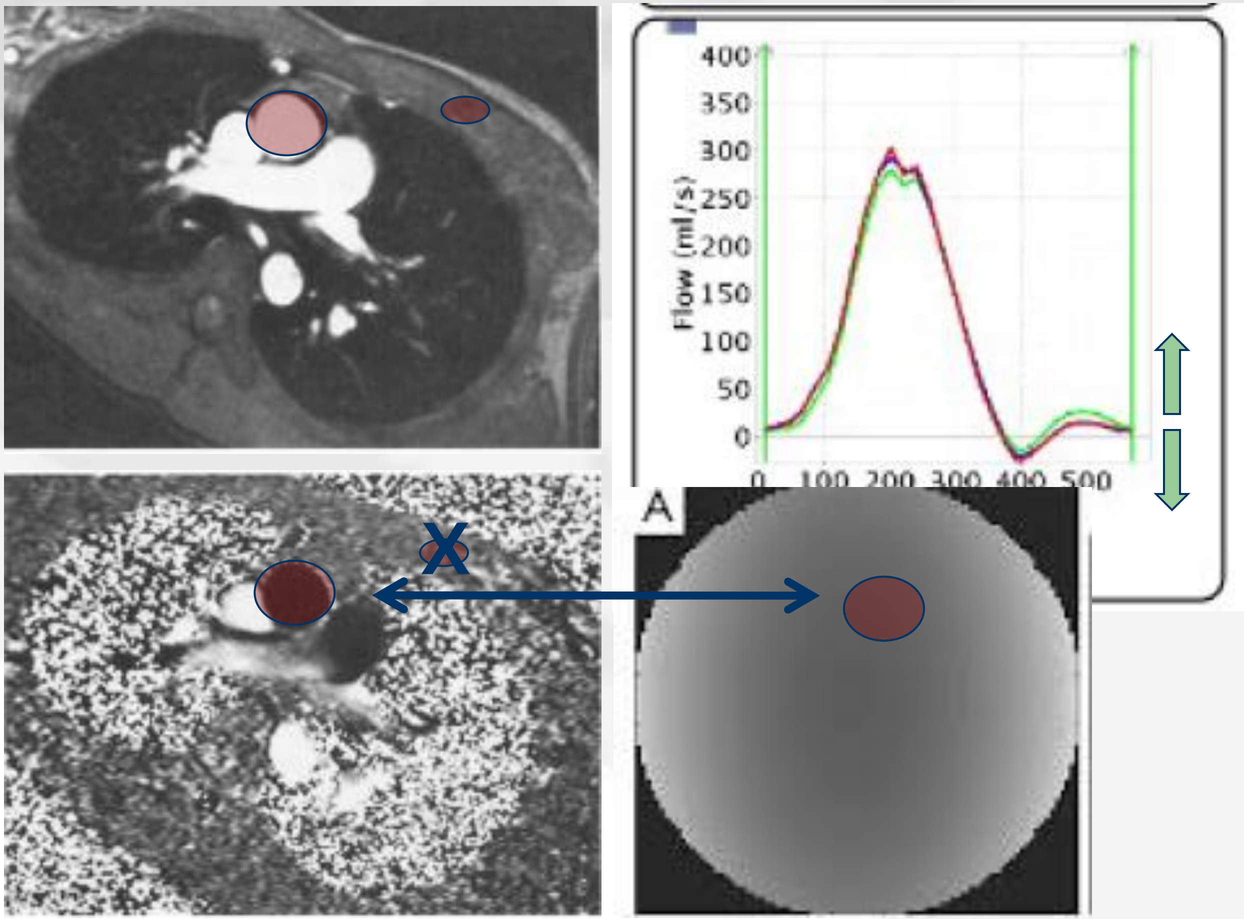
Fujita N, JACC 1994

ROLE OF CMR: protocol - PhC

Tricks and Tips: phantom correction



PITFALLS OF BACKGROUND CORRECTION

- ❑ Movements of static structure
- ❑ Homogeneity of static magnetic field

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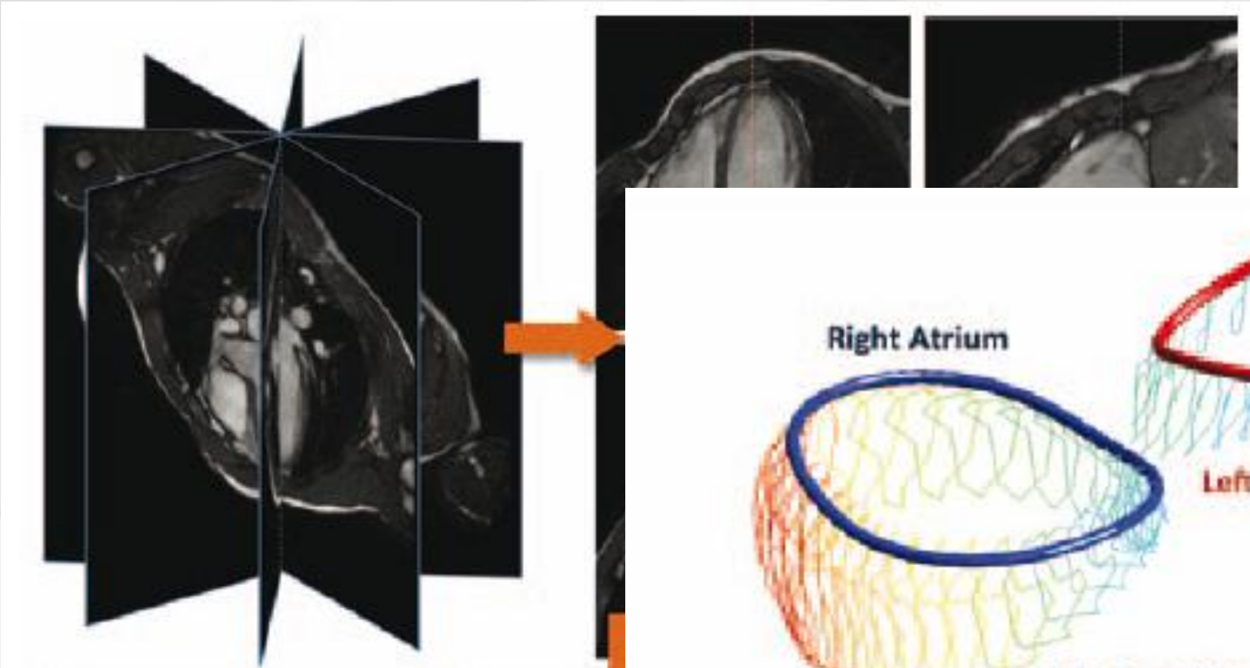
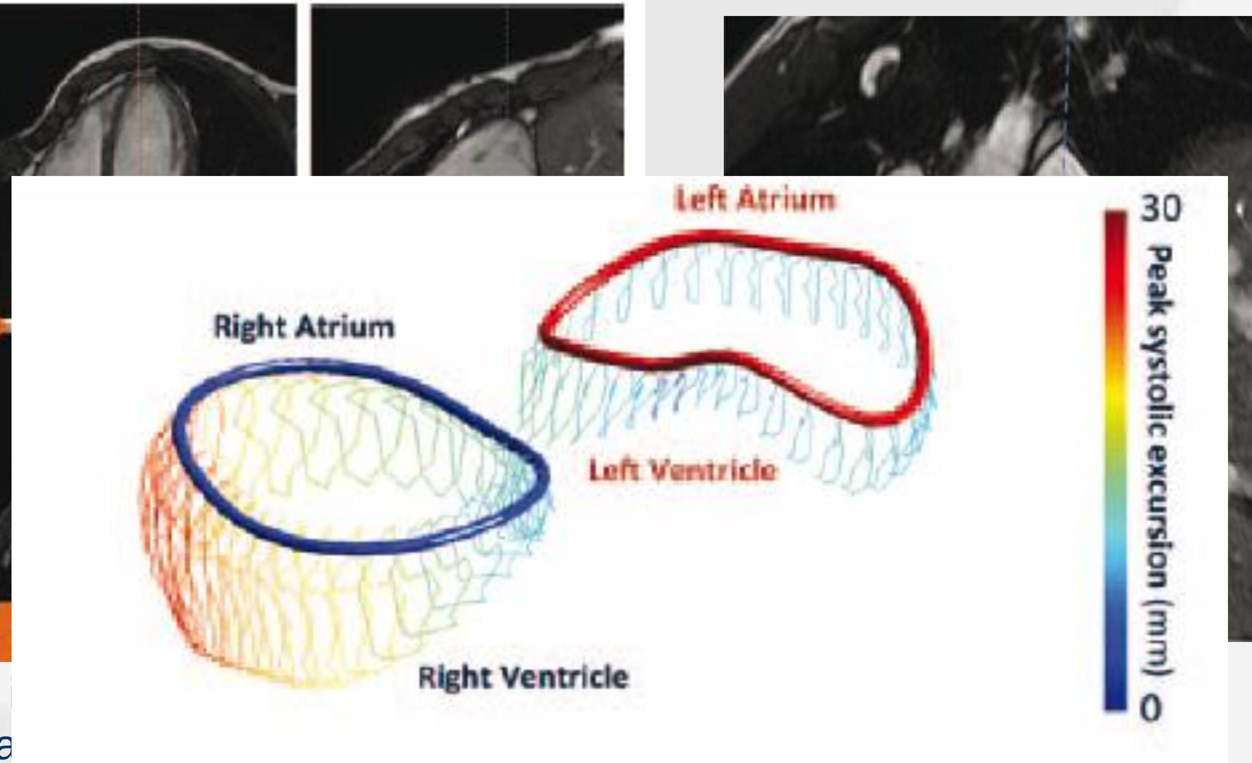
Improvement of 15-20% of flow detection by PhC has been proved

ROLE OF CMR: additional projections - radial





Custom software, developed
USA), was used to describe a
positions of two annular points were manually marked in correspondence of leaflet insertions in each plane (Figure 1, top right). Additional single points were placed in the centre of the aortic and pulmonary valves, to be used as an anatomic reference for the identification of different annular regions. Finally, the annular points were automatically tracked throughout the cardiac cycle using an algorithm based onnormalized cross-correlation.

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Maffessanti F, Gripari P, Pontone G et al, EHJCI 2013

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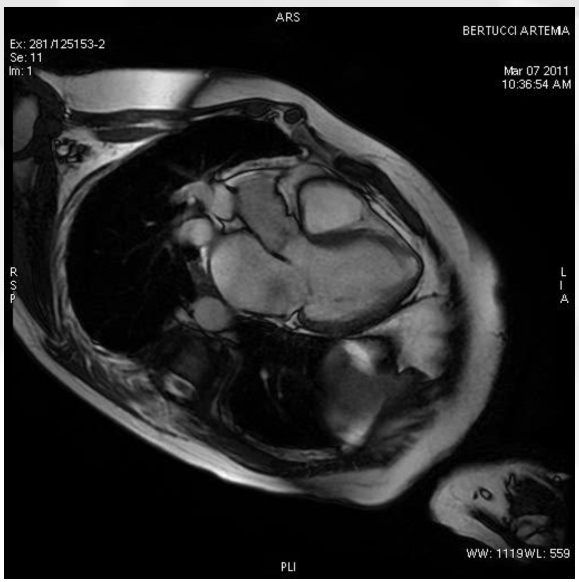
ROLE OF CMR: quantification VHD - Stenosis

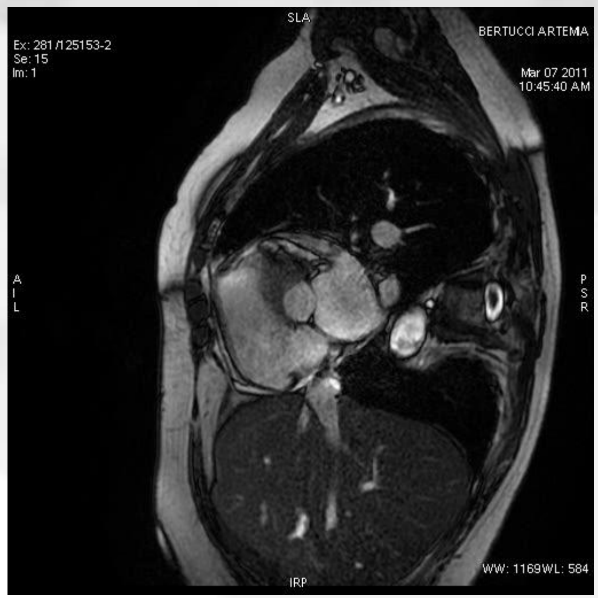
METHOD 1: planimetry of valve diseased

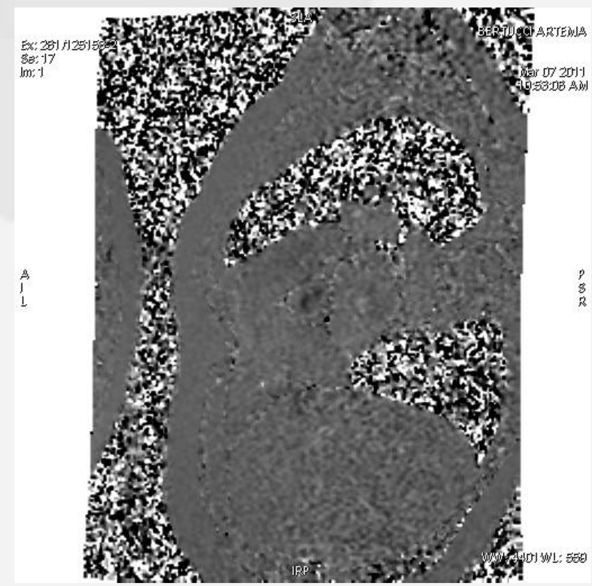
METHOD 2: transvalvolar pressure gradient

- Continuity equation for AoV
- PHT method for MV

Patients of 80 yo with aortic stenoses and poor acustic window







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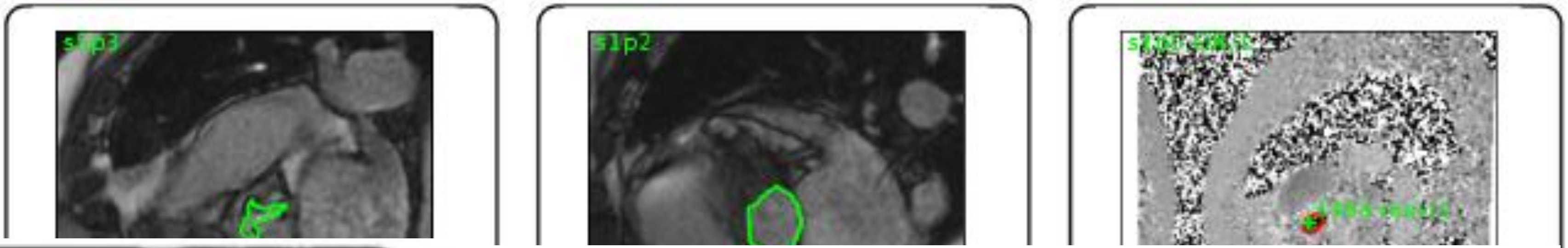
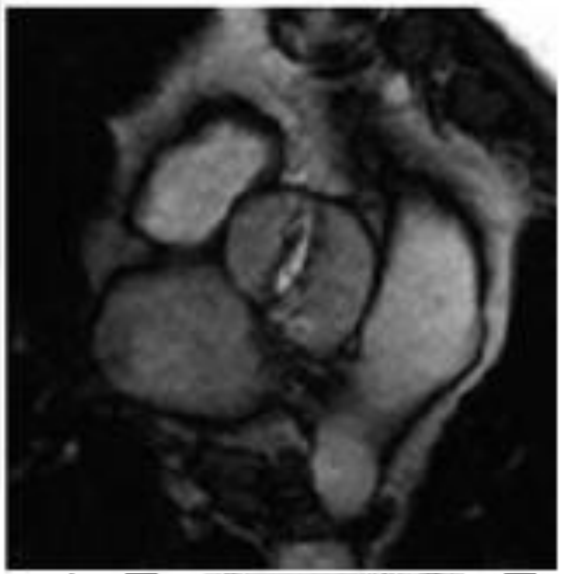
ROLE OF CMR: quantification VHD - Stenosis



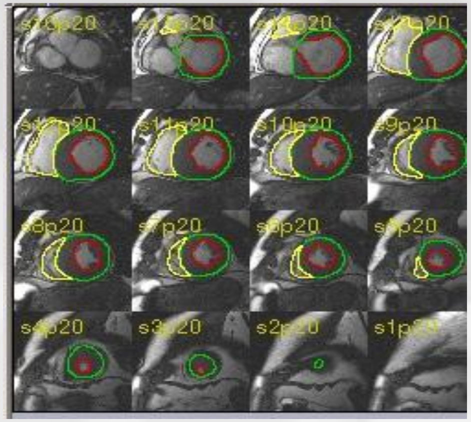


- ❑ CMR planimetry is more feasible vs. TTE due to the better spatial resolution, mainly for LVOT
- ❑ PhC in presence of stenosis is really time consuming due to the reasearch of optimal Venc
- ❑ PhC estimation of atrio-ventricular valve is less feasible due to the thin slice thickness required to avoid partial volume average error and the continous tilt of AV annulus in and out of plane …..

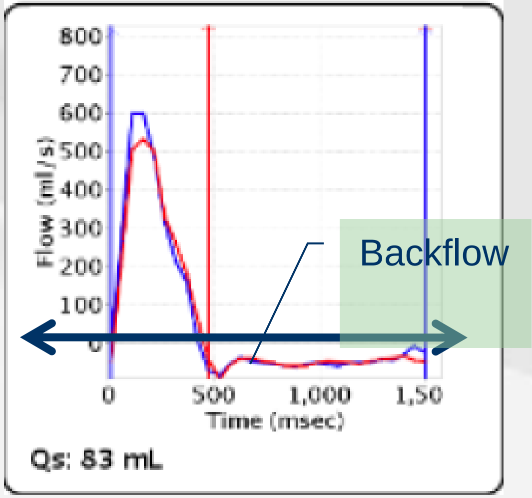
So, the method of choice is "anatomical planimetry".

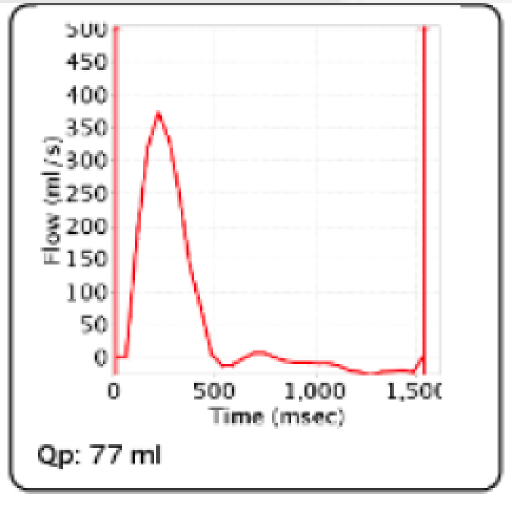
ROLE OF CMR: quantification VHD - Regurgitation

METHOD 1: indirect method



STEP 1: Measurement of left stroke volume (LSV) and right stroke volume (RSV)



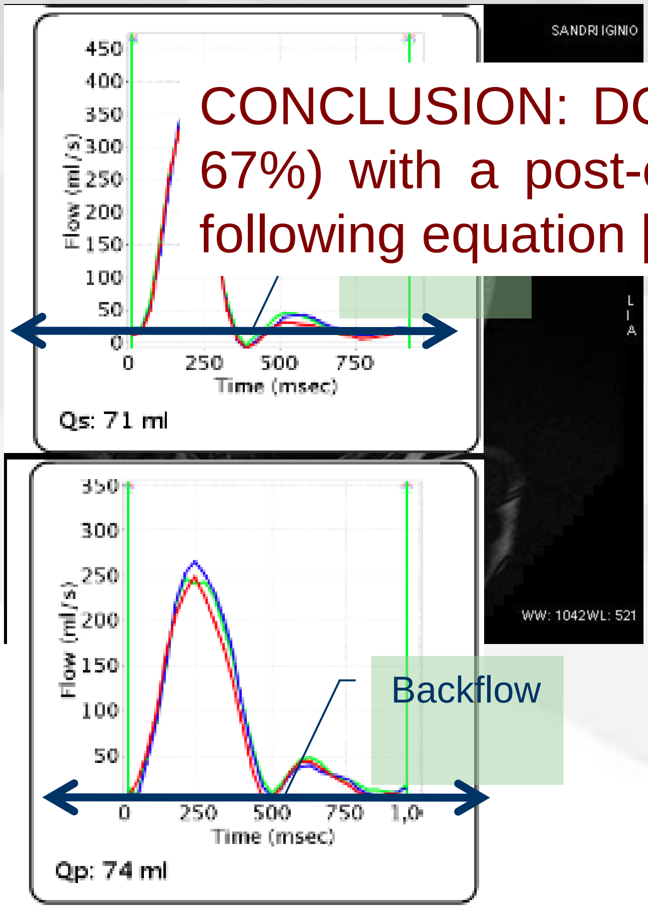


STEP 2: Measurement of Qs, Qp and Backflow

STEP 3: Semilunare Valve regurgitation = backflow
Atrio-ventricular regurgitaion = SV – Qx - Backflow

ROLE OF CMR: quantification VHD - Regurgitation

Patients of 52 yo, with cognitive disease, referred to congestive heart failure and detection of eccentric mitral regurgitation – Idhiopatic DCM or DCM due to MR



CONCLUSION: DCM due to severe MR (RV: 144 ml; RF: 67%) with a post-operative EF expected of 58% with the following equation [(LVEDV – RV)-LVESV]/(LVEDV –RV)

LV End-Diastolic Volume	265.4 ml	
LV End-Systolic Volume	50.3 ml	
Fractional Shortening	35 %	(18-42)
Stroke Volume	215.1 ml	
Stroke Volume Index	123.7 ml/m²	(30-65)

RV End-Diastolic Volume	121.8 ml	
RV End-Systolic Volume	48.6 ml	
RV Ejection Fraction	60 %	(50-68)
RV Stroke Volume	73.2 ml	
RV End-Diastolic Vol Index	70 ml/m²	(63-103)
RV End-Systolic Vol Index	27.9 ml/m²	(22-56)

Step 1: LSV=215 ml; RSV= 74 ml

Step 2: Qs: 71 ml; Qp: 74 ml

Step 3: Backflow Ao: 0 ml; Backflow PV: 0 ml;
TrR: RSV – Qp = 74 ml -74 ml = 0 ml
MR: LSV – Qs= 215 ml – 71 ml = 144 ml

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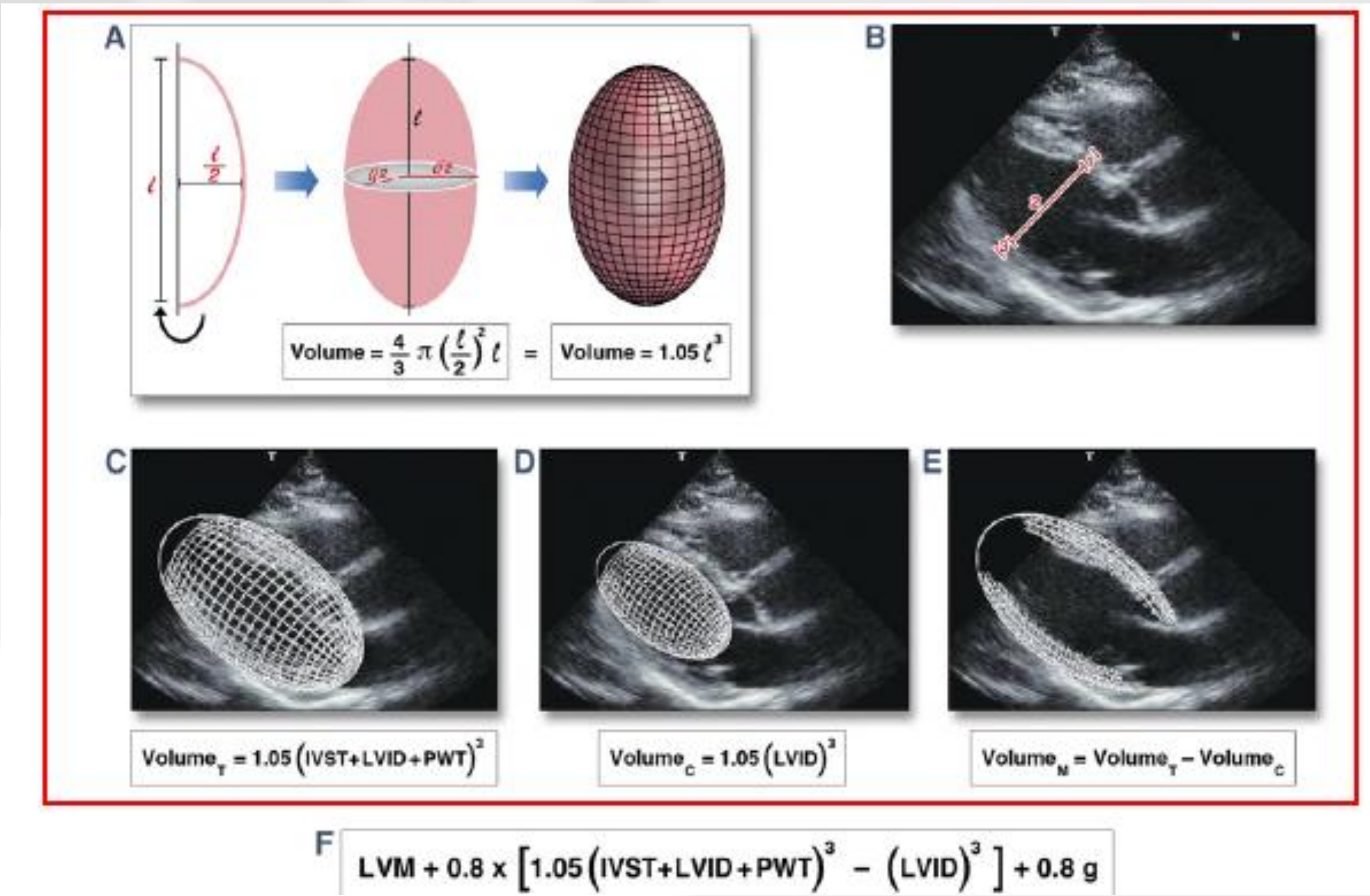
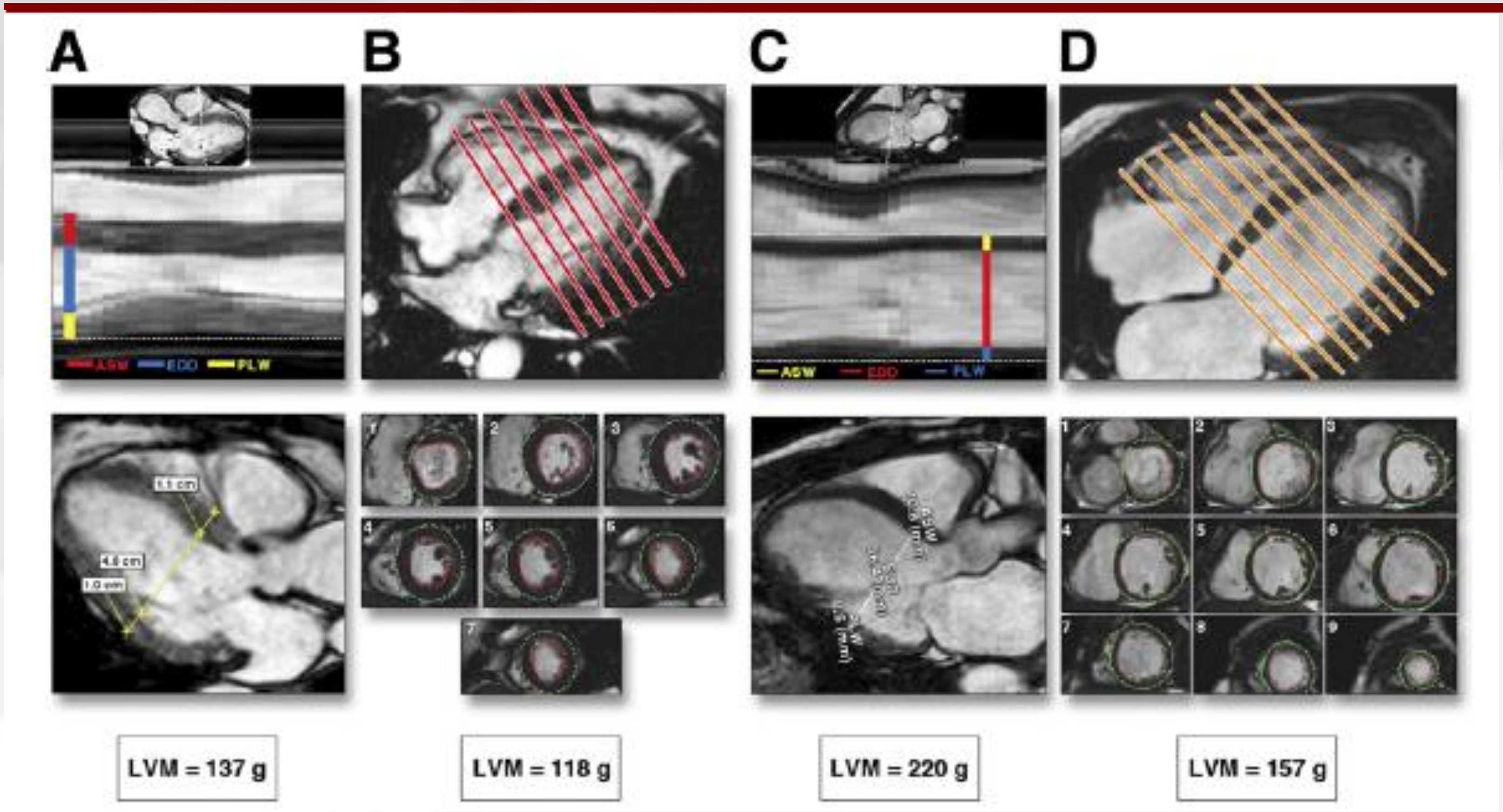
ROLE OF CMR: remodelling on LV (myocardial mass)



Armstrong A JACC CI 2012

ROLE OF CMR: remodelling on LV (myocardial mass)



Case 1 has preserved cardiac geometry, but case 2 shows left ventricular remodeling. The usual assessment of LVM by cardiac magnetic resonance (CMR) does not require cardiac geometry assumptions, as opposed to linear measurements used in echocardiography. (Courtesy of Dr. Gustavo Volpe.) (A and C) CMR-derived images representing usual echocardiography views for linear measurements assessing LVM. The anterior septal wall (ASW) corresponds to the interventricular septal thickness; the end-diastolic dimension (EDD) corresponds to the left ventricular internal dimension; and the posterior lateral wall (PLW) corresponds to the posterior wall thickness. At the bottom, the ASE-recommended formula was used to calculate LVM (see Fig. 1 for a full description). (B and D) Usual CMR assessment for LVM, using contiguous short-axis slices covering the entire left ventricle from the atrioventricular ring to the apex (1 to 9). The estimated LVM is displayed at the bottom.

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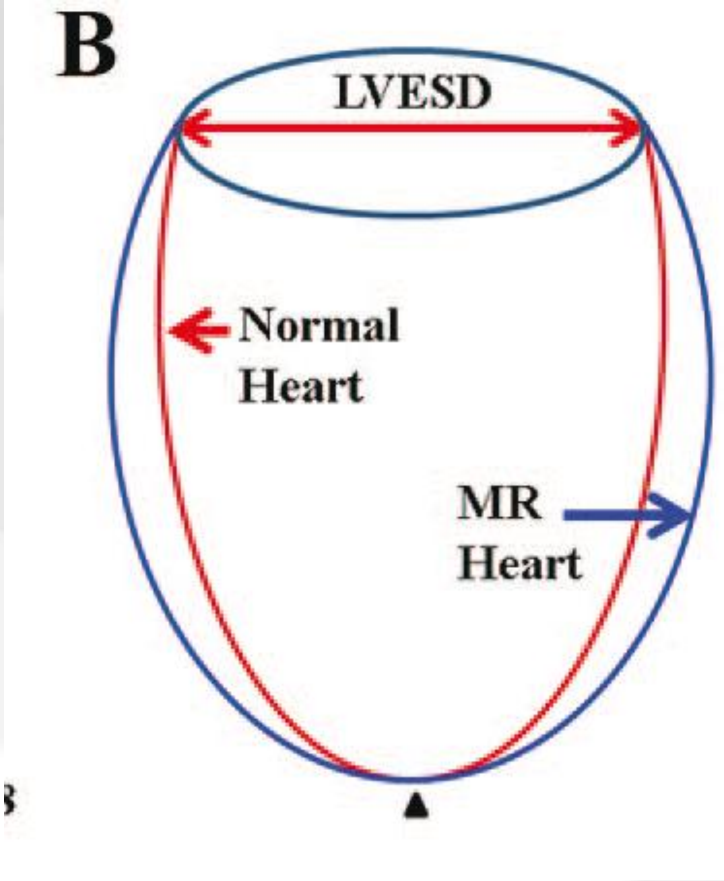
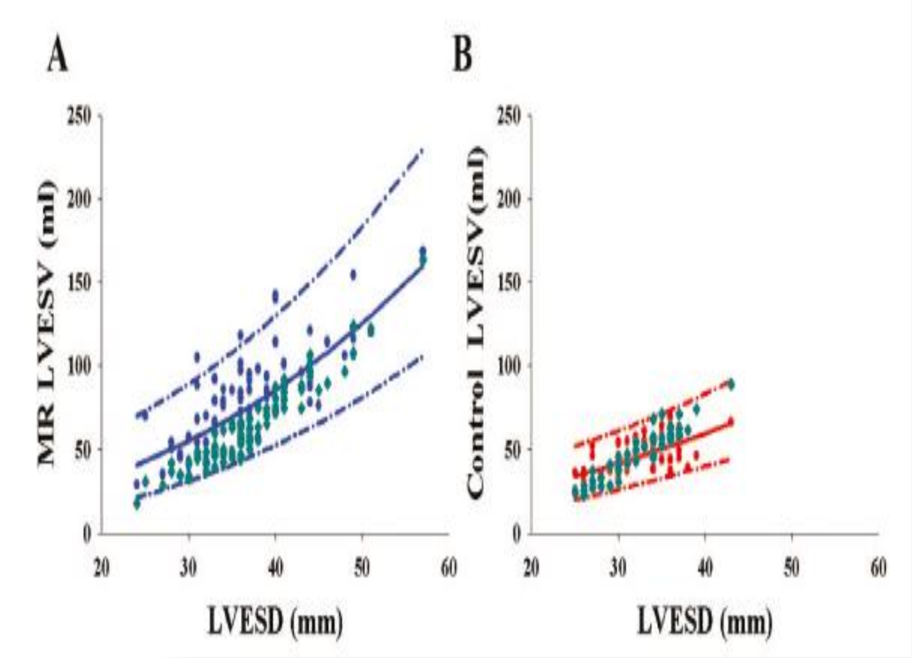
Armstrong A JACC CI 2012

ROLE OF CMR: remodelling on LV (volume)



Systematic simulation of MR LV remodeling with respect to control. The MR heart has the same LVES dimension (LVESD) as and a long-axis length similar to that of the control. However, there is less curvature from the mid to distal LV segments represented by the dimmer red in the MR patient vs control (bright yellow). These changes in the MR patient contribute to a more spherical LV remodeling and a larger LVES volume.



Schiros CG Circulation 2012

ROLE OF CMR: remodelling on LV (stifness)

Moon et al. Journal of Cardiovascular Magnetic Resonance 2013, 15:92
http://jcmr-online.com/content/15/1/92

Journal of Cardiovascular Magnetic Resonance

POSITION STATEMENT — Open Access

Myocardial T1 mapping and extracellular volume quantification: a Society for Cardiovascular Magnetic Resonance (SCMR) and CMR Working Group of the European Society of Cardiology consensus statement

James C Moon[1,2*†], Daniel R Messroghli[3†], Peter Kellman[4], Stefan K Piechnik[5], Matthew D Robson[5], Martin Ugander[6], Peter D Gatehouse[7], Andrew E Arai[4], Matthias G Friedrich[8], Stefan Neubauer[5], Jeanette Schulz-Menger[9,10] and Erik B Schelbert[11]

T1 mapping: T1 that reflects the intestitial disease due to diffuse fibrosis

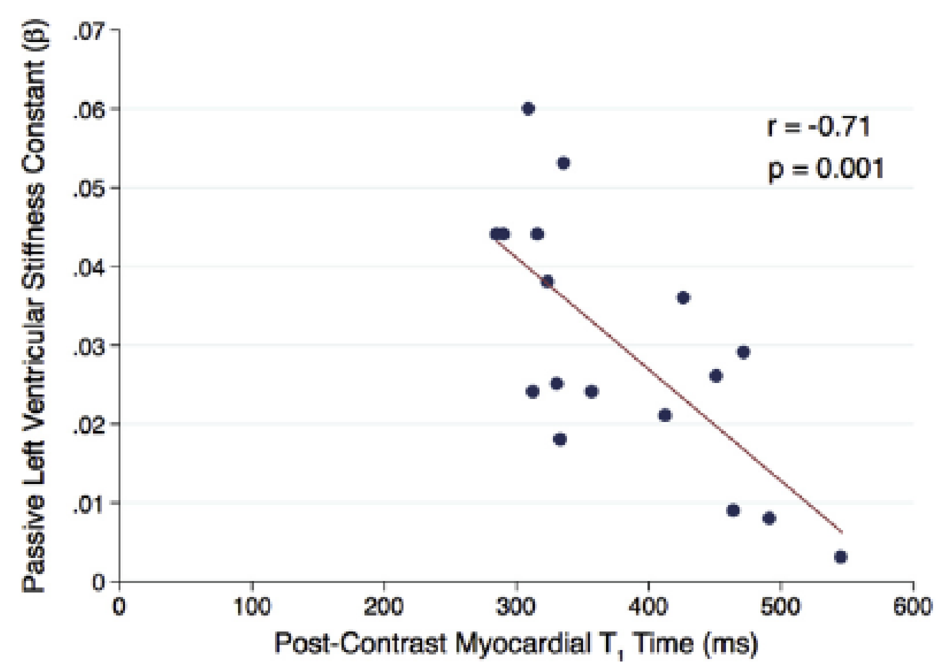


Figure 2 Post-Contrast Myocardial T_1 Time and Passive Left Ventricular Stiffness Constant

A significant positive negative correlation was observed between post-contrast myocardial T_1 time and passive left ventricular stiffness constant, β ($r = -0.71$, $p = 0.001$).

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Ellimies A JACC 2014

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ROLE OF CMR: weakness

However, CMR has some well known weakness:

- The limited use in patients with claustropobia and patients with pacemakers and implantable cardioverter defibrillators.

- Cost prognostic data and guidelines still rely on echo, although this is likely to change as more data are obtained on CMR for the assessment of valvular disease.

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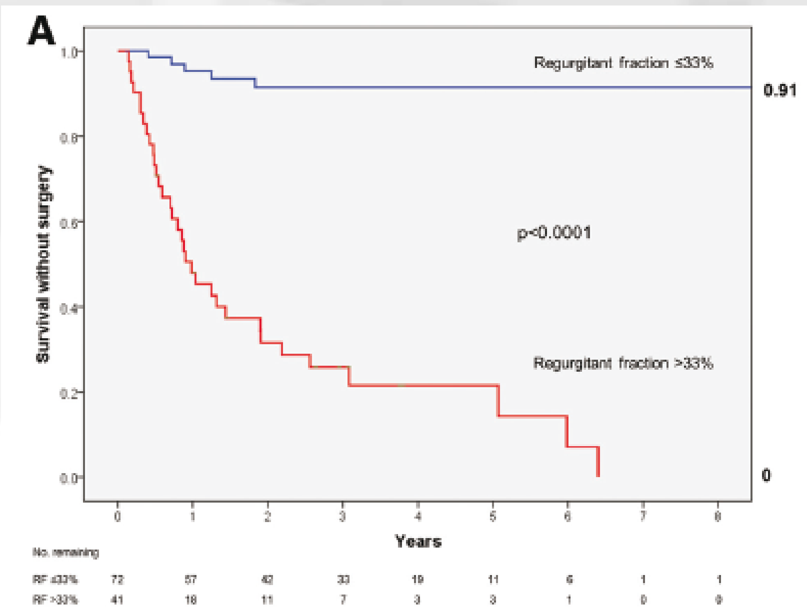
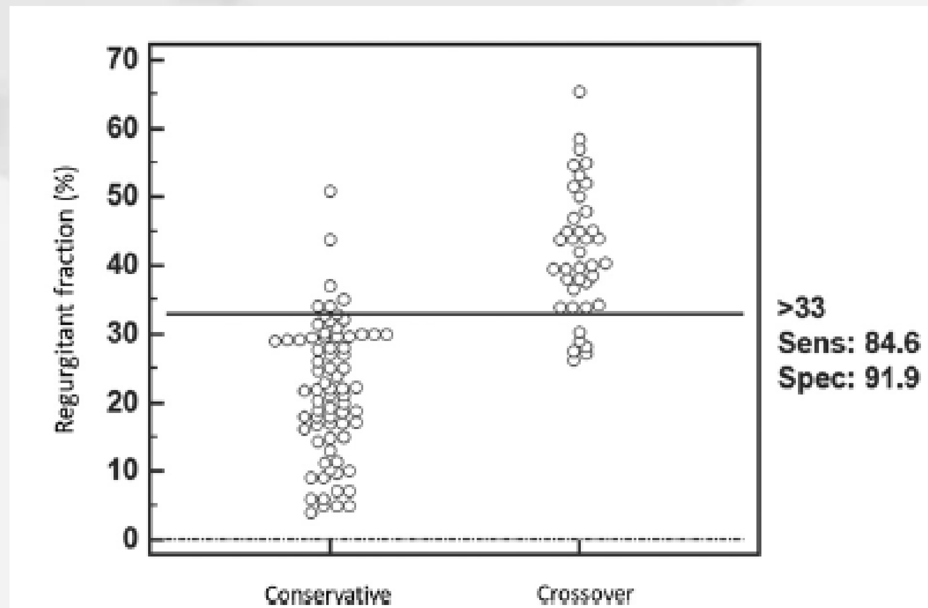
Morello A, **Current Heart Failure Reports 2009**

ROLE OF CMR: VHD and outcome

Methods and Results—One hundred thirteen patients with echocardiographic moderate or severe AR were monitored for up to 9 years (mean 2.6±2.1 years) following a CMR scan, and the progression to symptoms or other indications for surgery was monitored. AR quantification identified outcome with high accuracy: 85% of the 39 subjects with regurgitant fraction >33% progressed to surgery (mostly within 3 years) in comparison with 8% of 74 subjects with regurgitant fraction ≤33% (P<0.0001); the area under the curve on receiver operating characteristic analysis was 0.93 (P<0.0001). This ability remained strong on time-dependent Kaplan–Meier survival curves. CMR-derived left ventricular end-diastolic volume >246 mL had good, although lower, discriminatory ability (area under the curve 0.88),





Myerson S Circulation 2009

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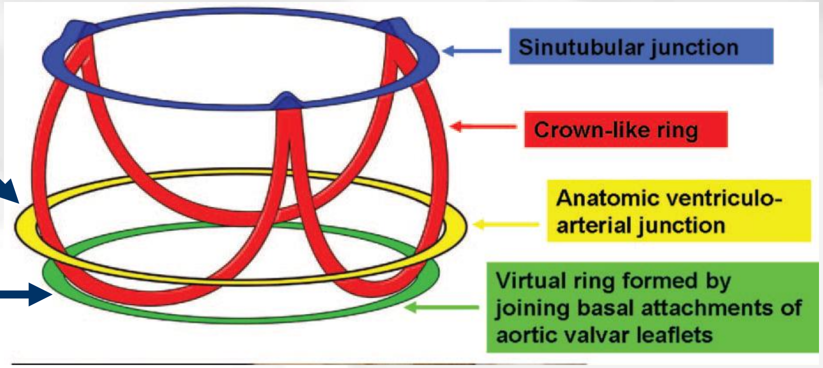
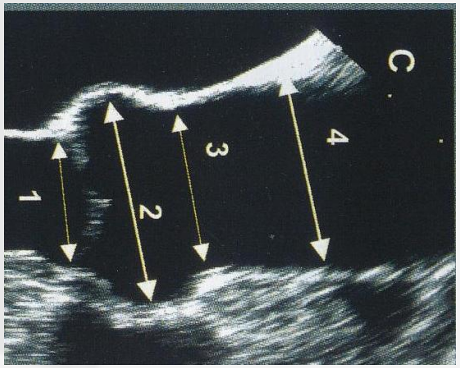
ROLE OF CMR: role of CMR in TAVI

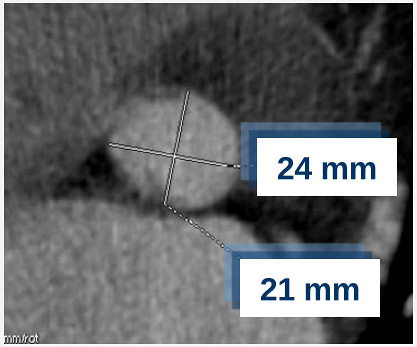
Anatomy of the Aortic Valvar Complex and Its Implications for Transcatheter Implantation of the Aortic Valve

Nicoló Piazza, MD; Peter de Jaegere, MD, PhD; Carl Schultz, MD; Anton E. Becker, MD, PhD; Patrick W. Serruys, MD, PhD; Robert H. Anderson, MD, FRCPath

Abstract—The books and articles devoted to the anatomy of the aortic valvar complex are numerous. Until now, however, little consideration has been given to understanding the anatomy with percutaneous valvar replacement in mind. It is axiomatic that knowledge of the anatomy of the valve is fundamental in understanding key principles involved in valvar replacement. Such an appreciation of the anatomy helps better understand the optimal positioning for the prosthetic valve within the root of the aorta with respect to the coronary arteries, mitral valve, and the conduction system and may circumvent complications that can arise during its implantation. In this review, therefore, we describe the anatomy of the trifoliate aortic valvar complex and its implications for percutaneous valvar replacement. (*Circ Cardiovasc Intervent.* 2008;1:74-81.)







The aortic root contains at least 3 circular rings and 1 crown-like ring. The valvar leaflets, of course, are attached throughout the length of the root. The base of the crown is a virtual ring, formed by joining the basal attachment points of the leaflets within the left ventricle.

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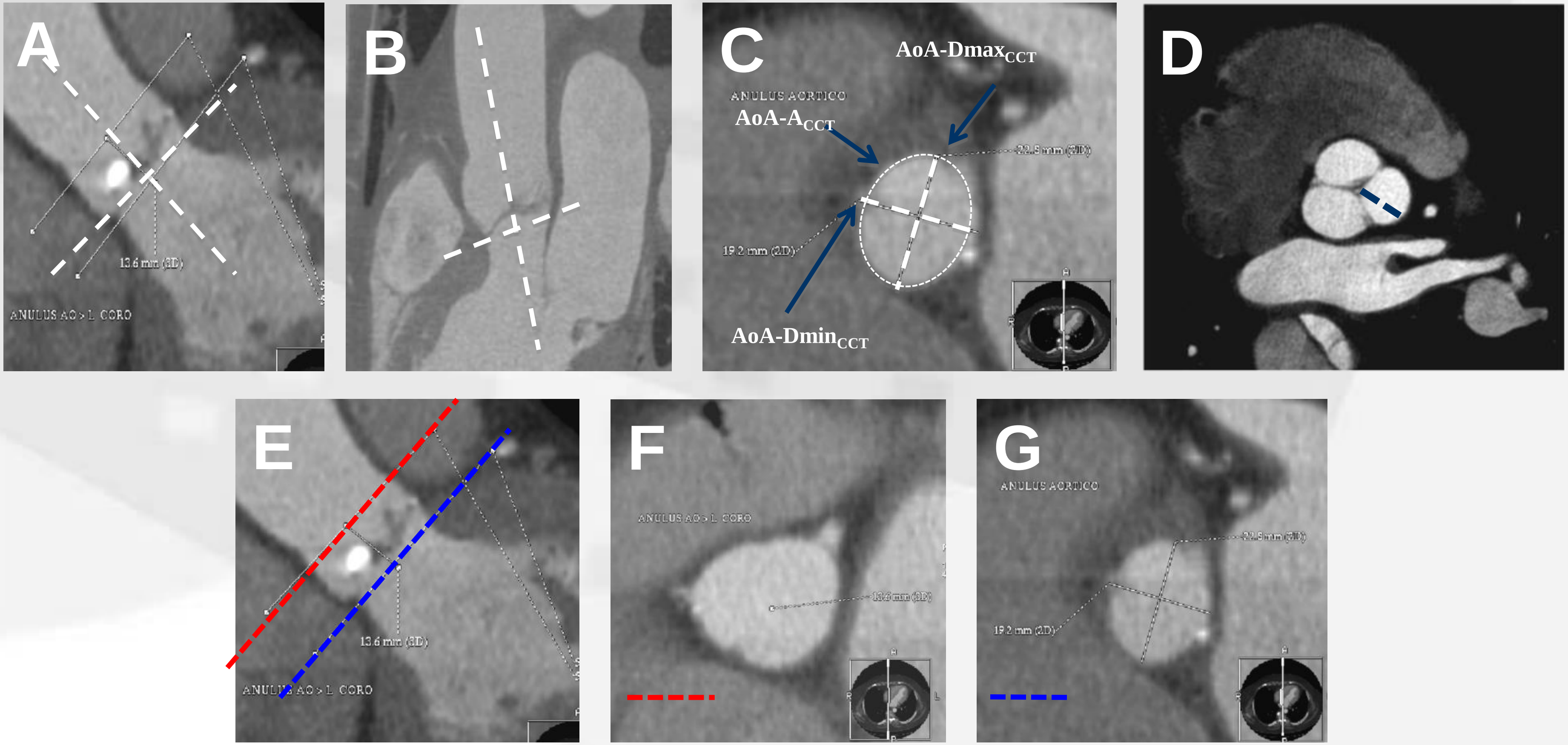
ROLE OF CMR: role of CMR in TAVI



Measurements of AoA **(Panel A-C)**: with MDCT, AoA (AoAMDCT) is defined as a virtual ring formed by joining the basal attachments of aortic valve leaflets. For each AoAMDCT, maximum diameter (AoA-DmaxMDCT), minimum diameter (AoA-DminMDCT) and area (AoA-AMDCT) were measured in an orthogonal plane on the center line of the aorta obtained in oblique-coronal and oblique-sagittal views, respectively. Measurement of leaflet size **(Panel D)**: the distance between the basal attachment and the apex of the leaflets (black line) is determined. Measurement of coronary ostia height **(Panel E-G)**: a coronal view of the ascending aorta (E) and two short axis at the level of the left main coronary ostium (red line) and AoA (blue line) are obtained. The distance between these two lines corresponds to the coronary ostium height.

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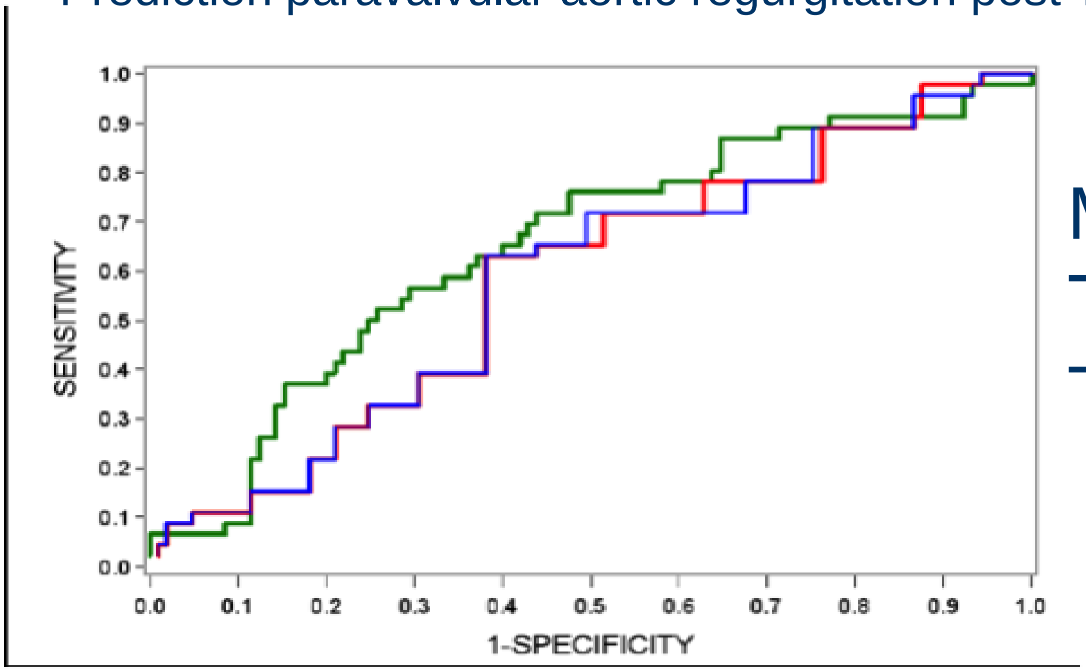
Prediction paravalvular aortic regurgitation post TAVI



MDCT (–)
TTE (–)
TEE (–)

❑ Unfortunately, up to 20% of patients undergoing TAVI have clinical conditions that make them unsuitable candidates for MDCT. Moreover, MDCT requires contrast agent administration that may be a hazard issue in patients with reduced kidney function who are a substantial proportion of TAVI patients

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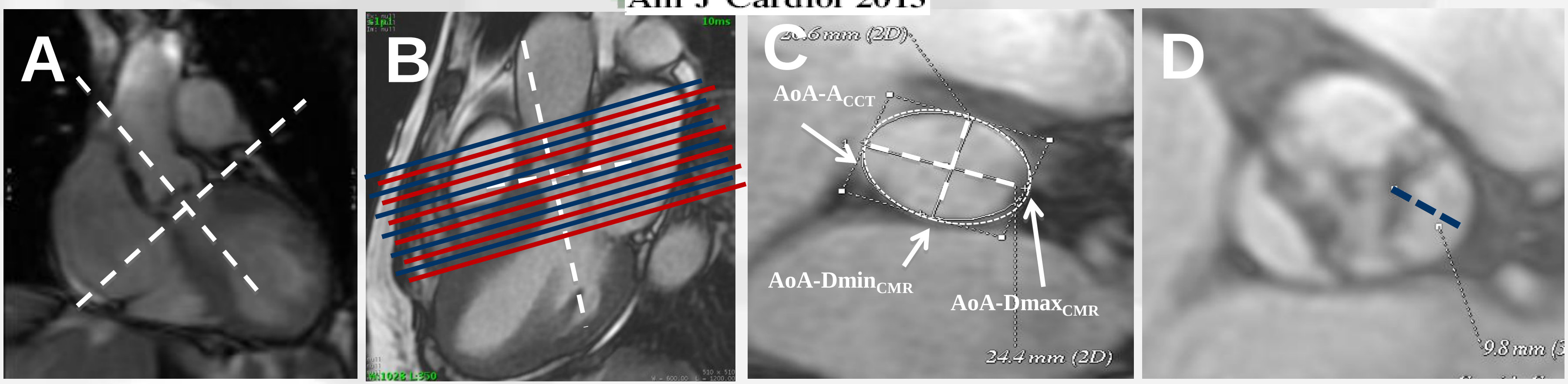
ROLE OF CMR: role of CMR in TAVI

Comparison of Accuracy of Aortic Root Annulus Assessment With Cardiac Magnetic Resonance Versus Echocardiography and Multidetector Computed Tomography in Patients Referred for Transcatheter Aortic Valve Implantation

Gianluca Pontone, MD[a,*], Daniele Andreini, MD[a,b], Antonio L. Bartorelli, MD[a,b], Erika Bertella, MD[a], Saima Mushtaq, MD[a], Paola Gripari, MD[a], Monica Loguercio, MD[a], Sarah Cortinovis, MD[a], Andrea Baggiano, MD[a], Edoardo Conte, MD[a], Virginia Beltrama, MD[a], Andrea Annoni, MD[a], Alberto Formenti, MD[a], Gloria Tamborini, MD[a], Manuela Muratori, MD[a], Andrea Guaricci, MD[c], Francesco Alamanni, MD[a,b], Giovanni Ballerini, MD[a], and Mauro Pepi, MD[a]

Am J Cardiol 2013



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PARAMETERS	CCT	CMR	CCT – CMR (95% Confidence Interval)	p
AoA-Dmax (mm), mean±SD	26.45±2.83	26.45±2.76	0±0.79 (-0.24 to 0.24)	1
AoA-Dmin (mm), mean±SD	20.17±2.20	20.59±2.35	-0.43±0.99 (-0.74 to -0.12)	0.08
Ao-A (mm^2), mean±SD	444,88±84.61	449.78±86.22	-4.90±21.19 (-11.5 to 1,70)	0.14
Aortic Valve Calcifications (grade 1 to 4)	3.40±0.70	2.97±0.77	0.43±0.23 (0.18 to 0.60)	0.03
Left coronary leaflet, (mm), mean±SD	14.02±2.27	13.95±2.18	0.07±0.46 (-0.07 to 0.21)	0.32
Right coronary leaflet, (mm), mean±SD	13.33±2.33	13.30±2.14	0.02±0.74 (-0.21 to 0.25)	0.83
Non-coronary leaflet, (mm), mean±SD	13.39±1.97	13.46±1.80	-0.07±0.60 (-0.26 to 0.12)	0.44
AoA to left coronary ostium distance (mm), mean±SD	16.21±3.07	16.14±2.83	0.07±1.09 (-0.27 to 0.41)	0.67
AoA to right coronary ostium distance (mm), mean±SD	16.02±4.29	16.14±4.36	-0.11±1.06 (-0.45 to 0.21)	0.47

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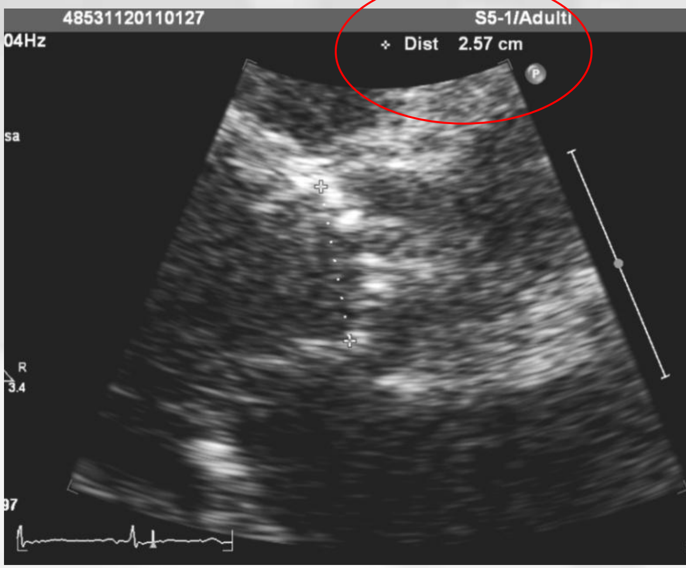
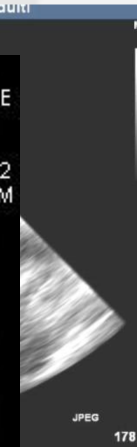
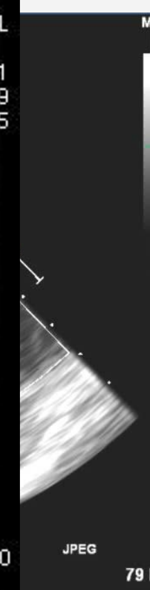
AoA-A: aortic annulus area; ; AoA-D: aortic annulus diameter; SD: standard deviation; CMR: cardiac magnetic resonance; MDCT: multidetector computed tomography

ROLE OF CMR: role of CMR in TAVI

Male, 92 yo, with history of severe AS selected for TAVI with severe renal failure







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TAKE HOME MESSAGE

- ❑ Poor acoustic window
- ❑ Equivocal TTE
- ❑ Low gradient Aortic Stenosis
- ❑ Severe regurgitant defect with normal volumes
- ❑ All right valve heart disease
- ❑ In TAVI patients to estimate aortic annulus size and contraindications to CT for renal insufficiency or heart rate control issues.

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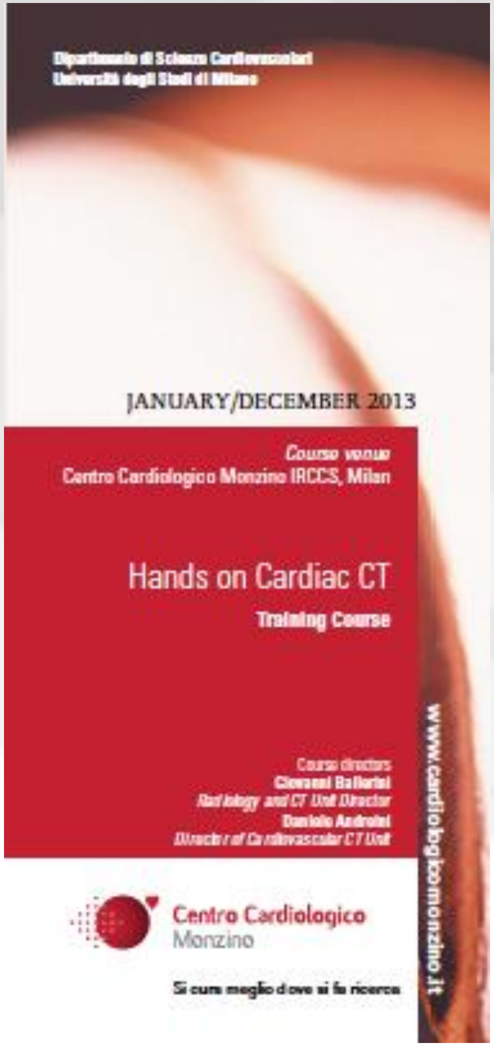

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