

Cardiology Department  
Leiden University Medical Center,  
The Netherlands



# 3DEchocardiography: Mitral and Aortic valve assessment

Nina Ajmone Marsan



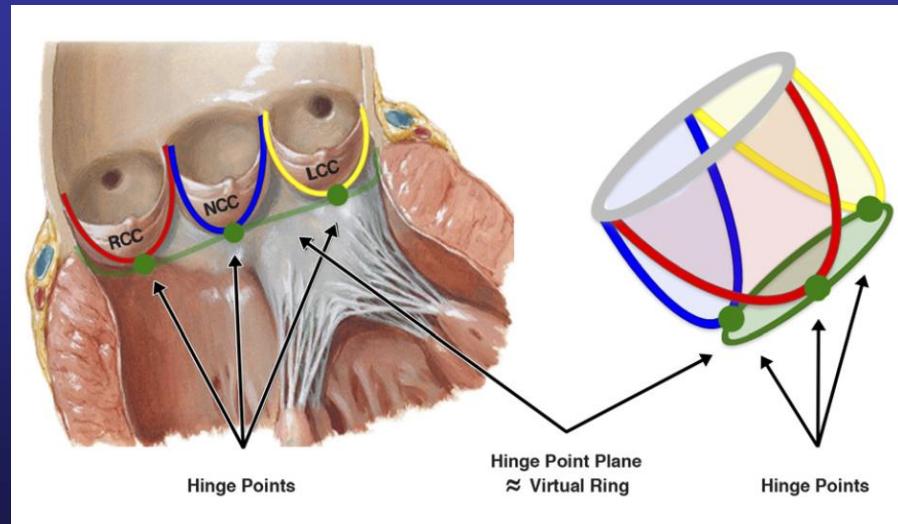
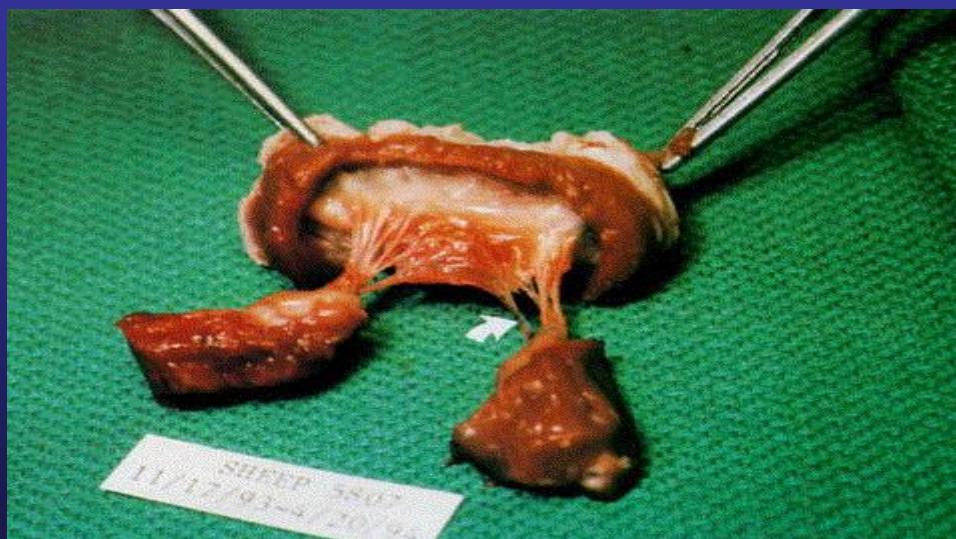
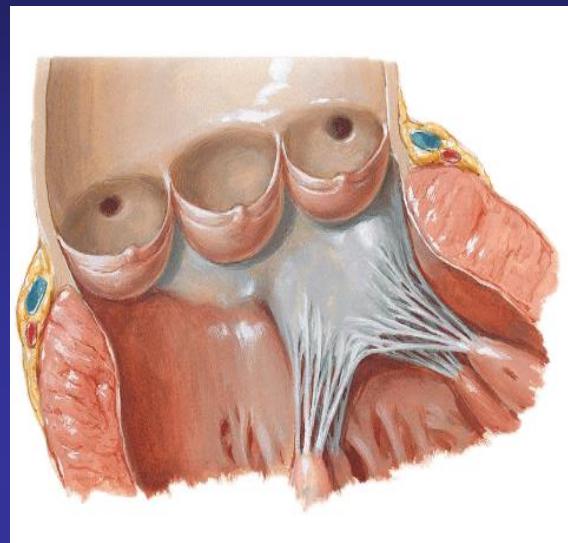
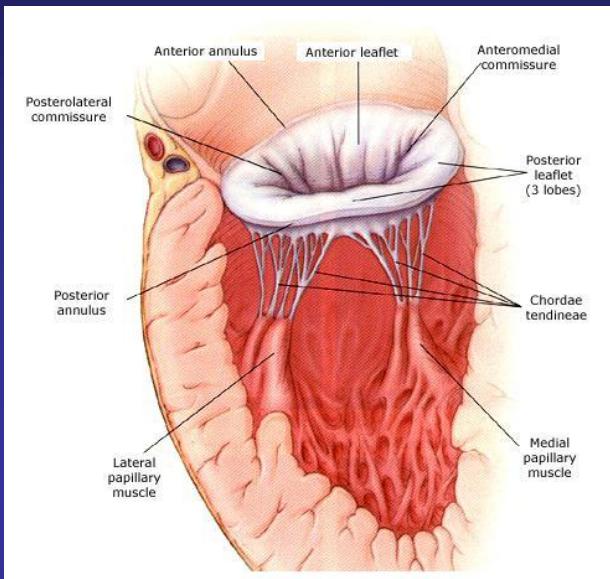
3DE MTE 2024  
Eindhoven



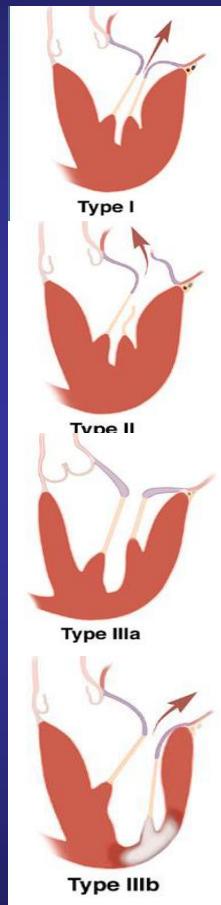
# Disclosures

- Speaker fees from GE Healthcare, Philips Ultrasound, Abbott Vascular, Pfizer, Omron
- Research grants from Alnylam, Pfizer, Novartis, Pie Medical

# MV and AV anatomy



# Pathophysiologic mitral valve anatomy



<i>Dysfunction</i>	<i>Lesions</i>	<i>Etiology</i>
<b>Type I</b> <b>Normal leaflet motion</b>	<b>Annular dilatation</b> <b>Leaflet perforation / tear</b>	<b>Dilated cardiomyopathy</b> <b>Endocarditis</b>
<b>Type II</b> <b>Excess leaflet motion (leaflet prolapse)</b>	<b>Elongation / rupture chordae</b>  <b>Elongation / rupture of papillary muscle</b>	<b>Degenerative valve disease</b>  <b>Fibroelastic deficiency</b> <b>Barlow's disease</b> <b>Marfan disease</b>  <b>Endocarditis</b>  <b>Trauma</b>  <b>Ischemic cardiomyopathy</b>
<b>Type III a</b> <b>Restricted leaflet motion (Diastole and Systole)</b>	<b>Leaflet thickening / retraction</b> <b>Leaflet calcification</b> <b>Chordal thickening / retraction / fusion</b>  <b>Commissural fusion</b>	<b>Rheumatic heart disease</b>  <b>Carcinoid heart disease</b>
<b>Type III b</b> <b>Restricted leaflet motion (Systole)</b>	<b>Left ventricular dilatation/ aneurysm</b>  <b>Papillary muscle displacement</b>  <b>Chordae tethering</b>	<b>Ischemic / Dilated cardiomyopathy</b>

*Carpentier A. J Thorac Cardiovasc Surg 1983*

# MR: evaluation of mechanism

## CENTRAL ILLUSTRATION: Classification of the Etiology of MR

Carpentier Type I (normal leaflet motion and position)	Carpentier Type II (excess leaflet motion)	Carpentier Type IIIa (restricted leaflet motion in systole and diastole)	Carpentier Type IIIb (restricted leaflet motion in systole)
PRIMARY MR			
	Leaflet Perforation Cleft	Mitral Valve Prolapse	Rheumatic Valve Disease Mitral Annular Calcification Drug Induced MR
SECONDARY MR			
	Atrial MR	Nonischemic Cardiomyopathy	Ischemic Cardiomyopathy

El Sabbagh, A. et al. J Am Coll Cardiol Img. 2018;11(4):628-43.

# MR: evaluation of mechanism

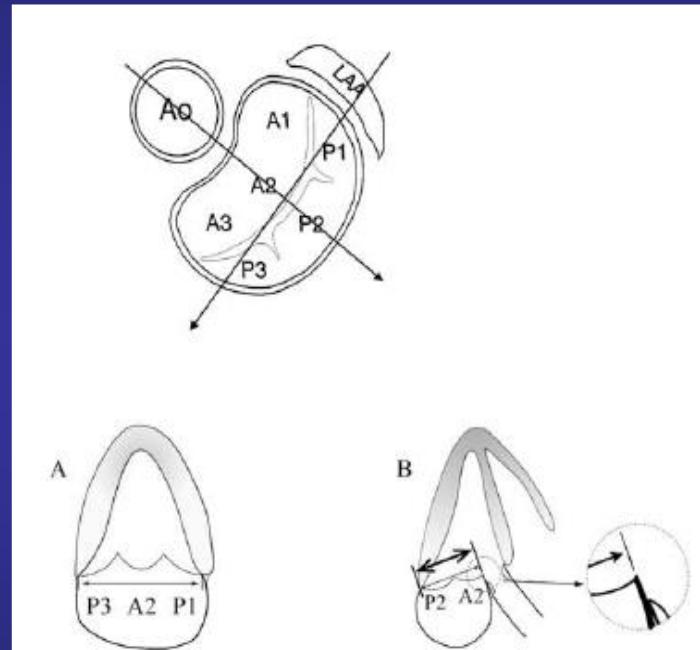
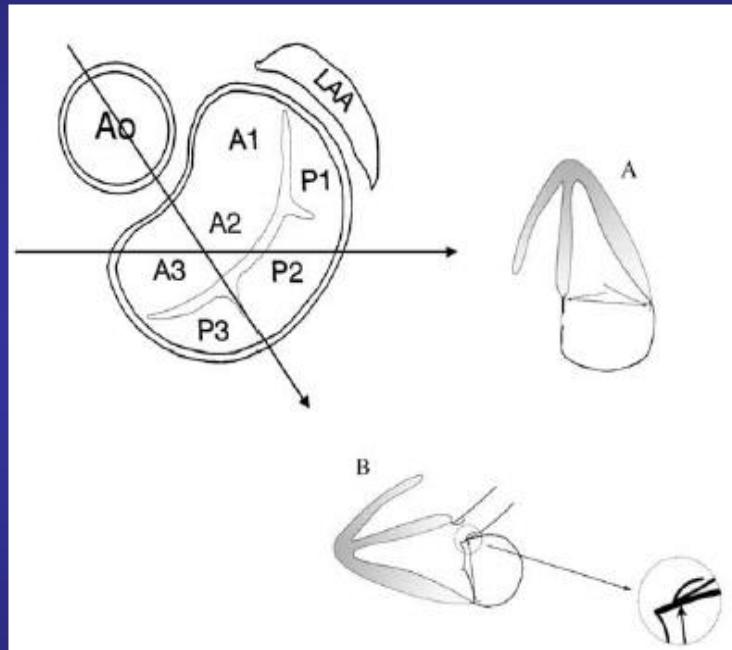
Dysfunction → Lesion → Etiology

- Primary vs Secondary MR
- Detailed and accurate MV segmental analysis

*Carpentier A. J Thorac Cardiovasc Surg 1983*

# 2D echocardiography: TTE

## All about alignment

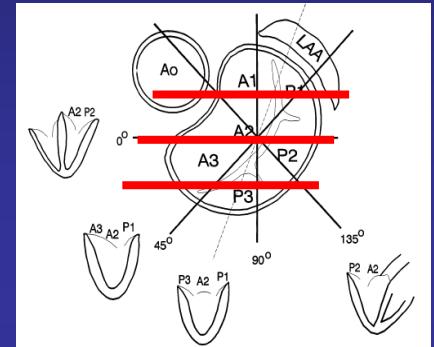


Traditional measurement

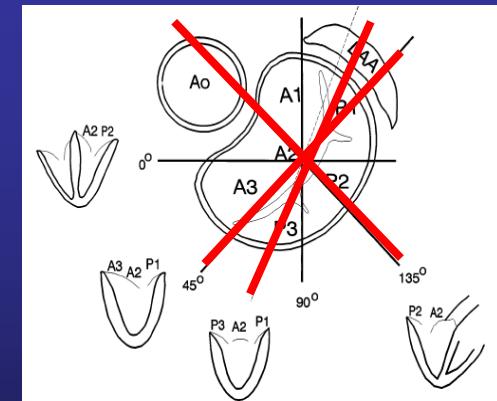


Correct anatomic measurement

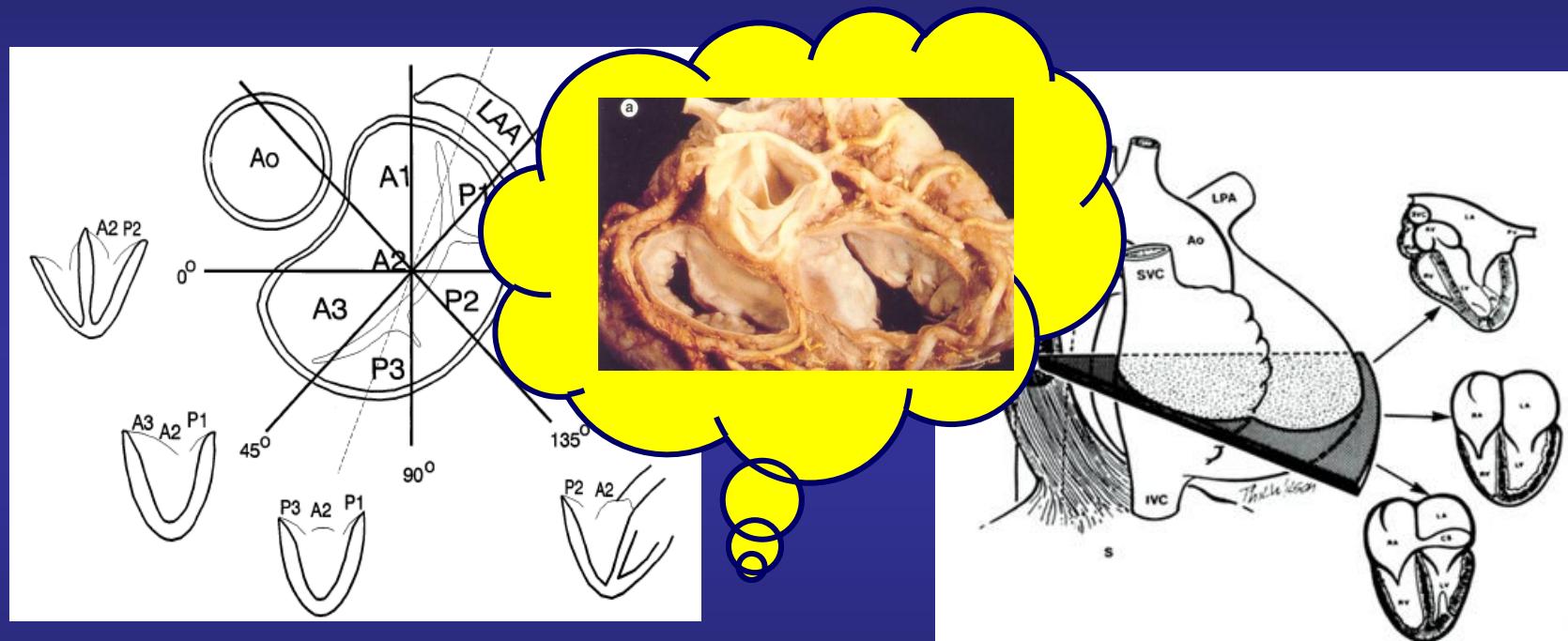
# Analysis with 2D TE Echocardiography



# Analysis with 2D Echocardiography

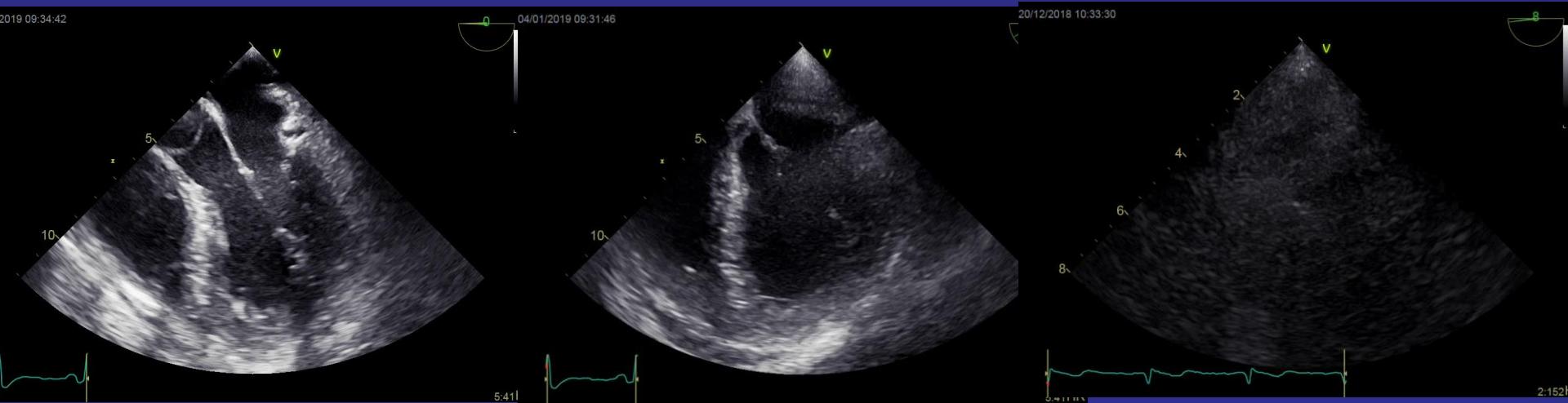


# Analysis with 2D Echocardiography

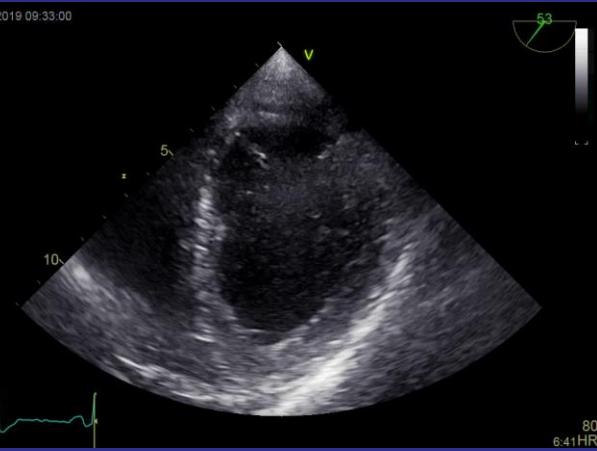


Foster et al. Ann Thorac Surg 1998;65:1025–31

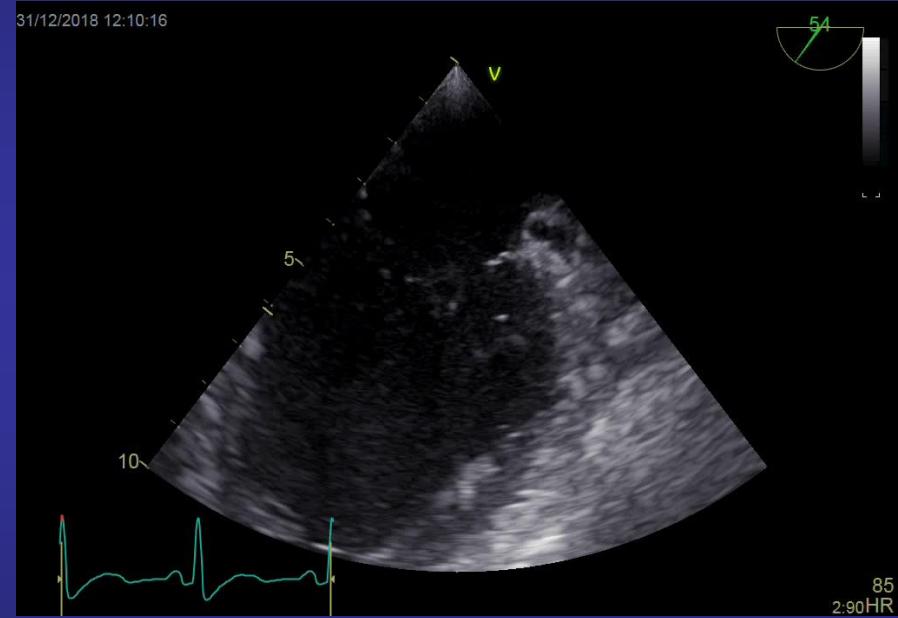
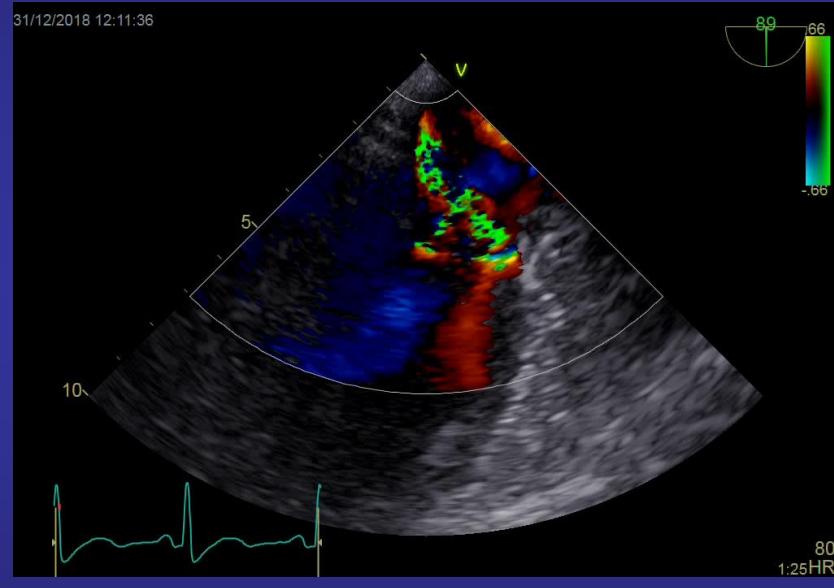
# Segmental analysis with 2D imaging

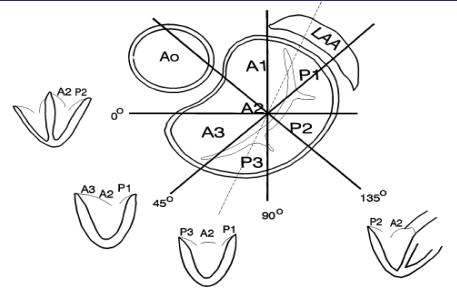


# Segmental analysis with 2D imaging

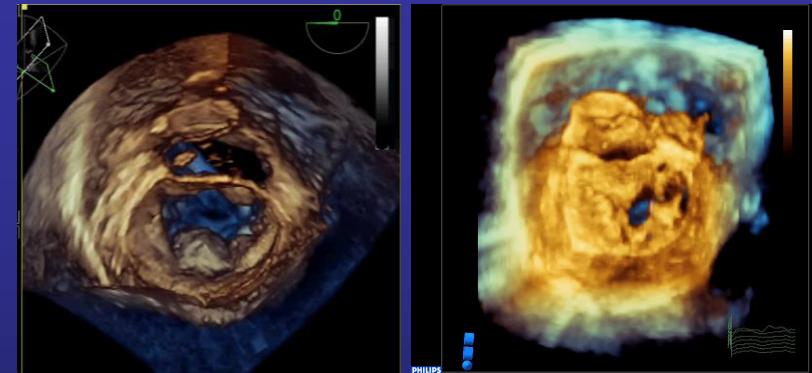
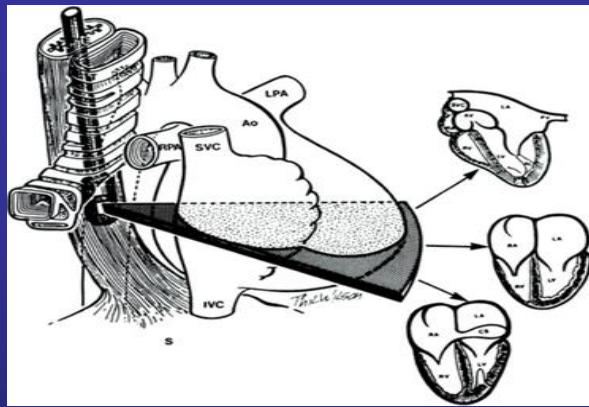
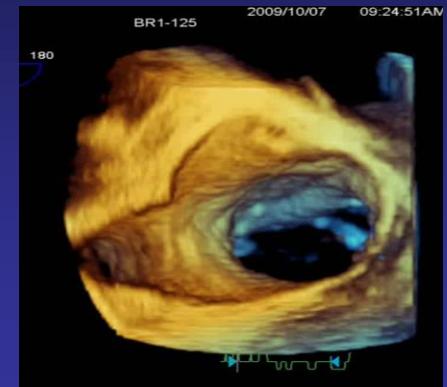


# Segmental analysis with 2D imaging

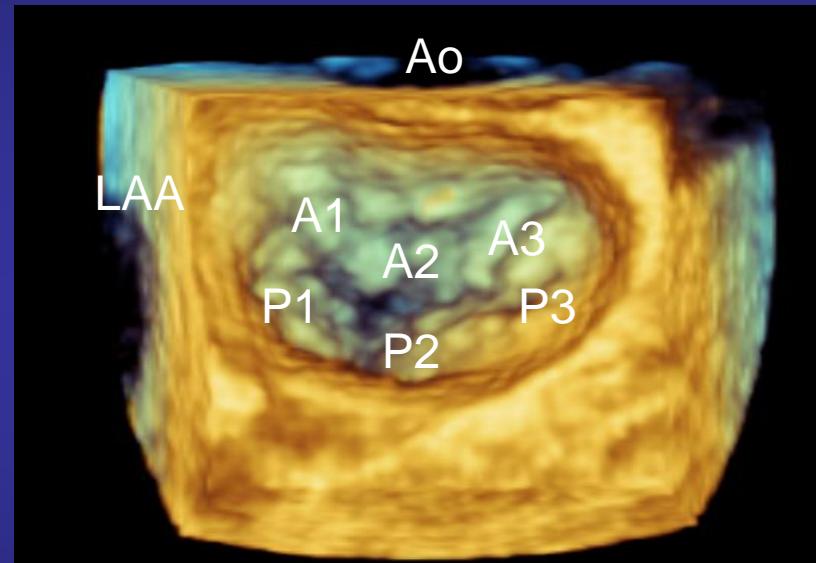
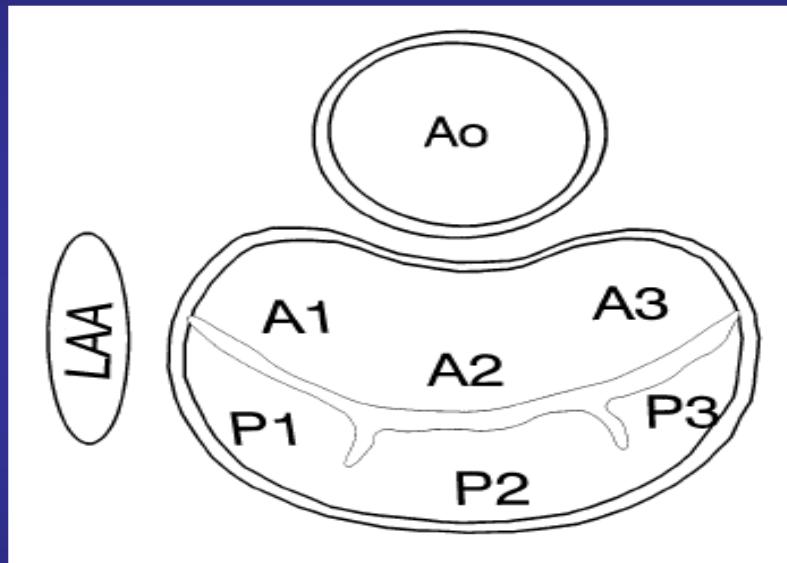




2Decho → 3Decho

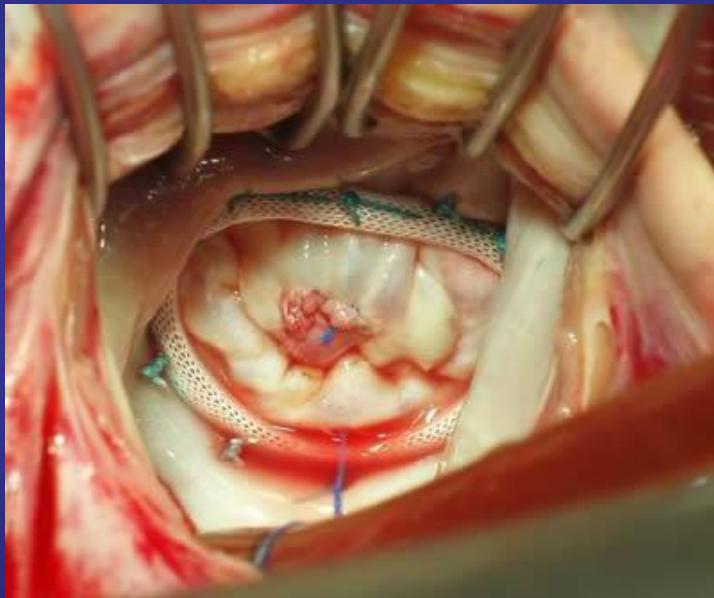


# Segmental analysis with 3D imaging



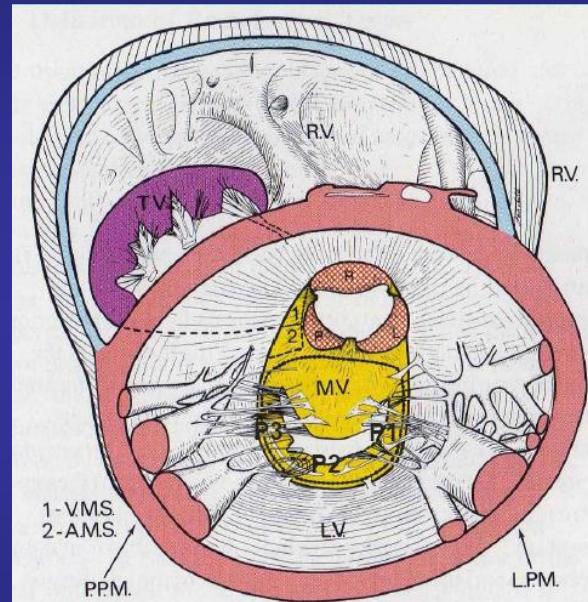
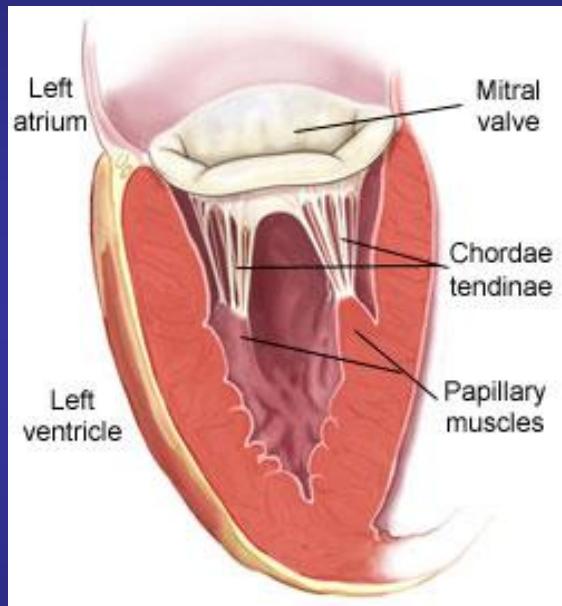
*Foster et al. Ann Thorac Surg 1998;65:1025–31*

**“En face view” = “Surgical view”**

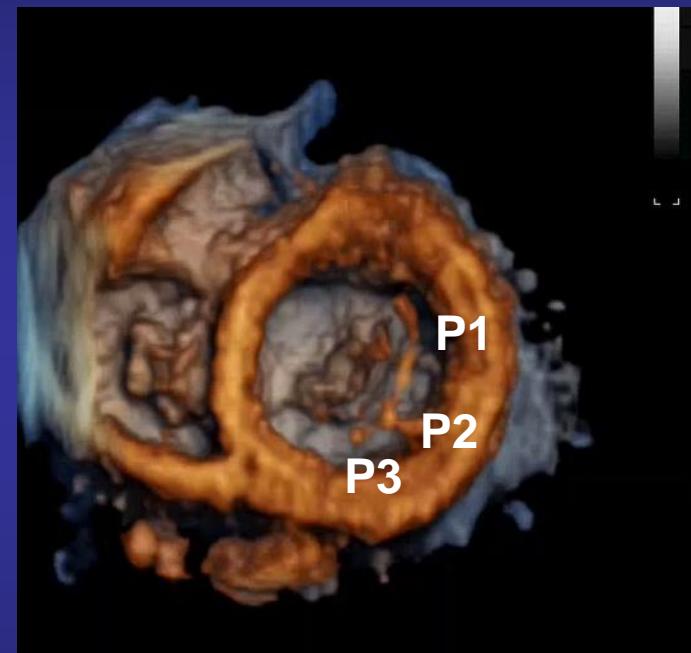
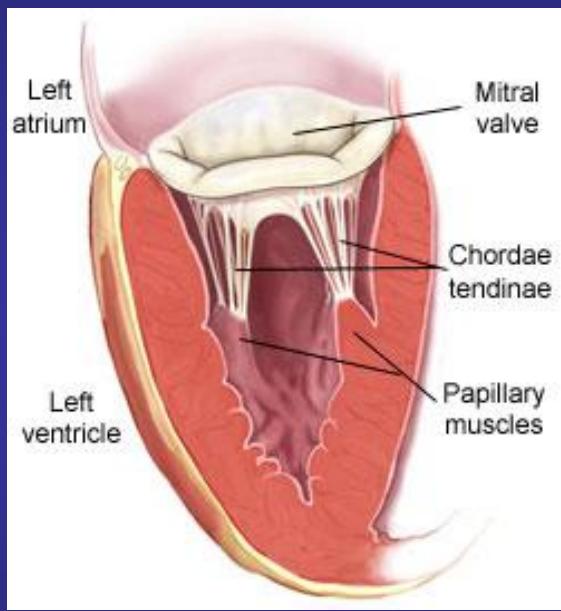


**“en face view”**

# Ventricular view

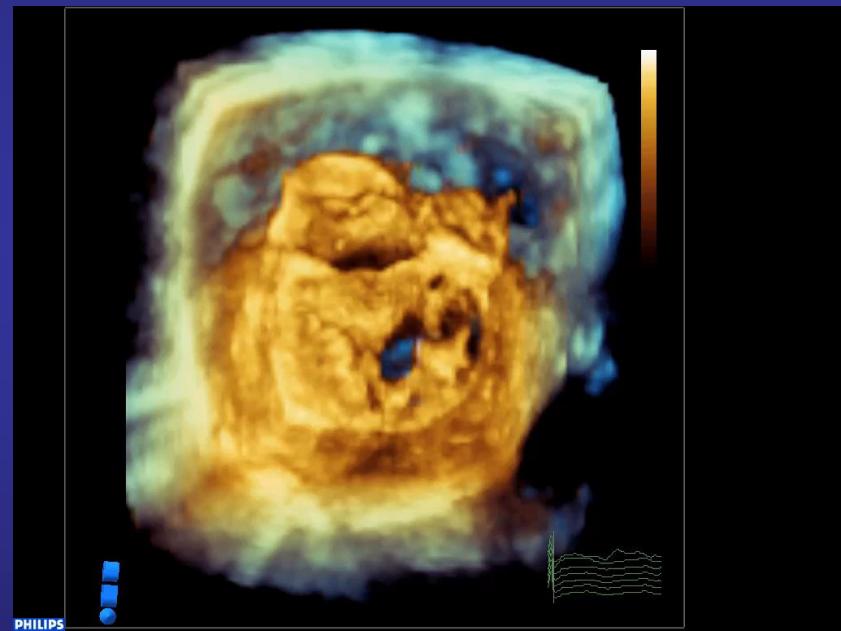


# Ventricular view

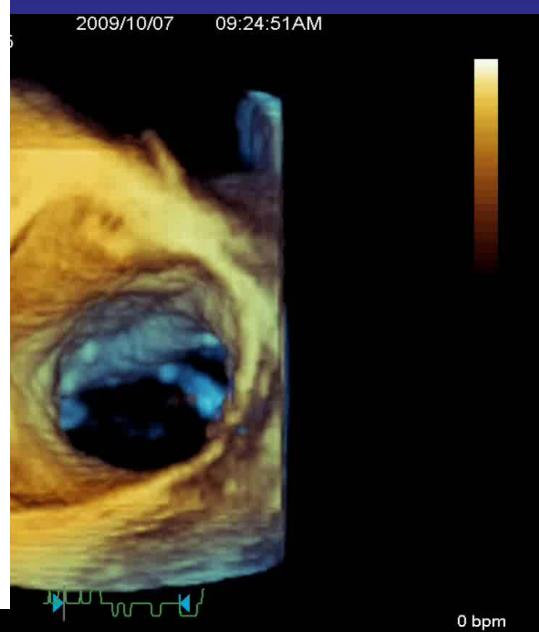
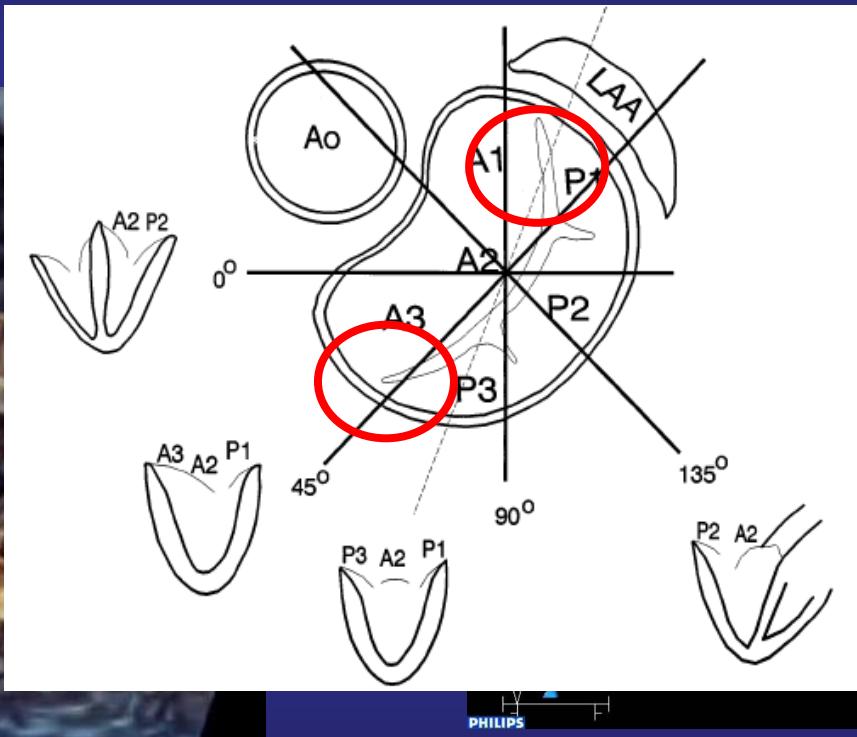
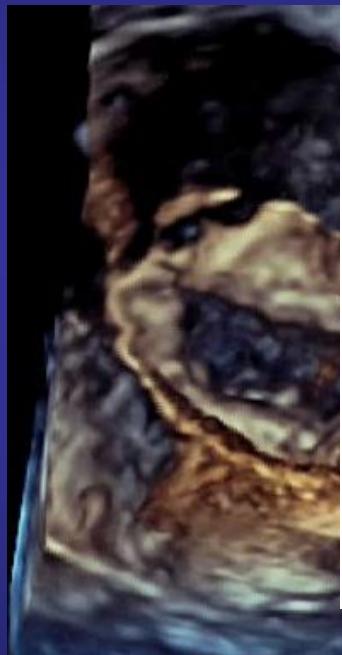


# 3D views: MV TEE

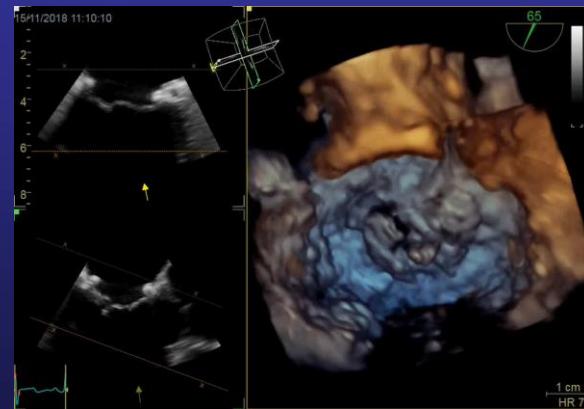
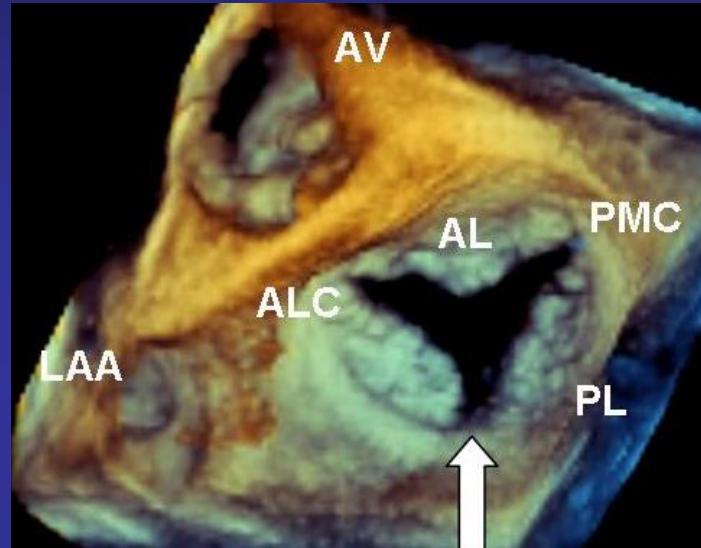
## Complex versus simple lesions



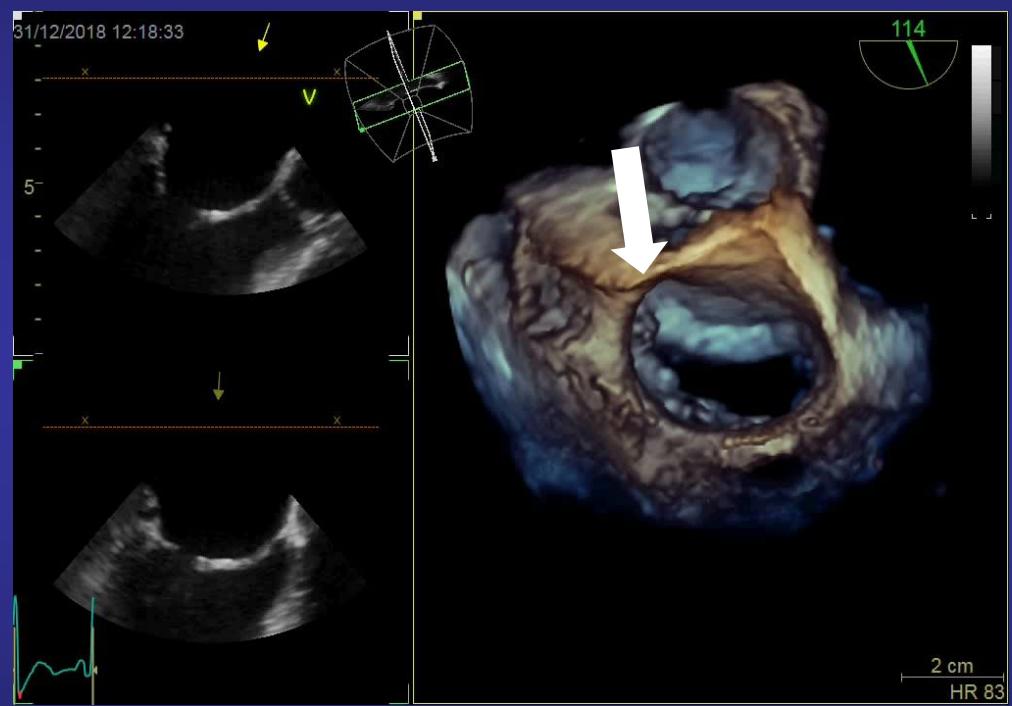
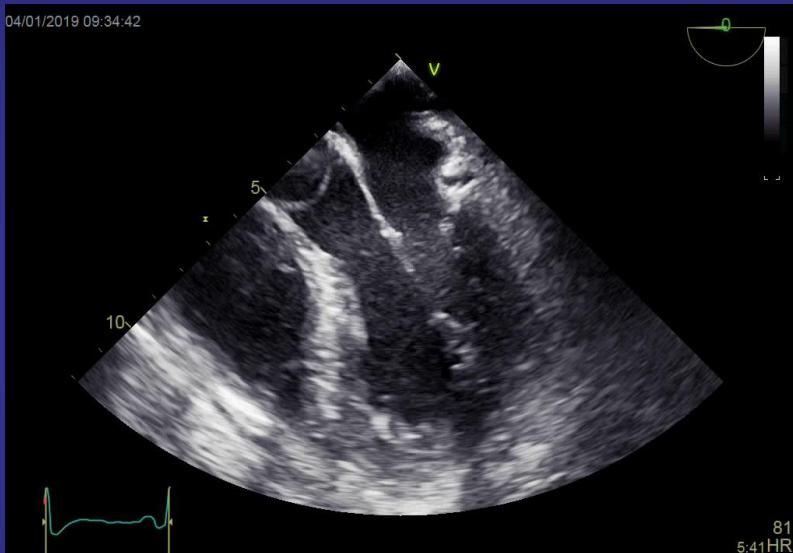
# Mitral valve prolapse: Simple vs complex lesions



# Identification of cleft and deep indentation



04/01/2019 09:34:42



## Head-to-Head Comparison of Two- and Three-Dimensional Transthoracic and Transesophageal Echocardiography in the Localization of Mitral Valve Prolapse

Mauro Pepi, MD, Gloria Tamborini, MD, Anna Maltagliati, MD, Claudia Agnese Galli, MD,  
Erminio Sisillo, MD, Luca Salvi, MD, Moreno Naliato, MD, Massimo Porqueddu, MD,  
Alessandro Parolari, MD, Marco Zanobini, MD, Francesco Alamanni, MD

*Milan, Italy*

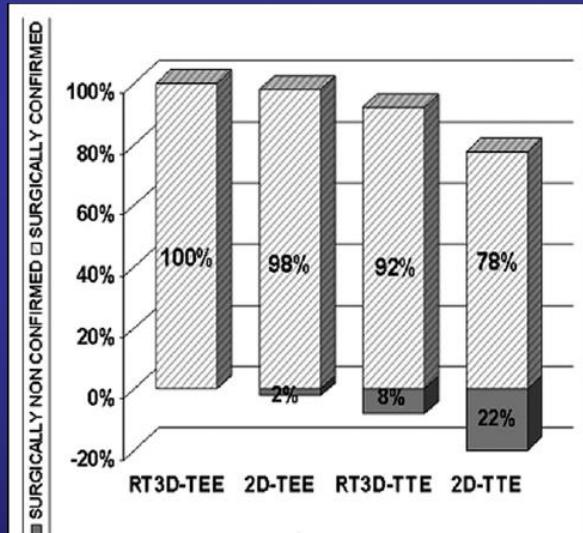
Routine application of  
2D transthoracic and 3D transthoracic ECHO  
intraoperative 2D and 3D transesophageal ECHO:

**RESULTS ON 110 CASES vs SURGICAL INSPECTION**

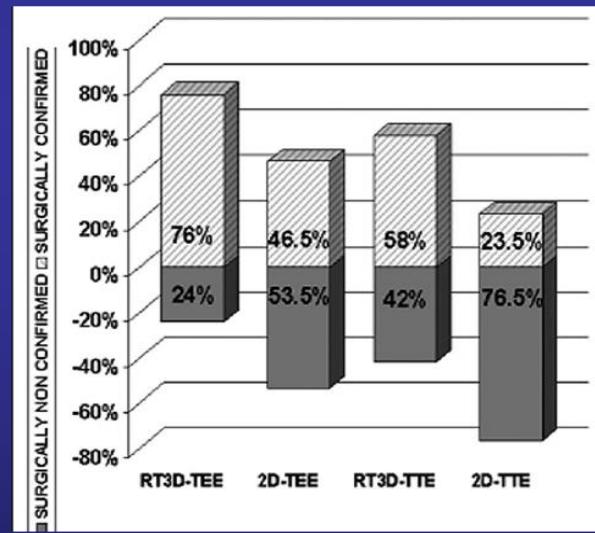
# Real-Time Three-Dimensional Transesophageal Echocardiography for Assessment of Mitral Valve Functional Anatomy in Patients With Prolapse-Related Regurgitation

Giovanni La Canna, MD<sup>a,\*</sup>, Iryna Arendar, MD<sup>a</sup>, Francesco Maisano, MD<sup>b</sup>, Fabrizio Monaco, MD<sup>a</sup>, Egidio Collu, MD<sup>a</sup>, Stefano Benussi, MD<sup>b</sup>, Michele De Bonis, MD<sup>b</sup>, Alessandro Castiglioni, MD<sup>b</sup>, and Ottavio Alfieri, MD<sup>b</sup>

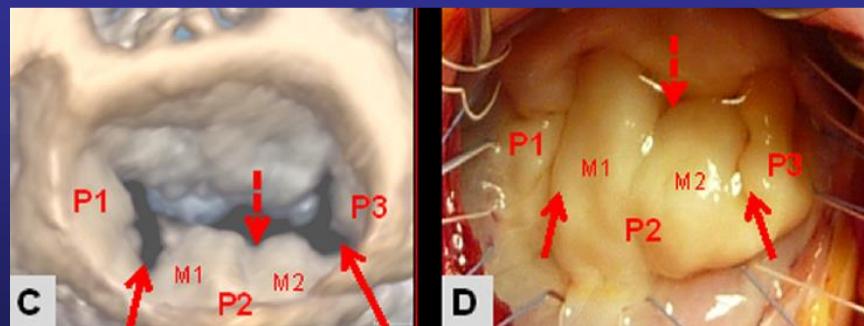
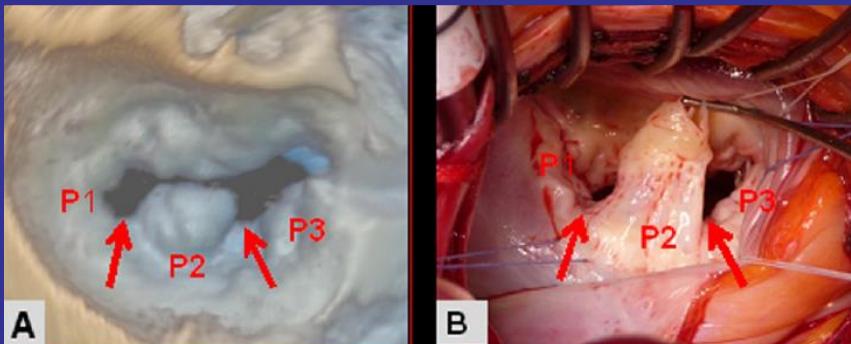
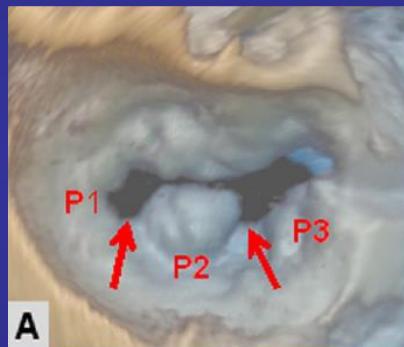
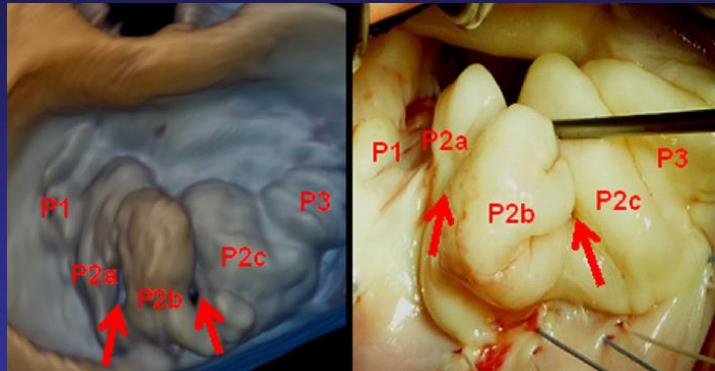
Am J Cardiol 2011



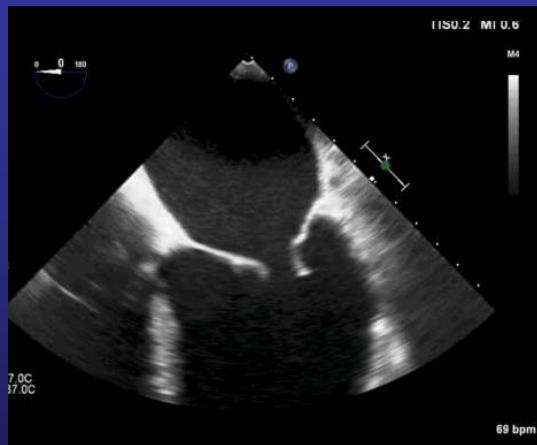
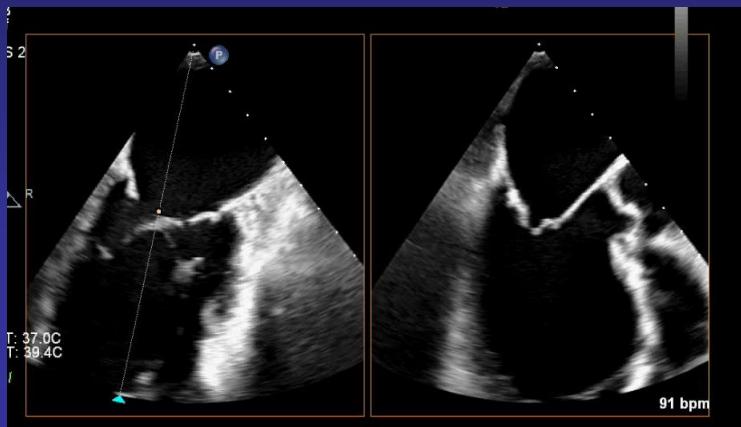
Simple lesions



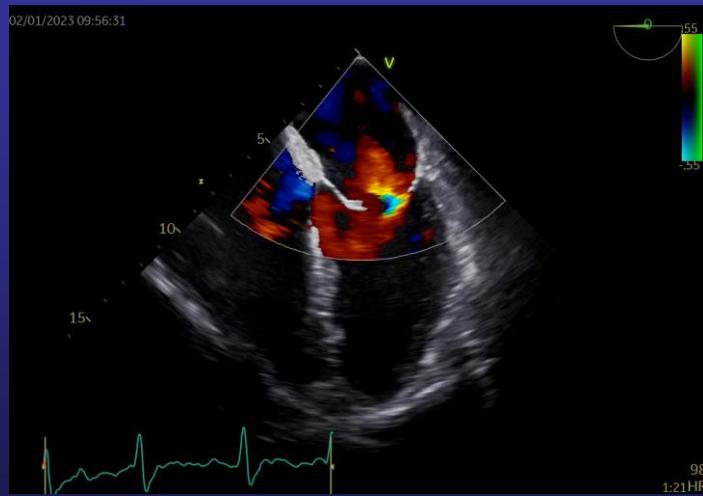
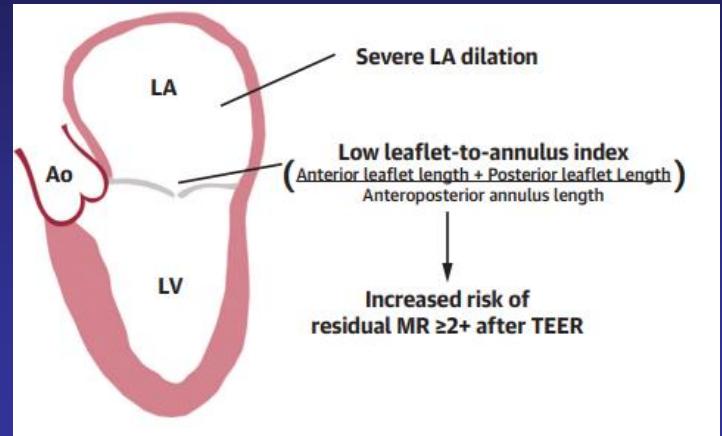
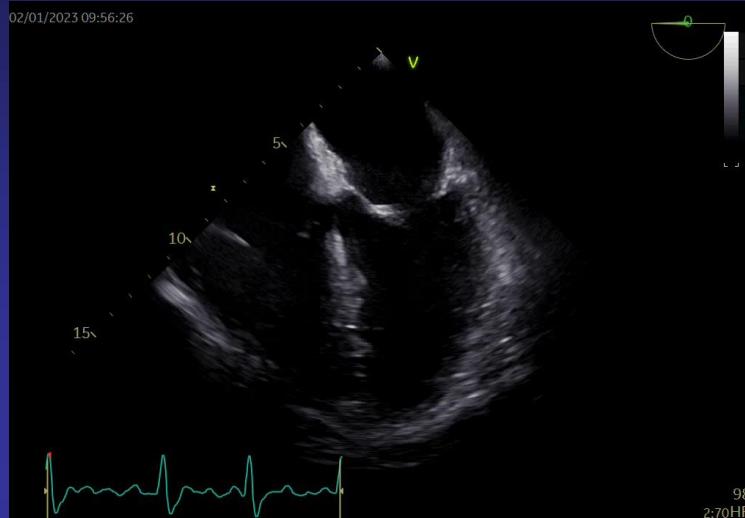
Complex lesions



# Ventricular Secondary MR



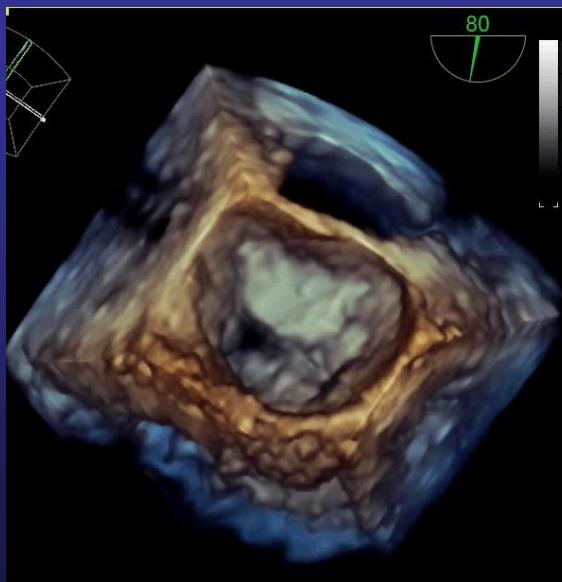
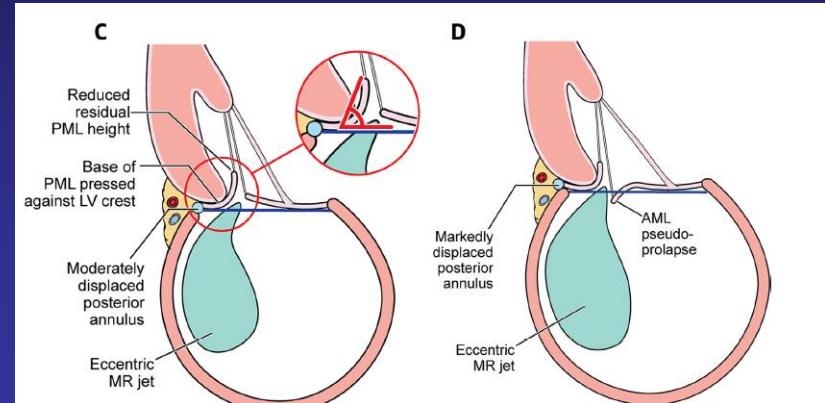
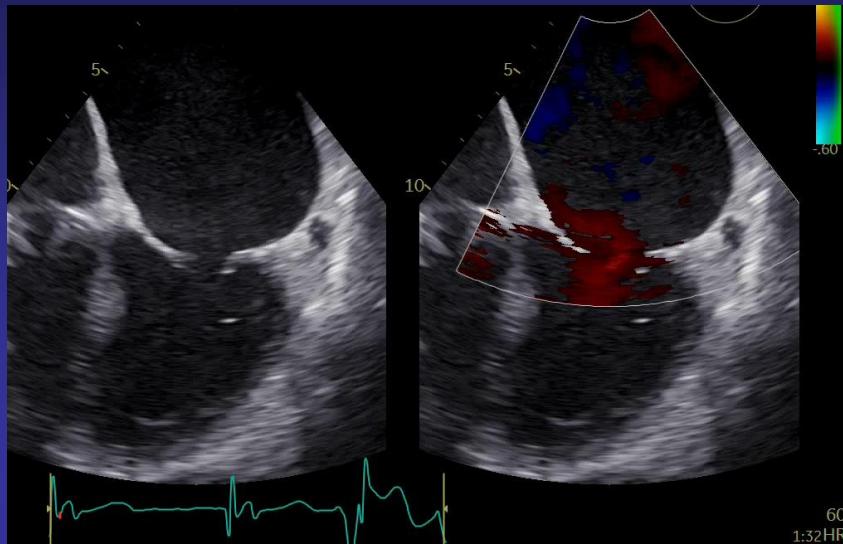
# Atrial Secondary MR



Annulus-leaflet area imbalance

Kagiyama et al, JACC Img 2020

# Atrial Secondary MR

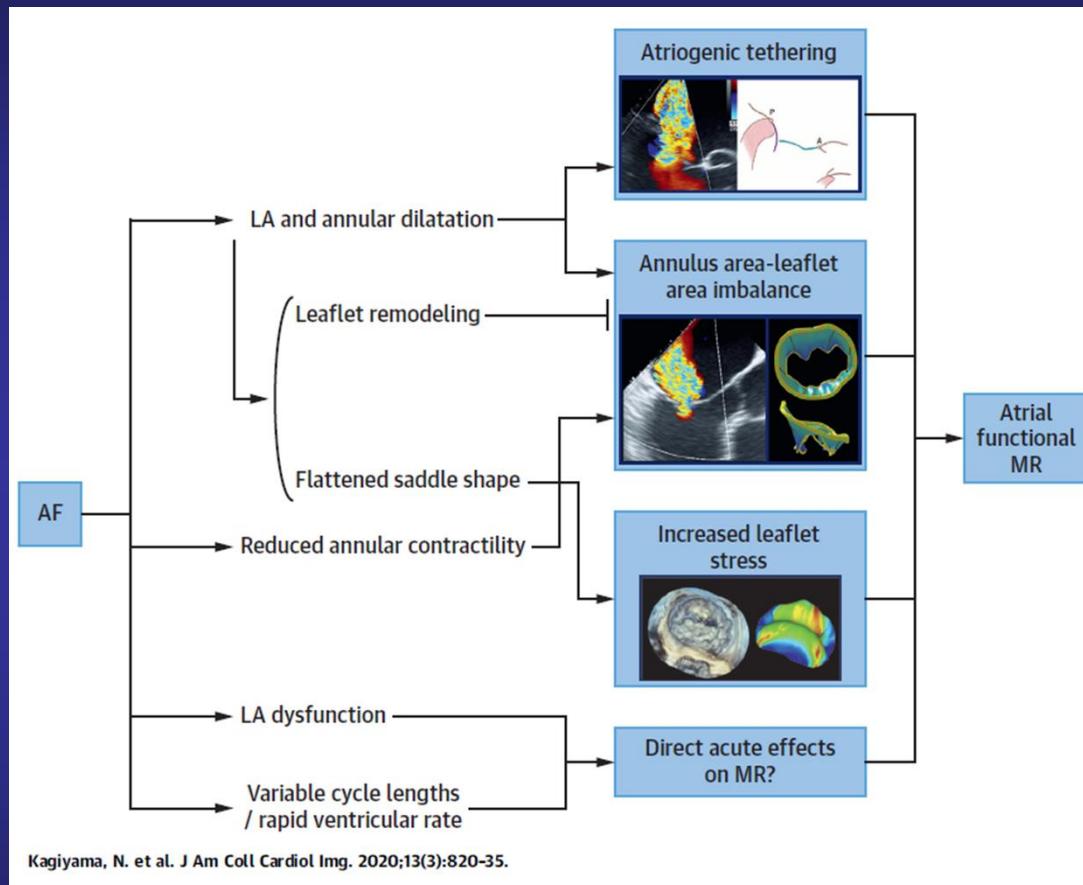


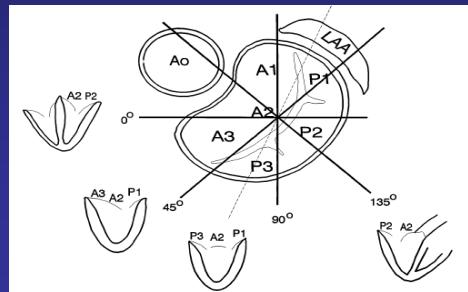
## Atriogenic leaflet tethering

- Shorter PML with increased angle
- Pseudo-prolapse AML

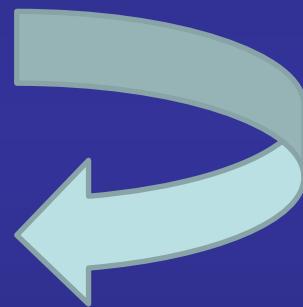
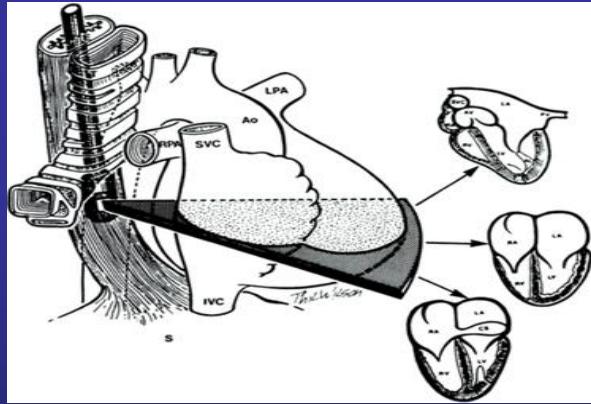
*Fahran et al, JACC 2022*  
*Tanaka et al, JACCInt 2022*

# Atrial secondary MR

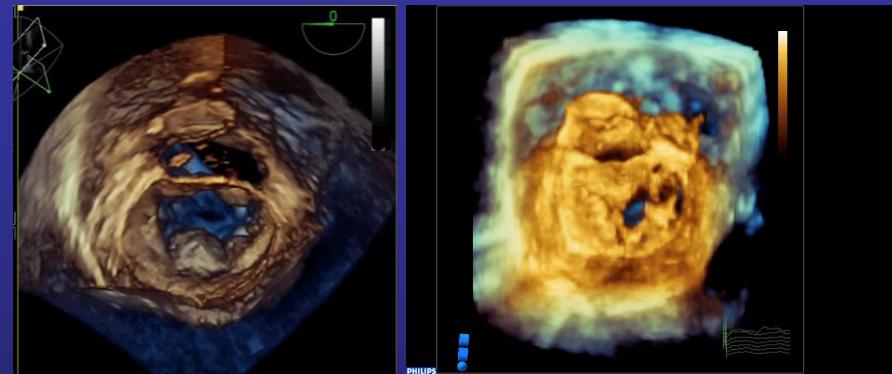
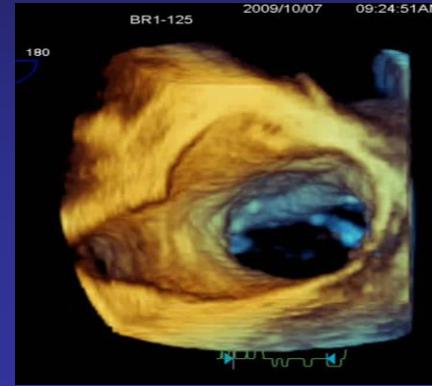




## 2Decho

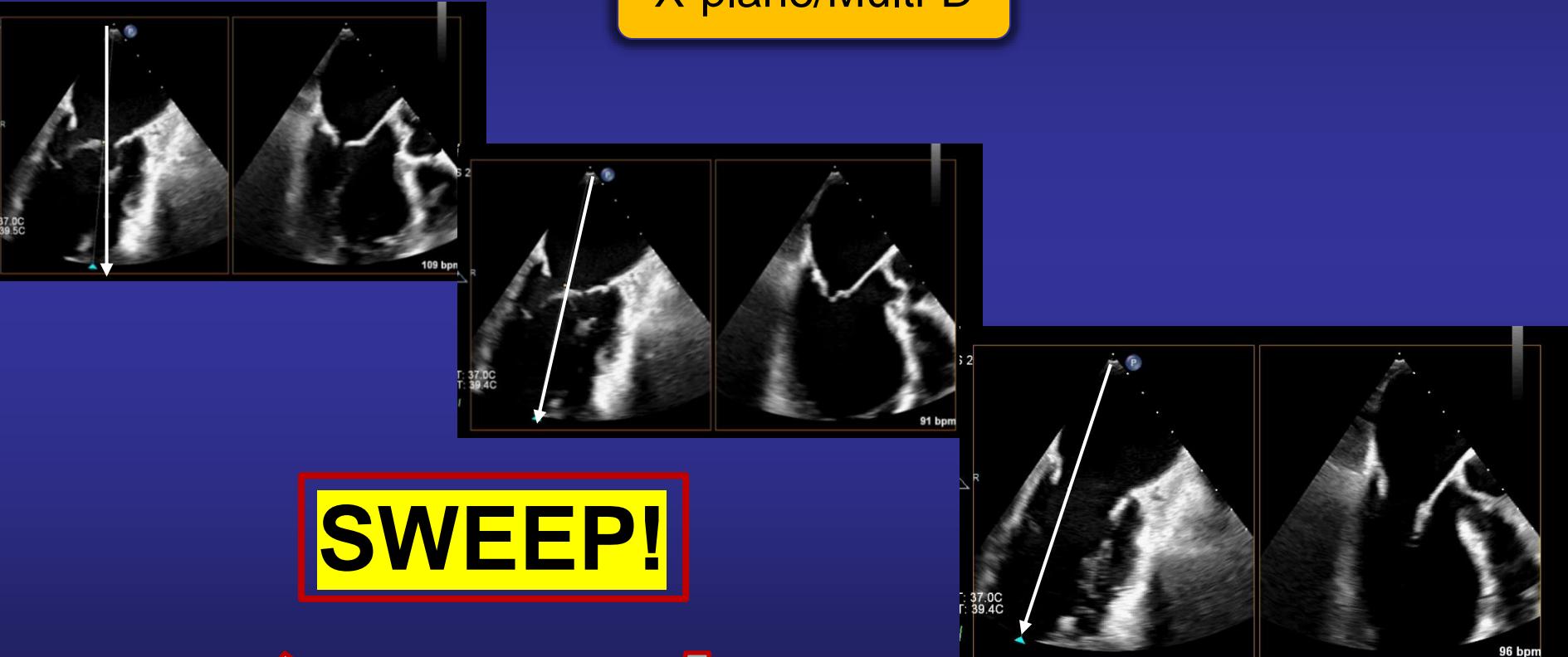


## 3Decho

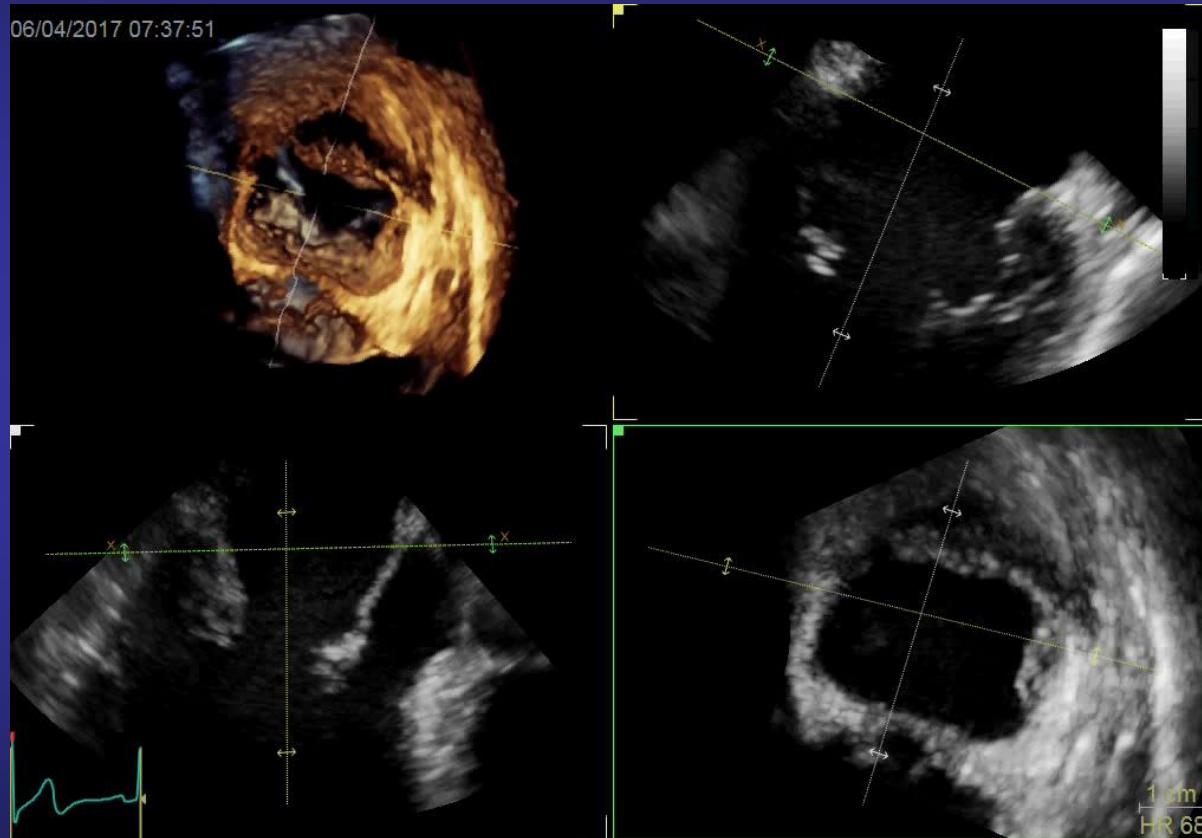


# 2D views from 3D Echocardiography

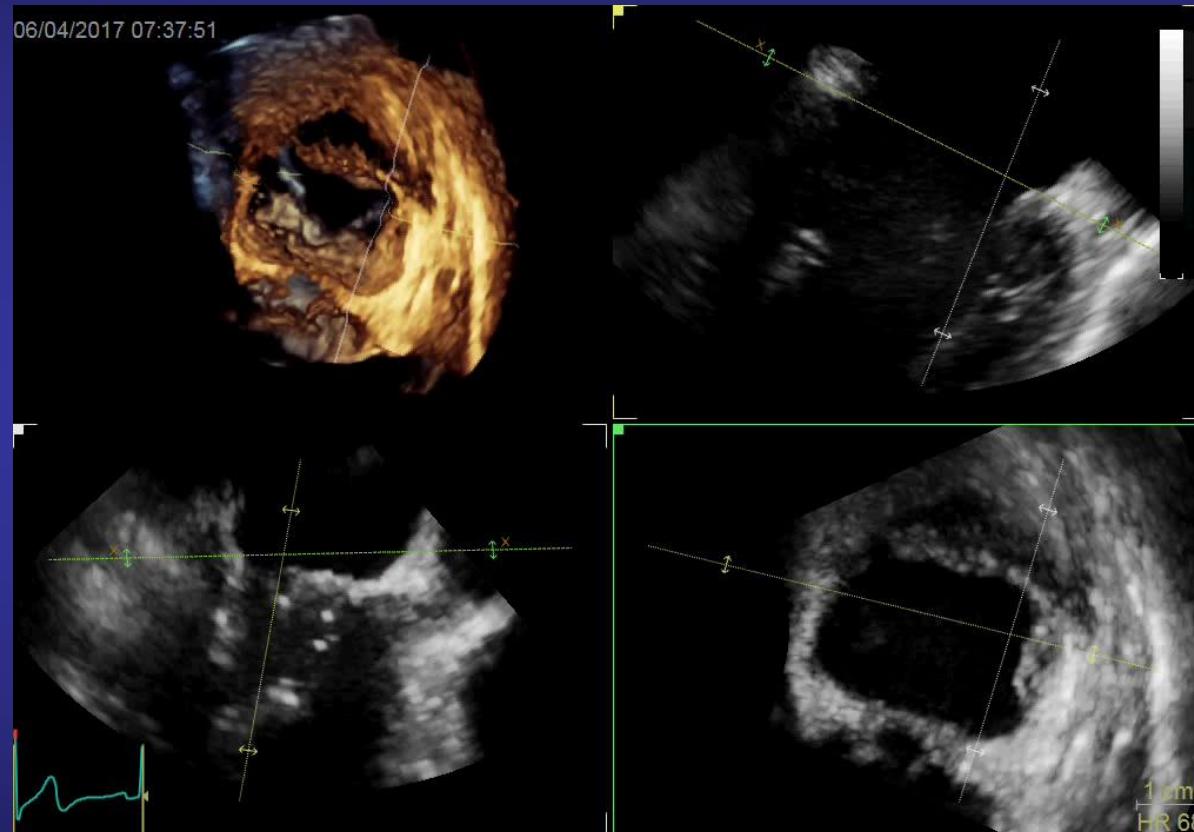
X-plane/Multi-D



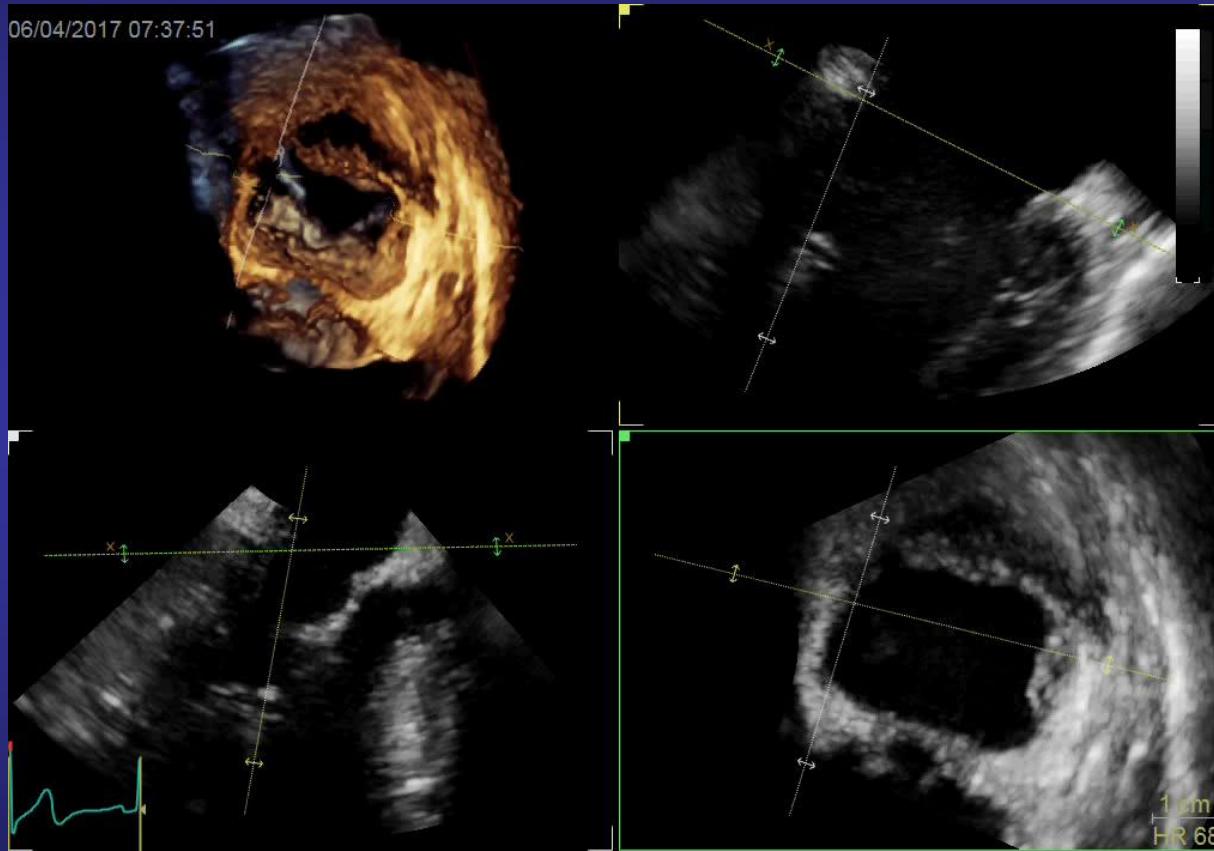
# 3D analysis of MV: MPRs



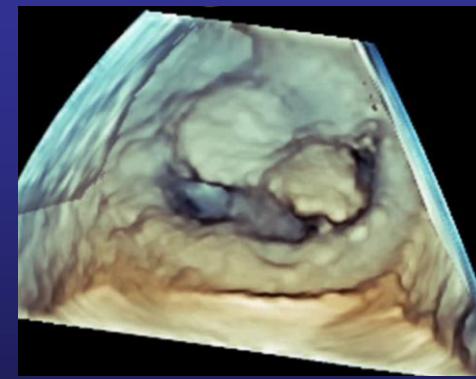
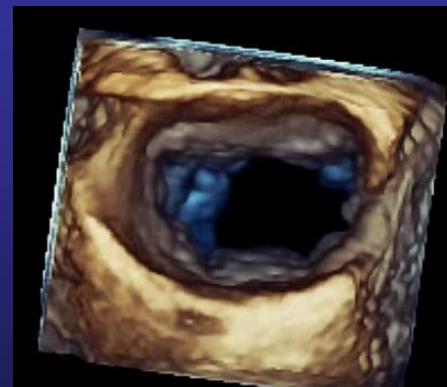
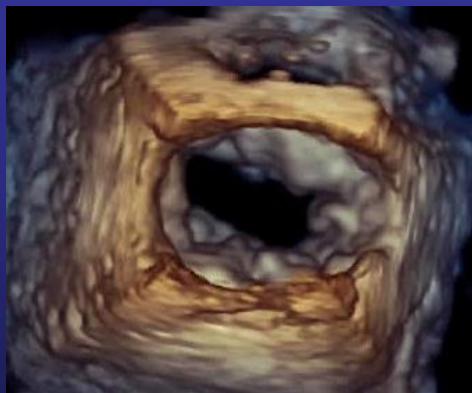
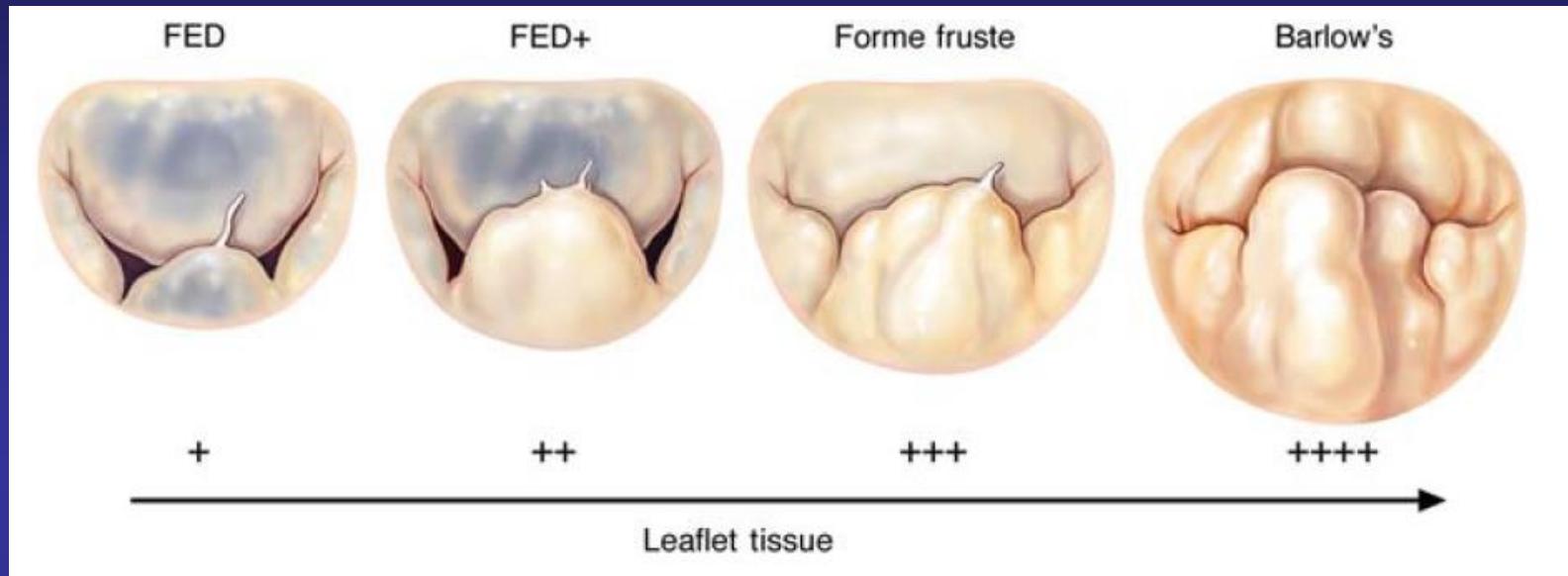
# 3D analysis of MV: MPRs

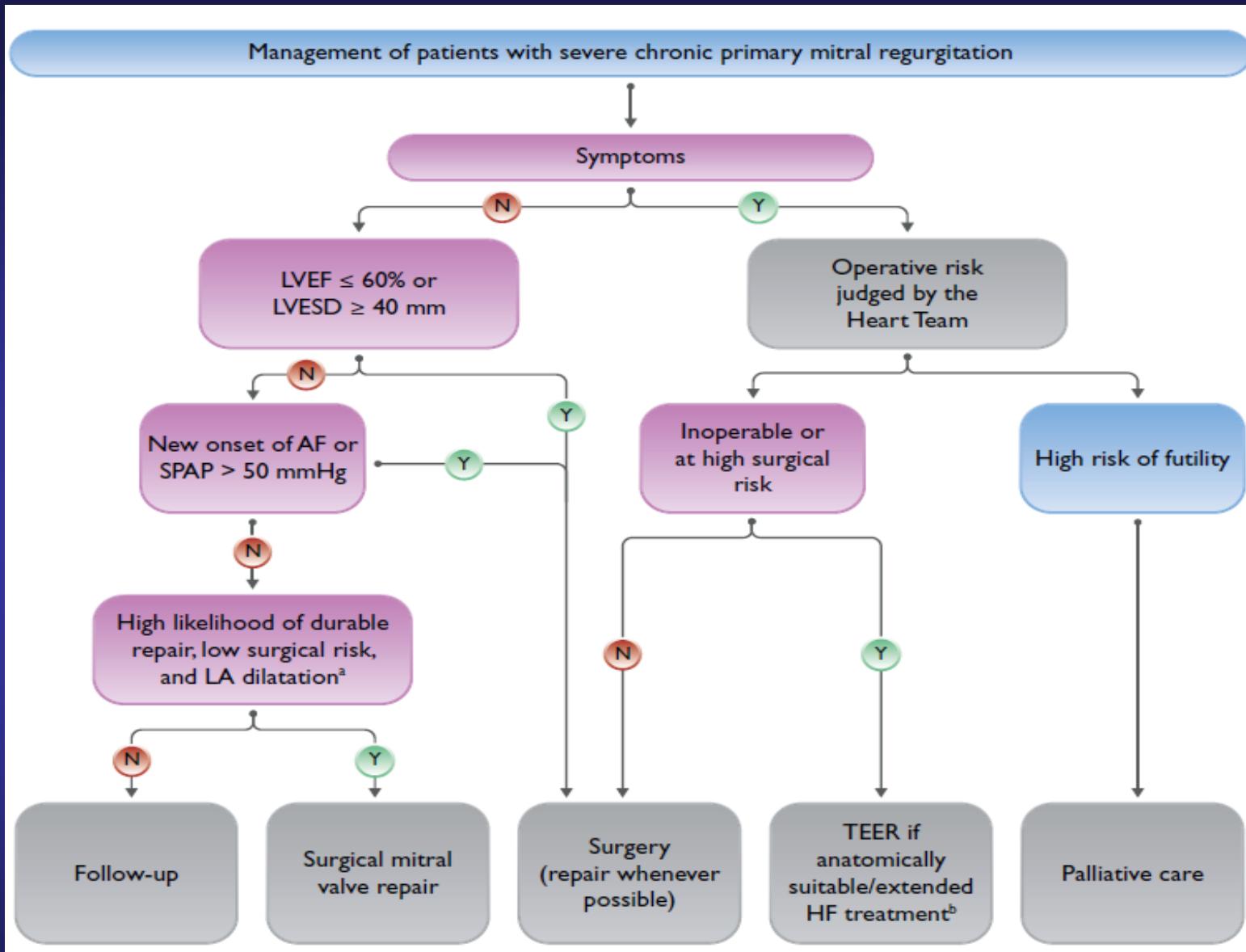


# 3D analysis of MV: MPRs

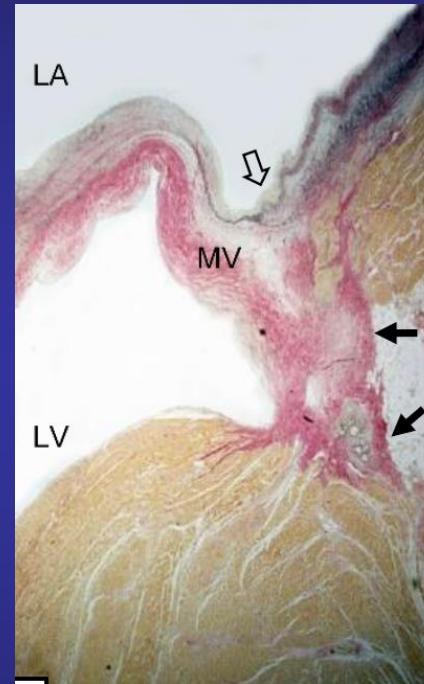
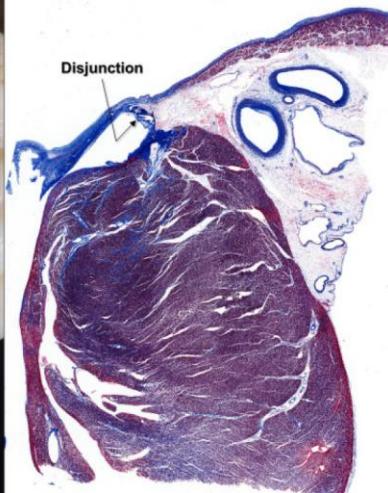
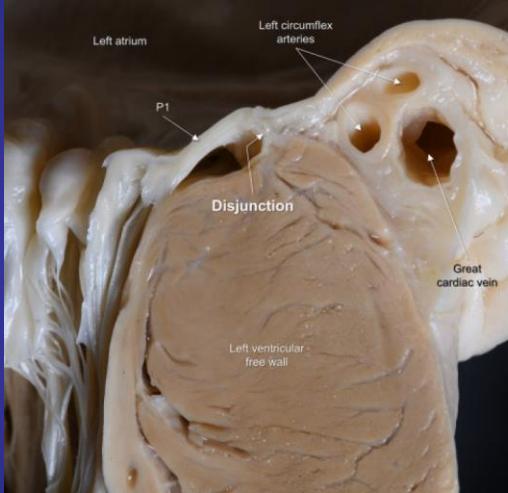


# Chronic primary MR



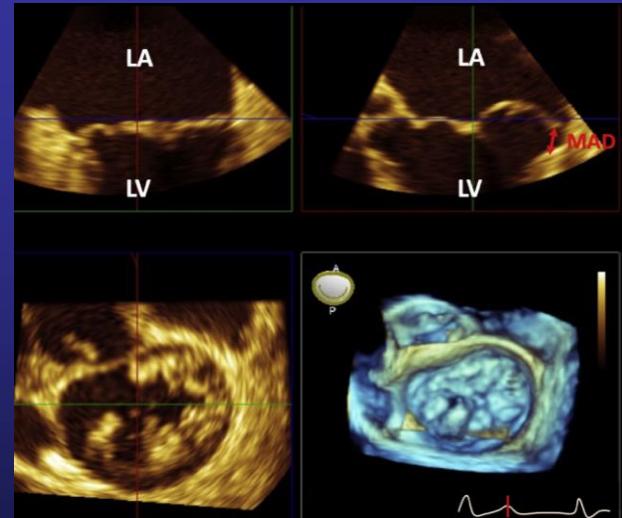
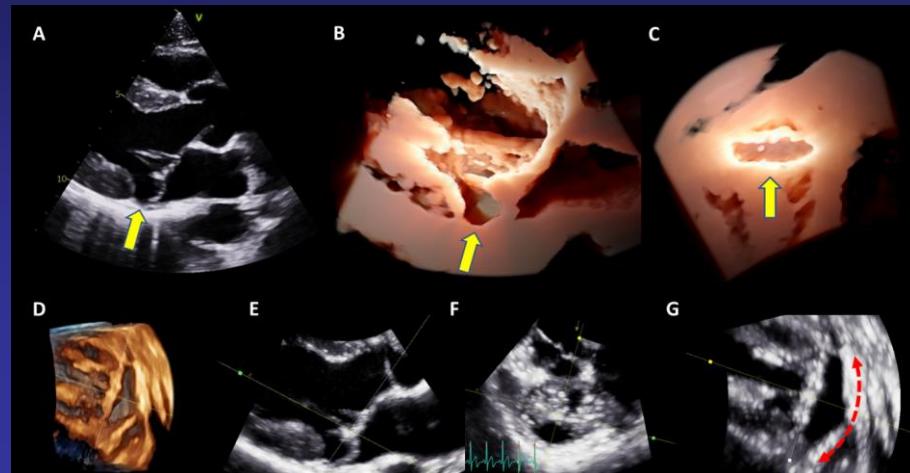
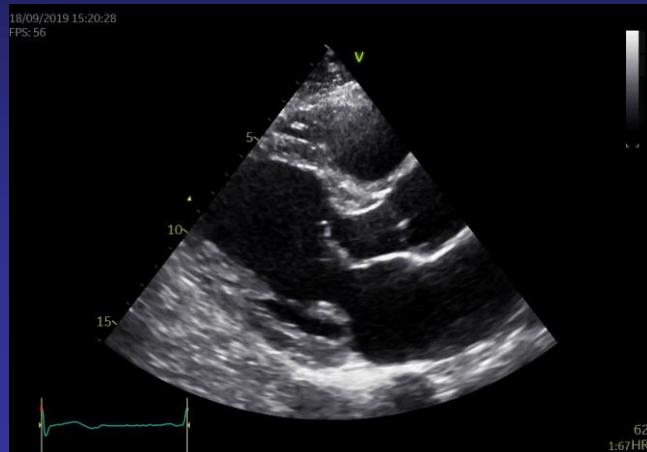


# Mitral annulus disjunction: MAD



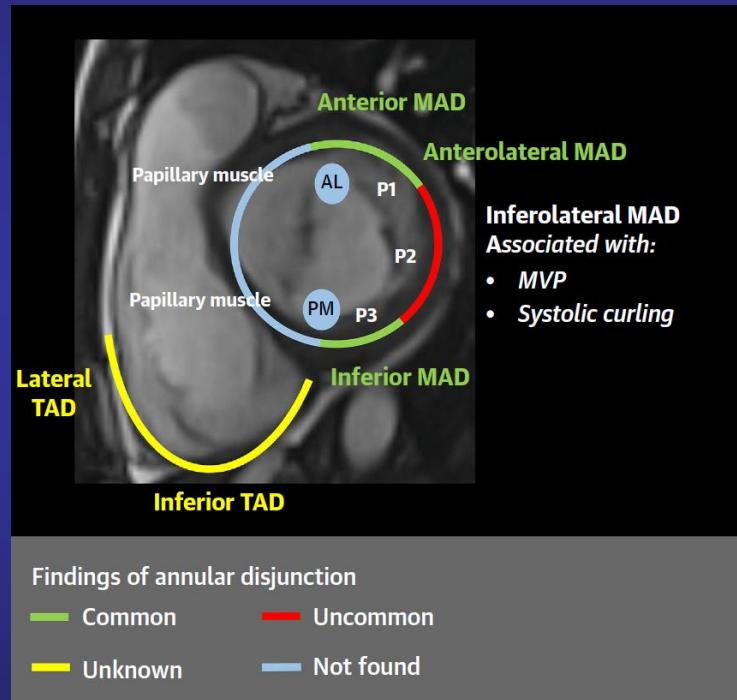
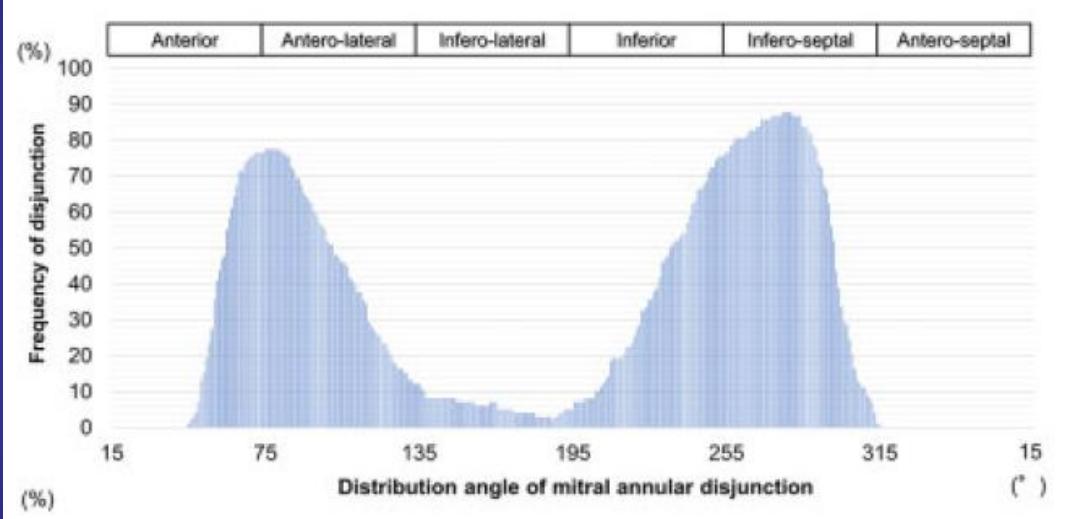
Henle et al, Nature 1871; Hutchins et al, NEJM 1986

# MAD: 3D Echocardiography



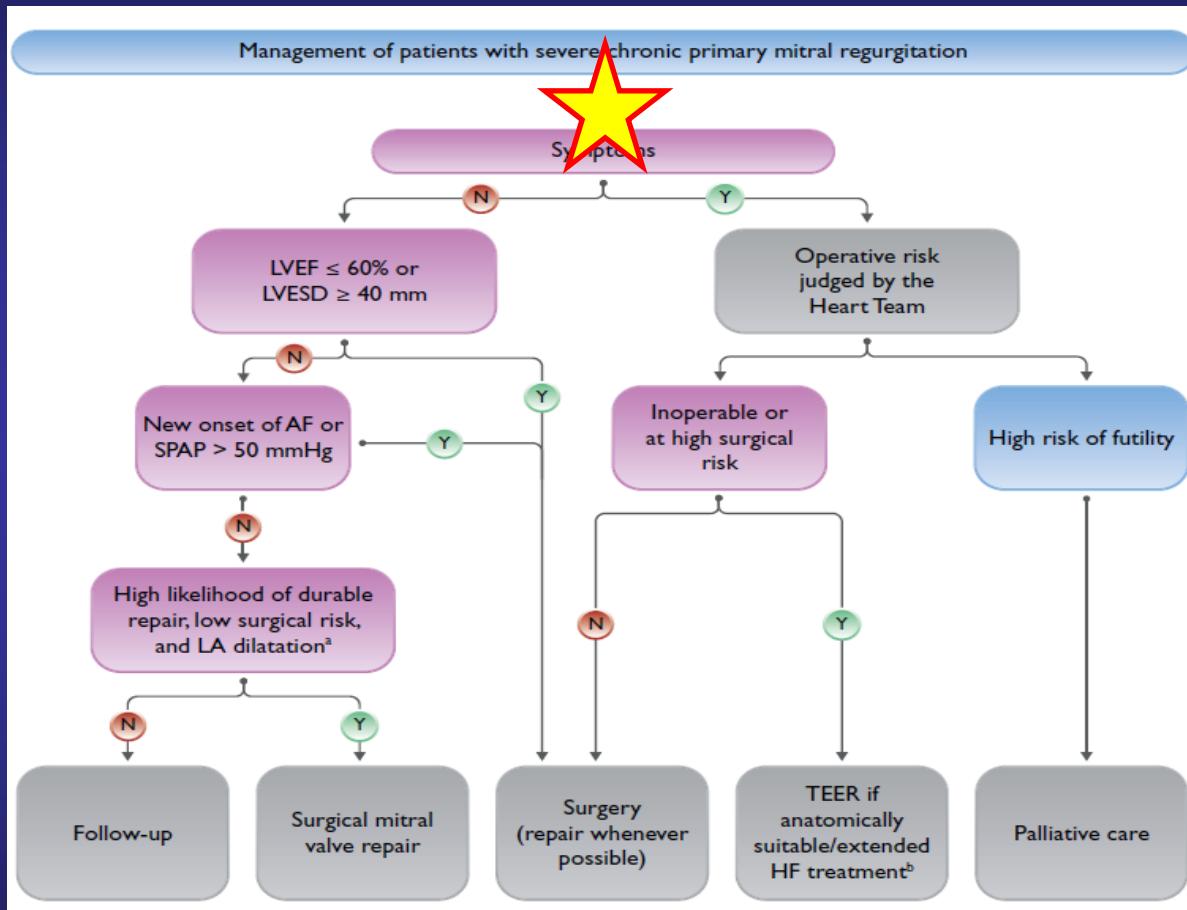
Essayagh et al JASE 2022

# MAD: Normal or Abnormal?



Toh et al, EHJ CVI 2021

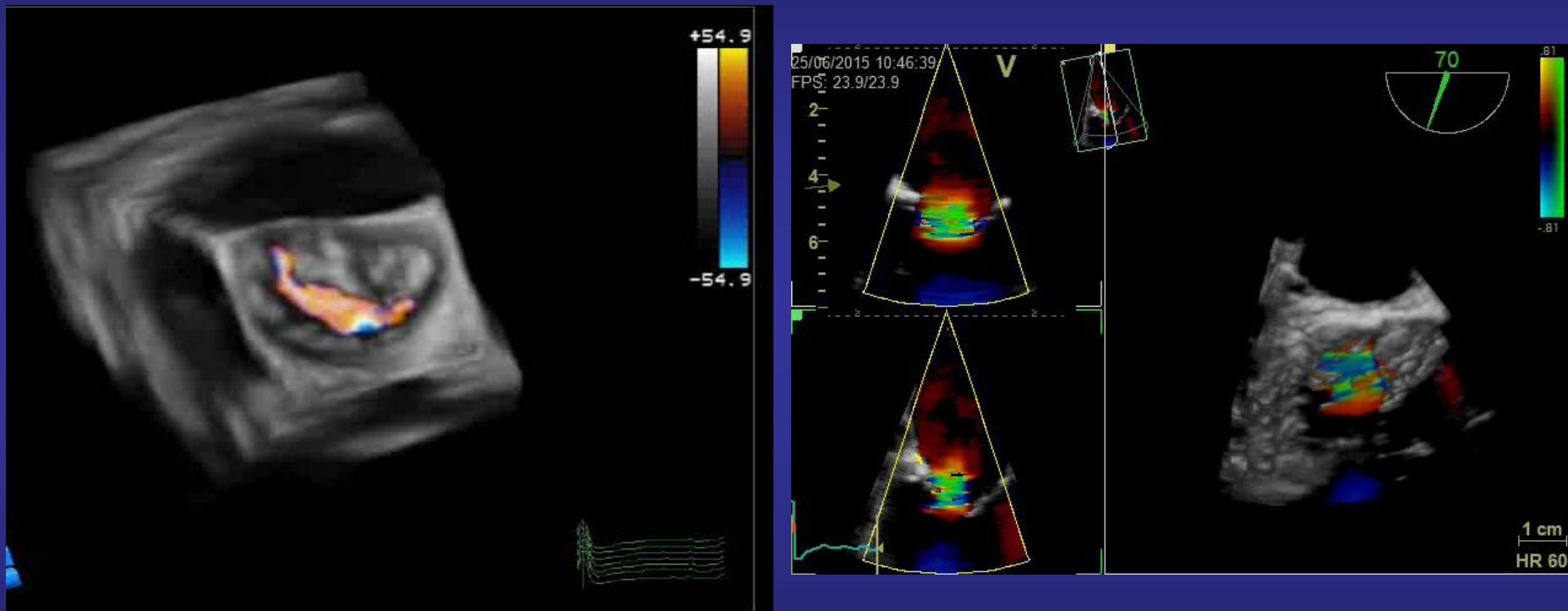
# Indication for Intervention



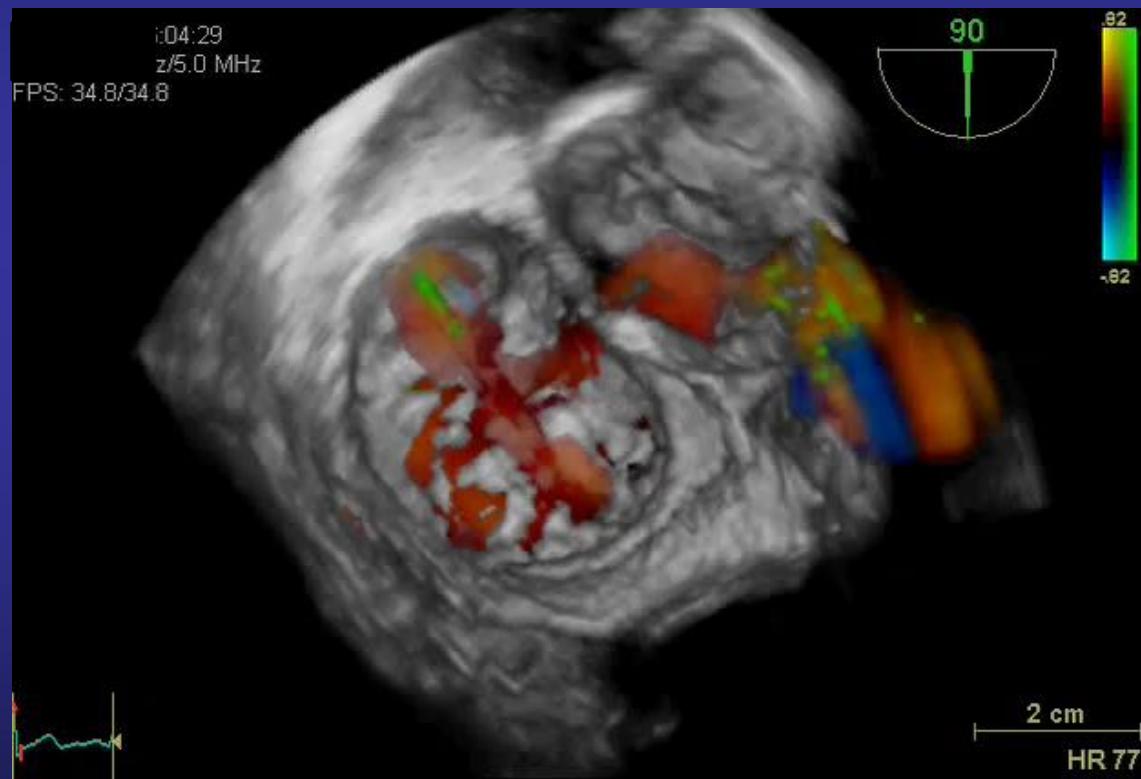
# Severity of mitral regurgitation

	Primary mitral regurgitation	Secondary mitral regurgitation
<b>Qualitative</b>		
Mitral valve morphology	Flail leaflet, ruptured papillary muscle, severe retraction, large perforation	Normal leaflets but with severe tenting, poor leaflet coaptation
Colour flow jet area	Large central jet (>50% of LA) or eccentric wall impinging jet of variable size	Large central jet (>50% of LA) or eccentric wall impinging jet of variable size
Flow convergence	Large throughout systole	Large throughout systole
Continuous wave Doppler jet	Holosystolic/dense/triangular	Holosystolic/dense/triangular
<b>Semiquantitative</b>		
Vena contracta width (mm)	$\geq 7$ ( $\geq 8$ mm for biplane)	$\geq 7$ ( $\geq 8$ mm for biplane)
Pulmonary vein flow	Systolic flow reversal	Systolic flow reversal
Mitral inflow	E-wave dominant (>1.2 m/s)	E-wave dominant (>1.2 m/s)
TVI mitral/TVI aortic	>1.4	>1.4
<b>Quantitative</b>		
EROA (2D PISA, mm <sup>2</sup> )	$\geq 40$ mm <sup>2</sup>	$\geq 40$ mm <sup>2</sup> (may be $\geq 30$ mm <sup>2</sup> if elliptical regurgitant orifice area)
Regurgitant volume (mL/beat)	$\geq 60$ mL	$\geq 60$ mL (may be $\geq 45$ mL if low flow conditions)
Regurgitant fraction (%)	$\geq 50\%$	$\geq 50\%$
<b>Structural</b>		
Left ventricle	Dilated (ESD $\geq 40$ mm)	Dilated
Left atrium	Dilated (diameter $\geq 55$ mm or volume $\geq 60$ mL/m <sup>2</sup> )	Dilated

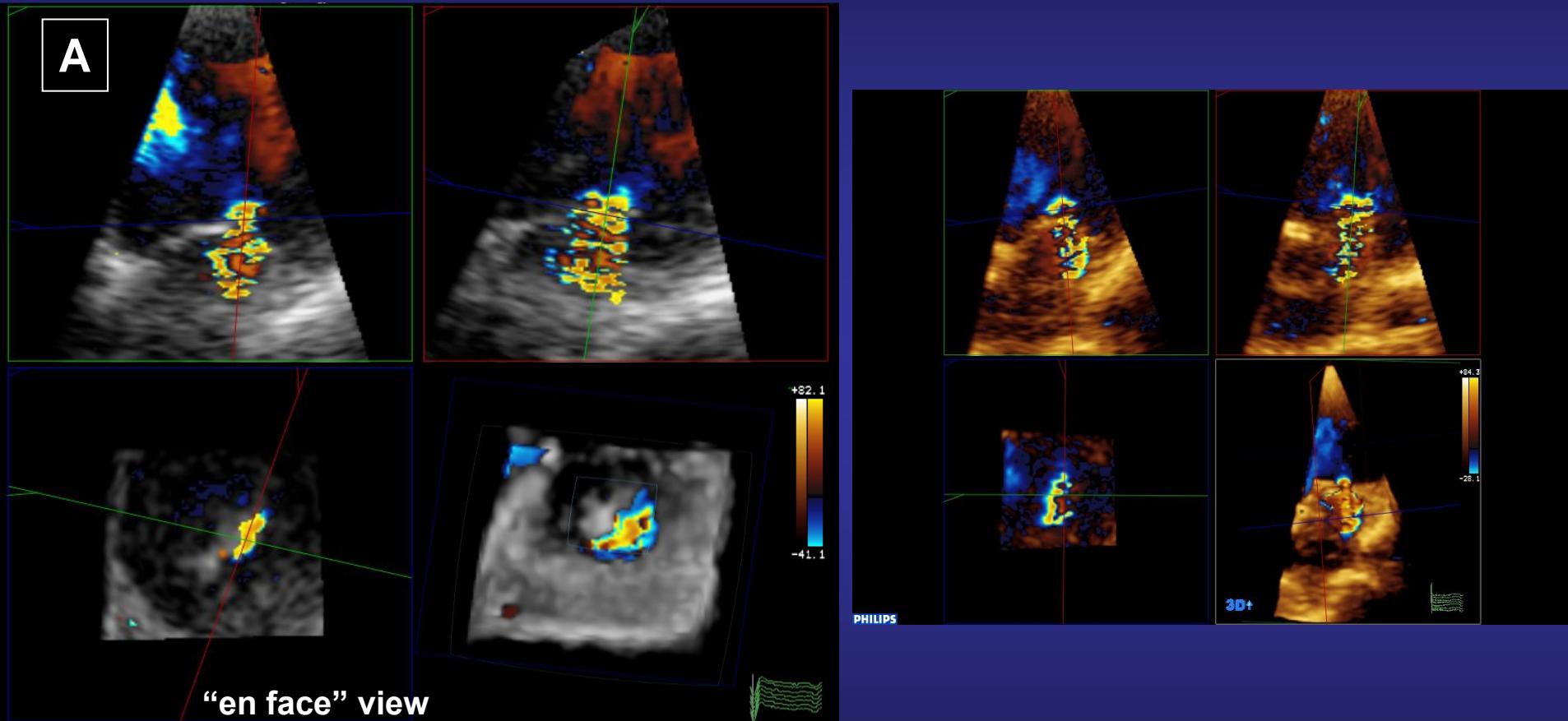
# Mitral regurgitation severity: Secondary MR



# Mitral regurgitation severity: Primary MR

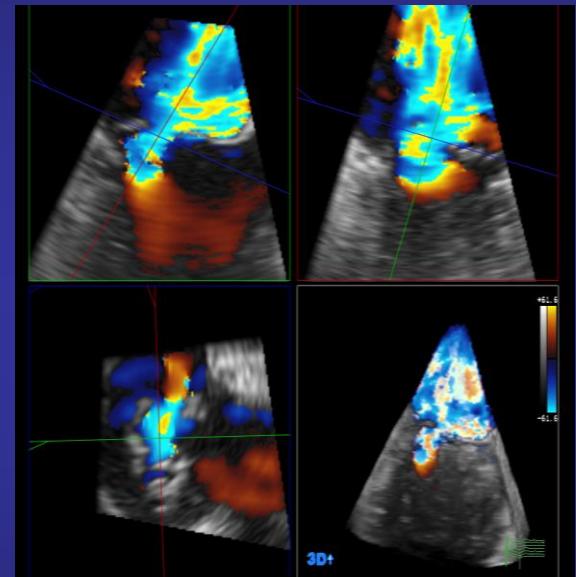
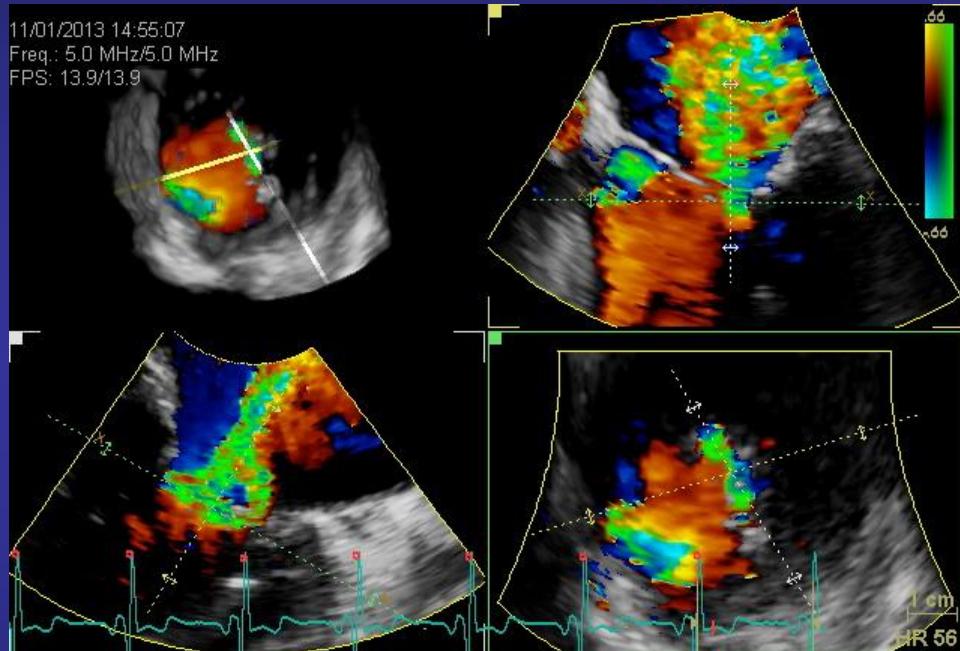


# Mitral regurgitation: 3D EROA



Ajmone Marsan et al JACC Imaging 2009  
Shanks et al, Circulation Imaging 2010

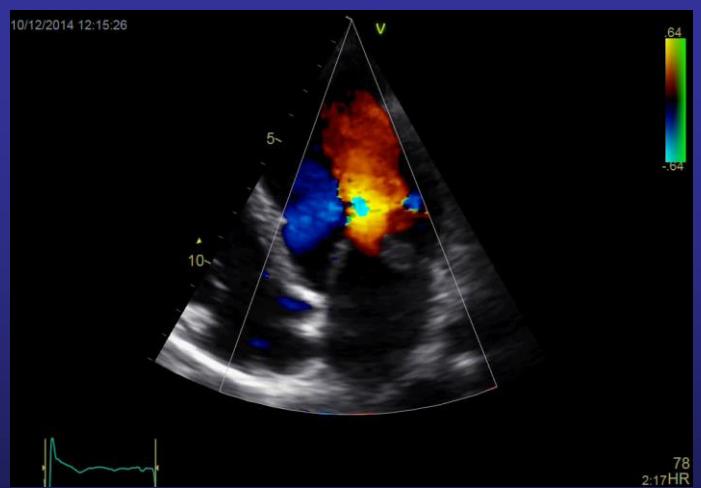
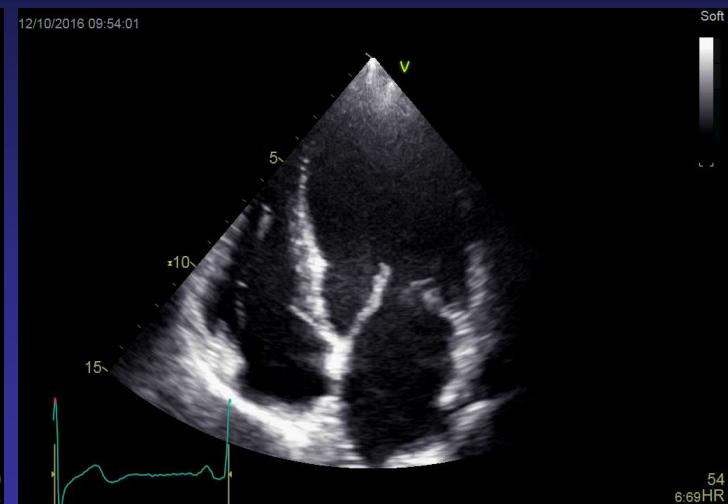
# Color 3D TEE: mitral regurgitation



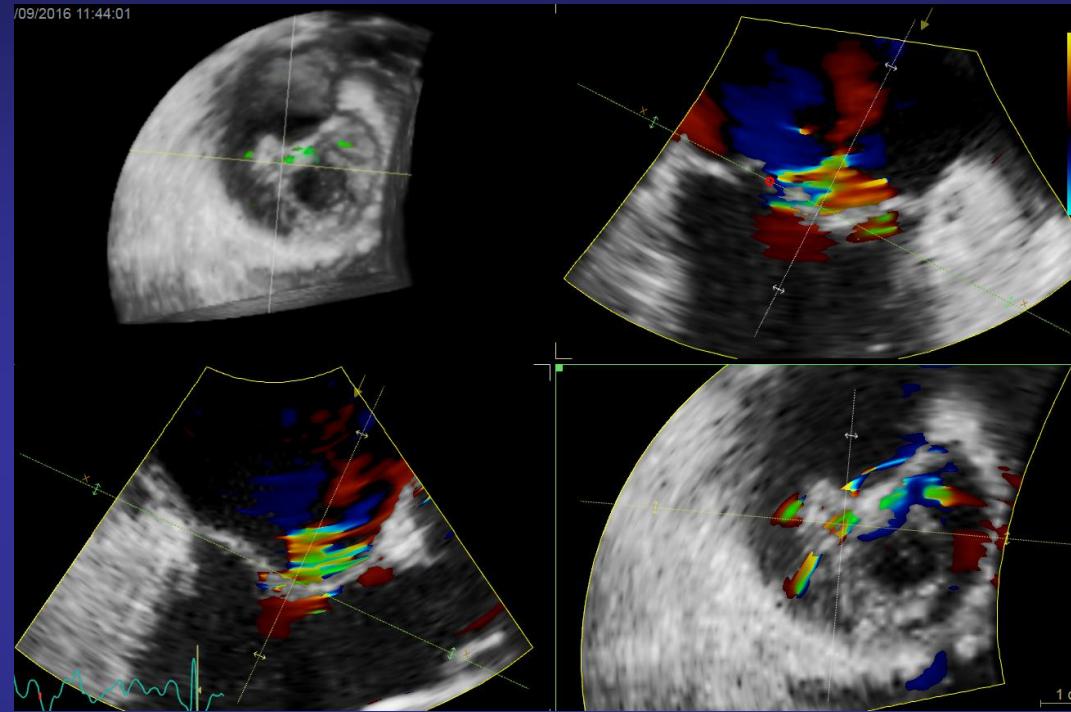
Quantitative assessment of mitral regurgitation: comparison between  
3D Transesophageal Echocardiography and MRI.  
*Circ Imaging 2010*

# Case

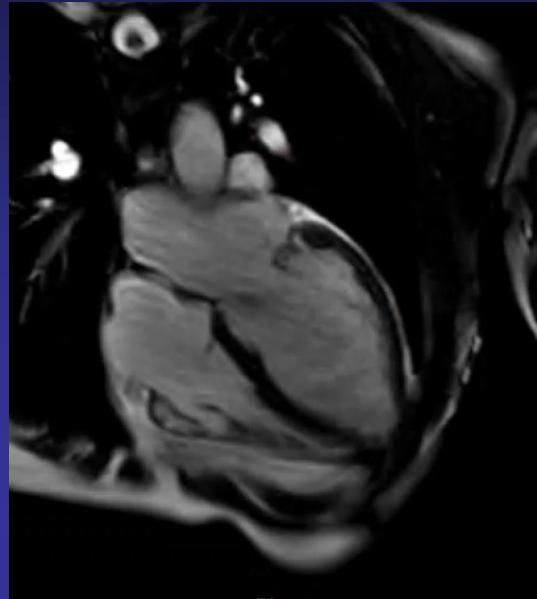
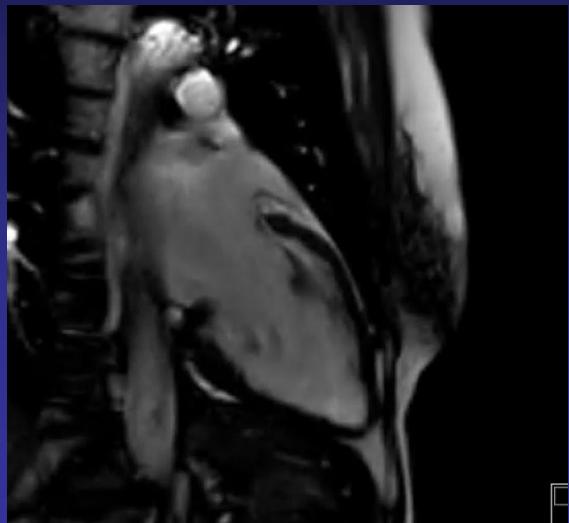
- **55 year old woman**
- **Known with Barlow MV with mild-moderate MR and under yearly regular FU**
- **Development of symptoms: fatigue**



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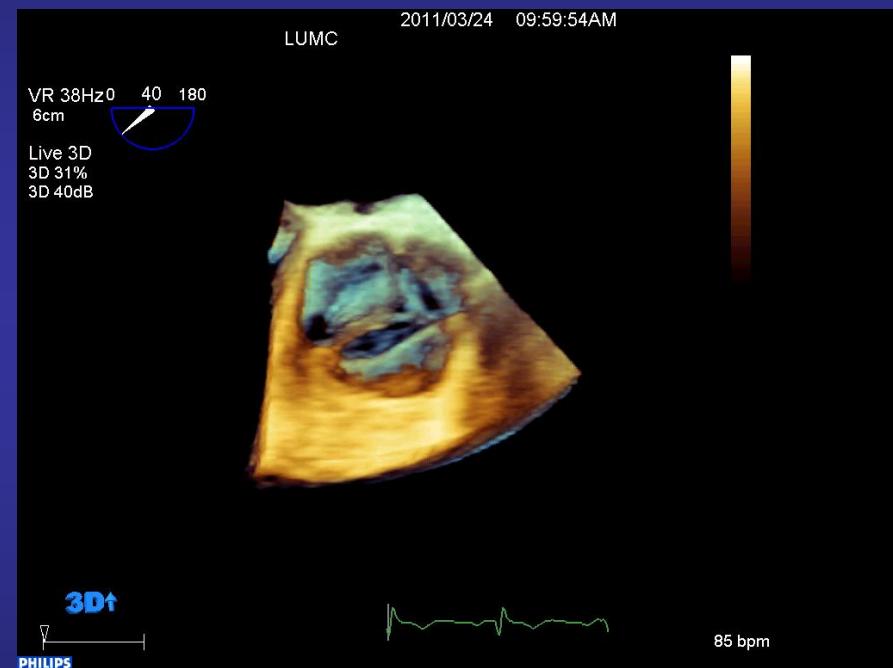
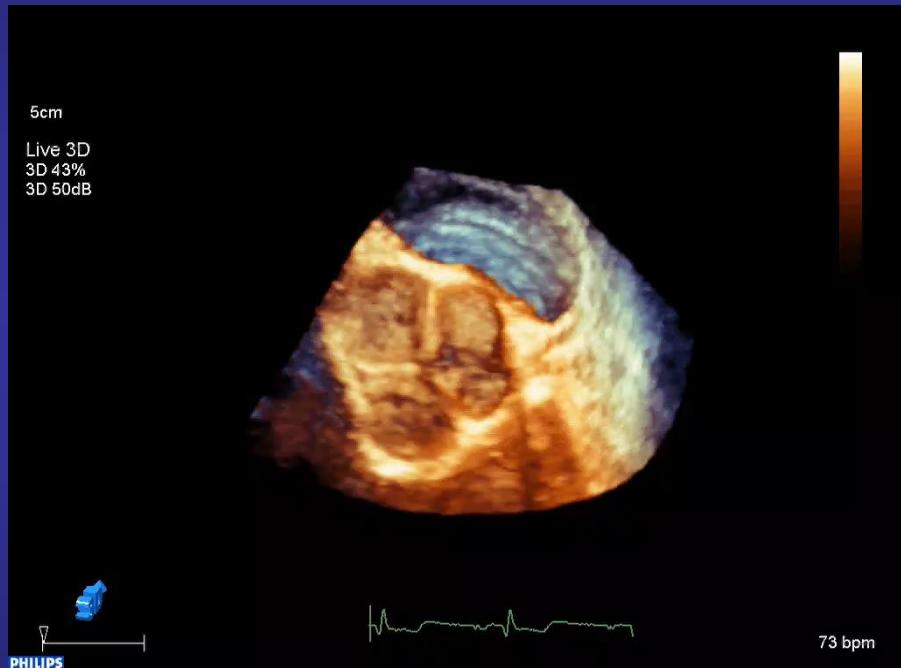


**3DEROA 39mm<sup>2</sup>**



**LV volume 206 ml, LVEF 46%**  
**Rvol 58 ml**

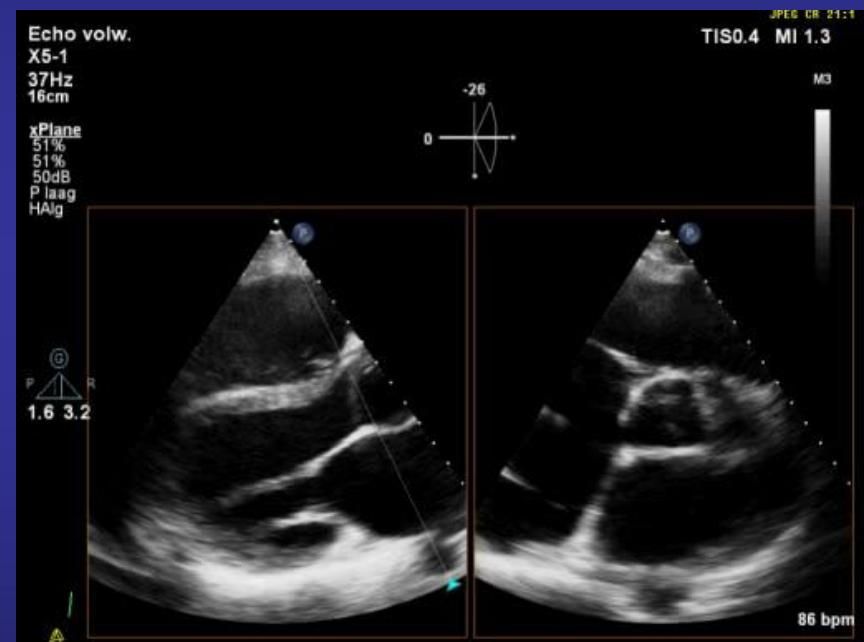
# 3D echocardiography: Aortic valve



# Xplane/Multi-D: AV



AV stenosis

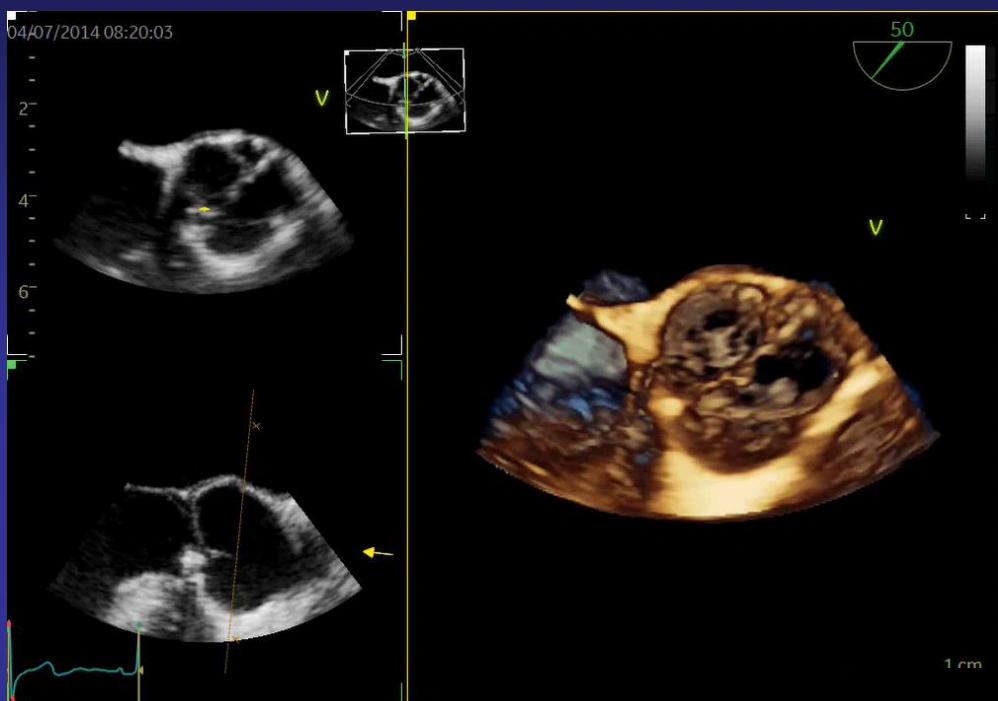


Bicuspid AV

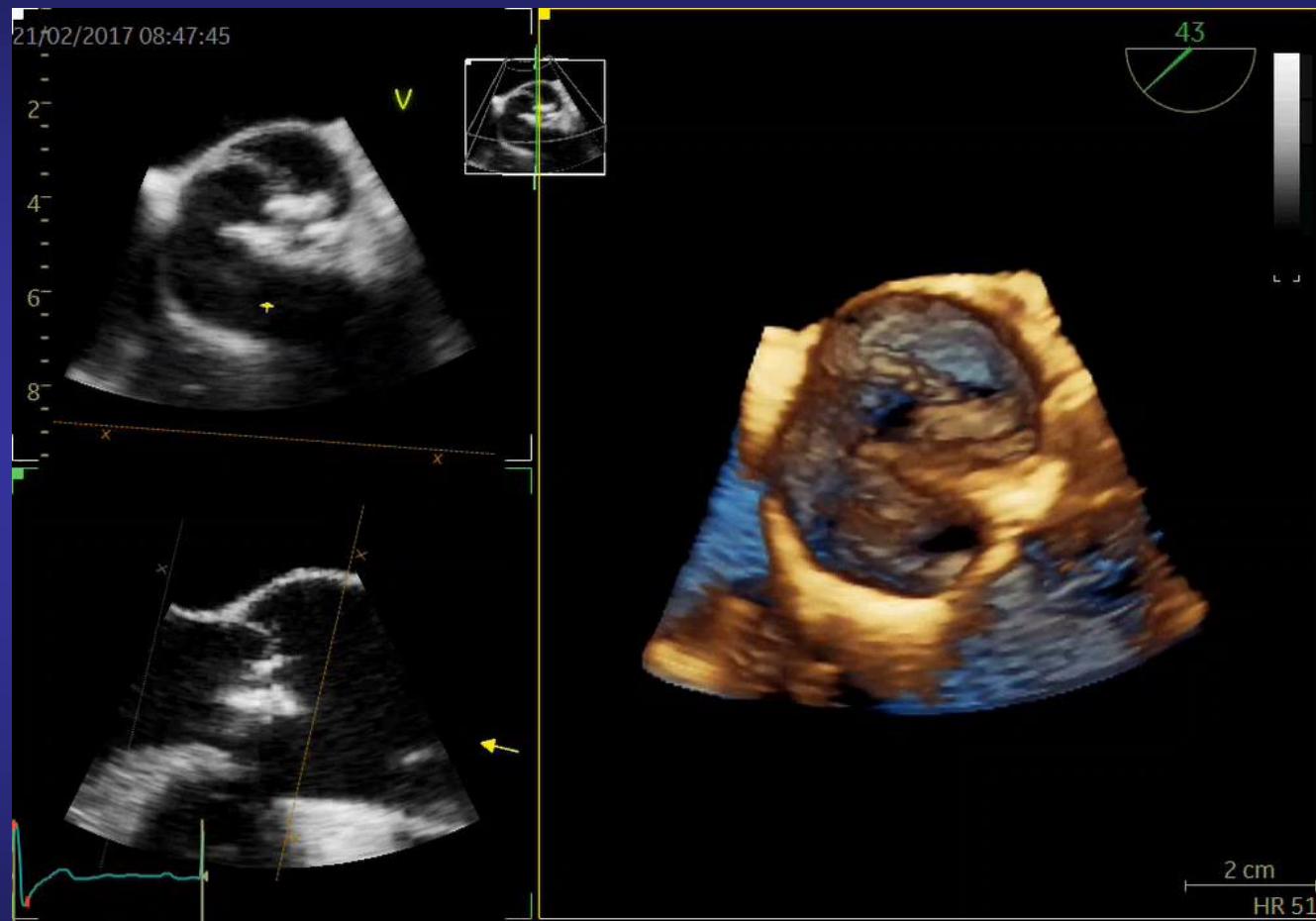
# 3D views: AV TEE



# 3D views: AV TEE

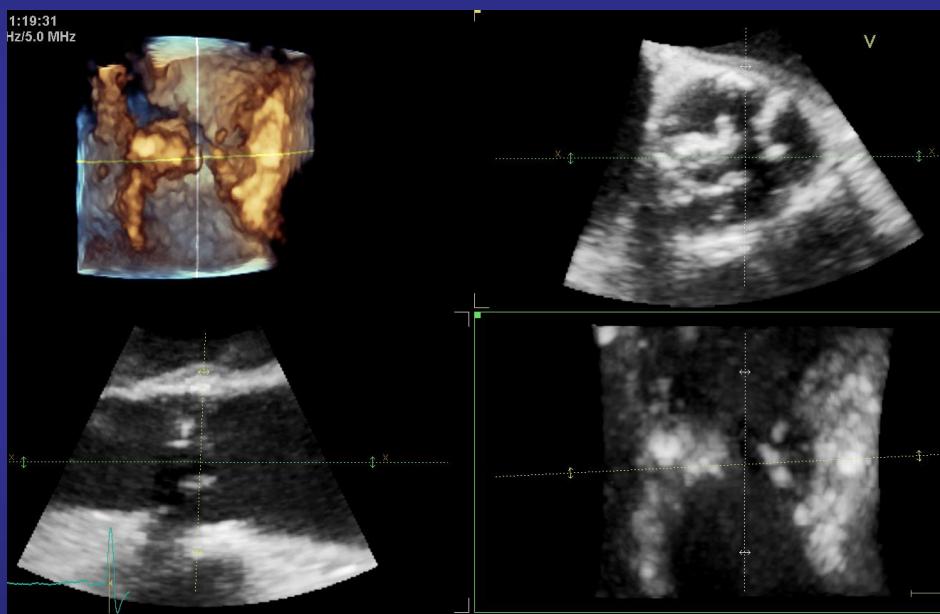


# 3D views: AV TEE



# Aortic valve stenosis: Quantification

Aortic valve area



LVOT



# **Conclusions**

- RT3DTTE and TEE are of great additional value for the assessment of MV and AV disease
- RT3DTEE should be implemented for these indication in the routine of the echolab