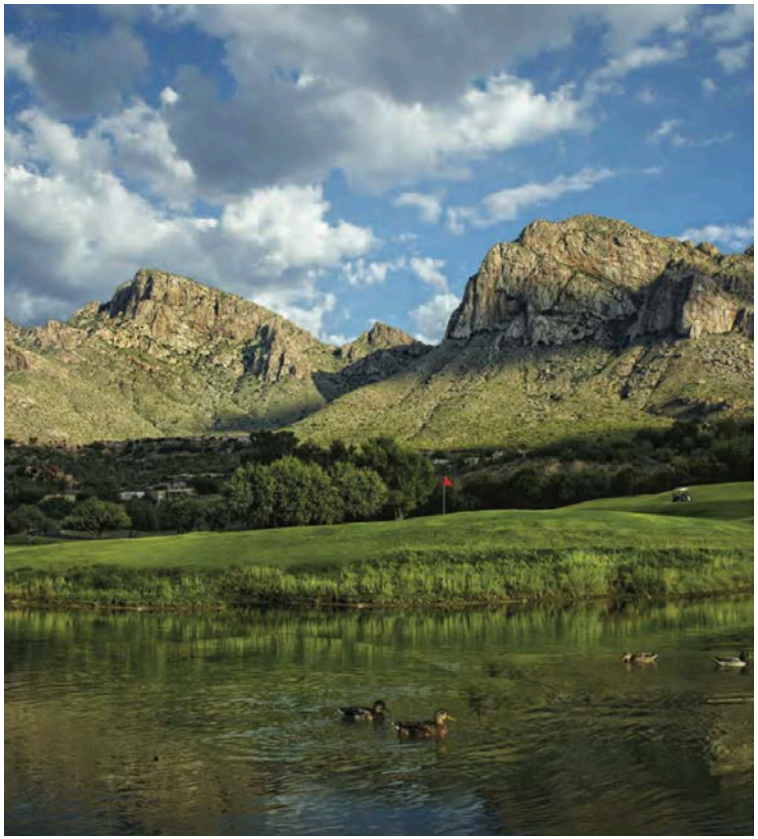


Echocardiographic Evaluation of Degenerative Mitral Valve Disease

State-of-the-Art ECHOCARDIOGRAPHY: ECHO SOUTHWEST

29th ANNUAL

THE UNIVERSITY OF CHICAGO

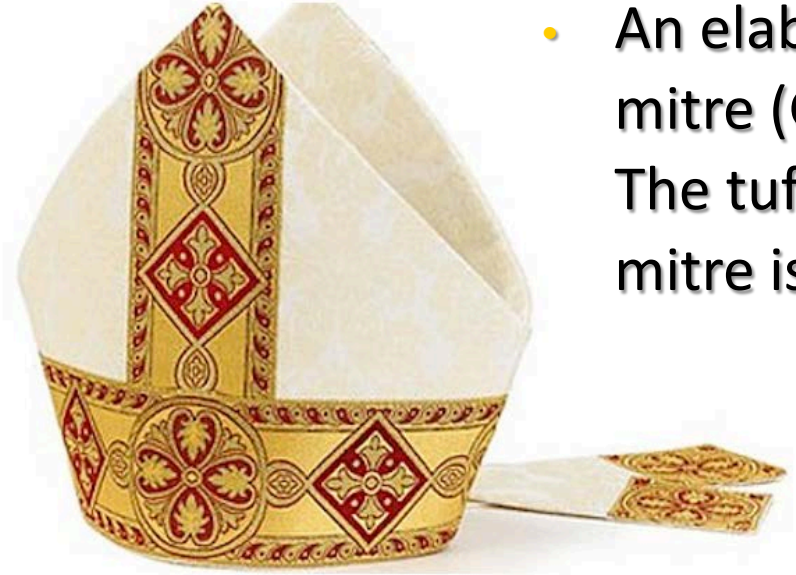
CARDIAC IMAGING CENTER

Roberto M. Lang, MD

Conflict of Interests

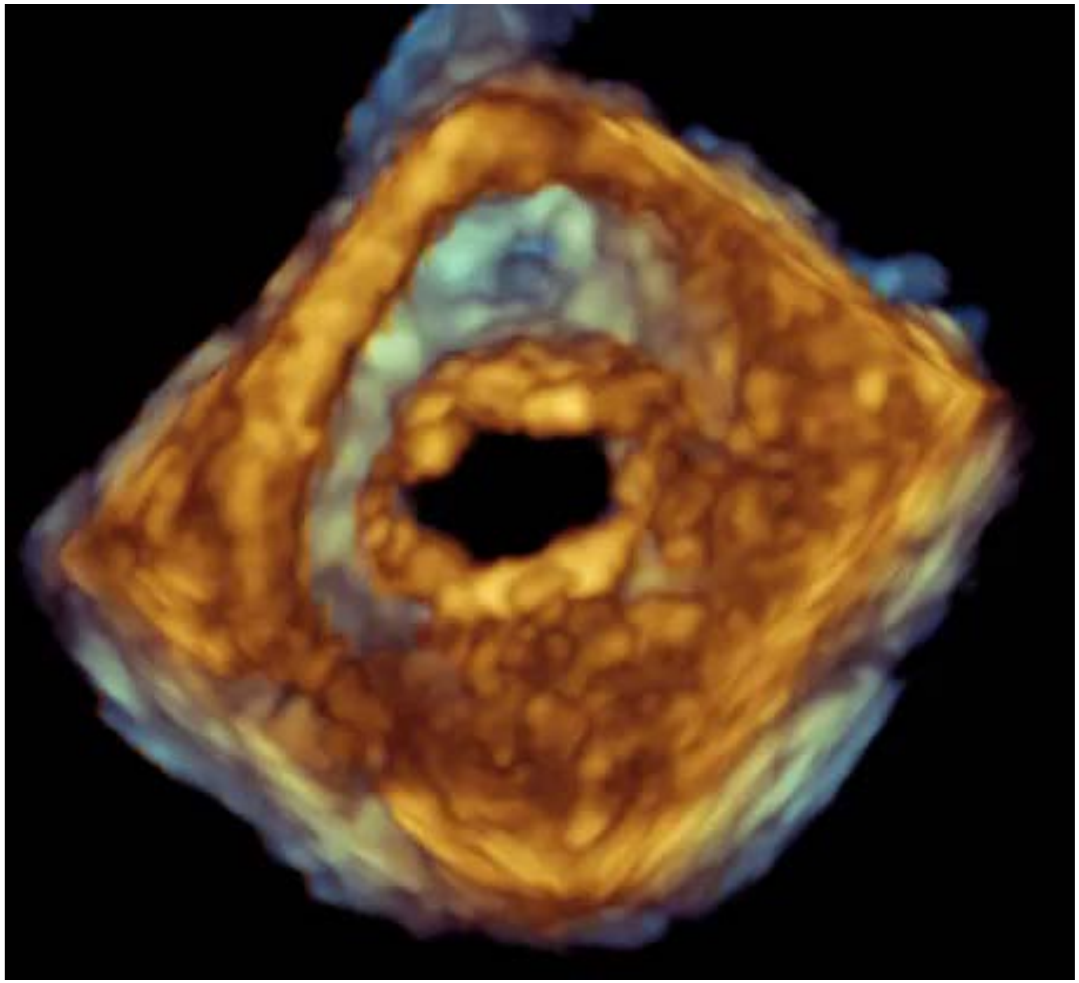
- **Echo-Insight**
  - **Research Grants**
- **Tomtec**
  - **Research Grants**
- **Philips Medical Imaging**
  - **Research Grants**
  - **Speakers bureau**
  - **Advisory bureau**

1953- The Technique is born



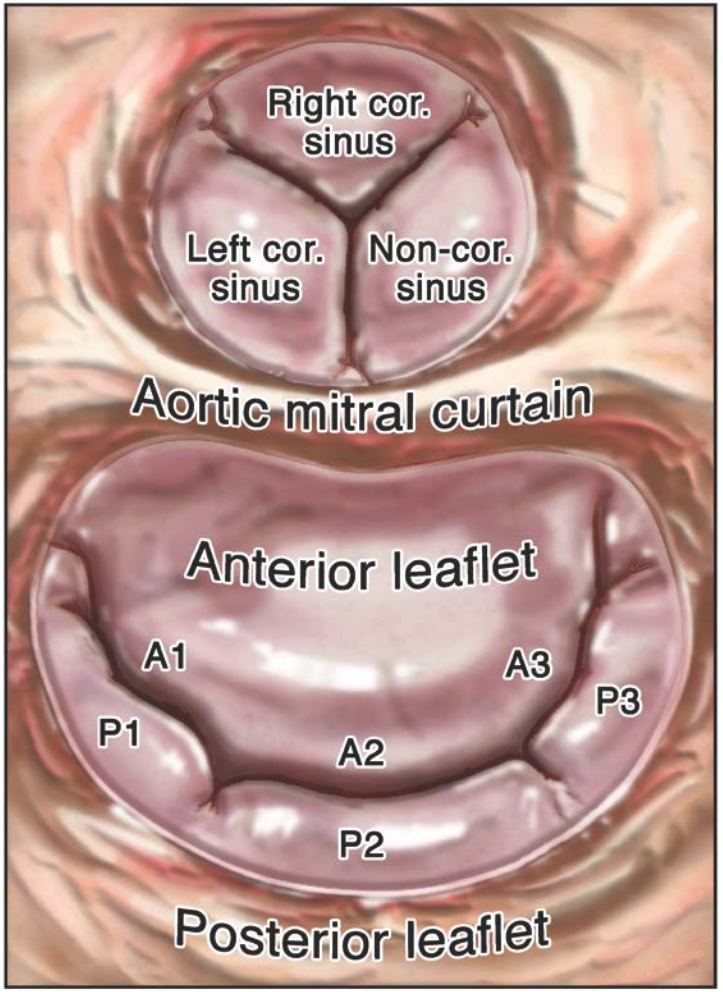
- An elaborately decorated heraldic Western mitre (Greek: μίτρα, "headband" or "turban"). The tufts along the edges indicate that this mitre is that of an archbishop

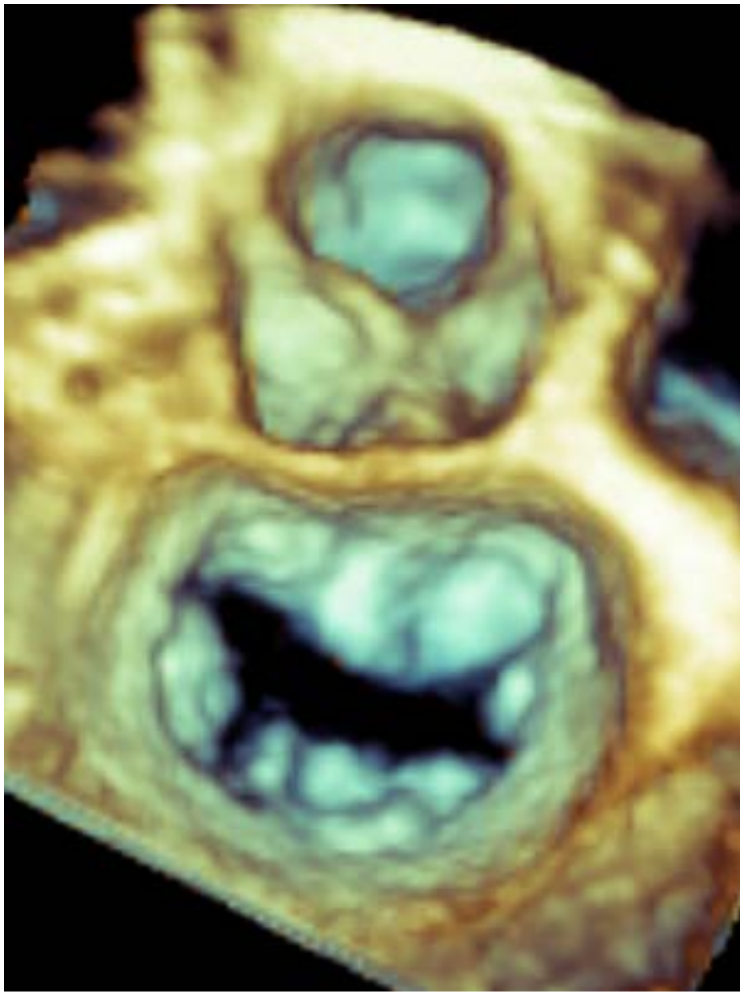
Matrix TEE Probe: 2007



Sugeng L, Shernan SK, Salgo IS, Weinert L, Shook D, Raman J, Jeevanandam V, DuPont F, Settlemier S, Savord B, Fox J, Mor-Avi V, Lang RM. *J Am Coll Cardiol* 2008 August 5;52(6):446-449.

Surgeon's View of the MV



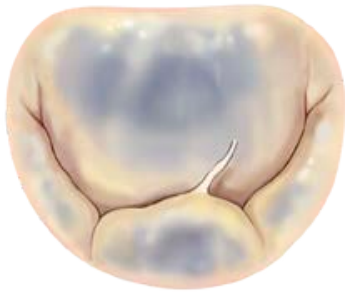
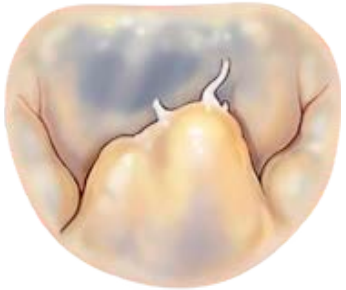
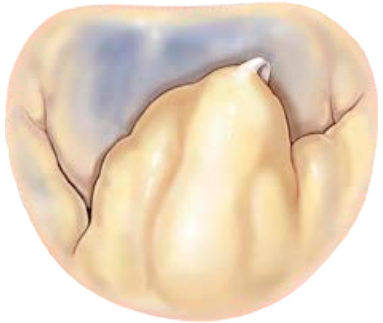


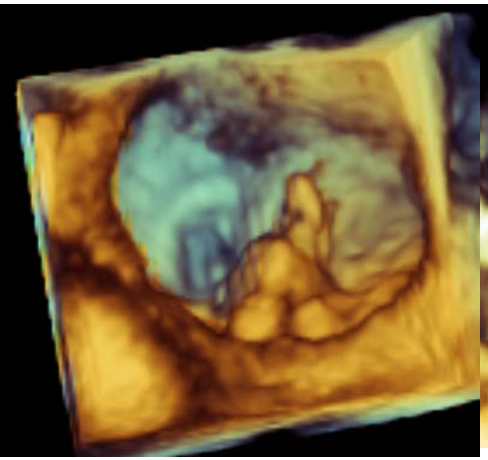
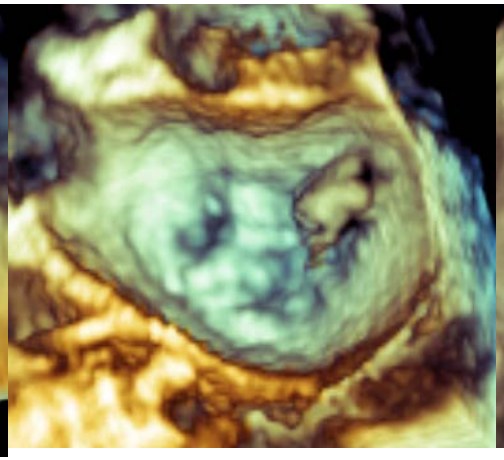
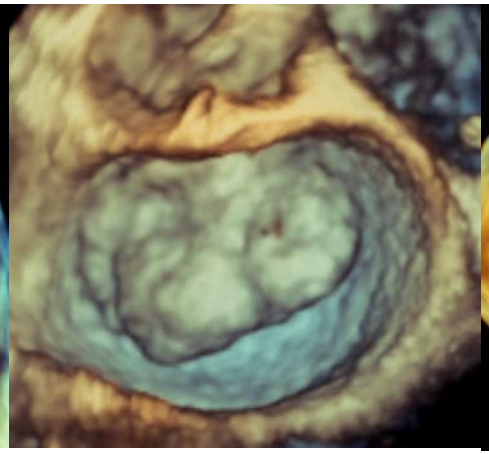
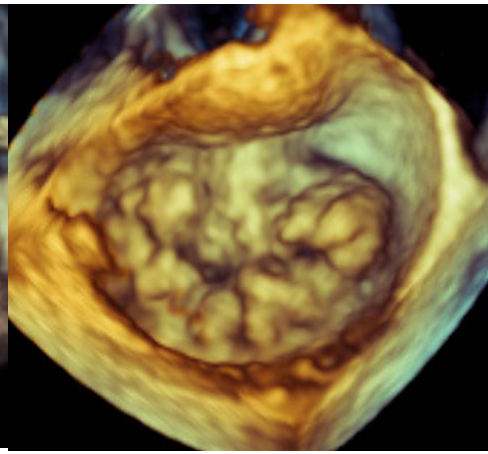
Lang RM, Tsang W, Weinert L, Mor-Avi V, Chandra S. J Am Coll Cardiol 2011 November 1;5 8(19):1933-1944.

Degenerative MV Disease

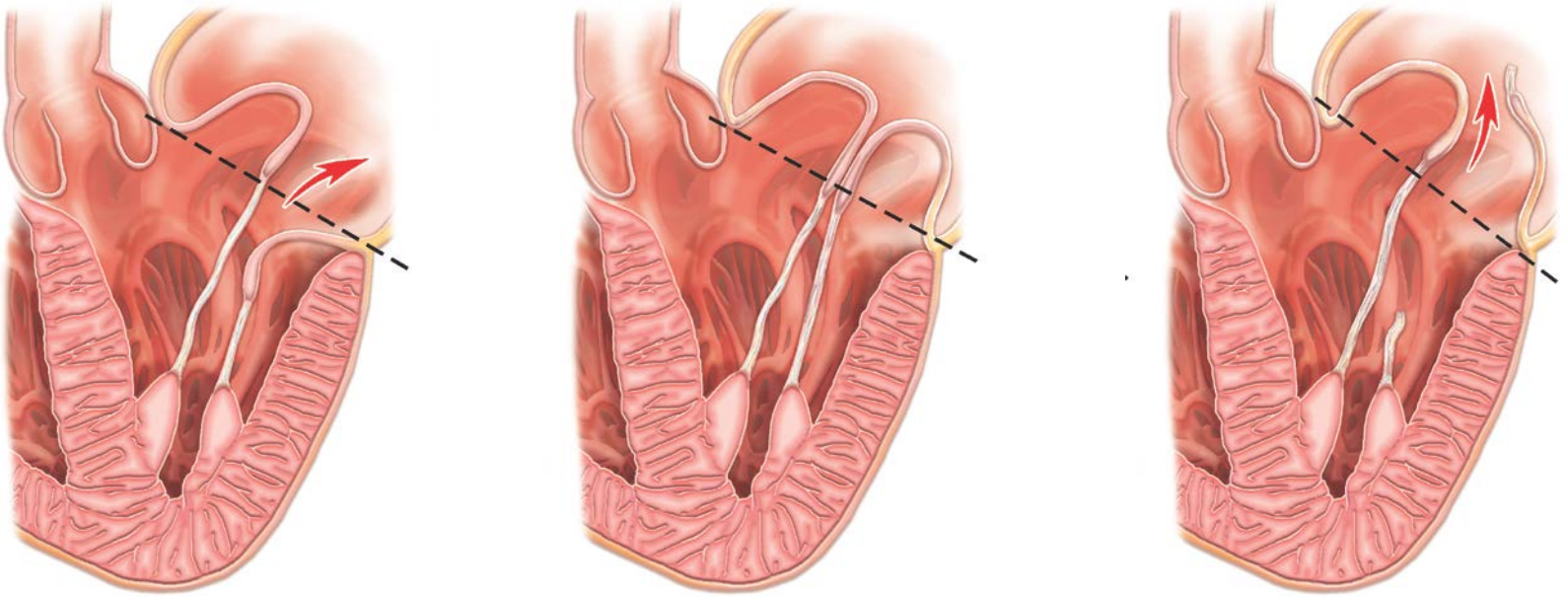
Excess Tissue

+	++	+++	++++
FED	FED+	Form Fruste	Barlow's

Degenerative MV Disease

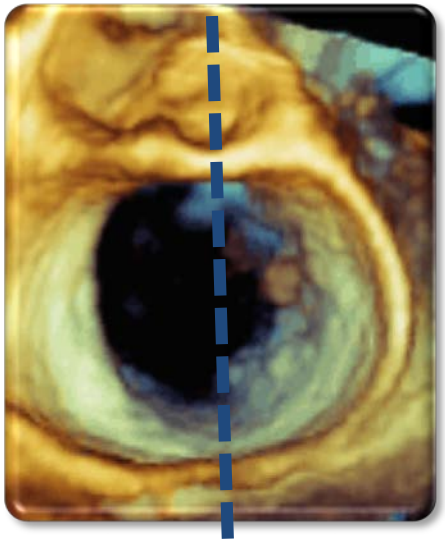


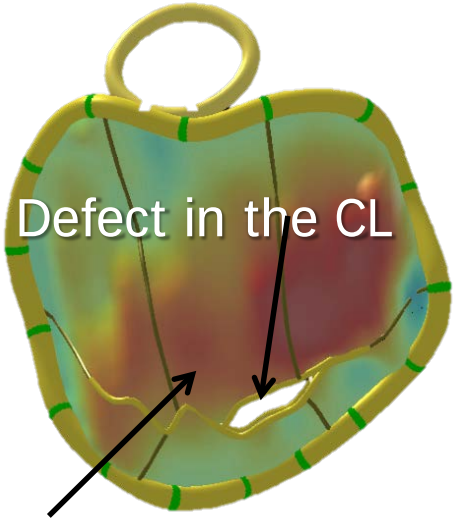
Prolapse: **Free edge of the leaflet above the plane of the annulus at end-systole. Disruption of coaptation.**

Billowing: **Systolic protrusion of leaflet body above the annulus plane Free leaflet edge remaining at or below the annular plane during end-systole**

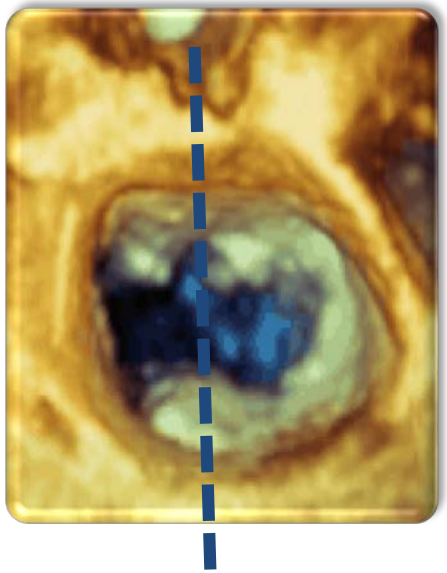
Lang RM, Tsang W, Weinert L, Mor-Avi V, Chandra S. J Am Coll Cardiol 2011 November 1;5 8(19):1933-1944.

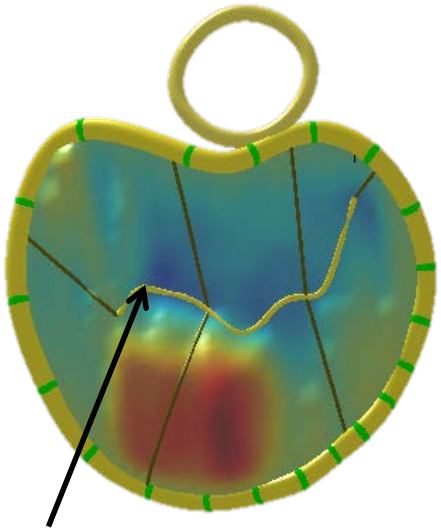
3D Definition for Billowing and Prolapse



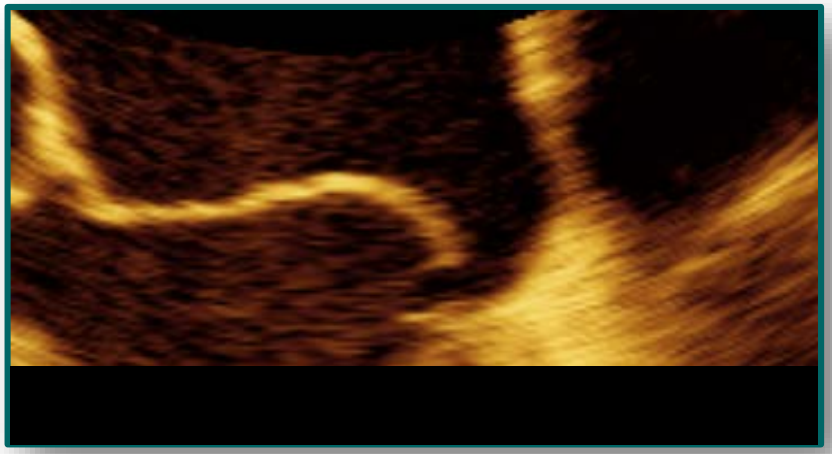


Prolapse extending to CL

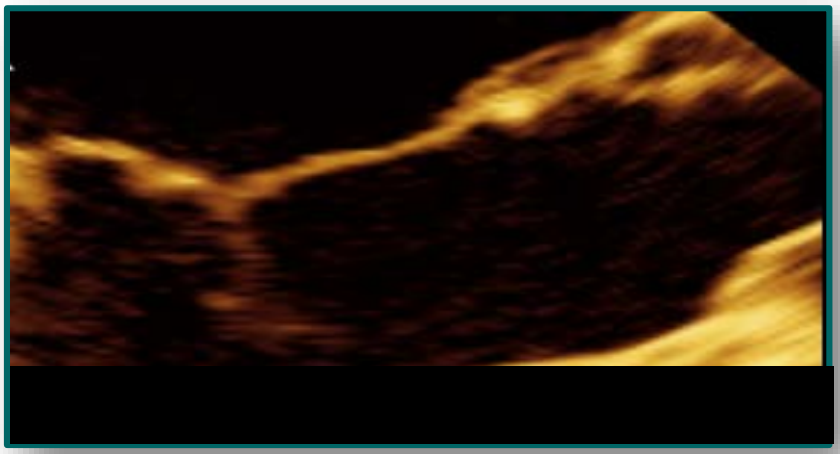




Intact CL

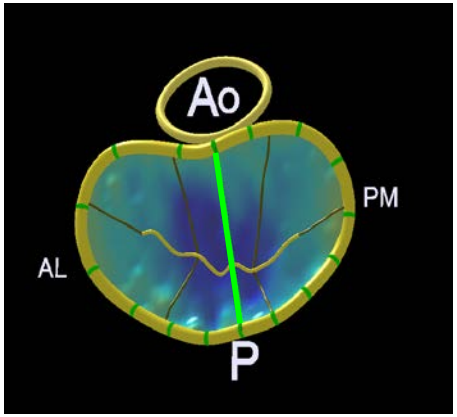


Prolapse



Billowing

Addetia K , Lang RM et. al. J Am Soc Echocardiogr. 2014 Jan;27(1):8-16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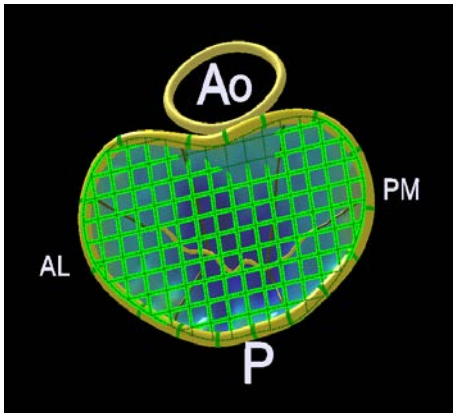
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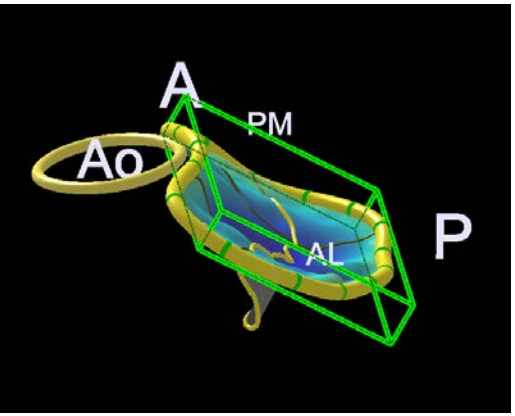
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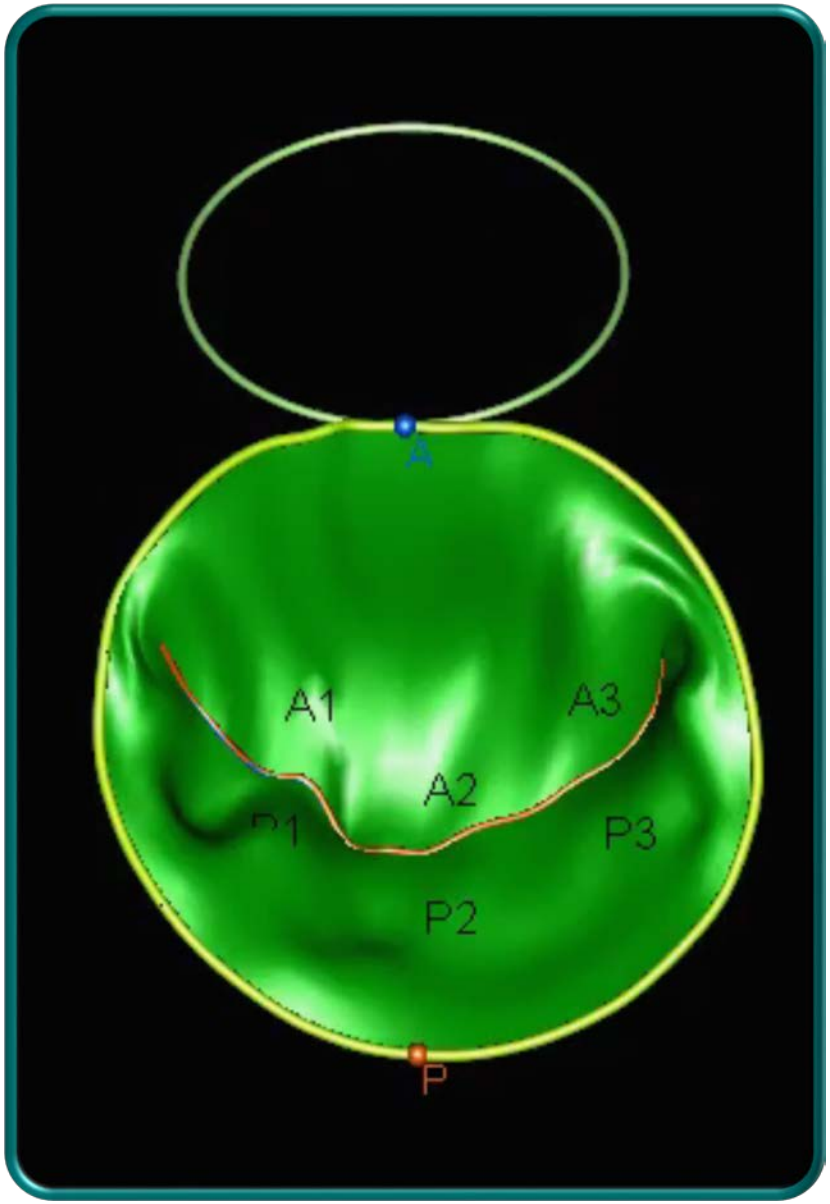
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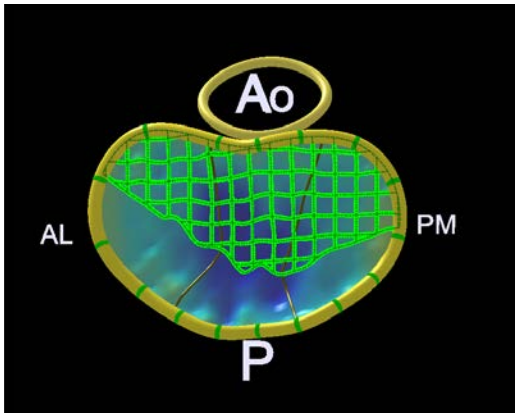
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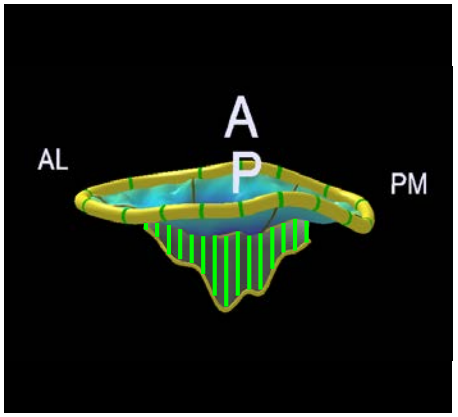
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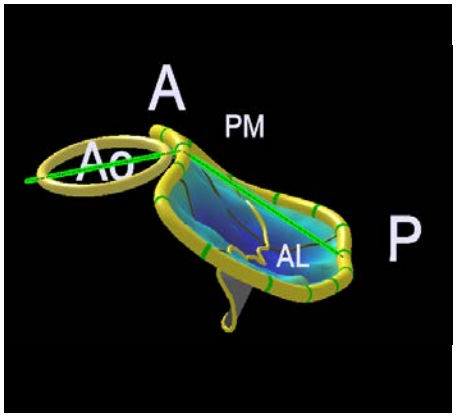
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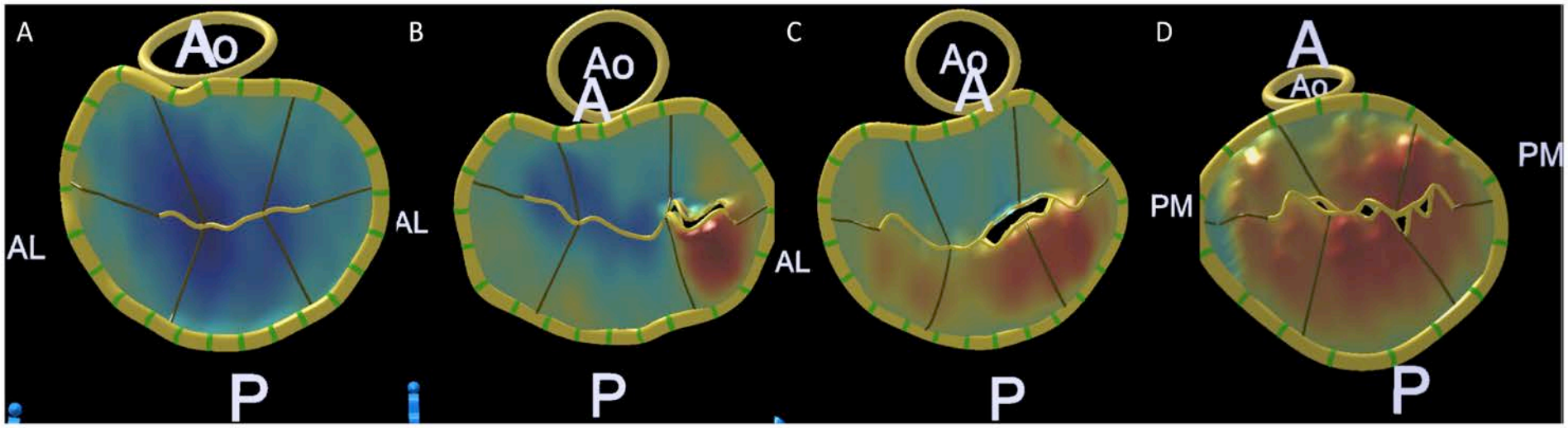
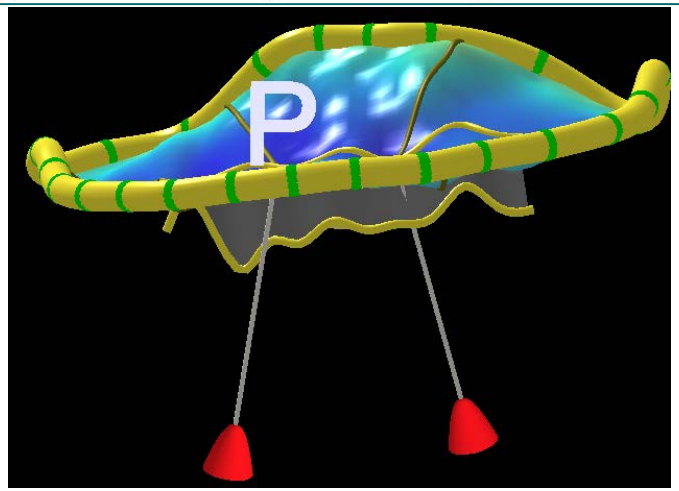
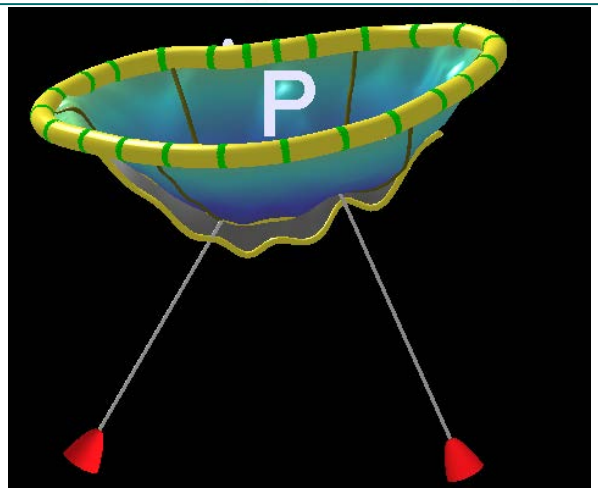
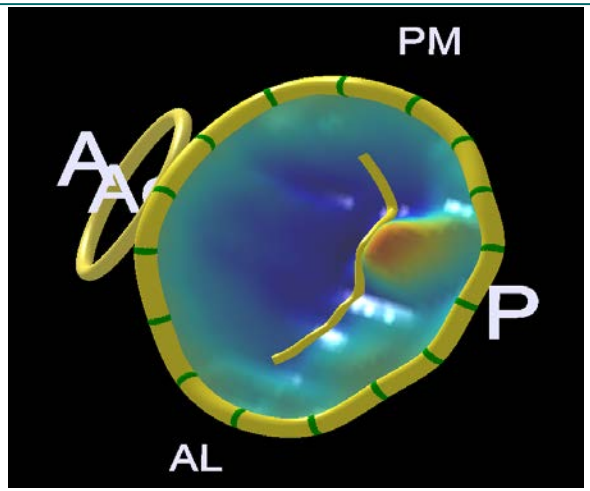
MV Parametric Maps

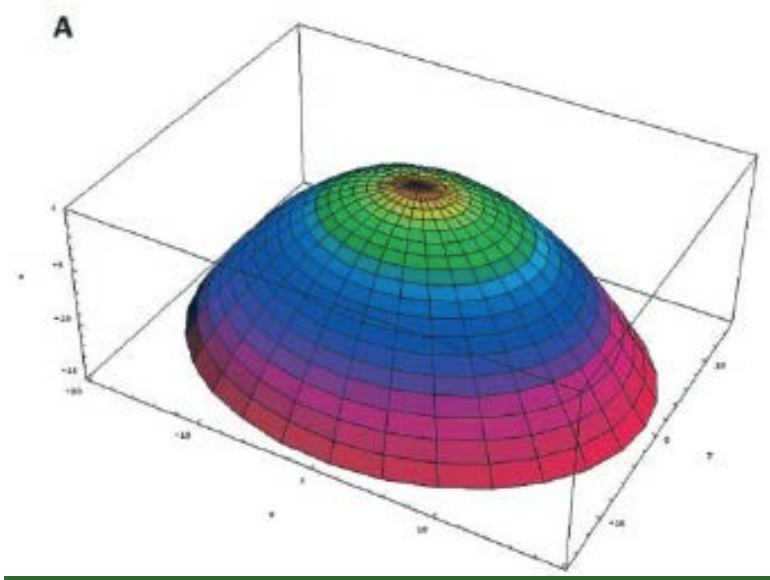


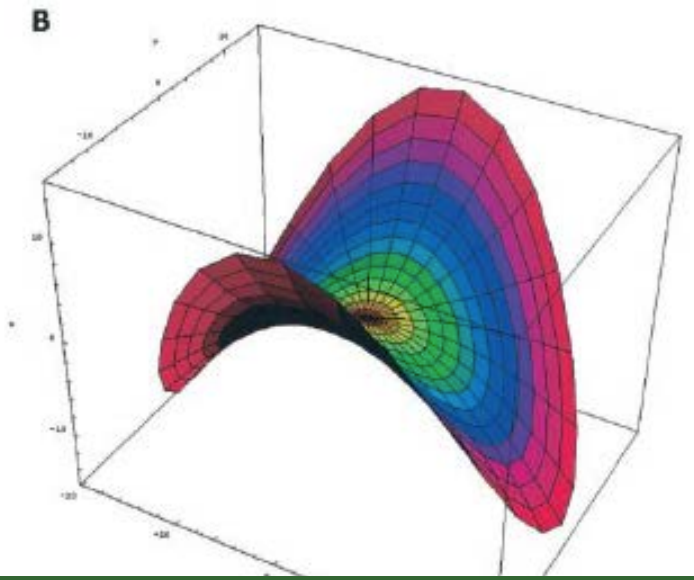






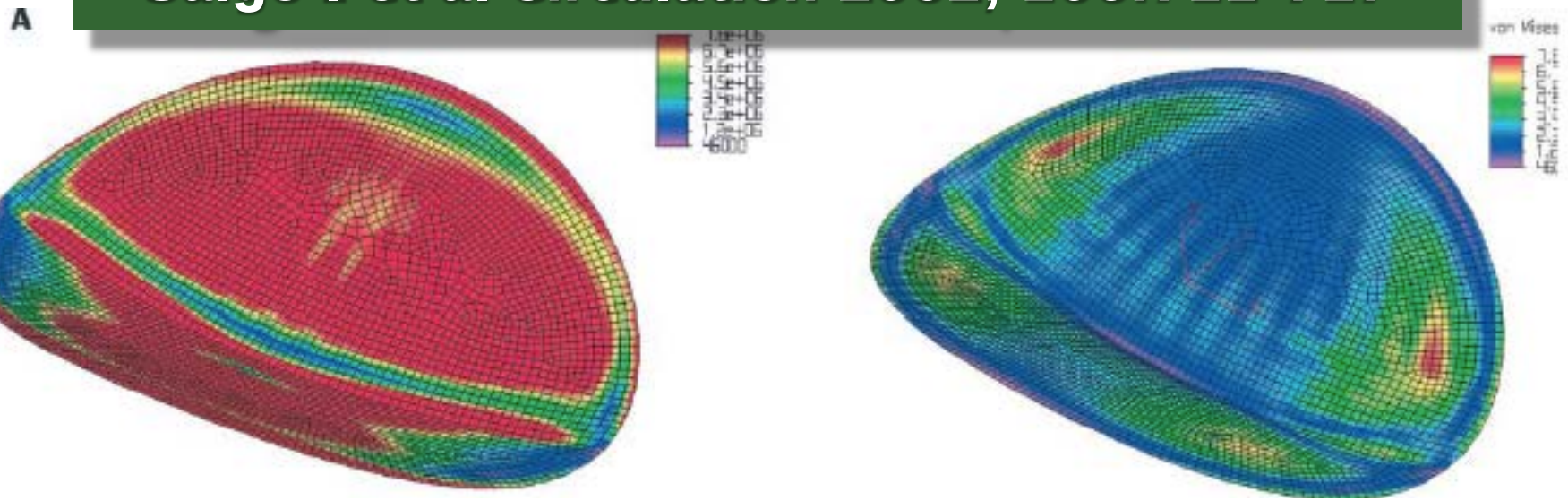
Tsang W, Lang RM., *J Am Soc Echocardiogr* 2011;24:860-7.



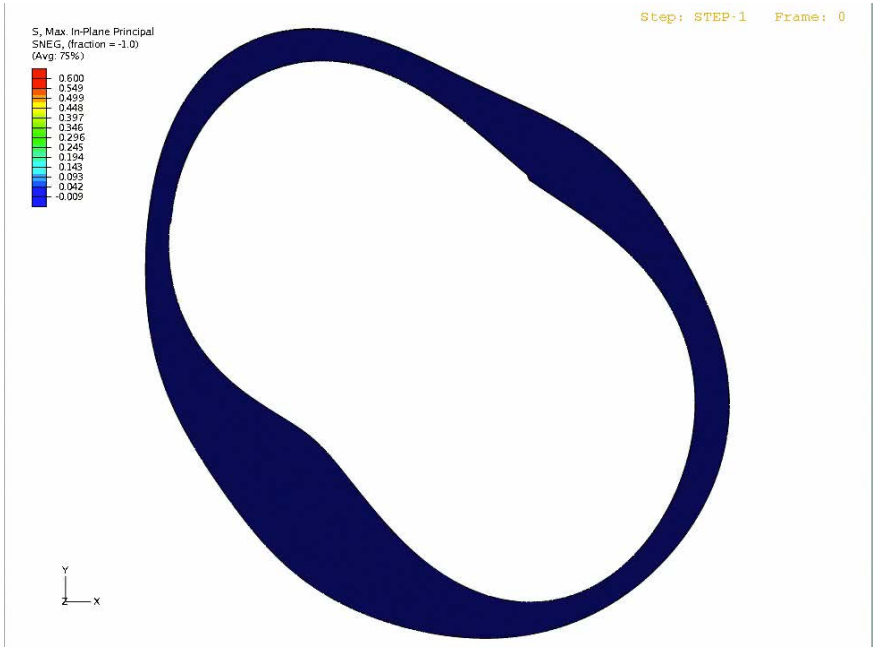


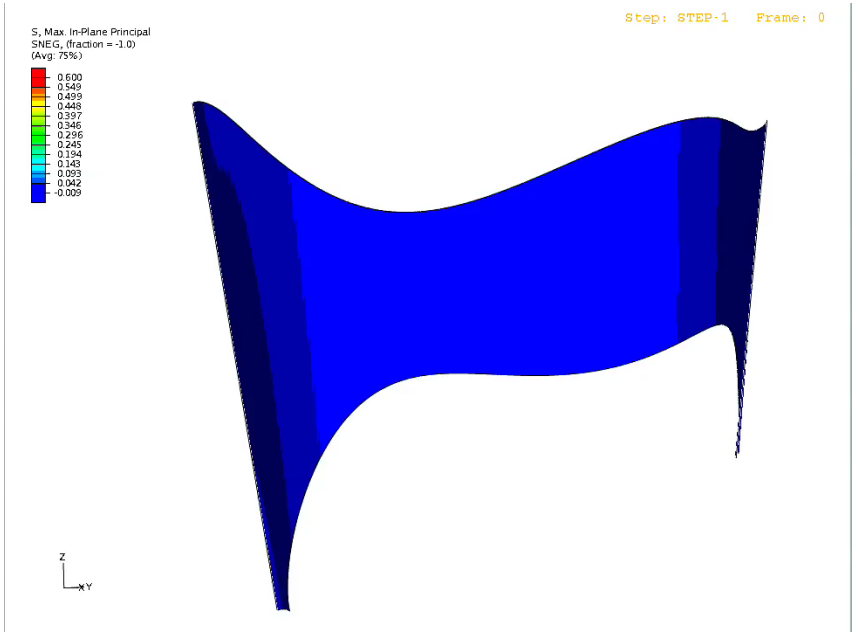
Effect of Annular Shape on Leaflet Curvature in Reducing Mitral Leaflet Stress

Salgo I et al Circulation 2002; 106:711-717



Principal Stress



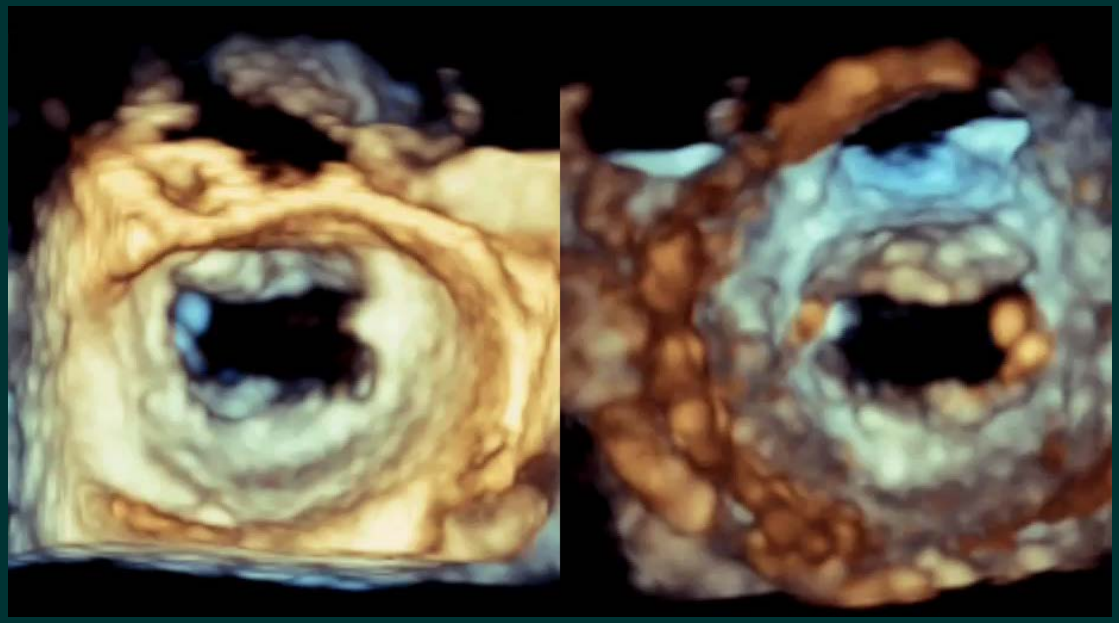


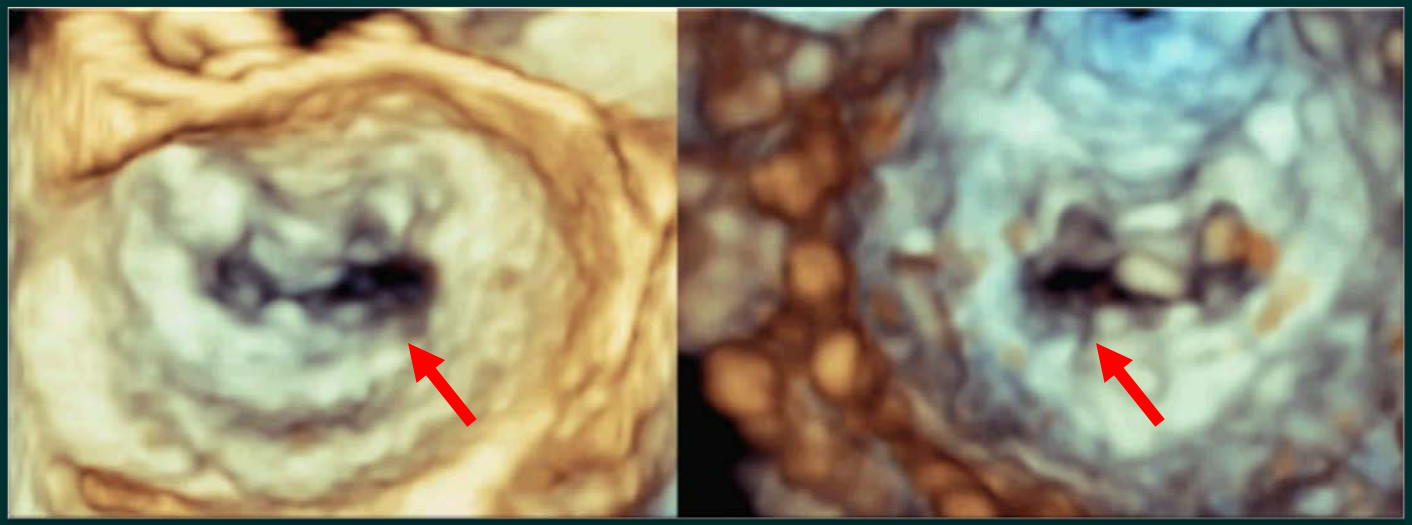
[Caiani and Votta, www.surgaid.org]

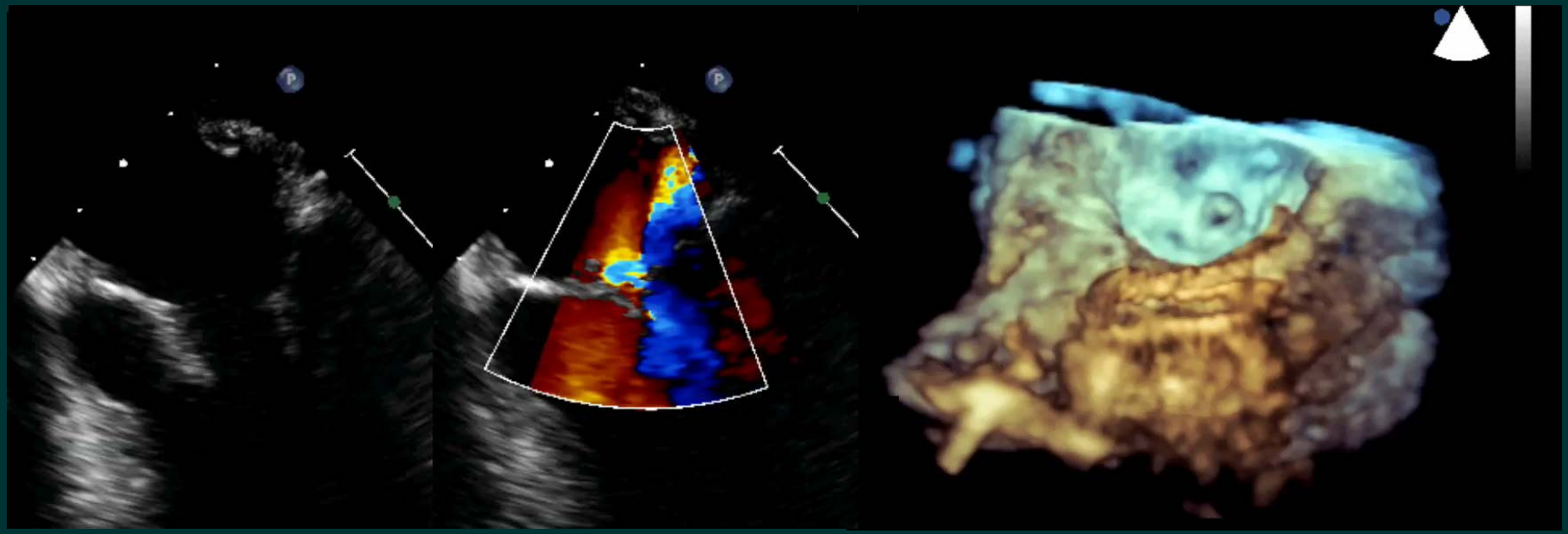
Pathology	Observation
TYPE 1	***Normal leaflet motion.*** A. Leaflet perforation B. Cleft deformity C. Dilated annulus (without leaflet tethering)
TYPE II	***Exaggerated leaflet motion*** A. Flail leaflet, generally with chordal rupture (eccentric jet) B. Billowing leaflets with prolapse (central jet) C. Billowing leaflets with associated flail (multiple central and eccentric jets)
TYPE III	***Restricted leaflet motion*** A. Systolic and diastolic restriction (rheumatic) central jet B. Systolic restriction with symmetric tethering of both leaflets (central jet) C. Systolic restriction with asymmetric tethering (eccentric jet)
TYPE IV	***Systolic anterior motion (SAM)*** A. Upper septal hypertrophy (e.g. hypertrophic cardiomyopathy) B. Post mitral valve repair C. Hypovolemic, hyperdynamic left ventricle
TYPE V	***Hybrid conditions*** Prolapse of anterior leaflet with restricted posterior leaflet Prolapse of posterior leaflet with SAM of anterior leaflet Intrinsic pathology with super added lesion of infective endocarditis

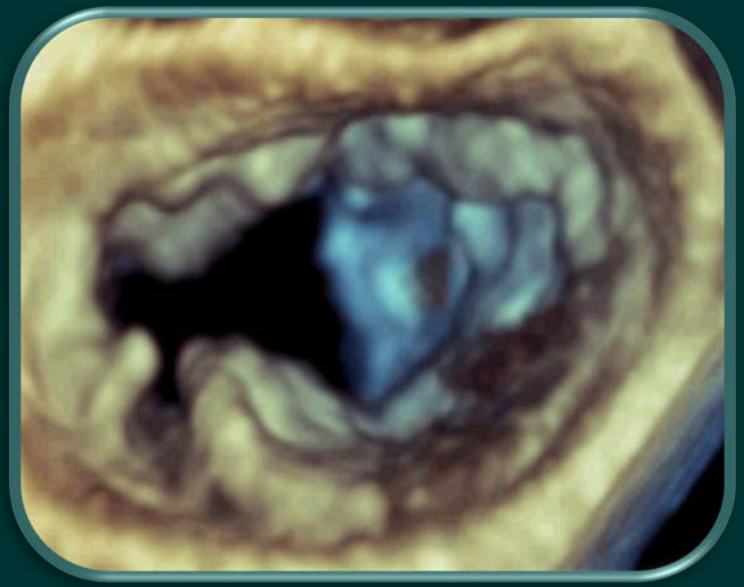
The Journal of Heart Valve Disease 2012;21:37-40

Type 1: Normal Leaflet Motion





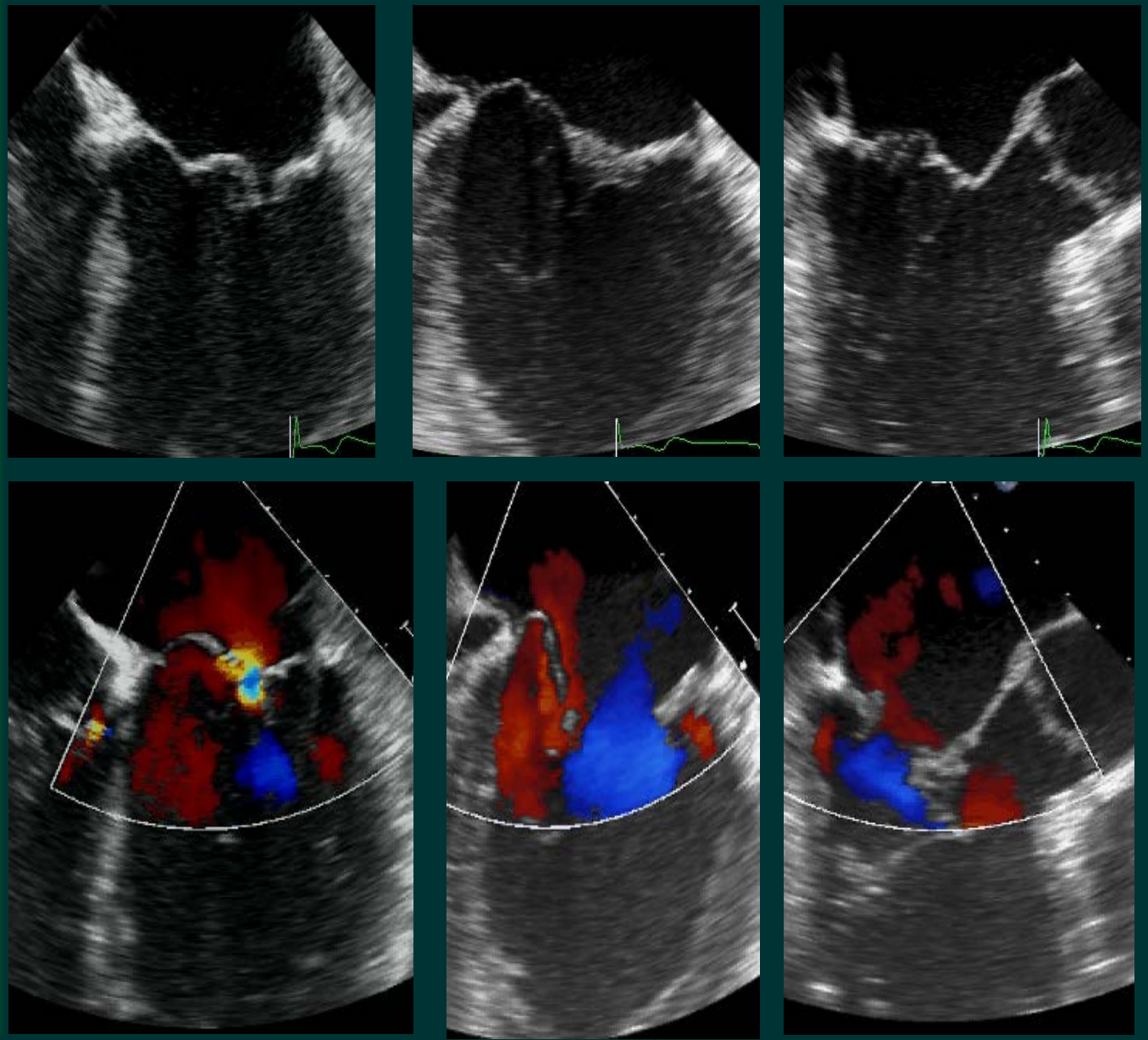




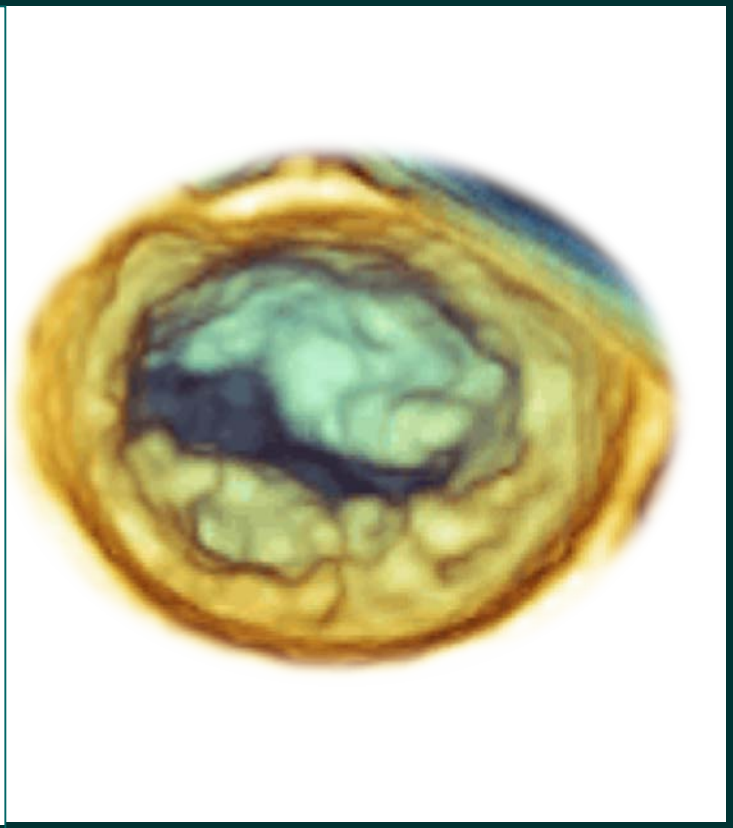
Barlow's Prolapse

Case History

42year-old woman who complains of decreased exercise capacity of recent duration.

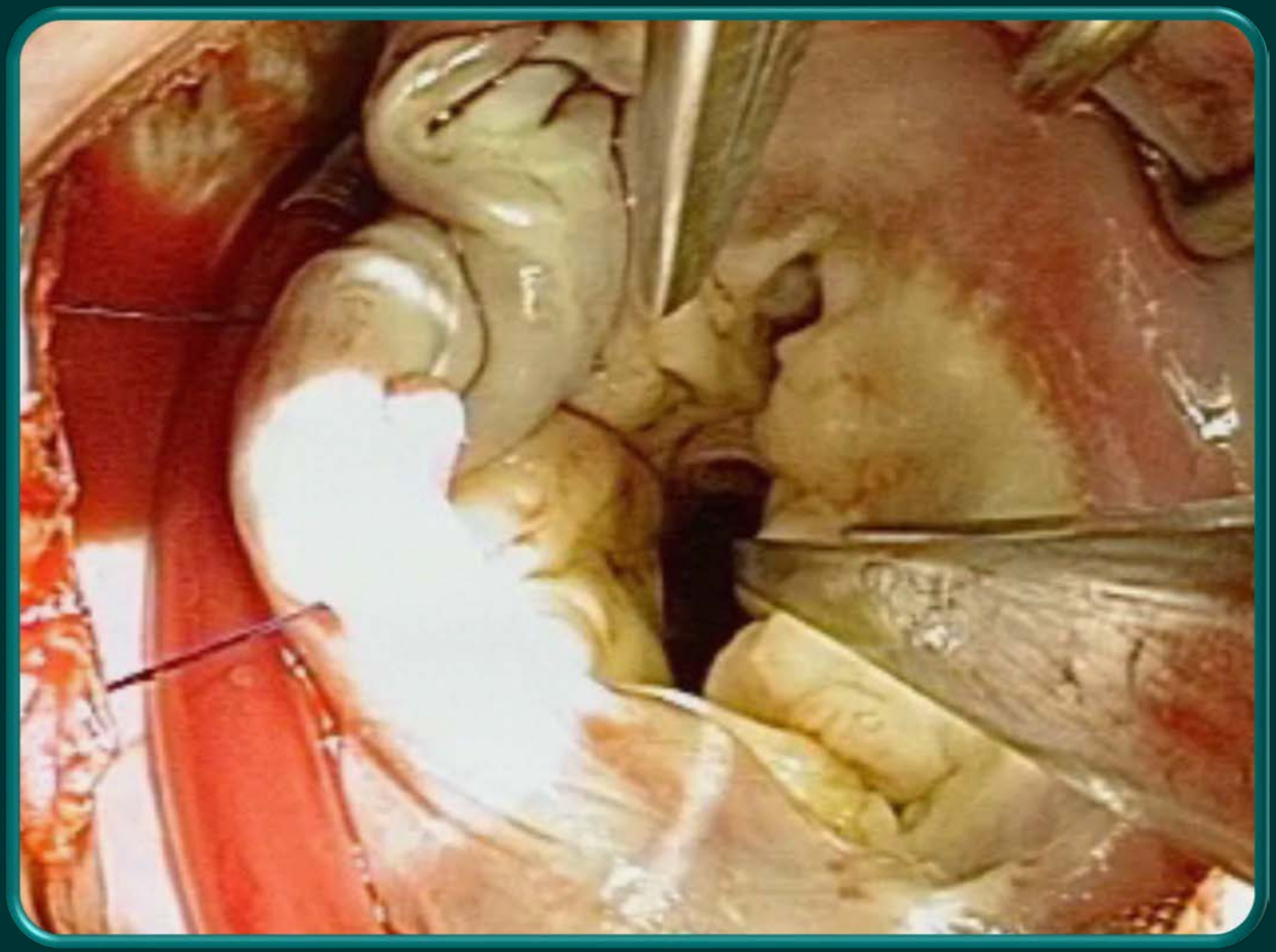


Barlow's Prolapse

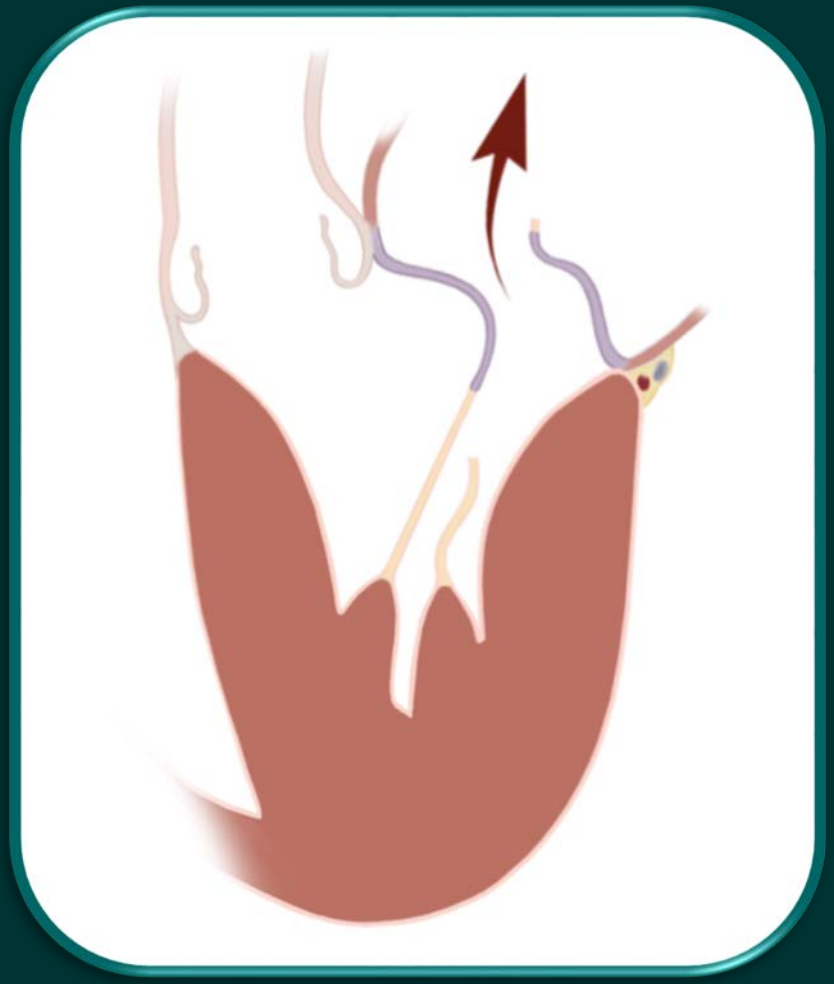


Excess leaflet tissue with billowing, thickened leaflets and chordae, large annulus

Barlow's Prolapse

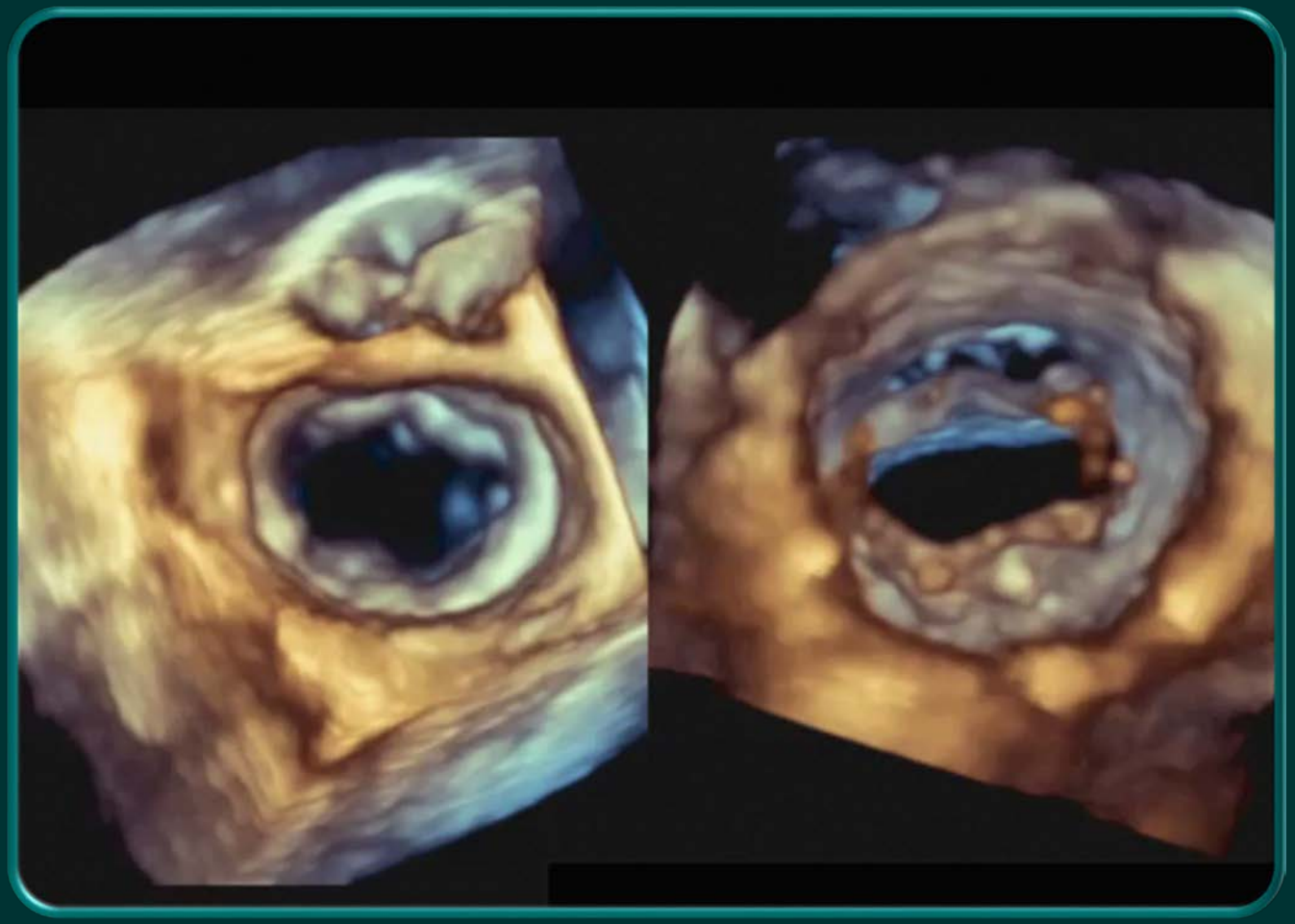


Fibroelastic Deficiency



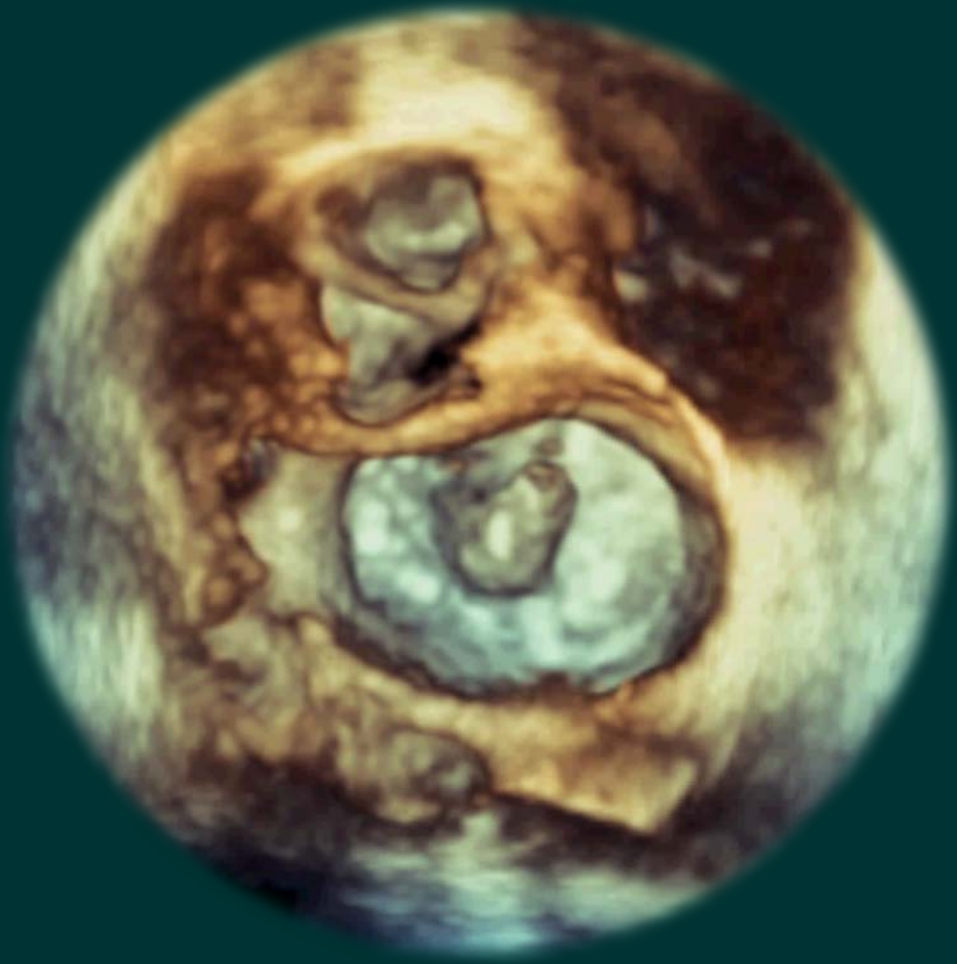
- Older individuals
- Short Hx of MR
- Rupture or elongation of a single chord
- Remaining segments are normal
- Posterior annulus may be dilated

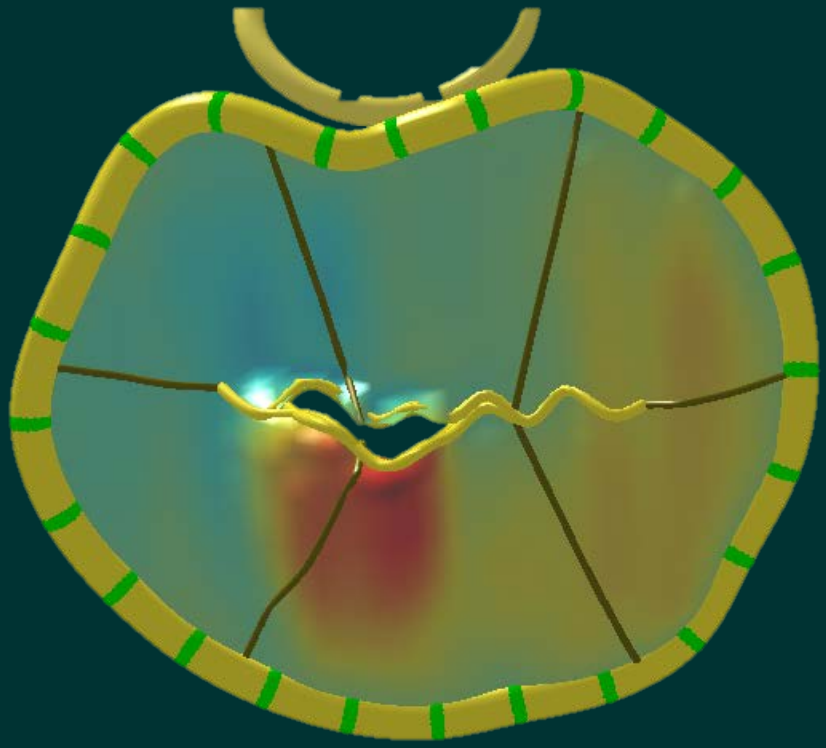
Fibroelastic Deficiency



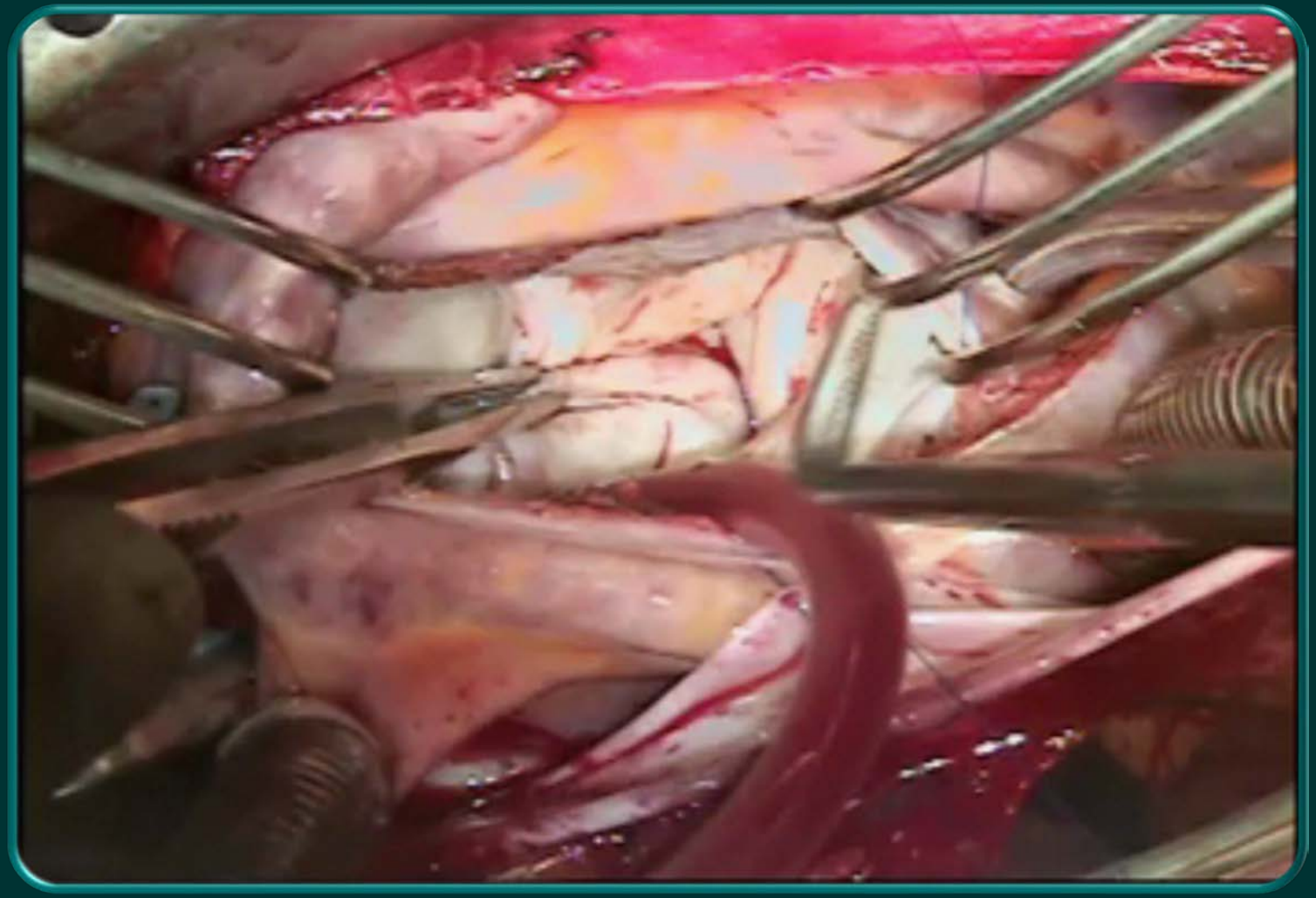
P2 - Prolapse

Fibroelastic Deficiency





Fibroelastic Deficiency



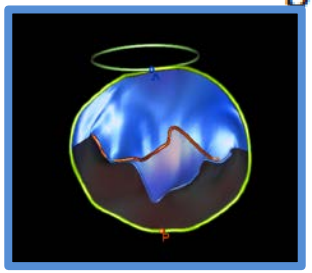
Flail MV: Ruptured chords

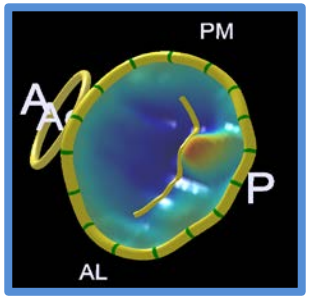
Can three-dimensional echocardiography accurately predict complexity of mitral valve repair?

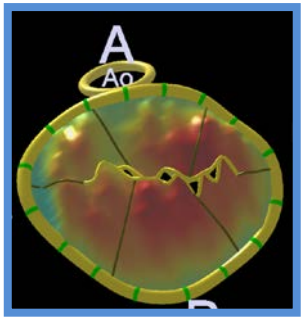
Joanna Chikwe[a,*], David H. Adams[a], Kevin N. Su[b], Anelechi C. Anyanwu[a], Hung-Mo Lin[c], Andrew B. Goldstone[b], Roberto M. Lang[d] and Gregory W. Fischer[b]

Standard Repair
No or single leaflet resection
Sliding-plasty
Cleft Closure
Chordal or commissural repair techniques

Complex Repairs
Bi-leaflet repair techniques
Multiple resections required
Patch augmentation





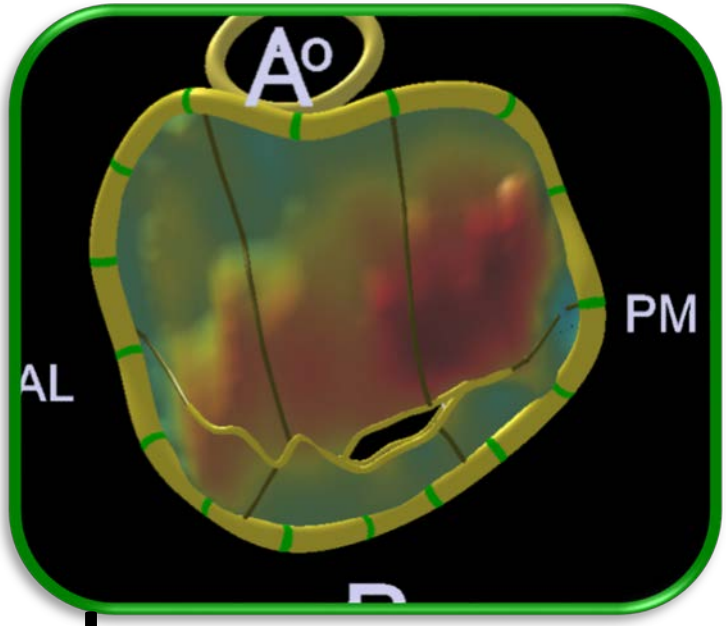


Prediction of Complexity of MV Repair
Multisegment Involvement
Anterior Leaflet Prolapse
Scarcity of leaflet tissue
Severe Calcification
Prolapsing Height
Annular Dilatation > 50 mm

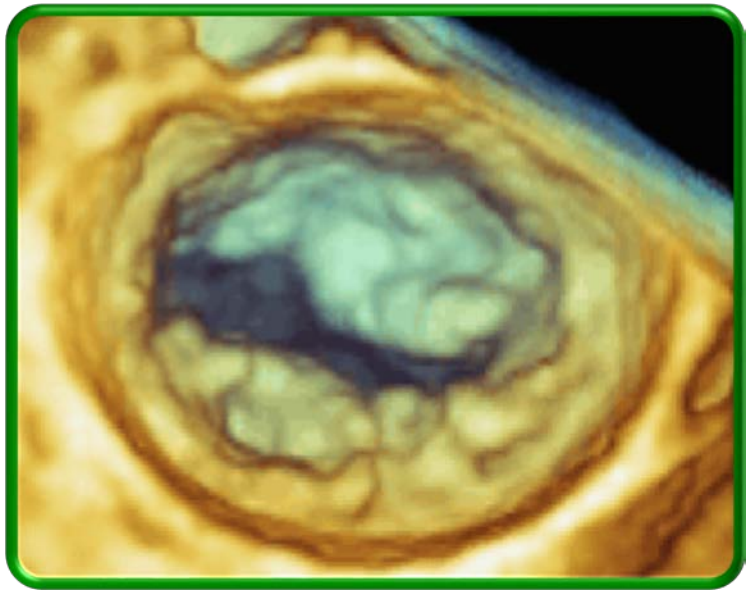
European Journal of Cardio-Thoracic Surgery 2012;41:518-524

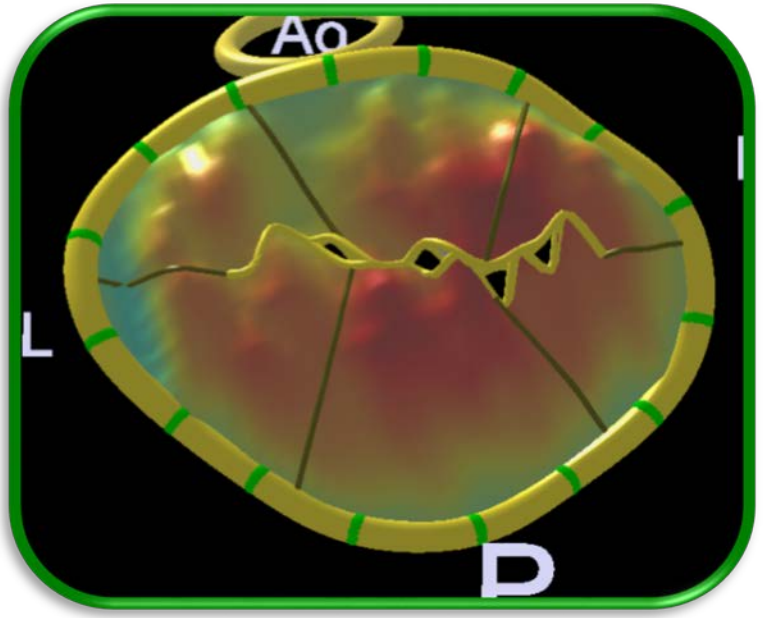
Lang RM et al. J Am Coll Cardiol 2011

Anterior Leaflet Prolapse

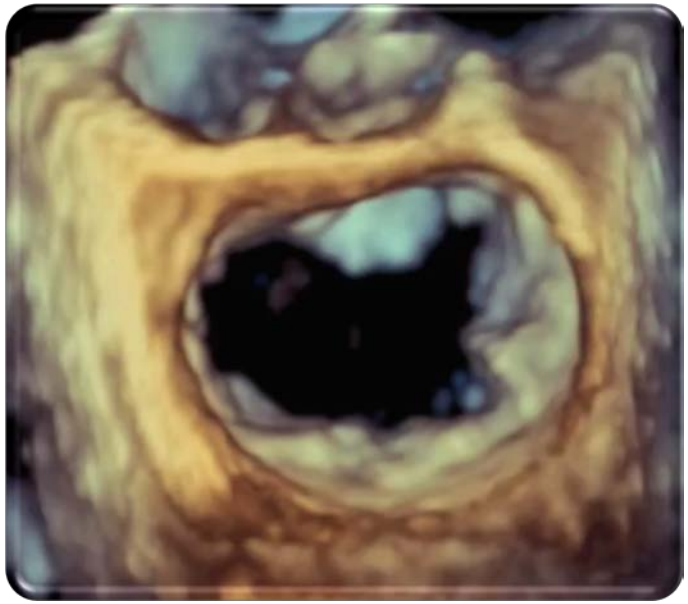


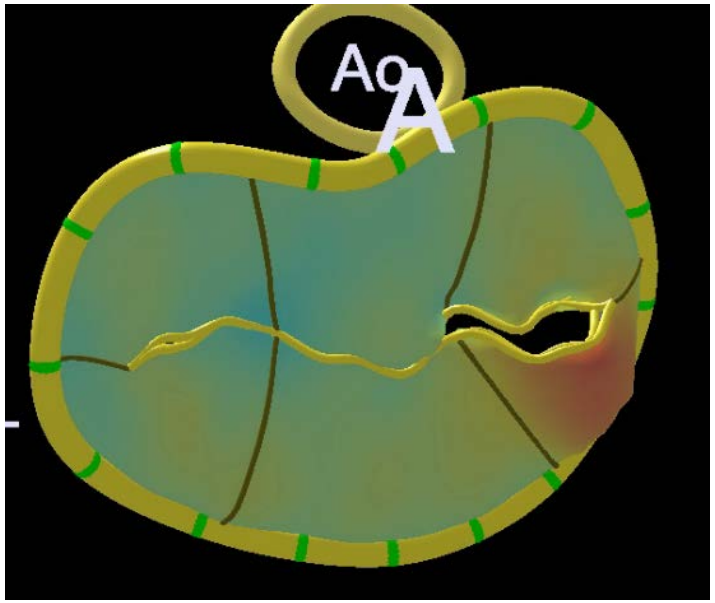
Barlows Prolapse



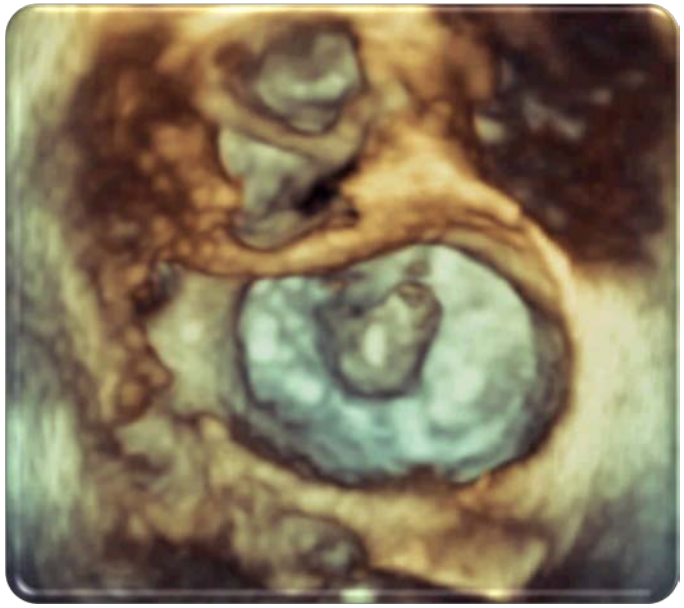


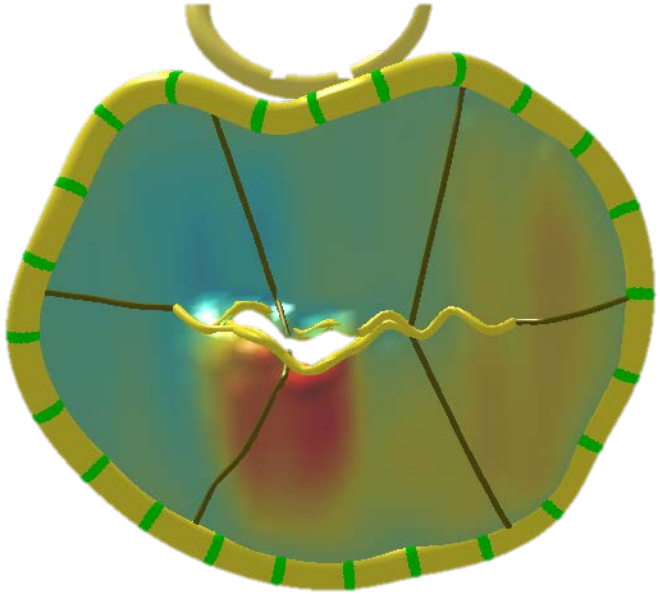
Medial Commissure

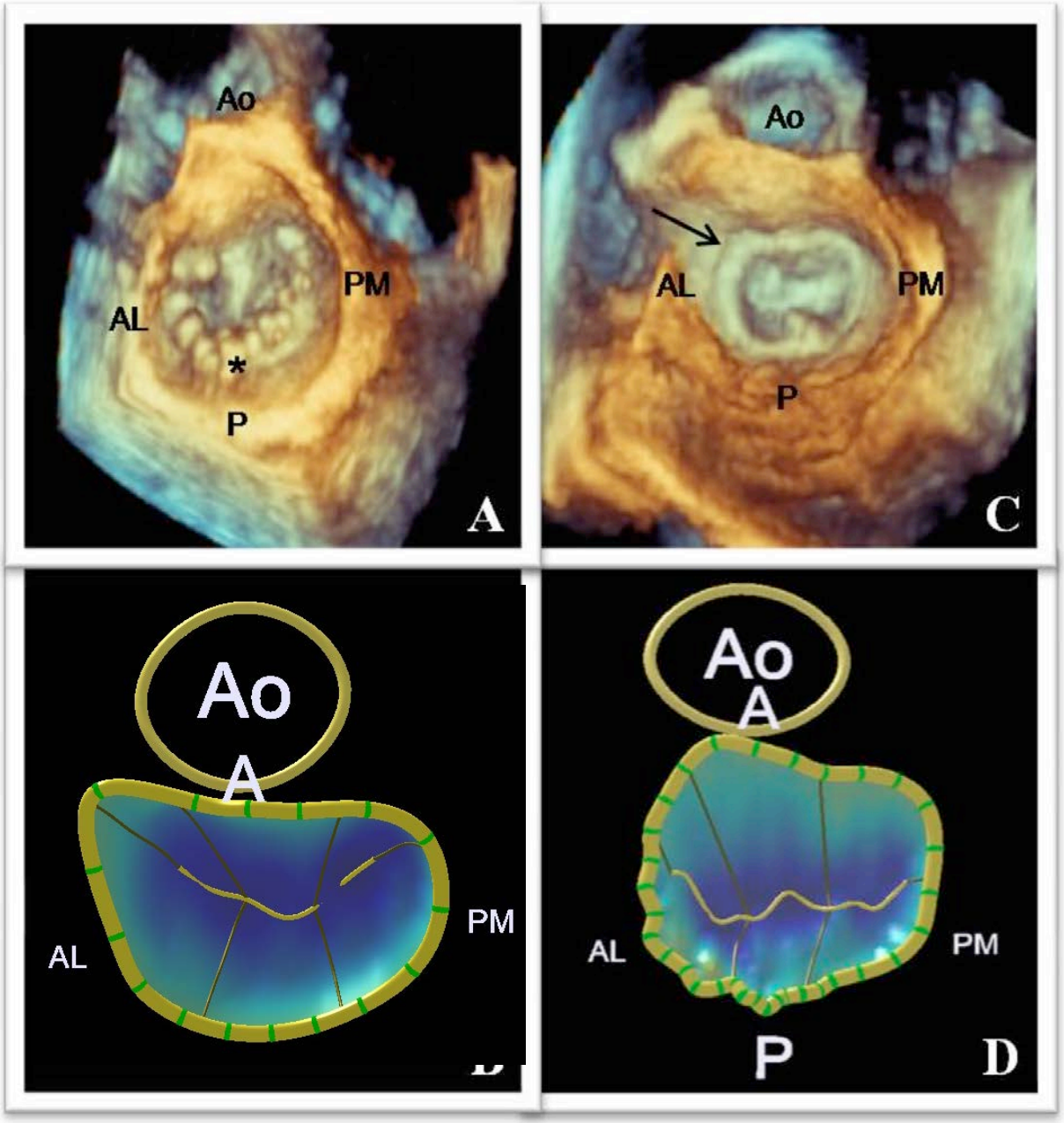




P2 Flail







Modified Carpentier

Leaflet resection and partial flexible ring

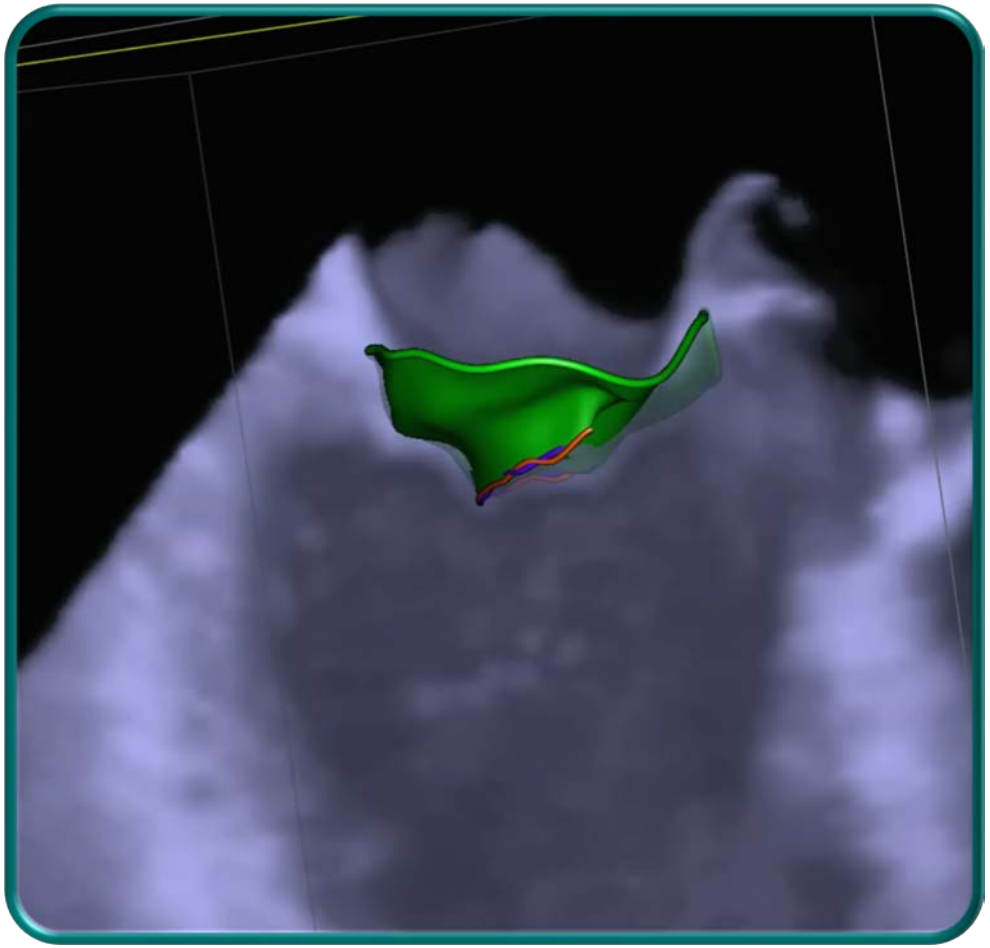
American Correction

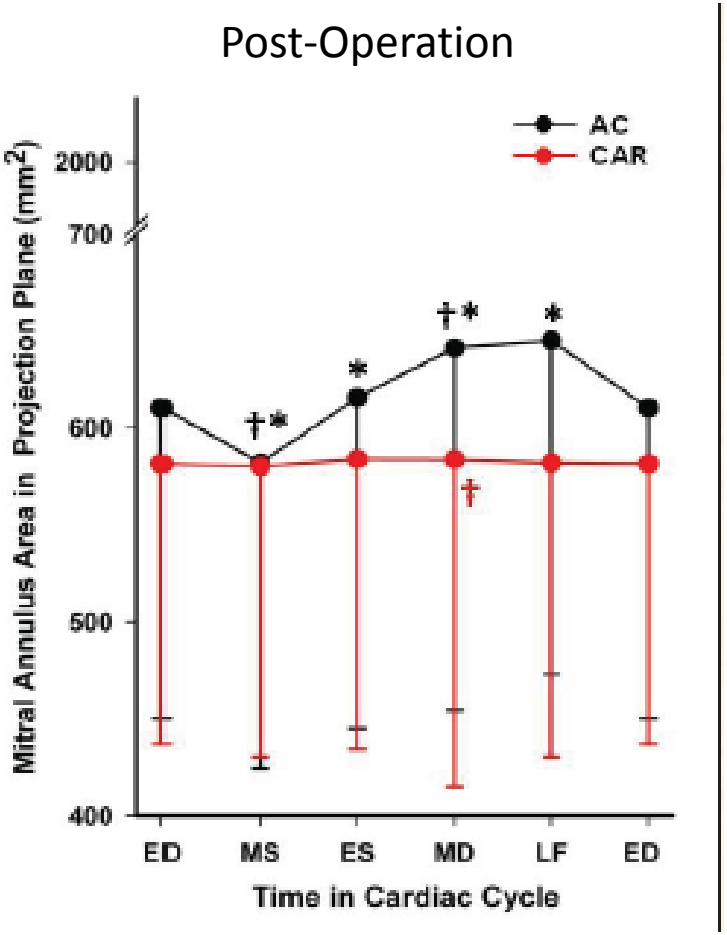
Full flexible ring, artificial chordae

Ben Zekry S, Lang RM, Zoghbi WA et al., *J Am Soc Echocardiogr* 2011; 24:1233-1242

Mitral Valve Repair

American Correction vs Modified Carpentier

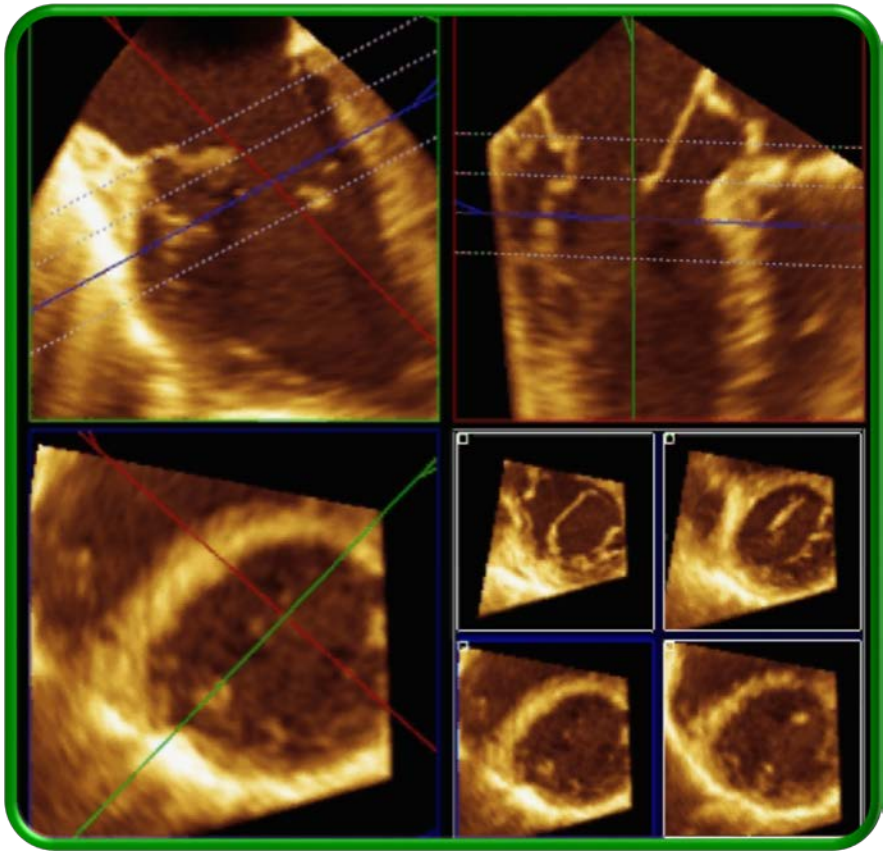




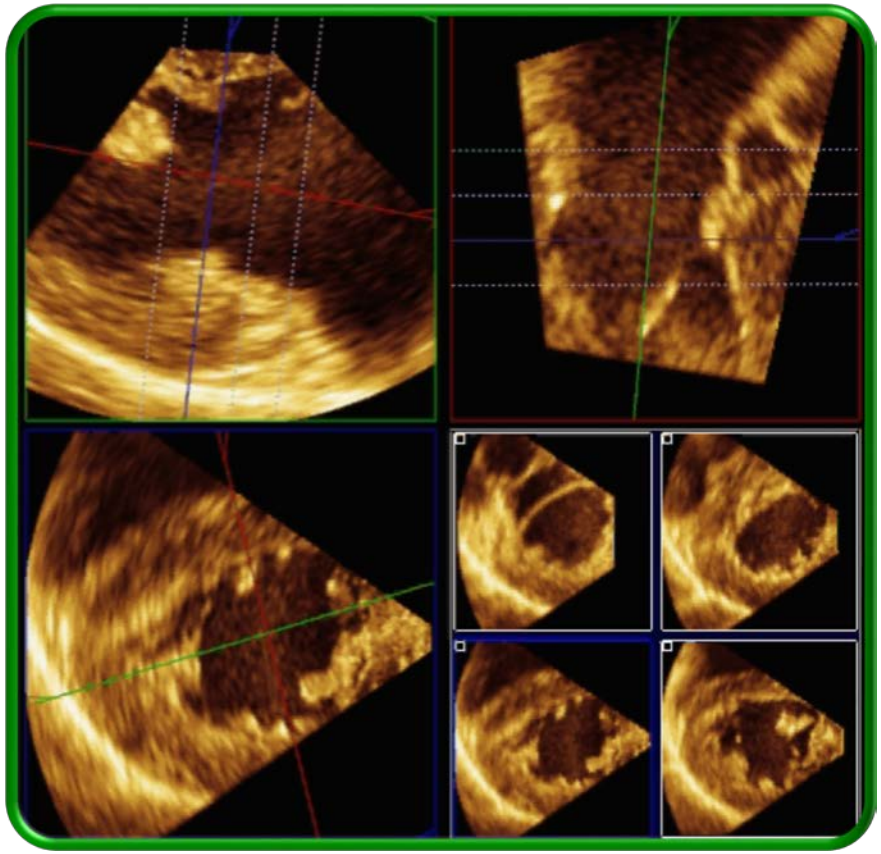
Ben Zekry S, Lang RM, Zoghbi WA et al., *J Am Soc Echocardiogr* 2011; 24:1233-1242

Sub-Mitral Apparatus

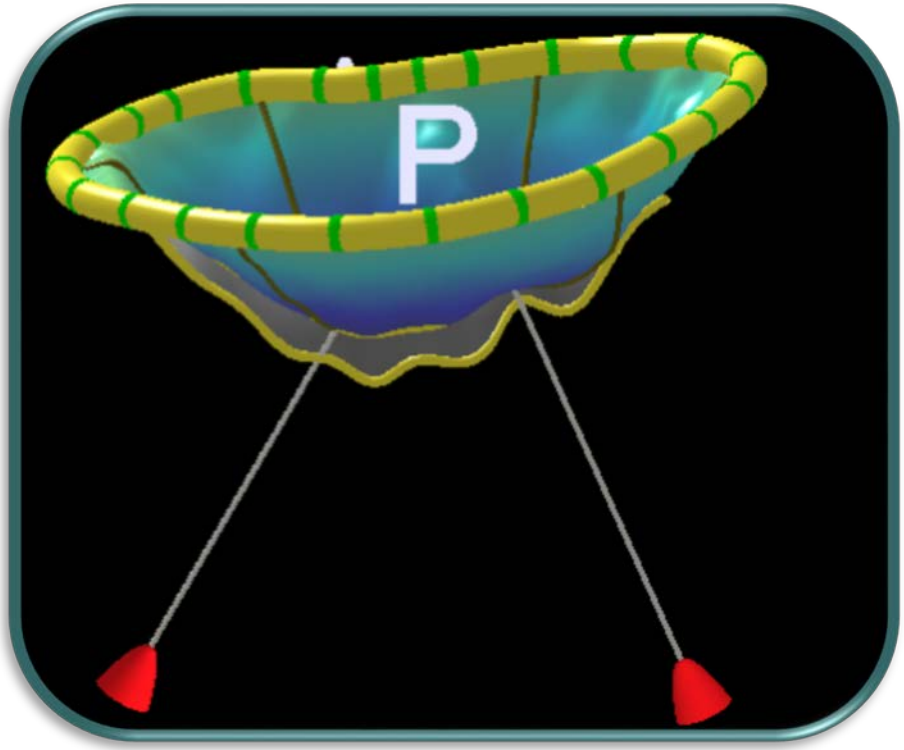
Mid-esophageal



Transgastric

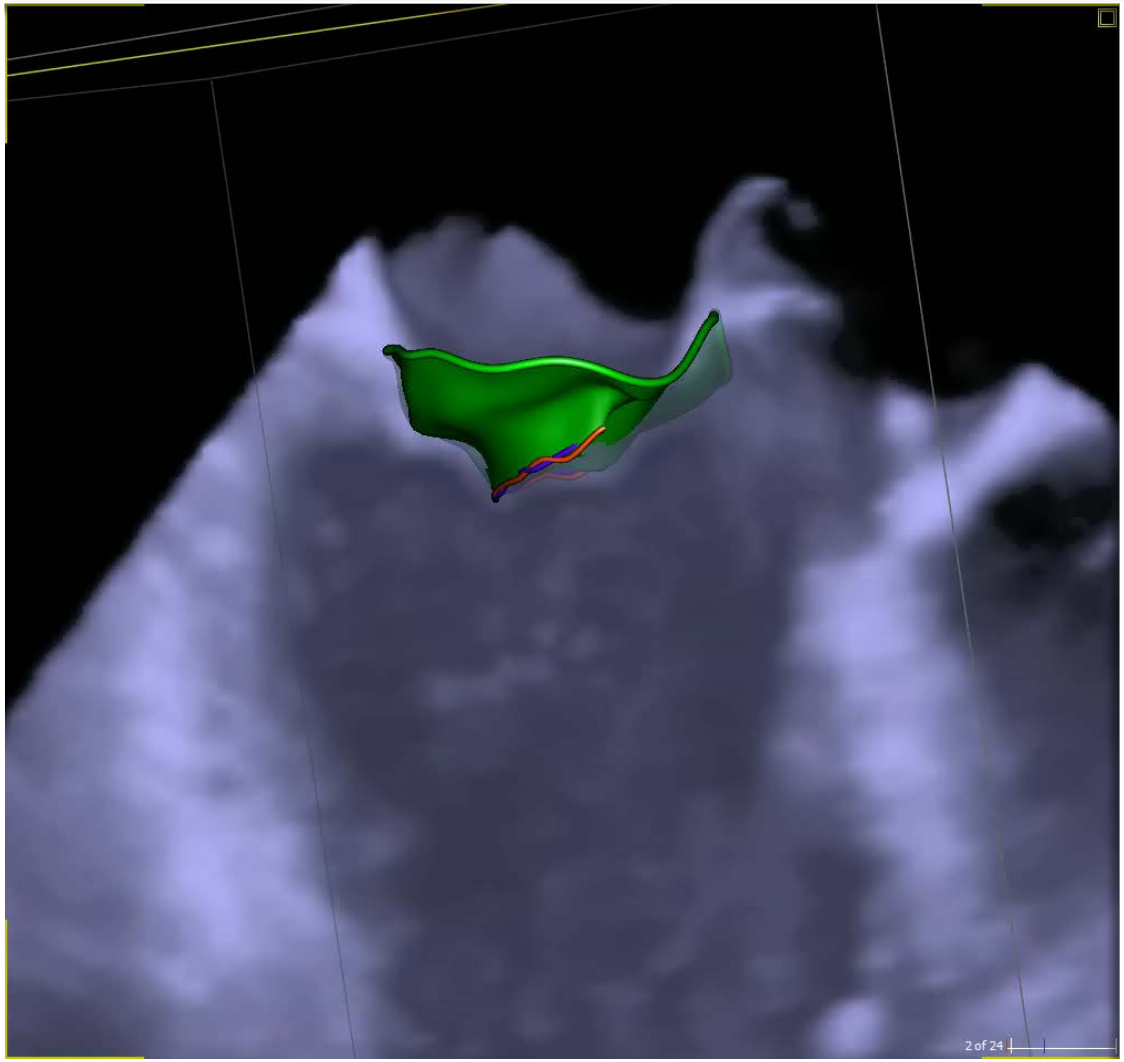


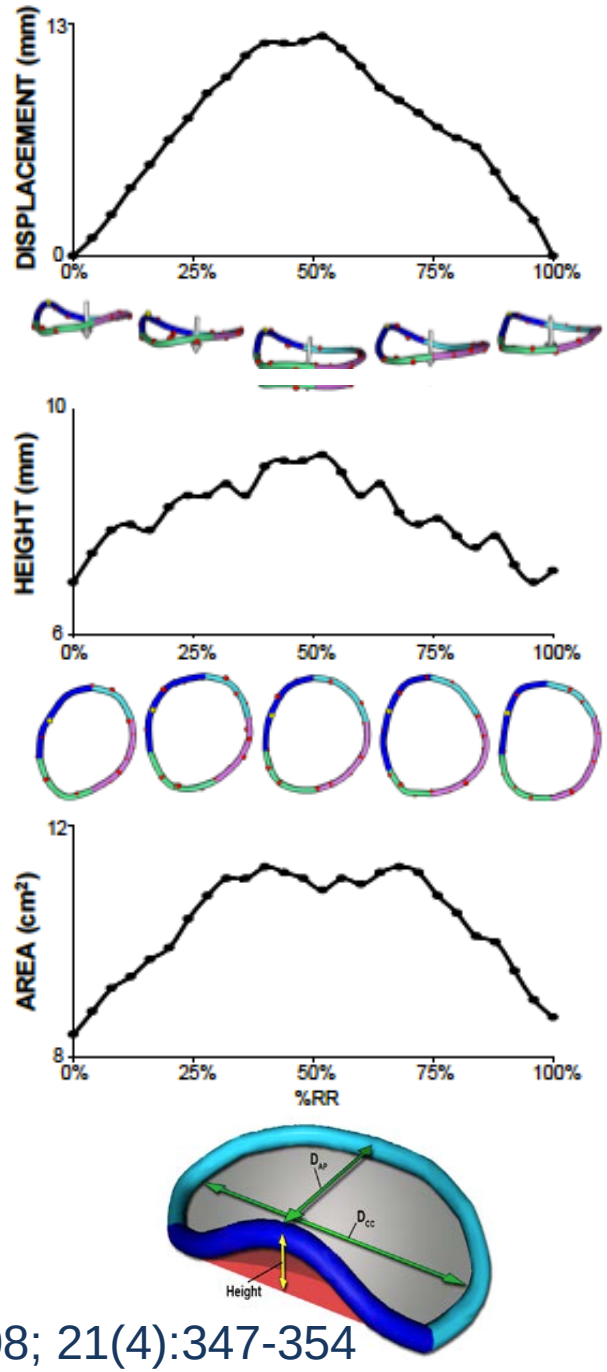
Papillary Muscle Positioning



Veronesi F, Lang RM et al., *J Am Soc Echocardiogr* 2008; 21(4):347-354

Dynamic Mitral Annulus Tracking

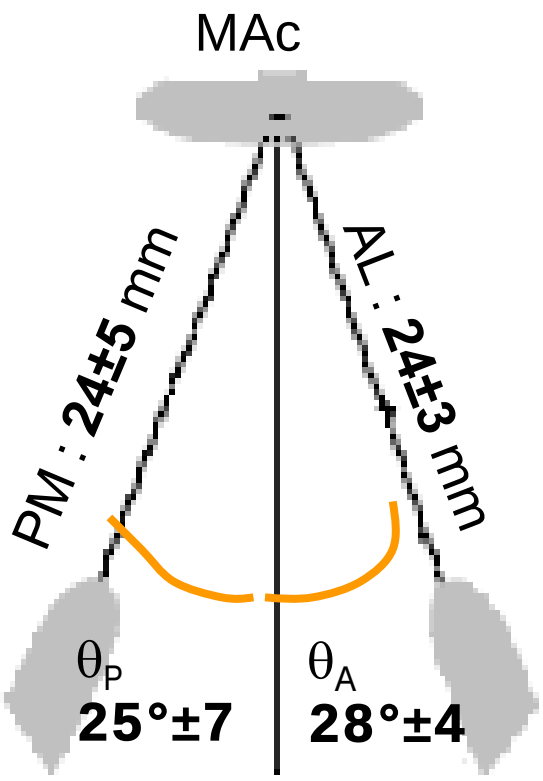




Veronesi F, Lang RM et al., *J Am Soc Echocardiogr* 2008; 21(4):347-354

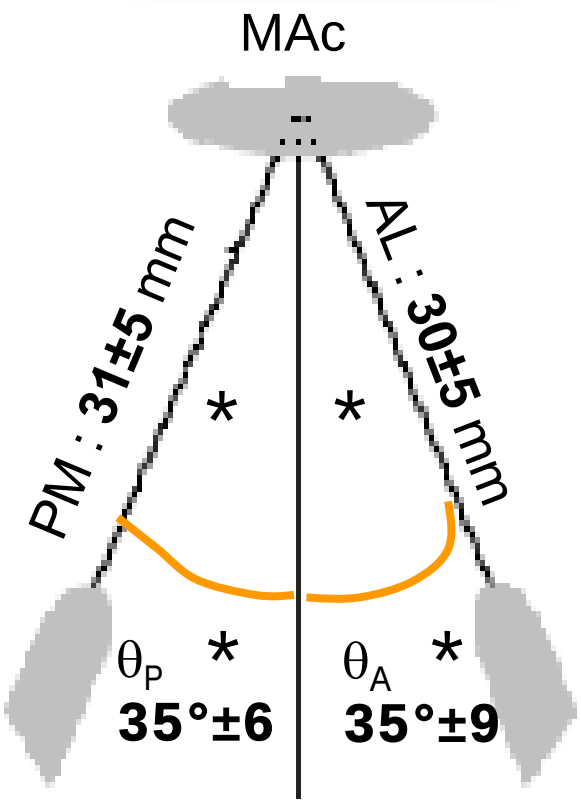
Dynamic MA Tracking + PM Positioning

Normal



$|\theta_P - \theta_A|$: **7°±4**

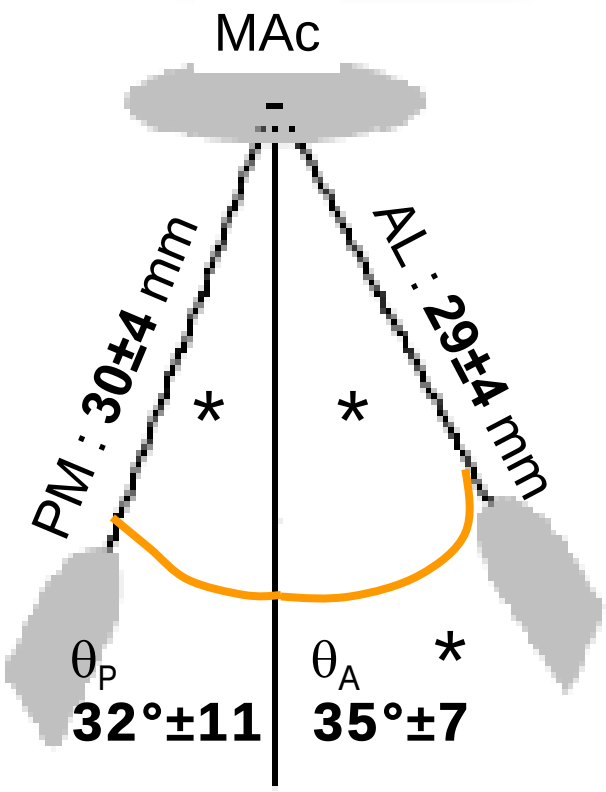
DCM-MR



$|\theta_P - \theta_A|$: **6°±4**

- **Longer tethering lengths**
- **Wider θ angles**
- **Preserved symmetry**

ISC-MR



$|\theta_P - \theta_A|$: **1 4°±5*†**

- **Longer tethering lengths**
- **Wider θ angles**
- **Lost symmetry**

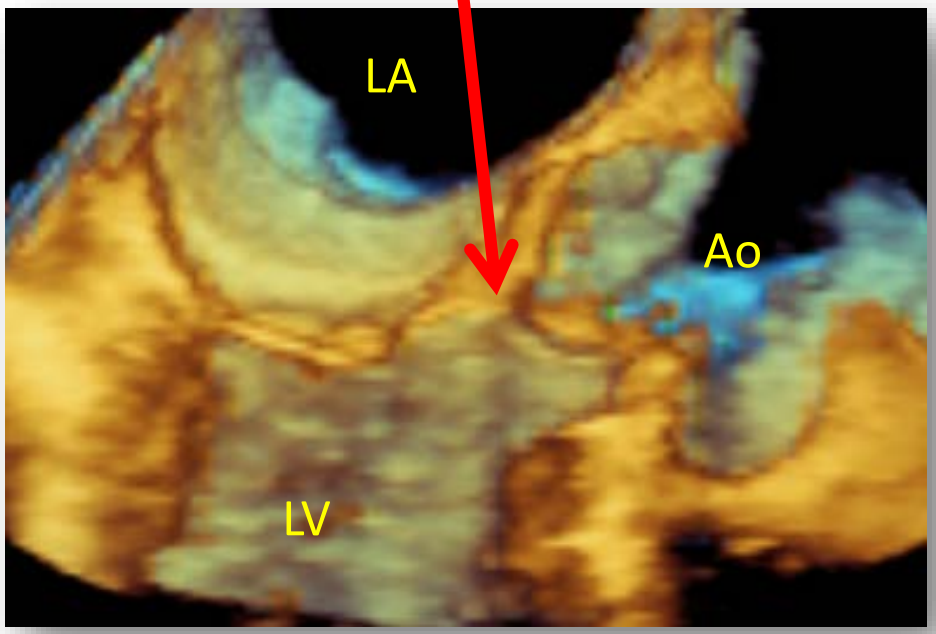
***: p<0.05 vs Normal**

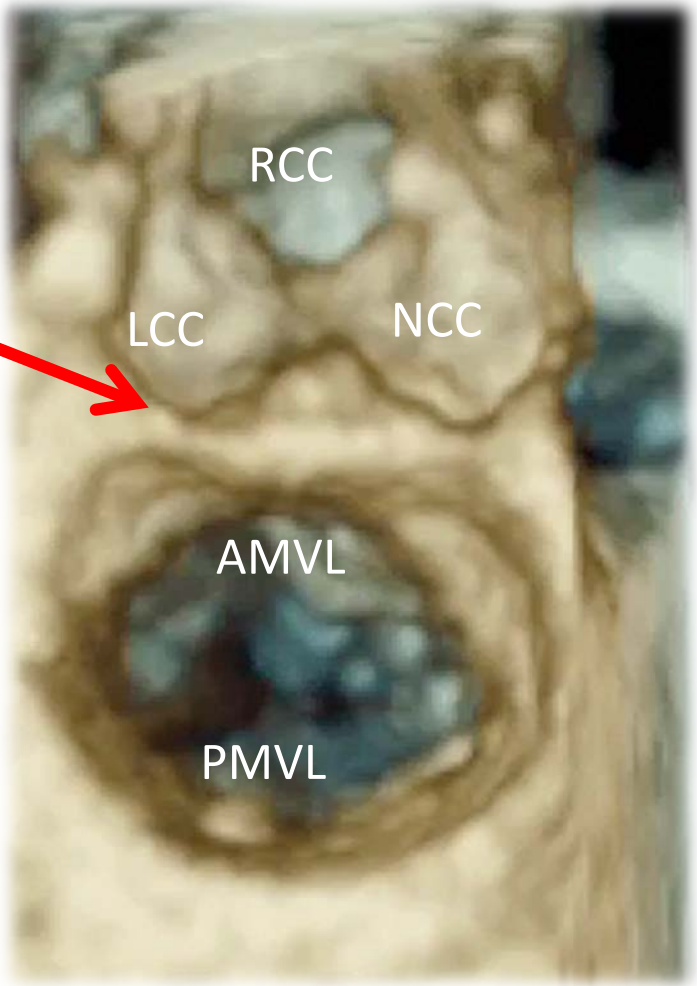
†: p<0.05 ISC-MR vs DCM-MR

[Veronesi et al. JASE2008]

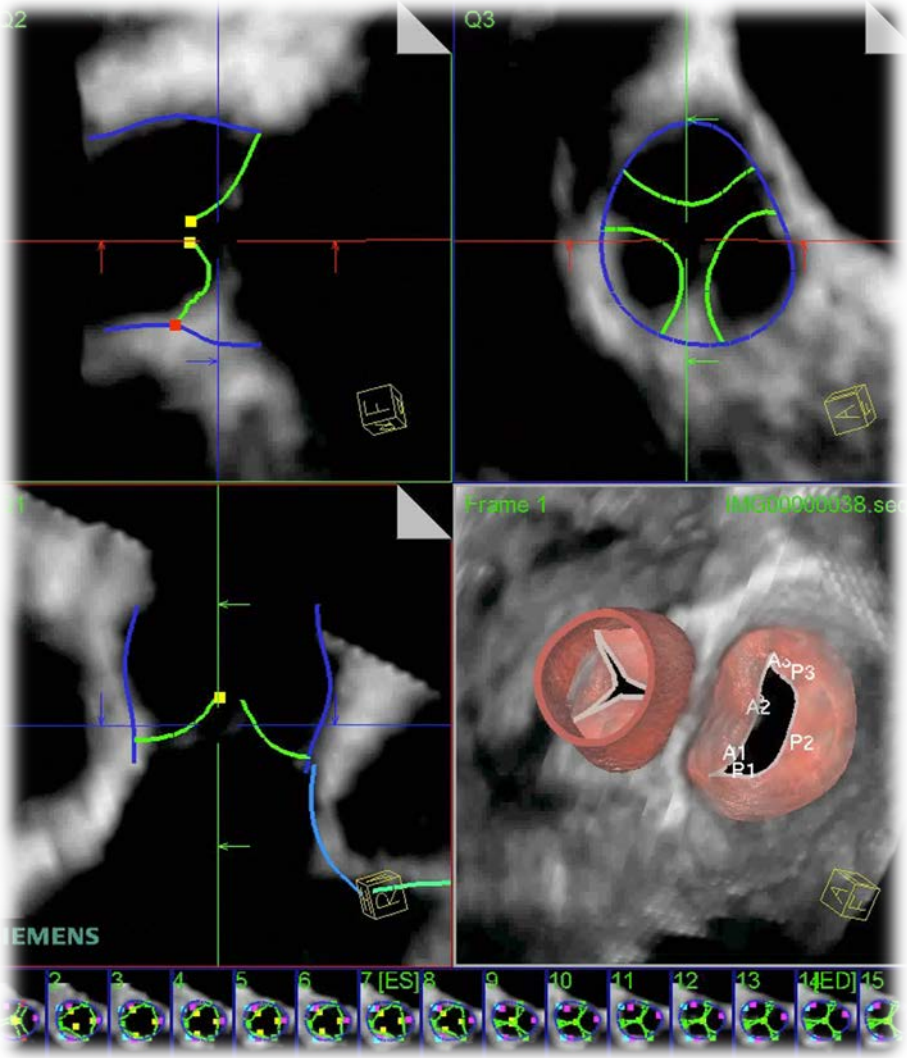
Aortic and Mitral Valve Anatomic Relationship

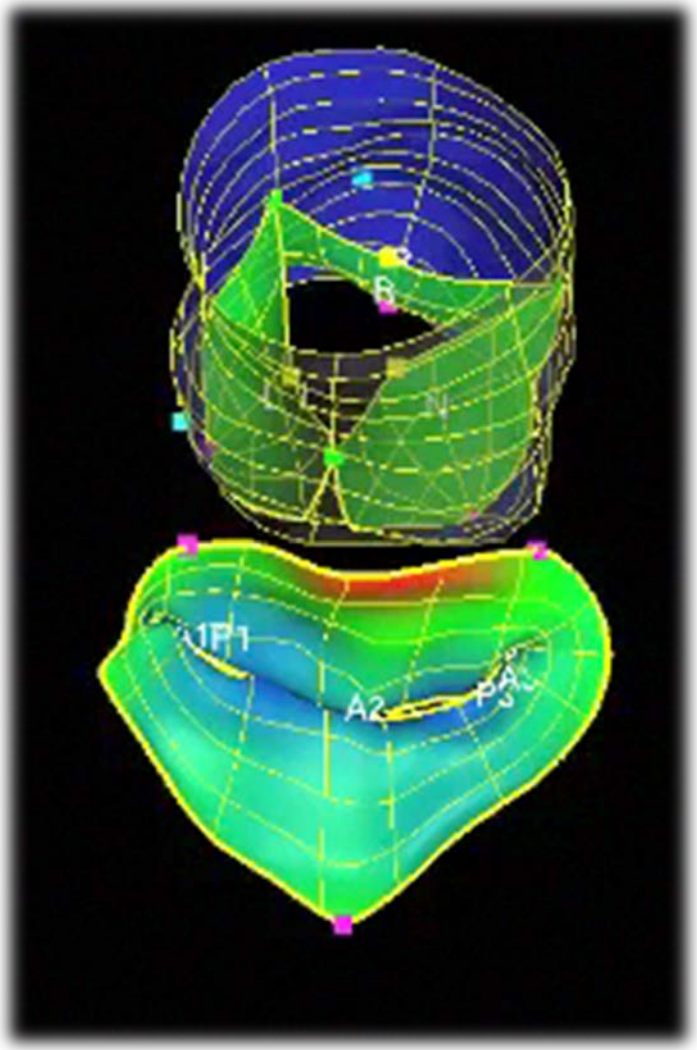
Aortic-mitral curtain



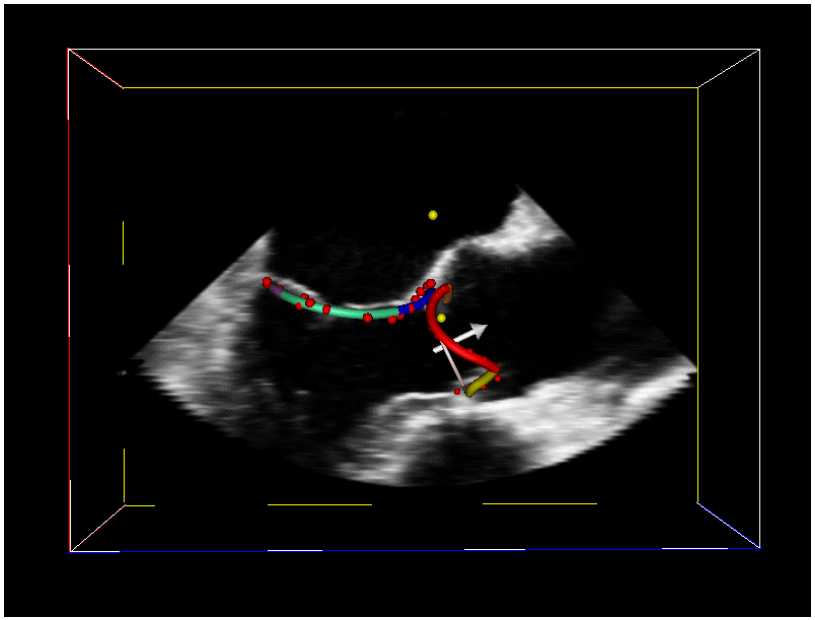


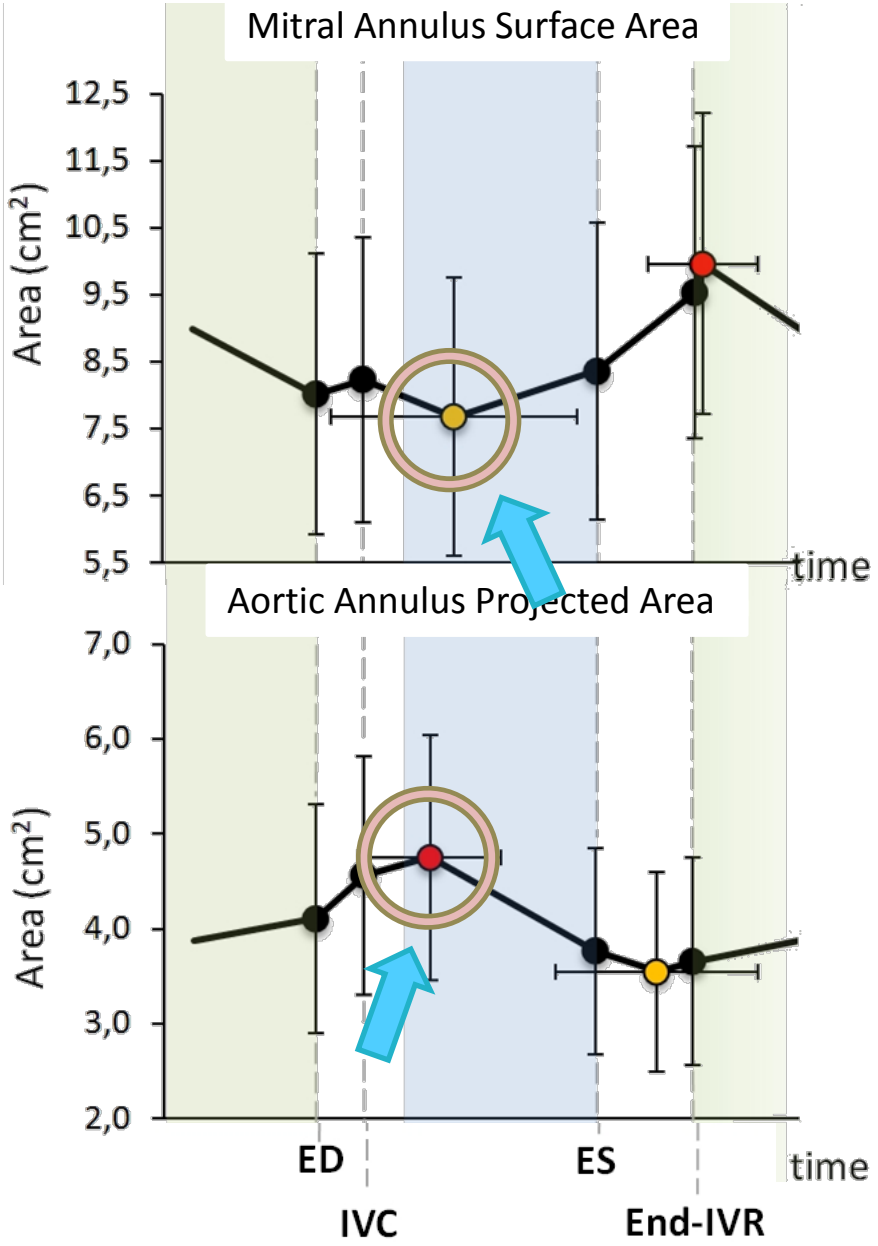
Aortic-Mitral Coupling





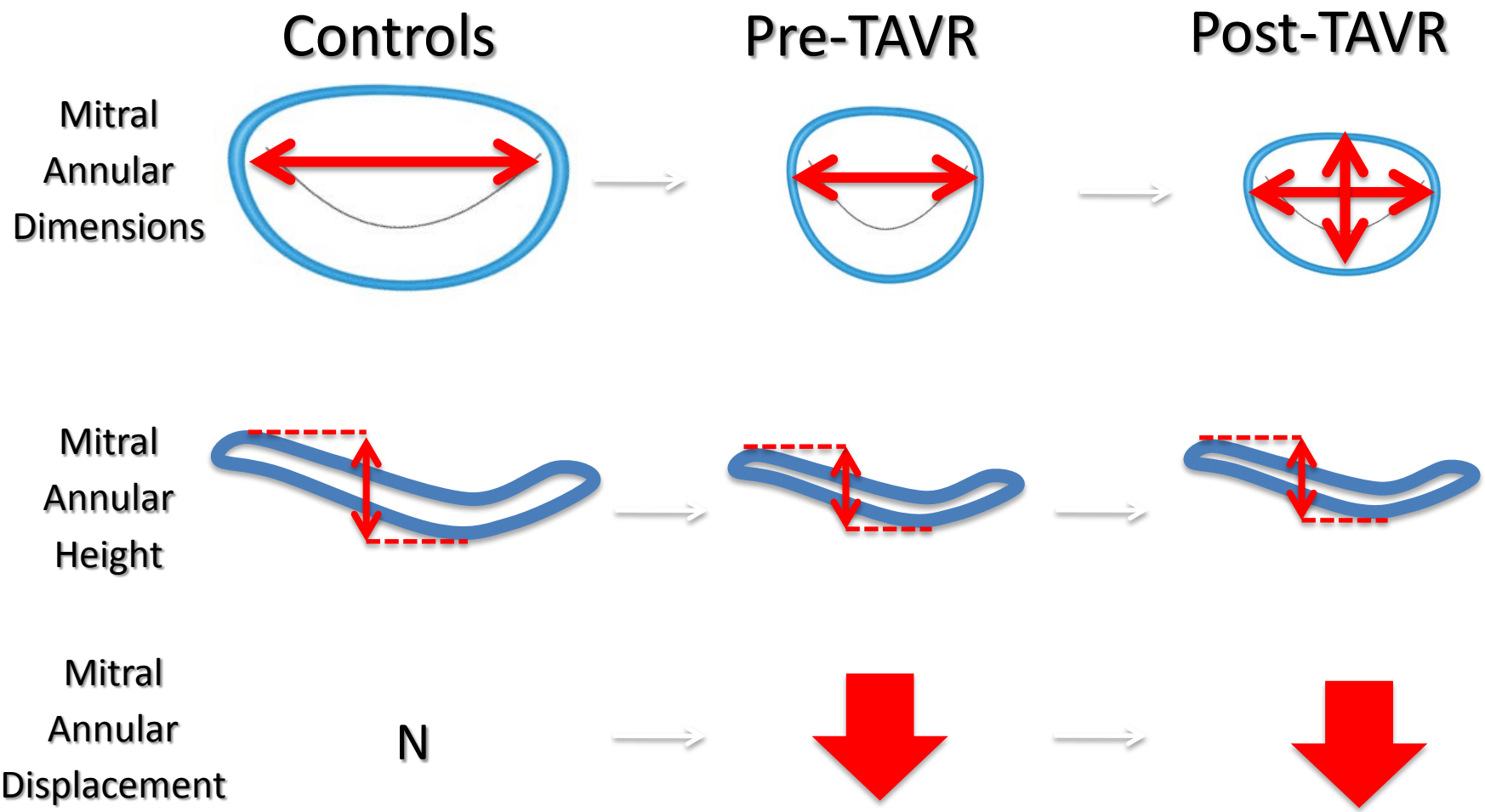
Normal Behavior





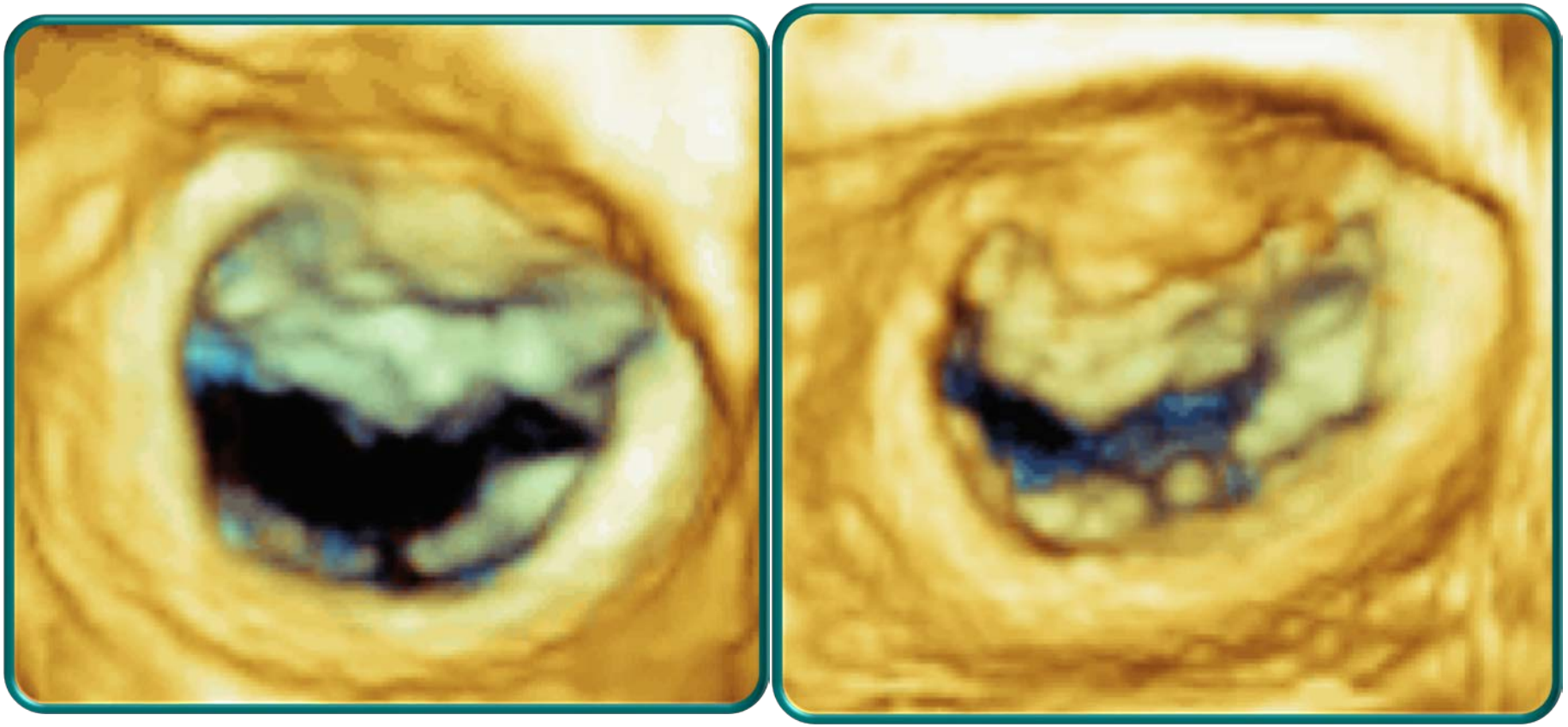
Veronesi F, Lang RM et al.,
Circ Imaging 2009:2(1):24-31

TAVR



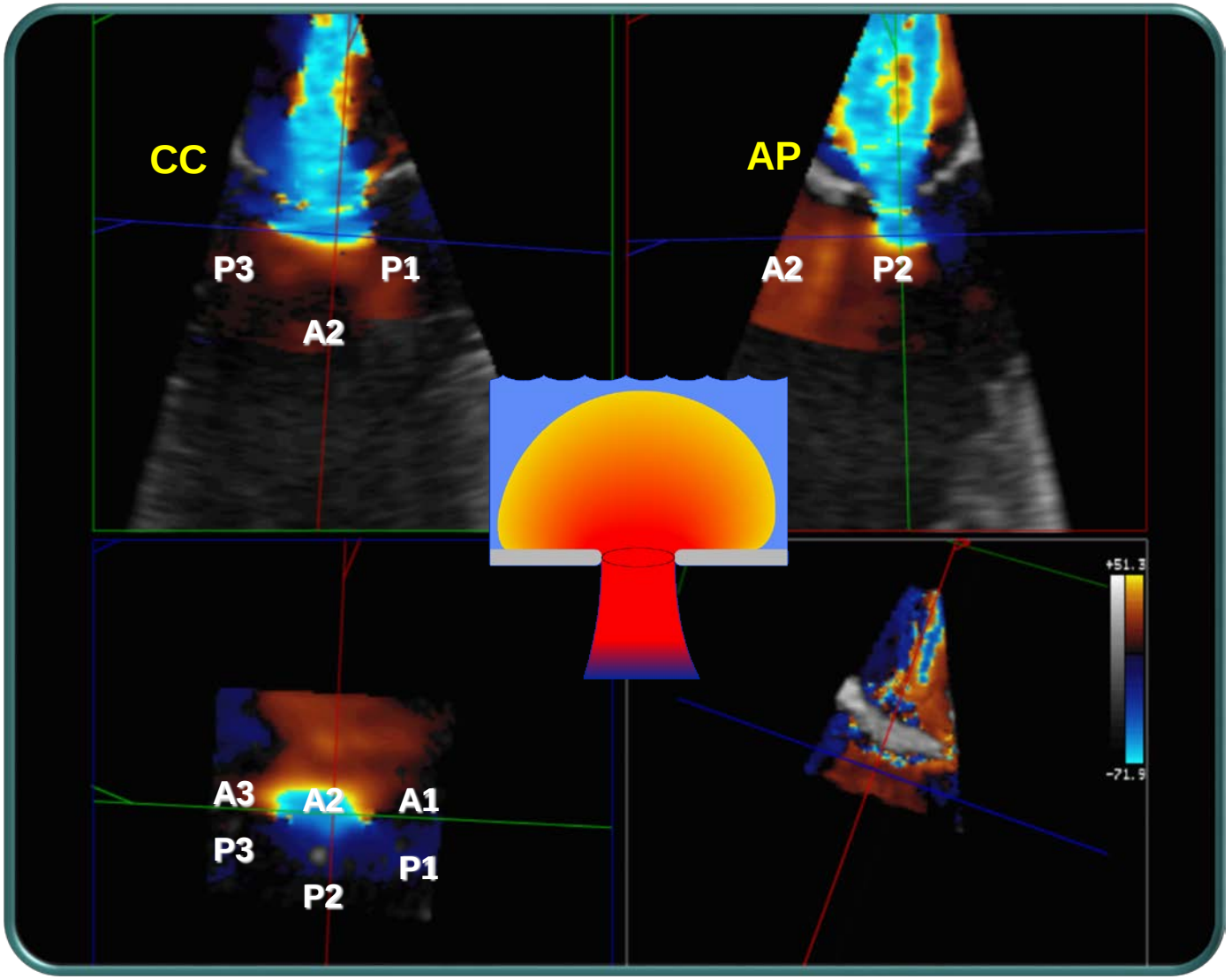
Tsang, Lang RM et al. EHJ: Cardiovascular Imaging 2013; doi:10.1093/ehjci/jet05

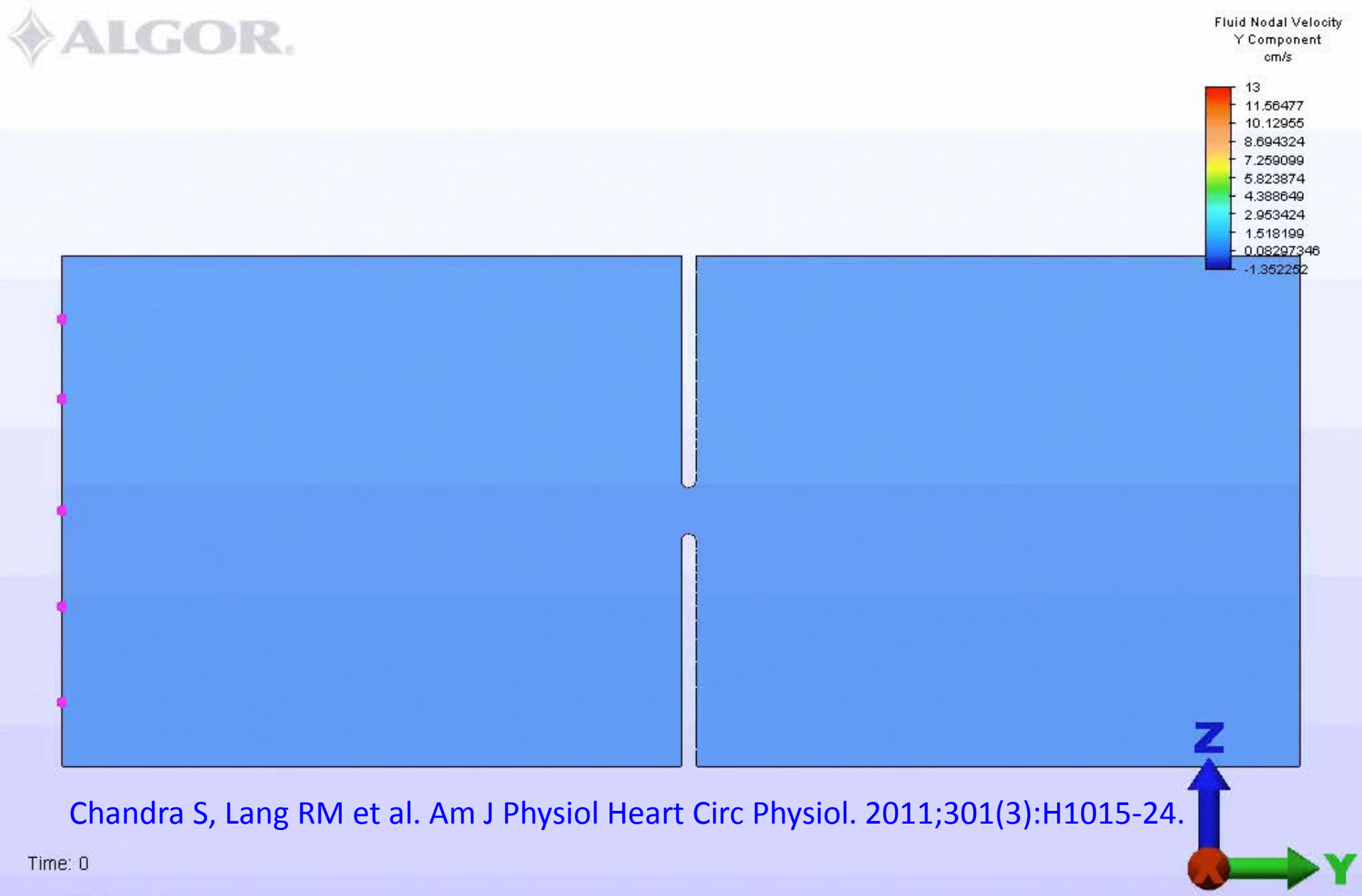
AORTIC-MITRAL COUPLING



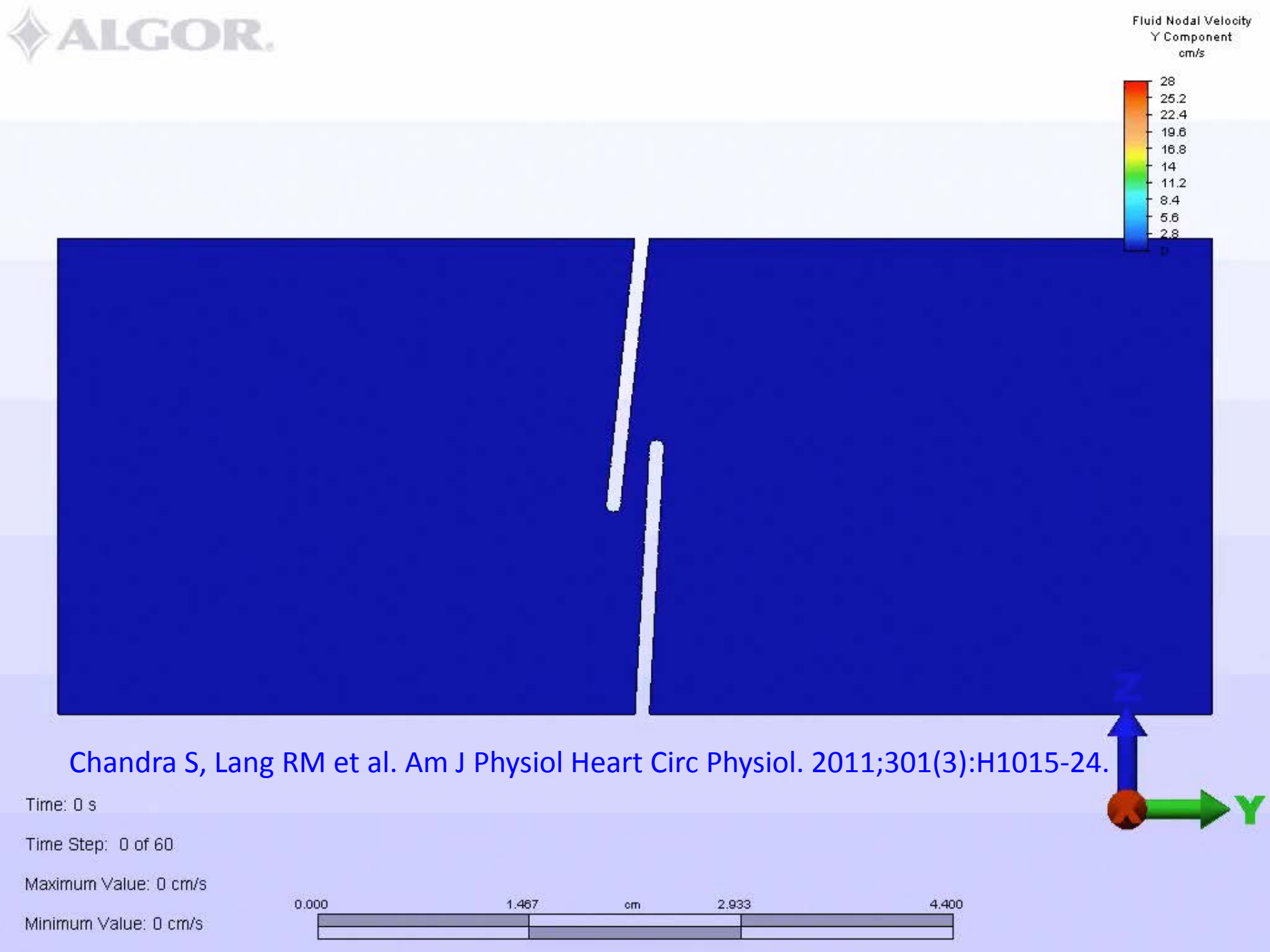
Tsang, Lang RM et al. EHJ: Cardiovascular Imaging 2013;

Challenging the Hemispheric Assumption of Flow Convergence





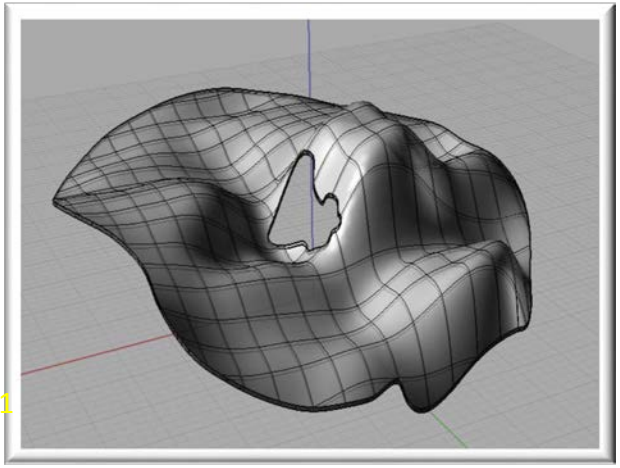
Chandra S, Lang RM et al. Am J Physiol Heart Circ Physiol. 2011;301(3):H1015-24.

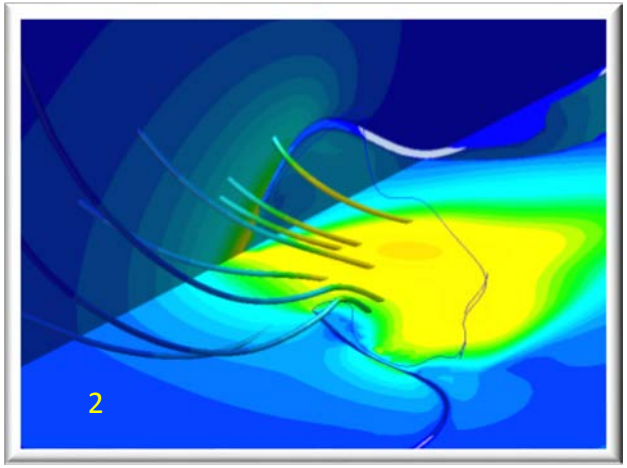


Chandra S, Lang RM et al. Am J Physiol Heart Circ Physiol. 2011;301(3):H1015-24.

3D COMPUTATIONAL FLUID DYNAMICS FROM MVQ

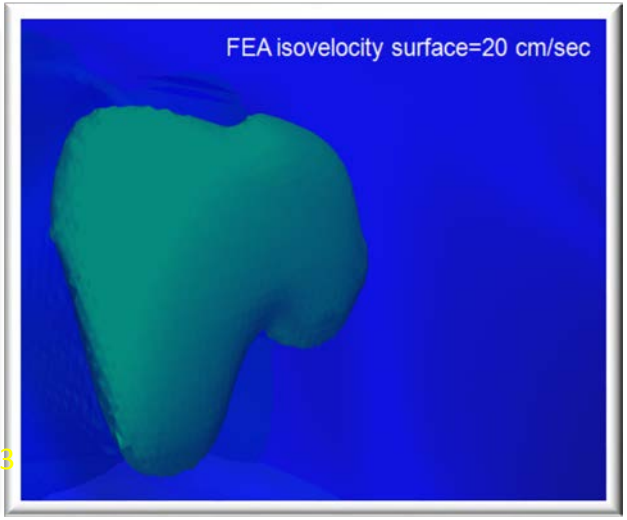
MVQ mesh

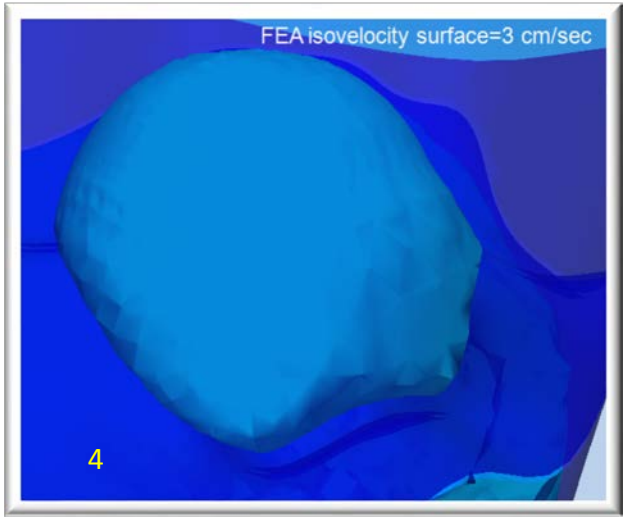




Iso-velocity contour

FC near from orifice less spherical

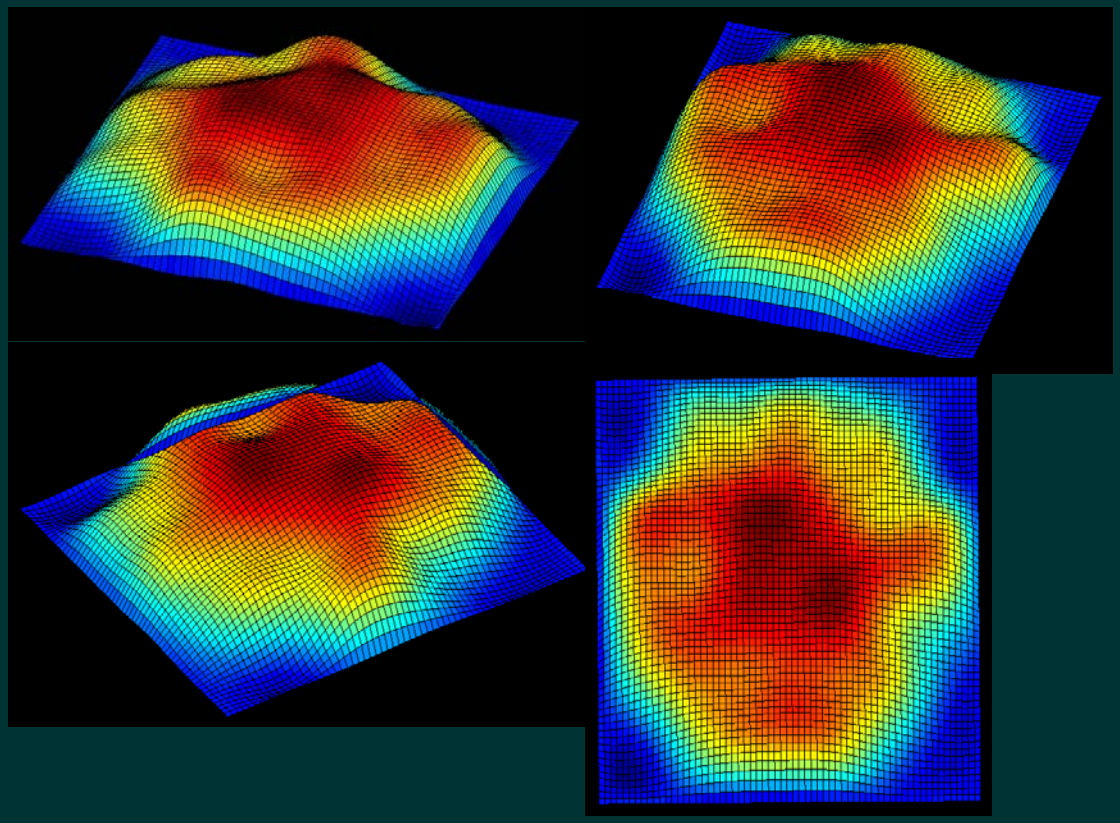


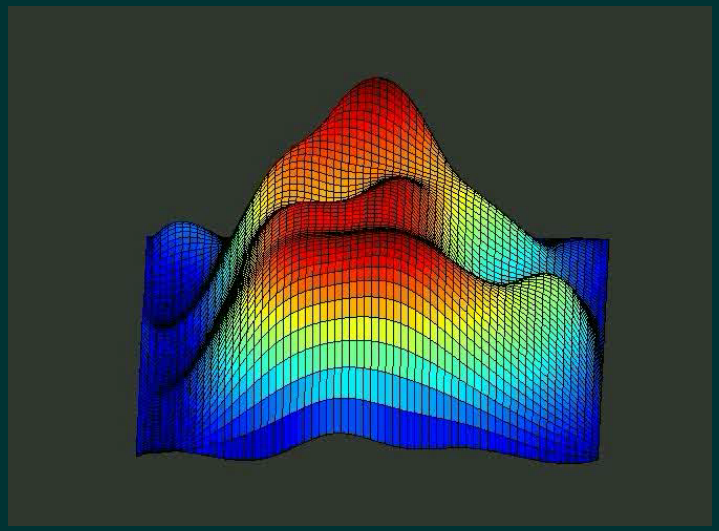


FC far from orifice more spherical

Chandra S, Lang RM et al. Am J Physiol Heart Circ Physiol. 2011;301(3):H1015-24.

Automatic 3D PISA Surface Area





3-D Surface

Courtesy: Mani Vannan

Promises and Perspectives

Valves

Where have we been?

- Rapid dissemination and integration into clinical practice
- Mechanistic insight into MV disease
- Volumetric quantification
- Guidance of percutaneous procedures

Where are we going?

- Quantification of regurgitant lesions
- Automation measurements
- Outcome measures
- Custom prosthesis
- Other valves (Aortic, Tricuspid)

Thanks for your attention