

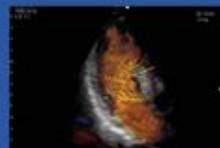
# EuroValve

November 8-9, 2013

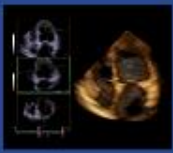


## 3D Echo In The Assessment of Valve Morphology

- Raluca Dulgheru -  
CHU Liege, Belgium



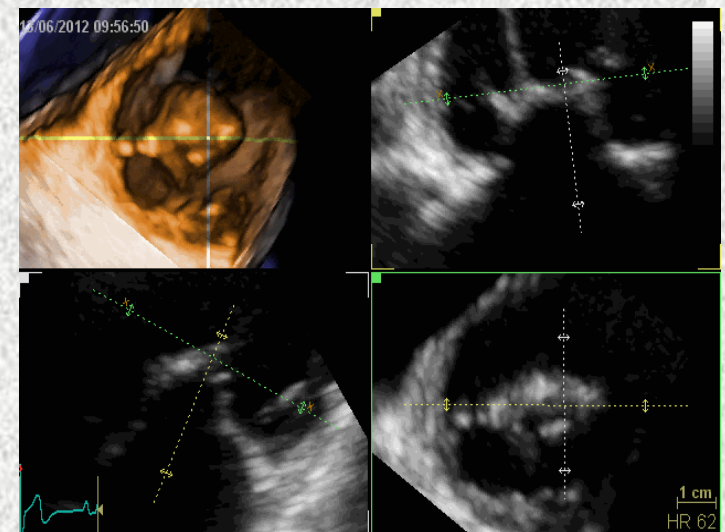
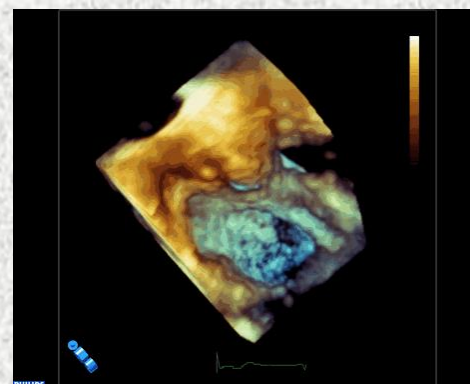
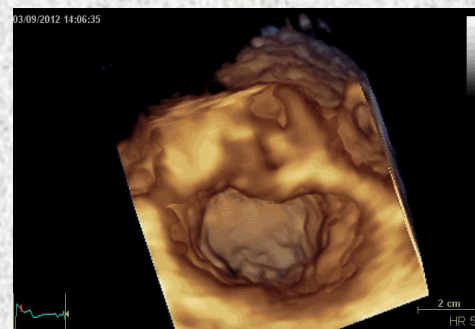
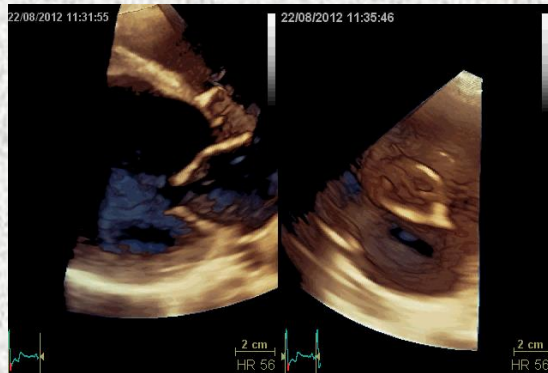
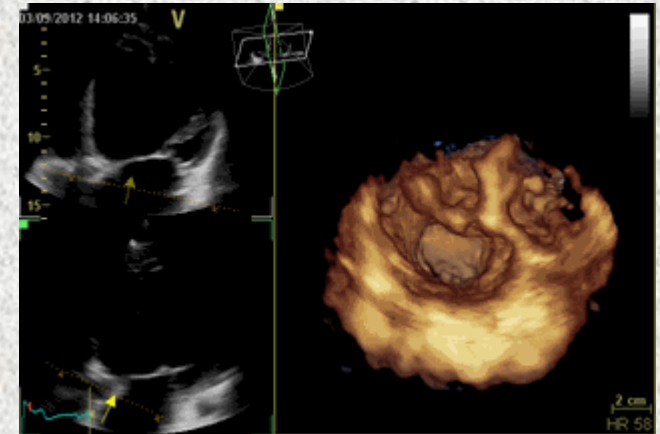
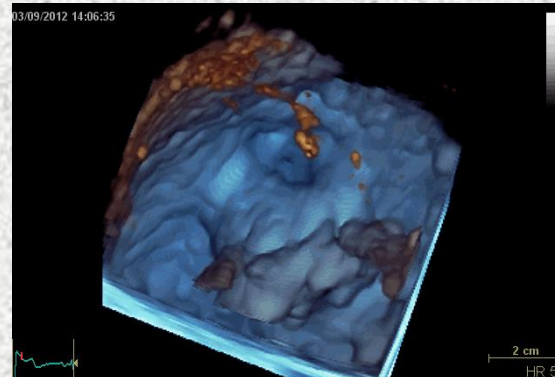
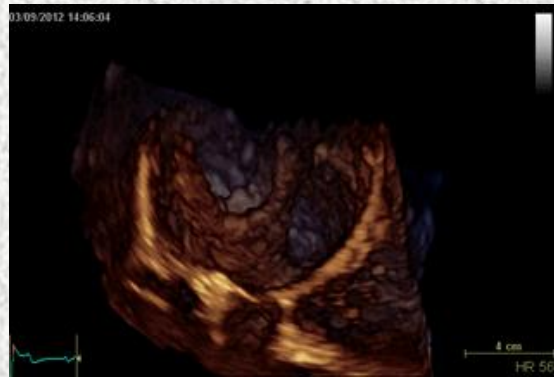
[www.eurovalvecongress.com](http://www.eurovalvecongress.com)



## **Faculty Disclosure**

**I, Raluca Dulgheru, DO NOT HAVE a financial interest/arrangement or affiliation with one or more organizations that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation**

# “All directions” journey around the heart





# From Morphology to Dysfunction.....

**Valves are inherently 3D structures**

Disease/Etiology

**SEE Morphology**

**Lesion**

Dysfunction

Better understanding of valvular morphology (LESION) by 3DE

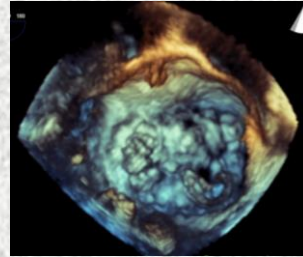
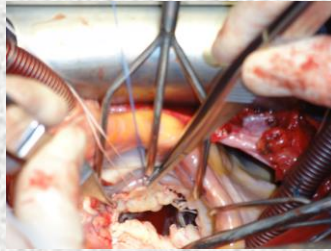
Better understanding of valve dysfunction

Potential benefits regarding valve repair procedures



# 3DE Advantages in Assessing Valve Morphology

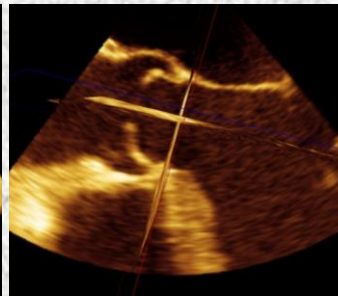
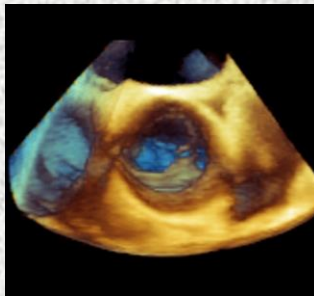
**MITRAL VALVE**



realistic representation

multiple orientations

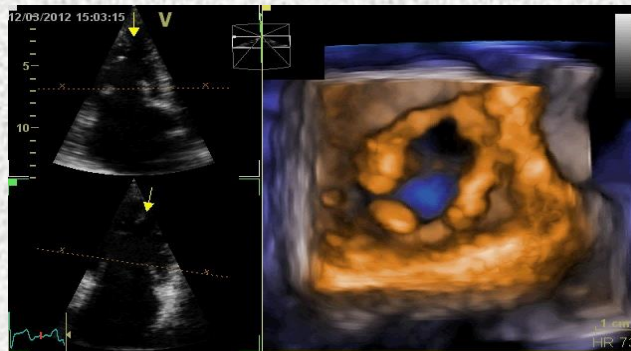
**AORTIC VALVE**



quantitative analysis  
(less/no geometrical  
assumption)

infinite possibility of cut  
planes (better  
understanding of valve  
morphology)

**TRICUSPID VALVE**

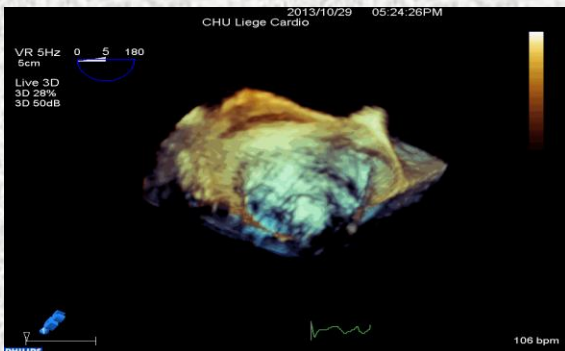
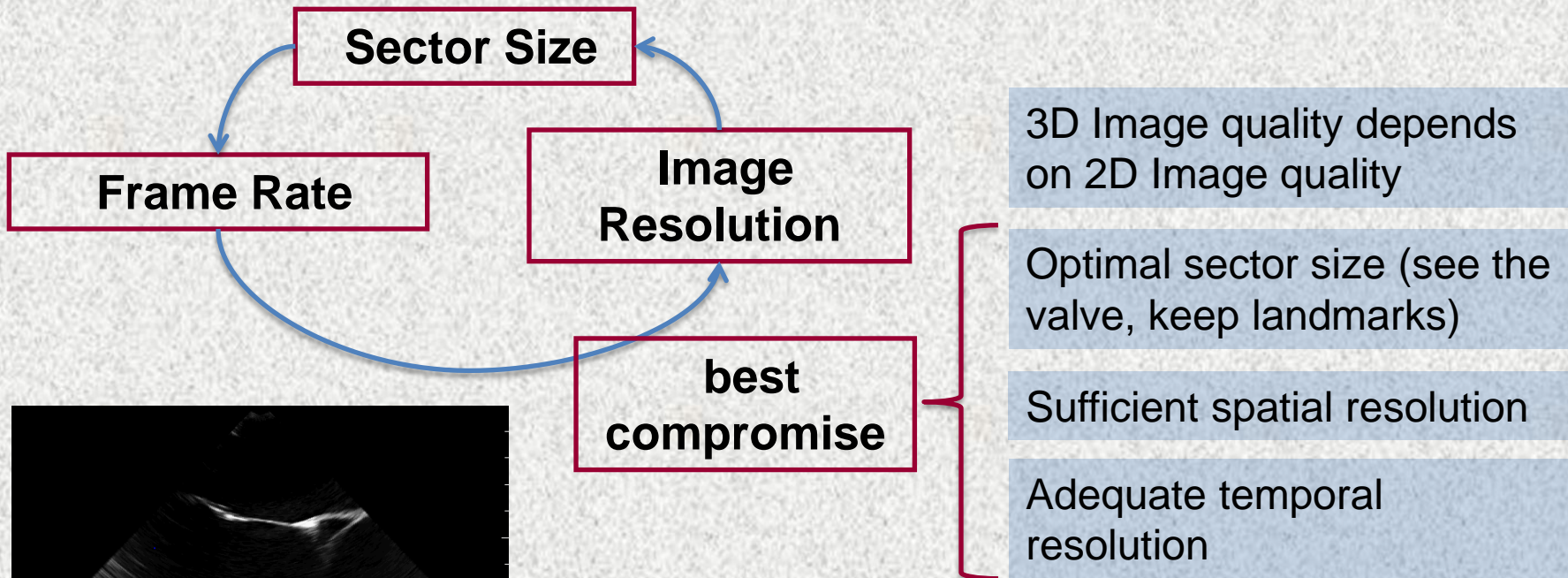


**PULMONIC VALVE**

improved assessment  
of valve dysfunction  
(stenosis/regurgitation)



# 3DE ...not always as good as it sounds!



**3DE complements not replaces  
2DE**

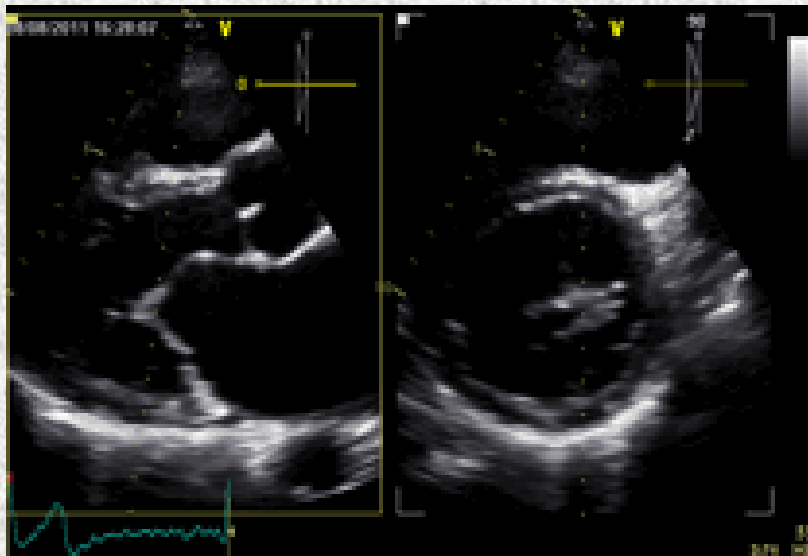
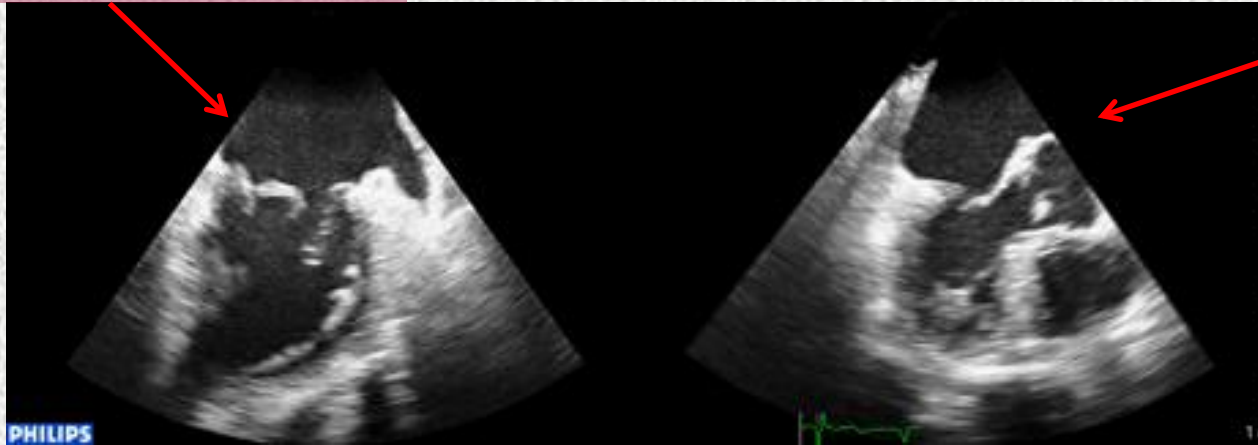
**Any valve  
morphology/dysfunction needs  
FIRST comprehensive 2DE  
evaluation, followed by 3DE**

# 3DE Modalities for Valve Morphology Assessment

X-plane / Multiplane (bi and triplane views)

Reference plane

Lateral plane



Excellent frame rate

Color Doppler can be added

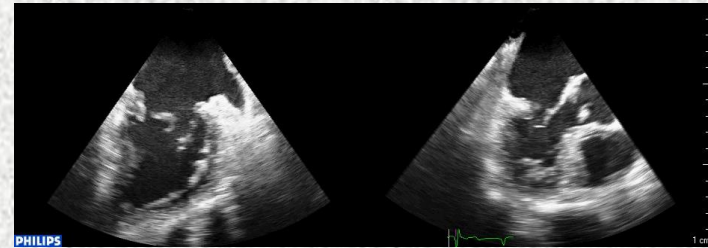
Multiple scanning planes no probe manipulation



# 3DE Modalities for Valve Morphology Assessment

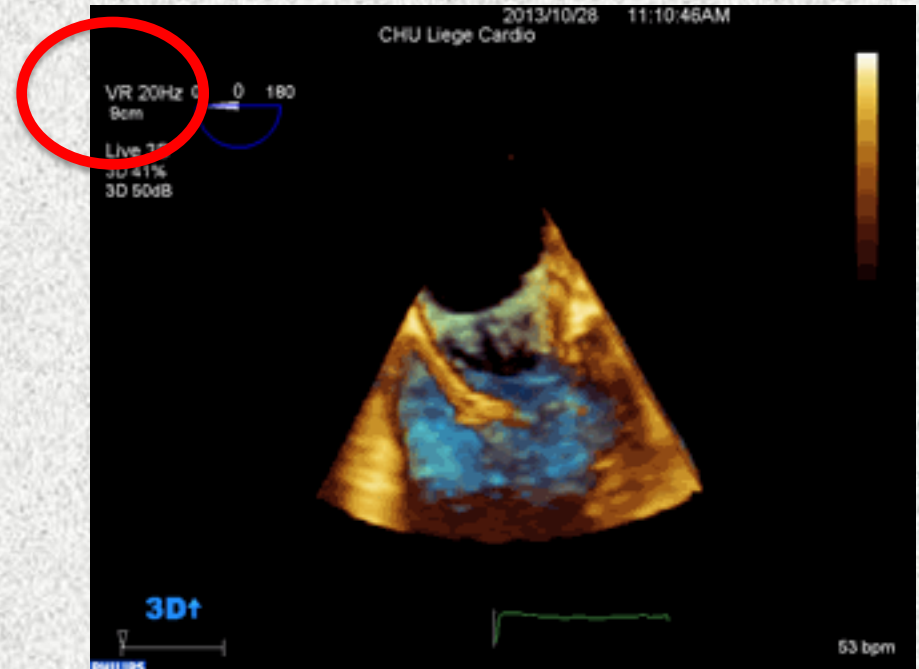
X-plane / Multiplane (bi and triplane views)

Real time “narrow volume” – “**In depth view**” of the 2D image plane



Good frame rate

Best for guiding procedures





# 3DE Modalities for Valve Morphology Assessment

X-plane / Multiplane (bi and triplane views)

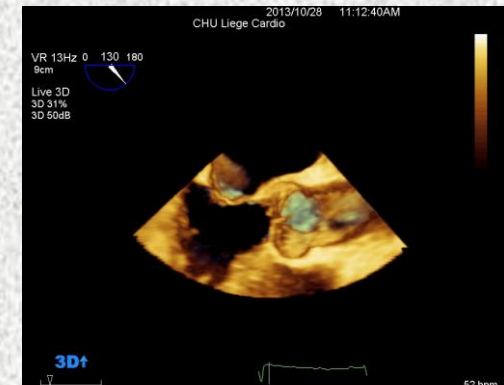
Real time “narrow volume” – “In depth view” of the 2D image plane, best for guiding procedures

Real time “3D Zoom”

**Best for Valve Morphology**

Good spatial resolution

Satisfactory temporal resolution



# 3DE Modalities for Valve Anatomy Assessment

X-plane / Multiplane (bi and triplane views)

Real time “narrow volume” – “In depth view” of the 2D image plane, best for guiding procedures

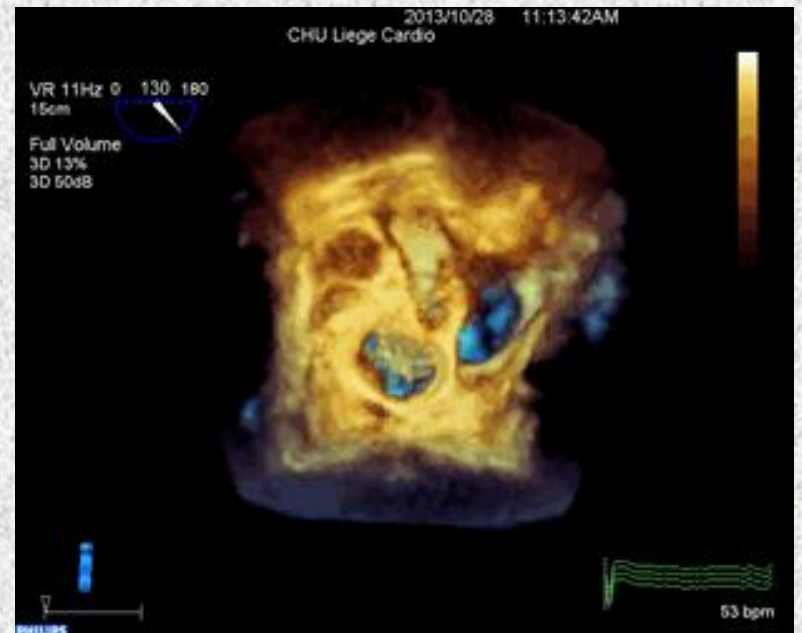
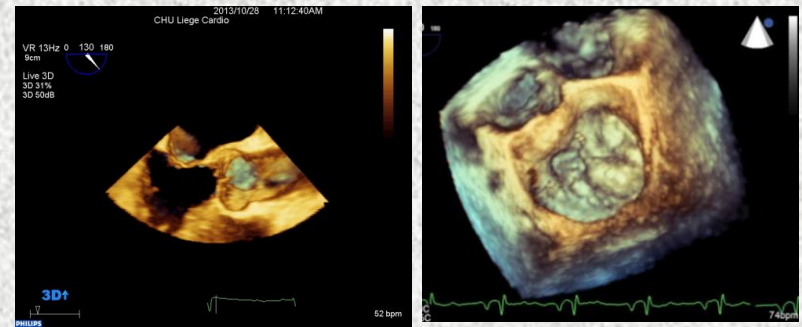
**Real time “3D Zoom”** –best for Valve Morphology

**Full Volume** – largest sector available

Stitching together multiple smaller volumes, ECG gating

Excellent trade off (good spatial and temporal resolution), largest sector

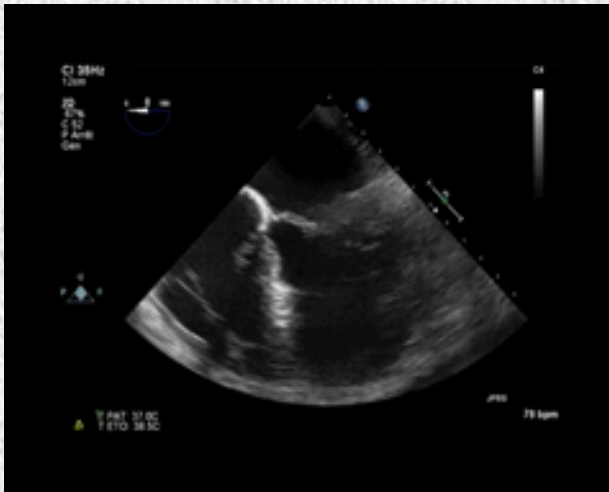
Stitching artifacts : irregular HR, breathing



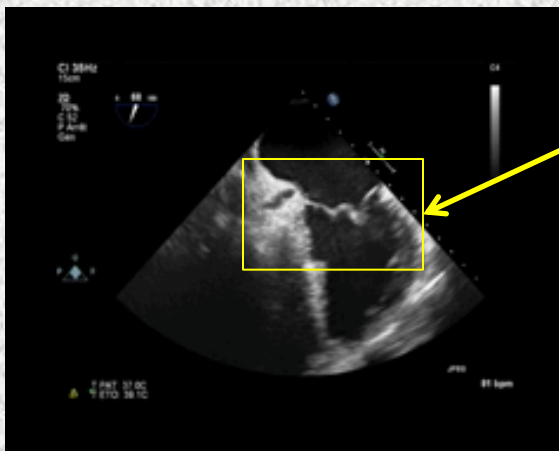


# 3DE Mitral Valve Morphology Assessment

## - 3DE Image Acquisition -



Starts from 2D mid-oesophageal 4ch view



Starts from 2D bicommissural view

**3D Full Volume**

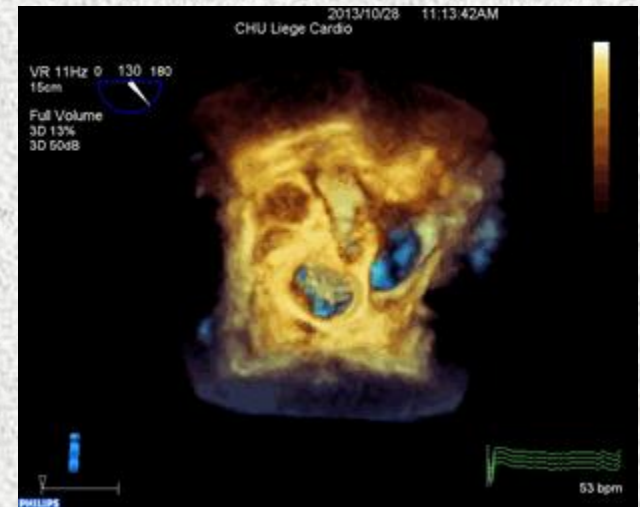
Optimize 2D image:

- Gain
- Sector width
- Sector depth

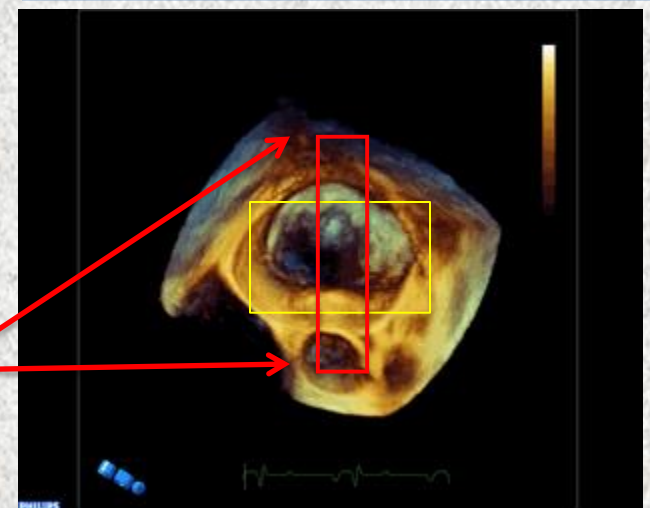
Lateral plane

**Zoom 3D**

Elevational plane



Full volume, breath holding



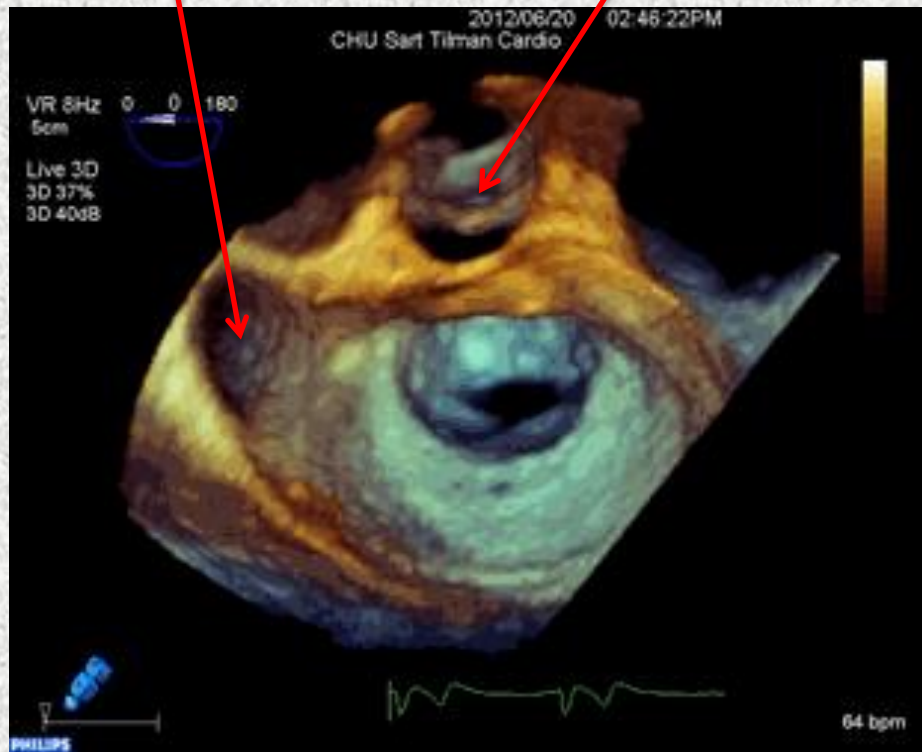
**Aorta UP**  
Zoom 3D volume

# 3DE Mitral Valve Morphology Assessment

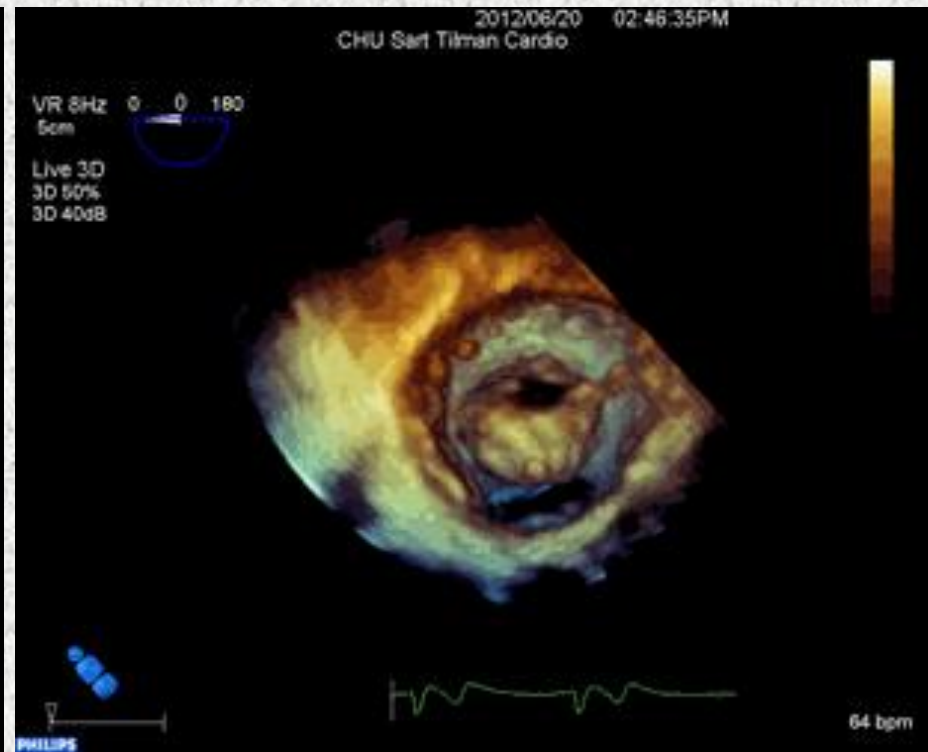
## SURGEON'S view

LA appendage

Aorta



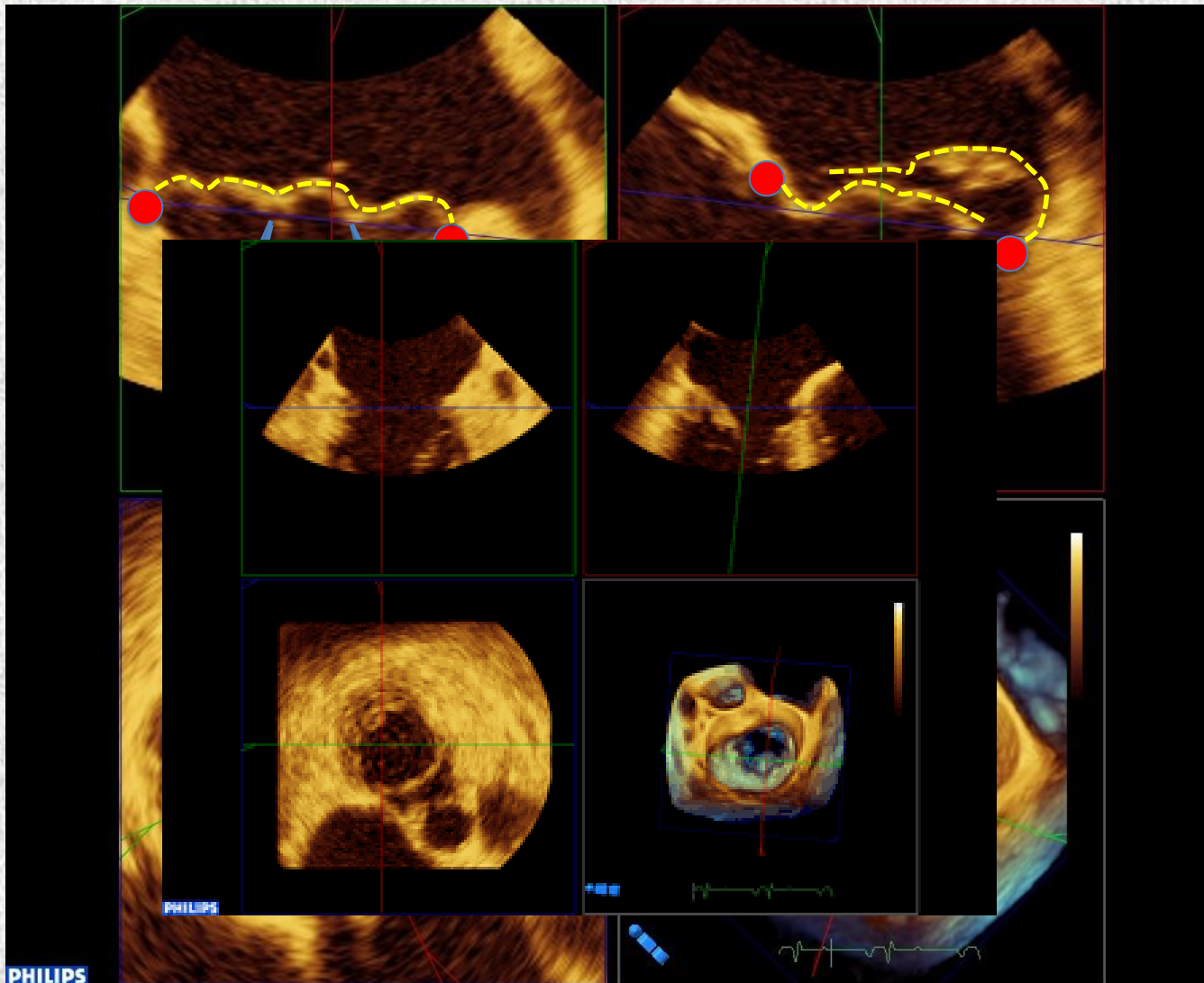
## VENTRICULAR view





# 3DE Mitral Valve

## Off line Multiplane review/Flexi-slice



**Annulus**

**Leaflets**

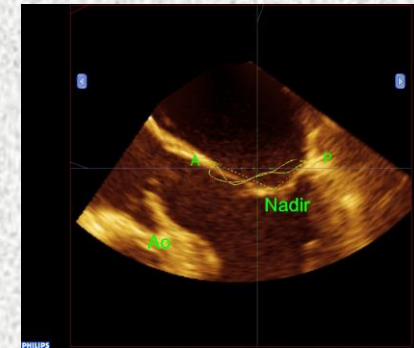
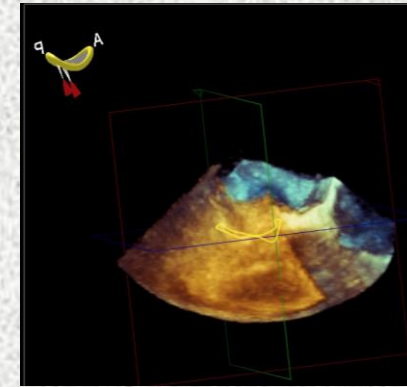
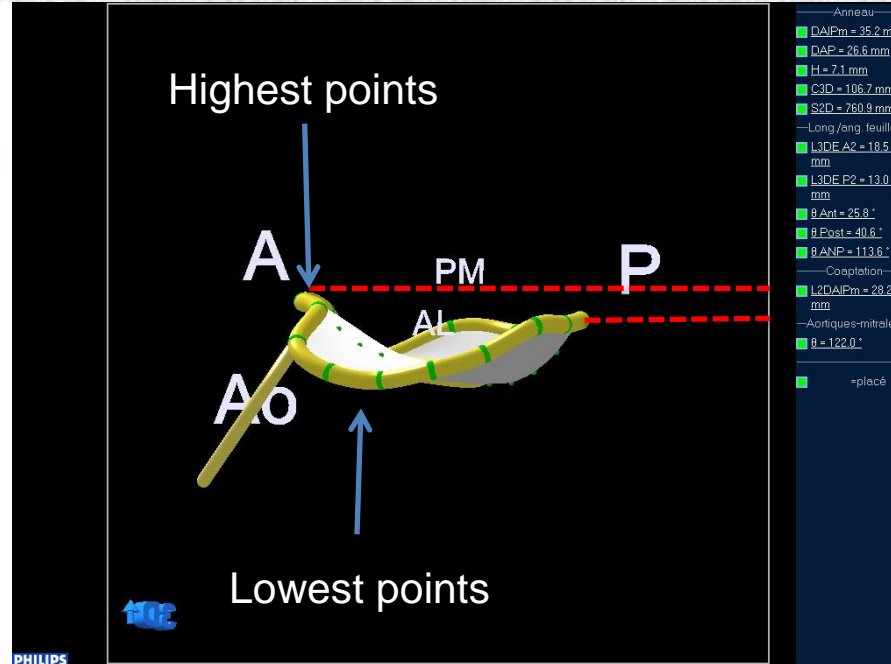
**Subvalvular  
apparatus**



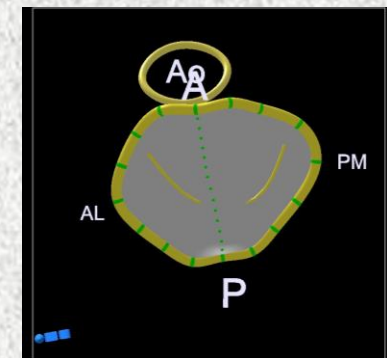
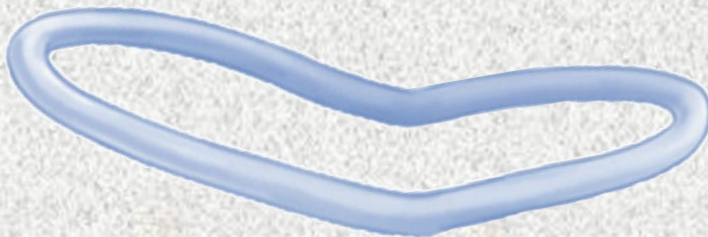
**Dynamic  
Interaction**

# The Mitral Valve - Annulus -

NON planar, saddle shape in normal subjects



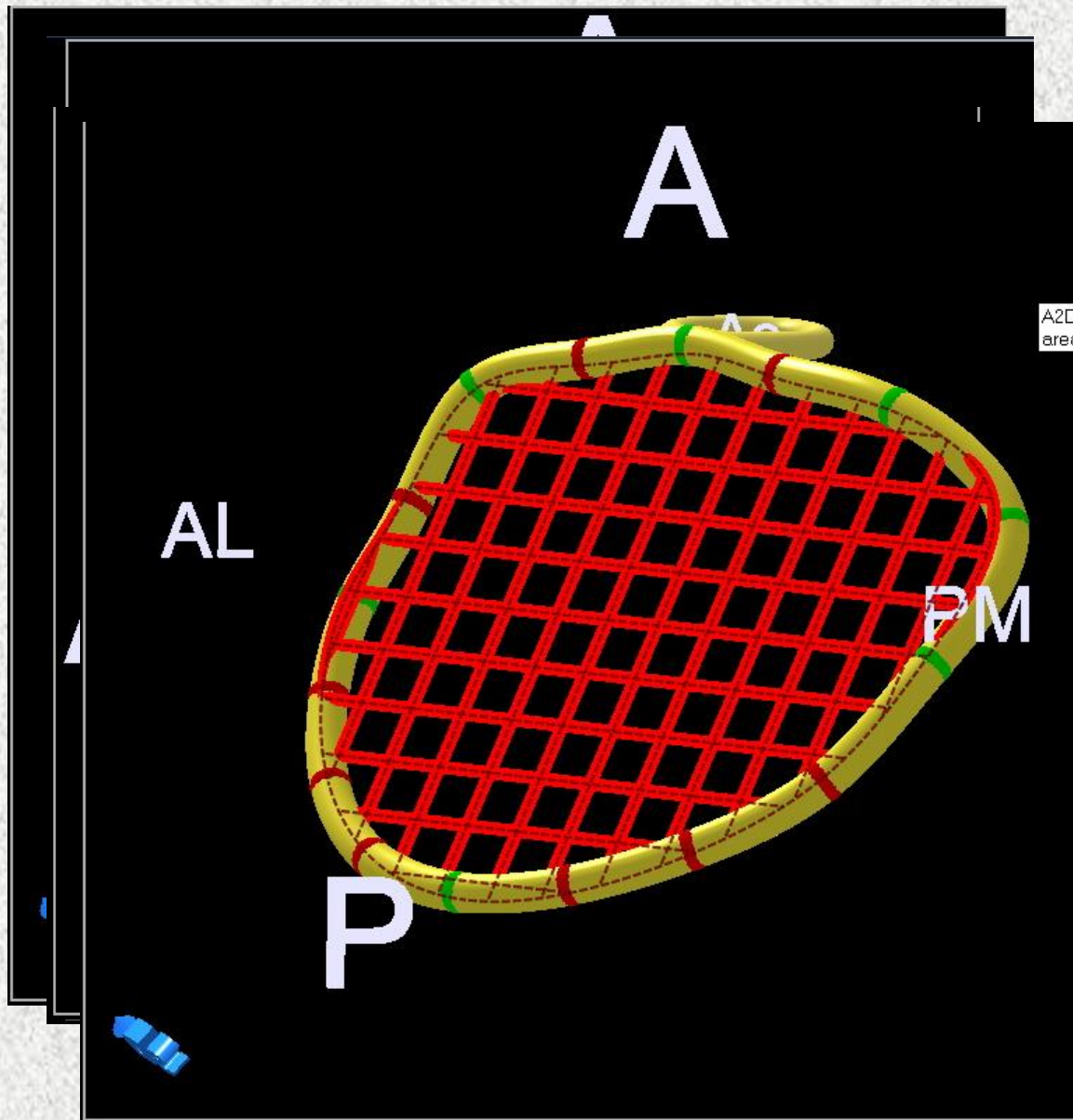
D shape when viewed from above, largest AL to PM commissures



Levine et al. Circulation 1989



# The Mitral Valve - *Annulus* -



**Antero-posterior  
Diameter**

**Intercommissural  
Diameter**

**Mitral Annulus  
Perimeter**

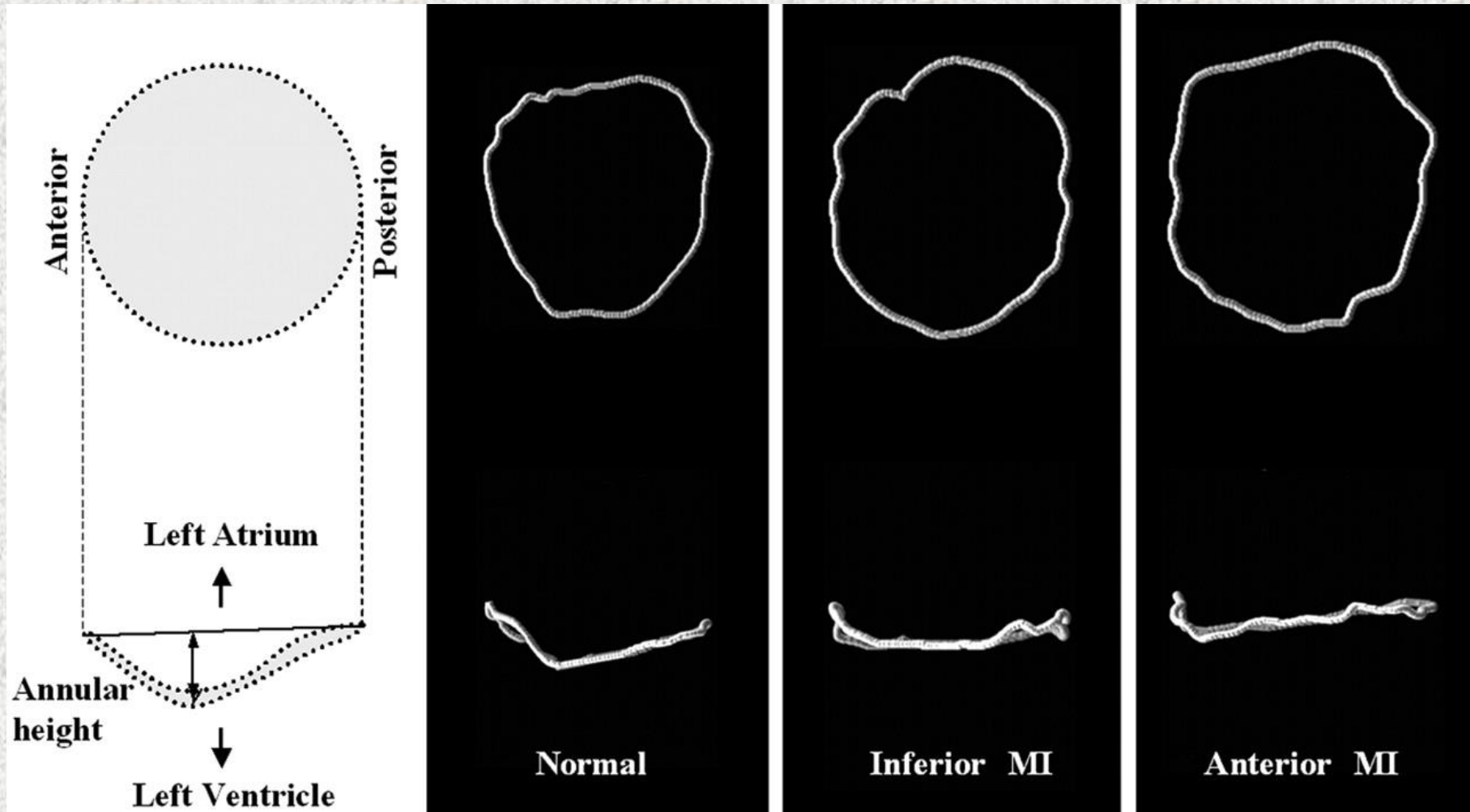
**Mitral Annulus Height**

**Annulus Area In  
Projected Plane**

**No geometrical  
assumptions  
!!!!**

# The Mitral Valve – *Annulus size & shape* -

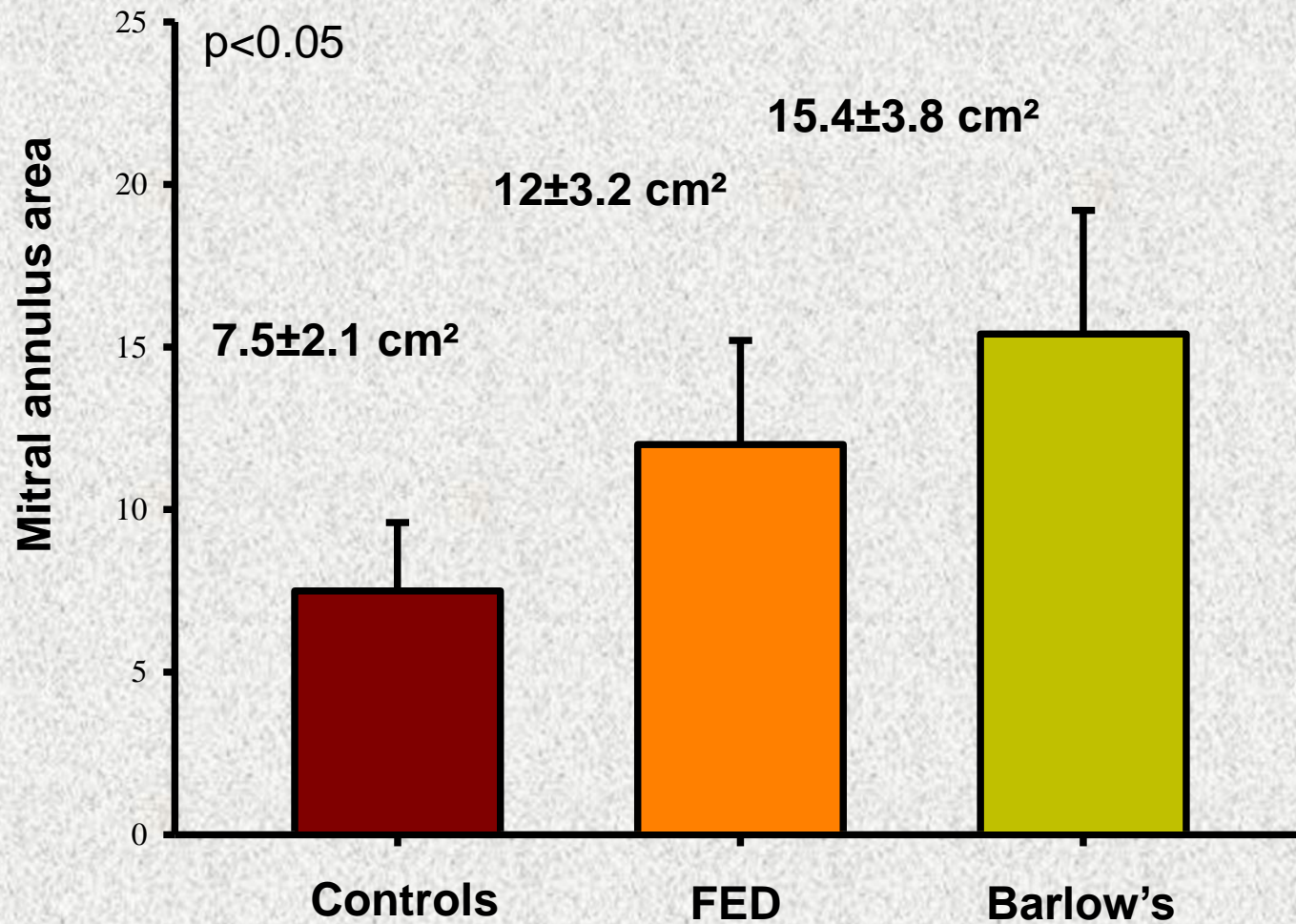
- in secondary mitral regurgitation -





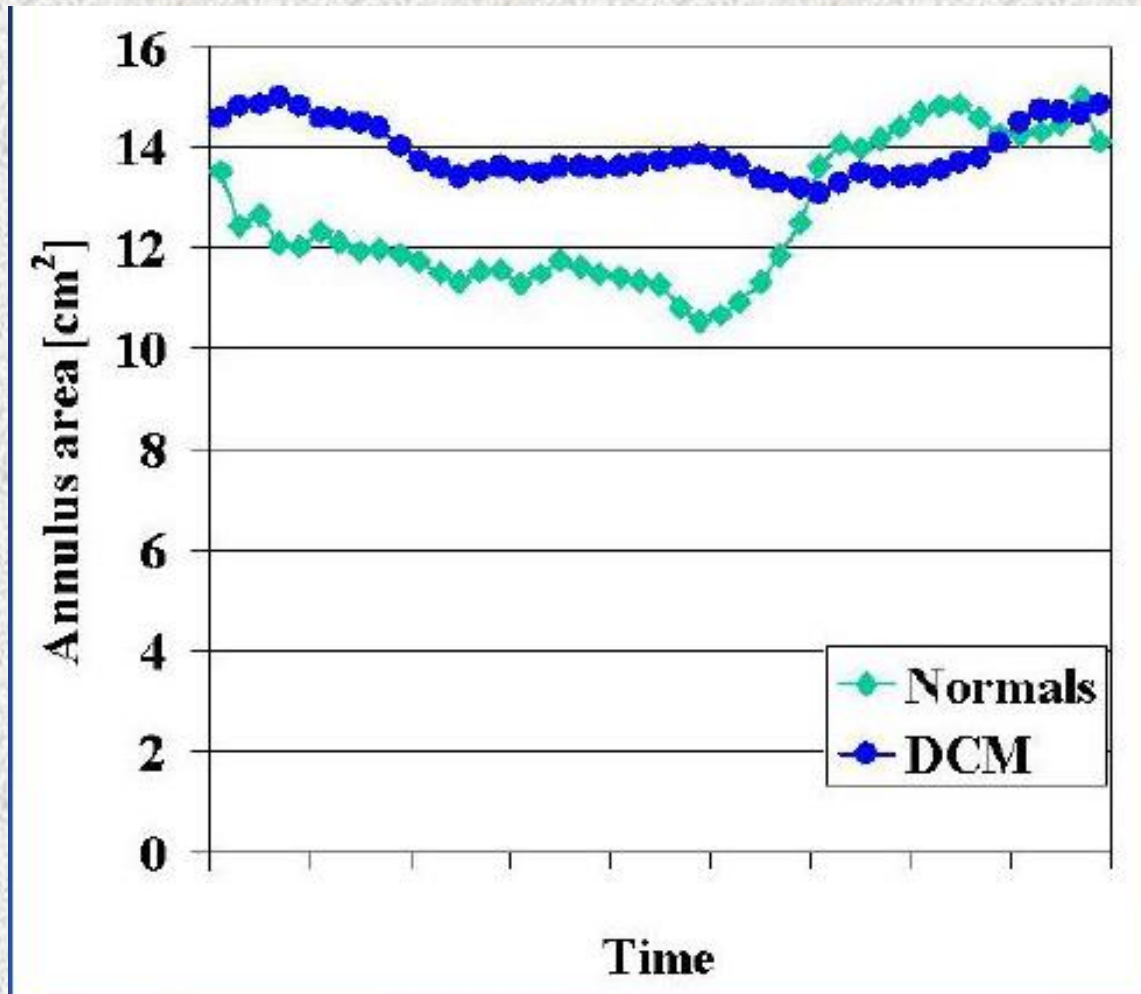
# The Mitral Valve – *Annulus size & shape* -

- in primary mitral regurgitation Barlow's disease and FED -



# The Mitral Valve – *Annulus dynamics* -

- change in mitral annulus area between diastole and systole -
  - The **SPHINCTER** function of the mitral annulus -

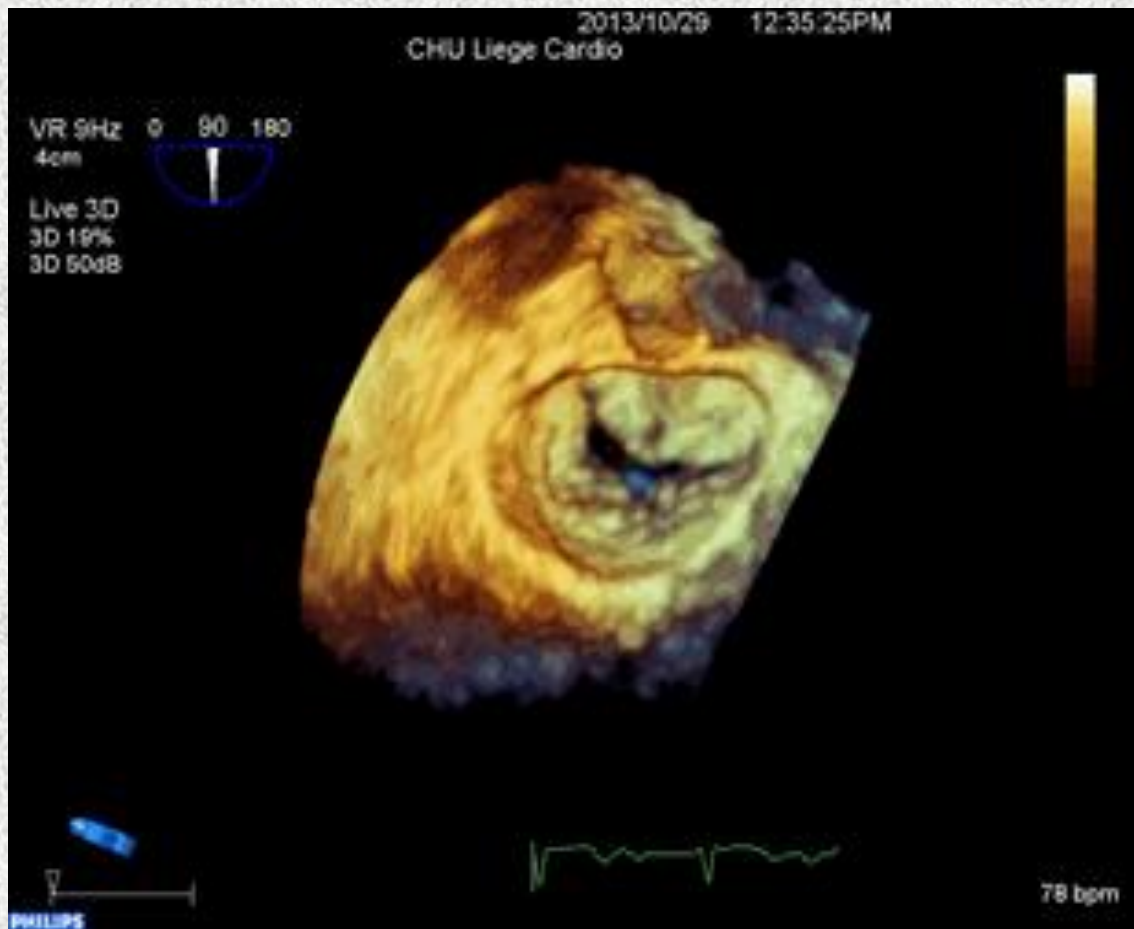


~ 25% reduction in annular area with systole in normal subjects



# 3DE and MV Morphology - Leaflets -

- unique “en face” –  
Normal Mitral Valve



## ANTERIOR LEAFLET

- trapezoid shape
- artificially divided into A1-A2-A3 scallops
- 1/3 of the annular circumference
- in continuity with NCC of the aortic valve (*intervalvular fibrosa*)

## POSTERIOR LEAFLET

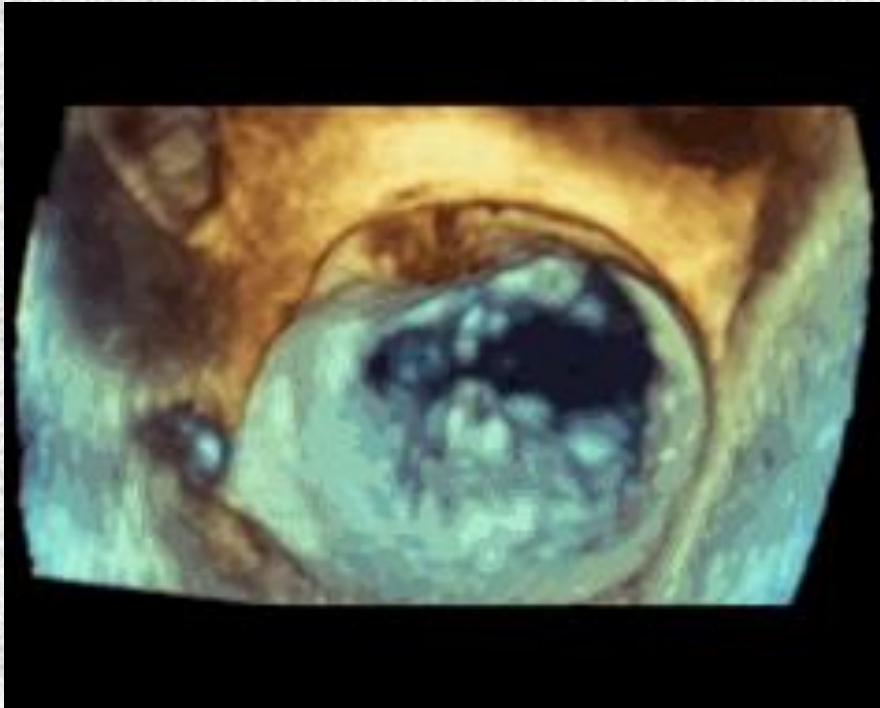
- crescentic shape
- 2 well defined indentations
- 3 individual scallops (P1-P2-P3)
- 2/3 of the annular circumference

## POSTERO-MEDIAL & ANTERO-LATERAL COMMISSURES

# 3DE and MV Morphology - Leaflets -

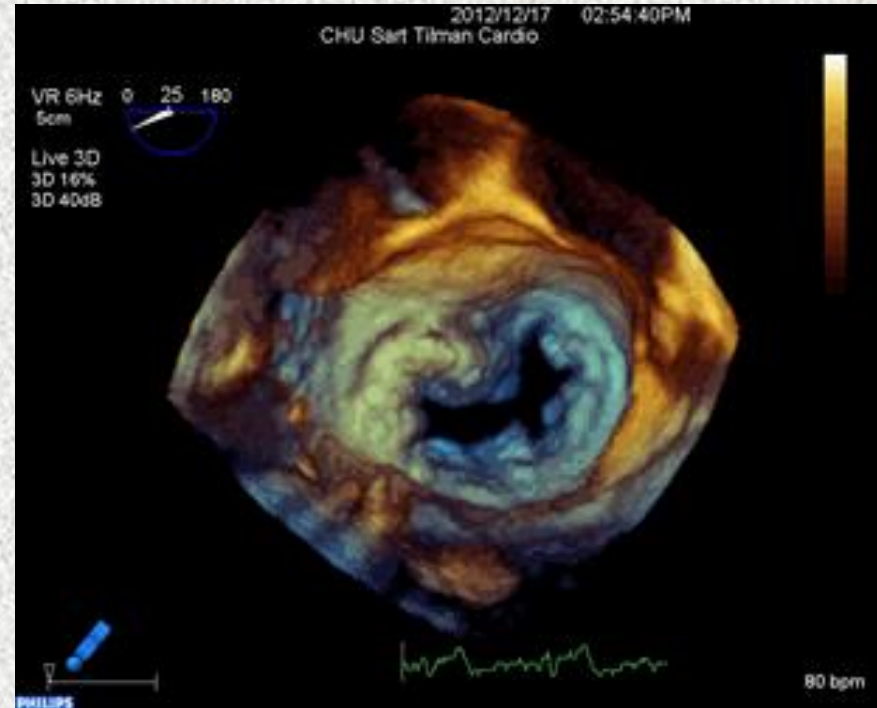
- unique “en face” view -

Rapid and confident identification of the valve lesion



Leaflet perforation

**Carpentier Type I**



Complex Prolapse with Flail  
Leaflet  
Barlow's Disease

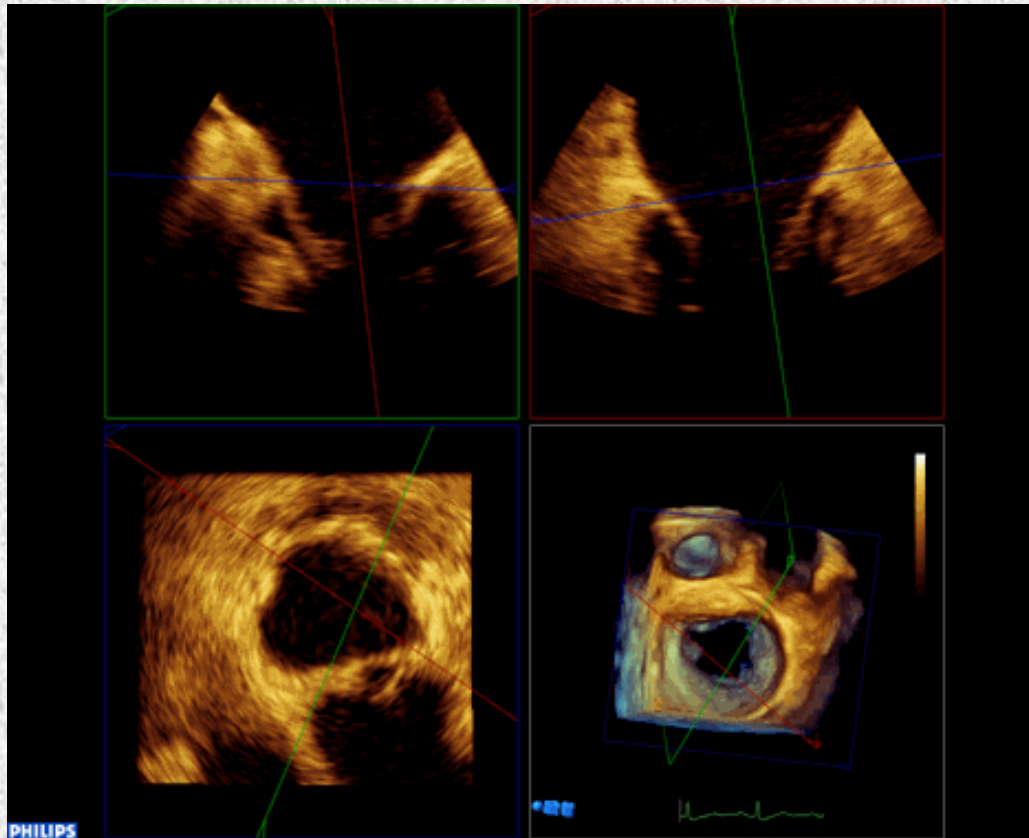
**Carpentier Type II**



# 3DE and MV Morphology - Leaflets -

- unique “en face” view -

Rapid and confident identification of the valve lesion



Higher accuracy  
than 2D TOE for:

Cleft

Leaflet perforation

Commissural disease

Rapid localization of  
vegetation's  
attachment point to  
the leaflets

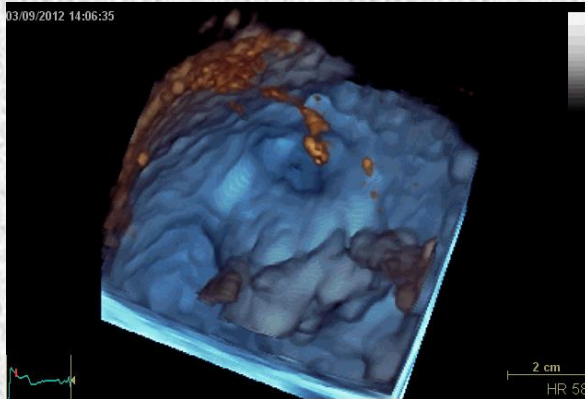
# Specific questions in Primary MR. Why move to 3D?

- Which scallop is affected? Surgeon's view and MPR view
- Are the commissures involved? Surgeon's view and MPR view
- Are there any calcifications? 2D better than 3D
- Is there lack of valve tissue? Extent? Surgeon's view, off line analysis
- Is there any abnormality of the MV apparatus? 3D gives in one volume the dynamic relationship between MV leaflets and subvalvular apparatus
- Is there severe annular dilatation? Mitral Annulus Reconstruction – no geometrical assumptions

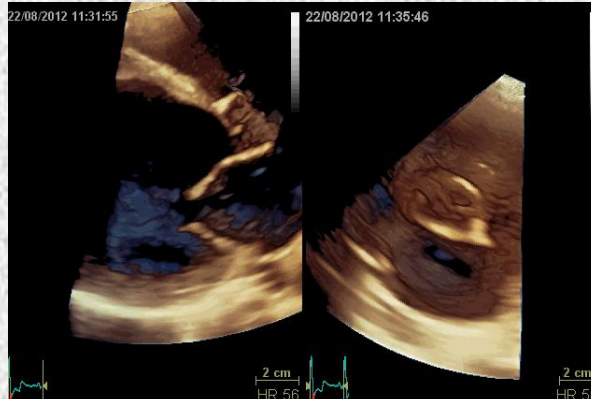


# 3DE MV Morphology in SMR

LV dilation/remodeling



Papillary muscles  
apical/outward  
displacement

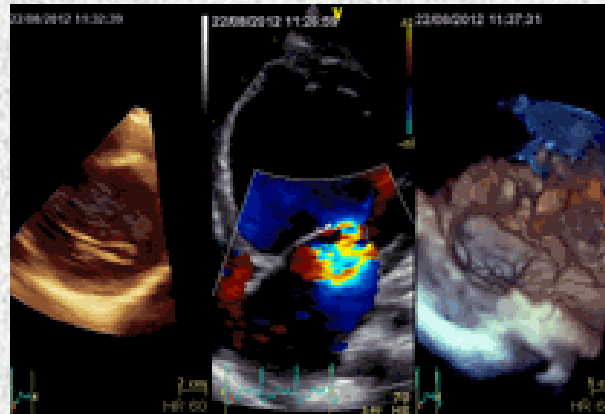
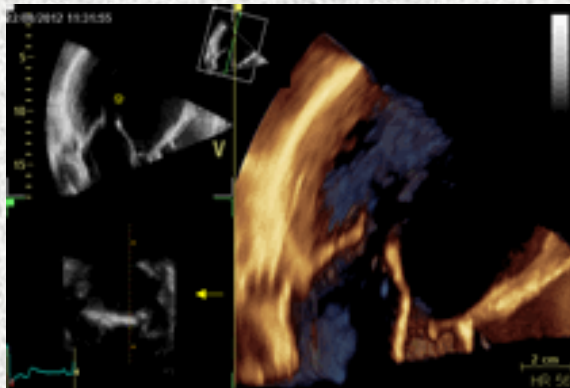


Tethering

Restricted systolic  
leaflet motion

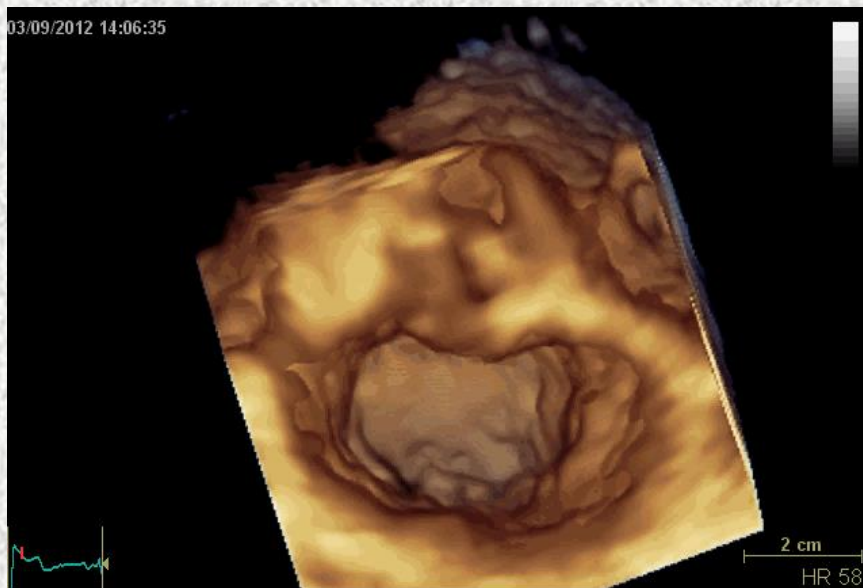
Apical displacement  
of coaptation line &  
decreased  
coaptation surface

Valve dysfunction



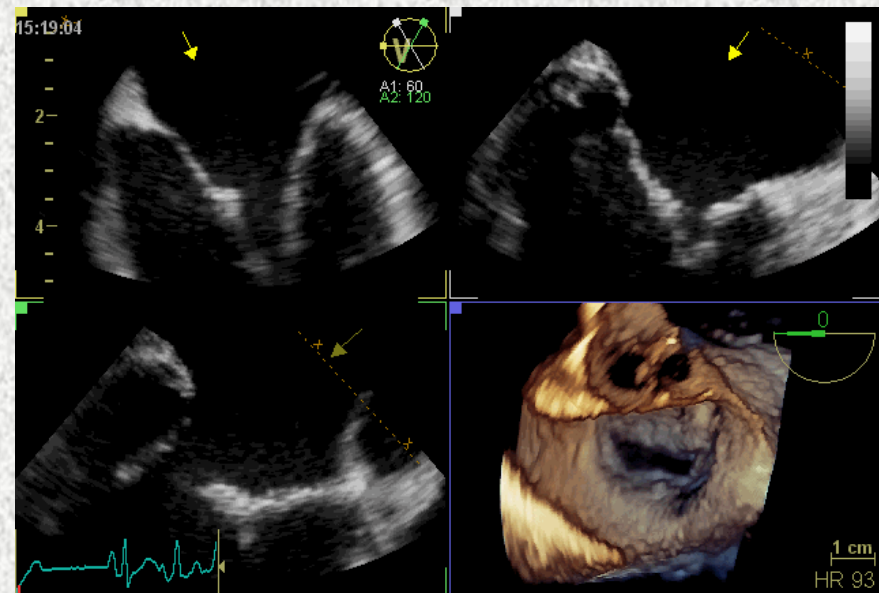
# 3DE MV Morphology in SMR “surgeon’s view”

“Funnel shape” MV



Symmetric tethering

“Funnel shape” MV



Asymmetric tethering

**Carpentier Type IIIb**



# 3DE MV Morphology in MS

- unique “en face” / ventricular view -  
Rapid and confident identification of the valve lesion



Doming of the  
anterior valve leaflet  
in diastole

Commissural/chordae  
fusion

Posterior Leaflet  
systolic and diastolic  
restriction (shortened  
chordae)

Non-planar mitral  
valve orifice

Pliability of the AML

Degree of  
commissural  
calcification  
(Suitability to PMC)

Careful search for  
Carpentier IIIa MR

MV area by  
planimetry

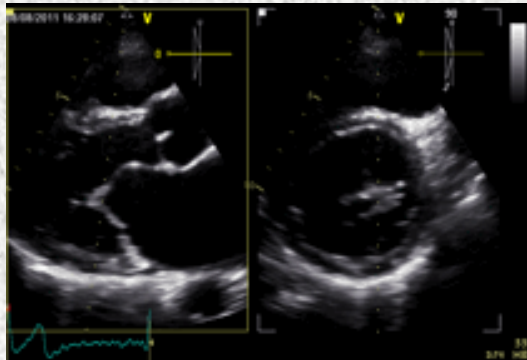


**Assists patient's  
selection for PMC**



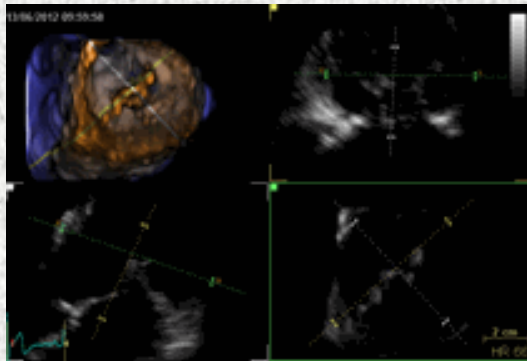
# 3DE MV Morphology in MS

## Accurate assessment of MA area by planimetry



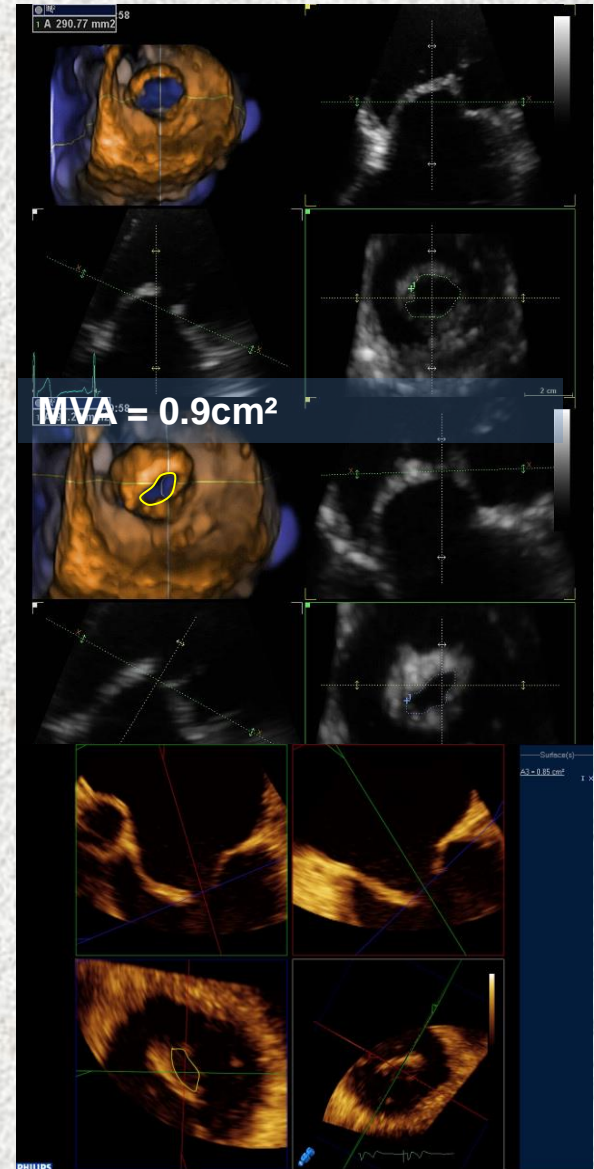
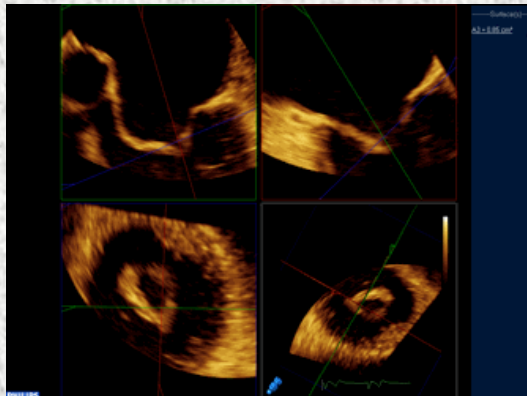
### 3D TTE biplane:

- Good alignment
- Orthogonal plane in systole at leaflet opening site
- Advantage over 2DE, better control of the cutting plane orientation



### 3D TTE 1/multiple beat volume or 3D zoom mode:

- off line cropping of the volume
- smallest orifice is planimetered
- some vendors allow planimetry directly on the cropped volume





# 3DE -The Aortic Valve

## Drawbacks:

### TOE:

- anterior position relative to probe
- oblique incidence of US
- thin cusps

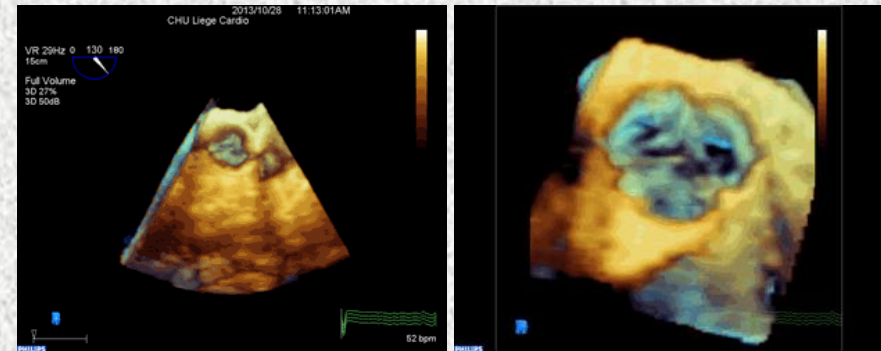
### TEE:

- superior position relative to apex (best viewed in PSLA)
- oblique incidence of US
- thin cusps

## - Image Acquisition -

### Full Volume

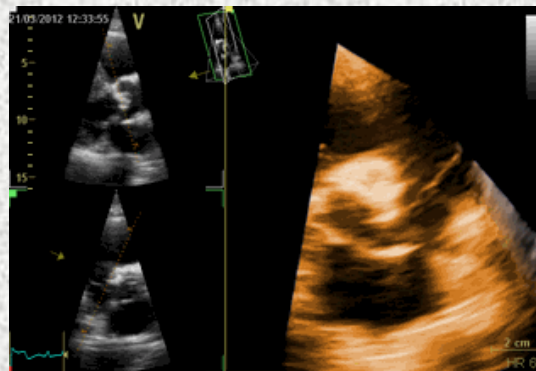
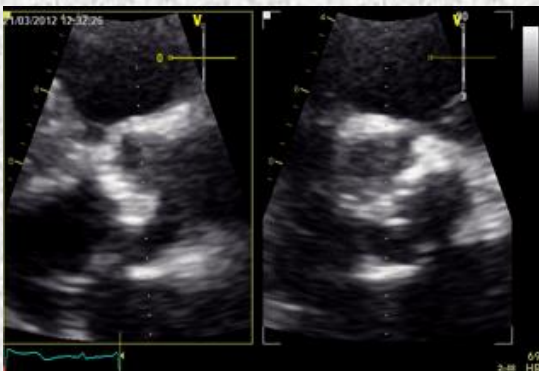
Live 3D from mid-oesophageal short axis/3ch view



### 3D Zoom



Parasternal long axis:  
Biplane  
Full Volume



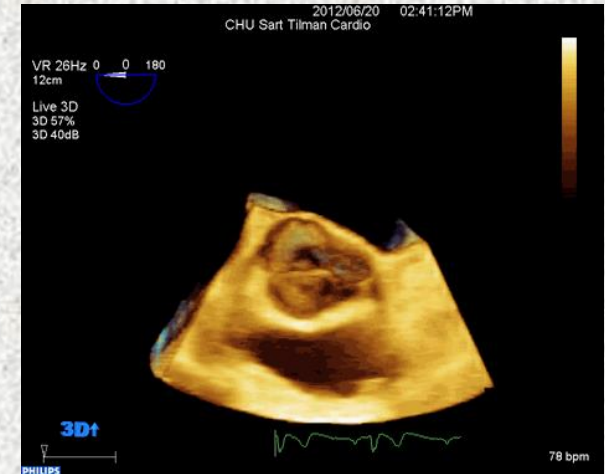
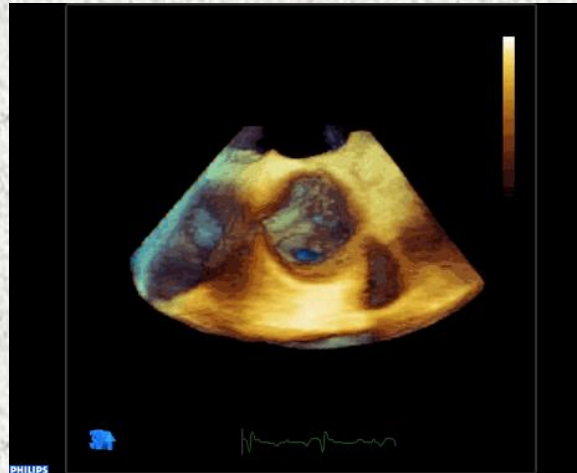
# 3DE -The Aortic Valve

## - Advantages -

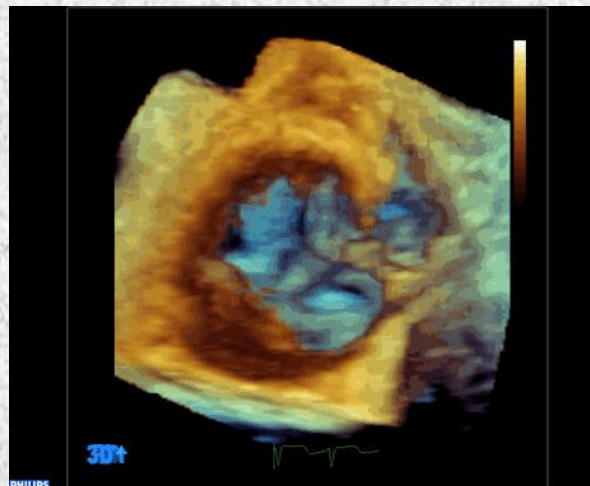
Elegantly depicts AV leaflet morphology (bicuspid vs. tricuspid aortic valve)

**Aortic view and ventricular view**

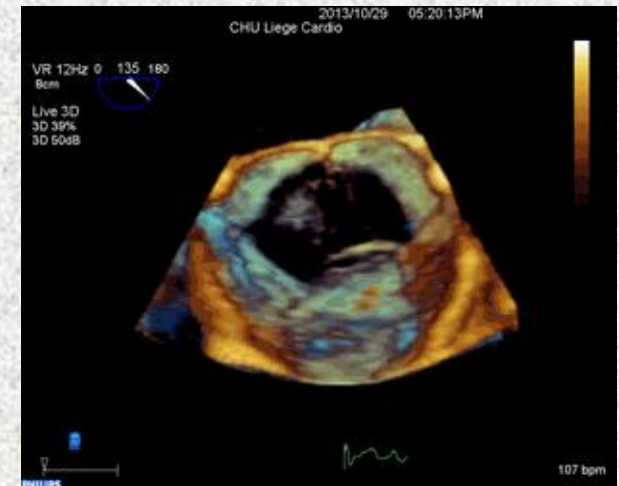
Rapidly identifies abnormalities (masses attached to leaflets)



*Singh et al. Echocardiography 2009*



**Fibroelastoma**



**Functional AR**



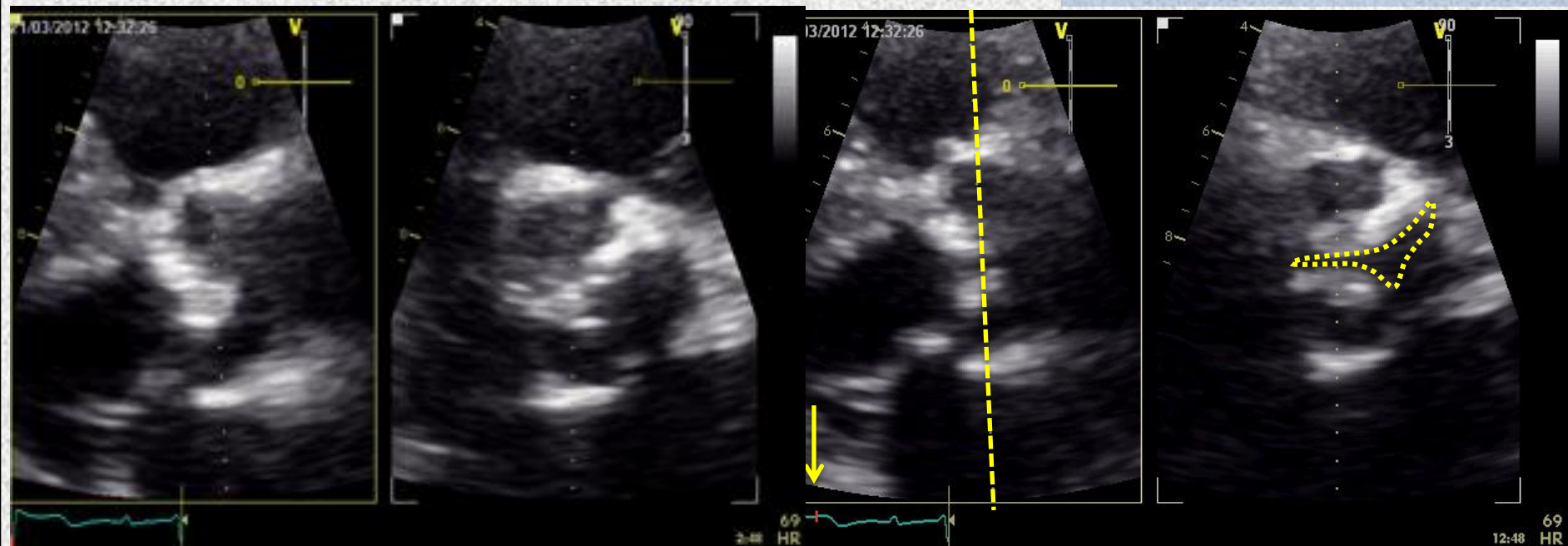
# 3DE -The Aortic Valve

- Improved assessment of AS severity (anatomic AVA) 3D TTE-

Planimetry of the  
anatomic AVA

Biplane from PSLA

Anatomic AVA =  $0.85 \text{ cm}^2$



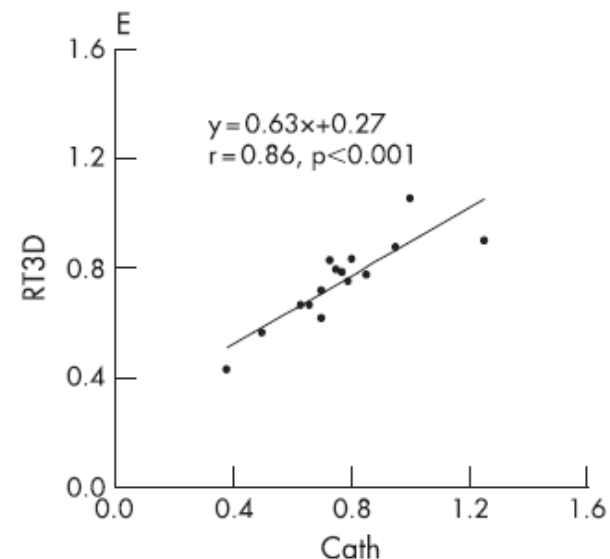
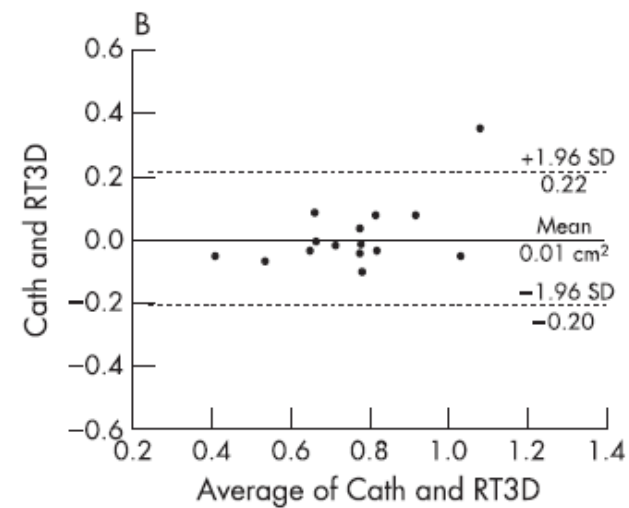
Still frame in mid-systole, cutting plane at  
the level of AV tips

# 3DE -The Aortic Valve

- Improved assessment of AS severity (anatomic AVA) 3D TOE -

Off line planimetry of the anatomic AVA

3D Zoom or Full Volume data set



Goland et al. Heart 2007

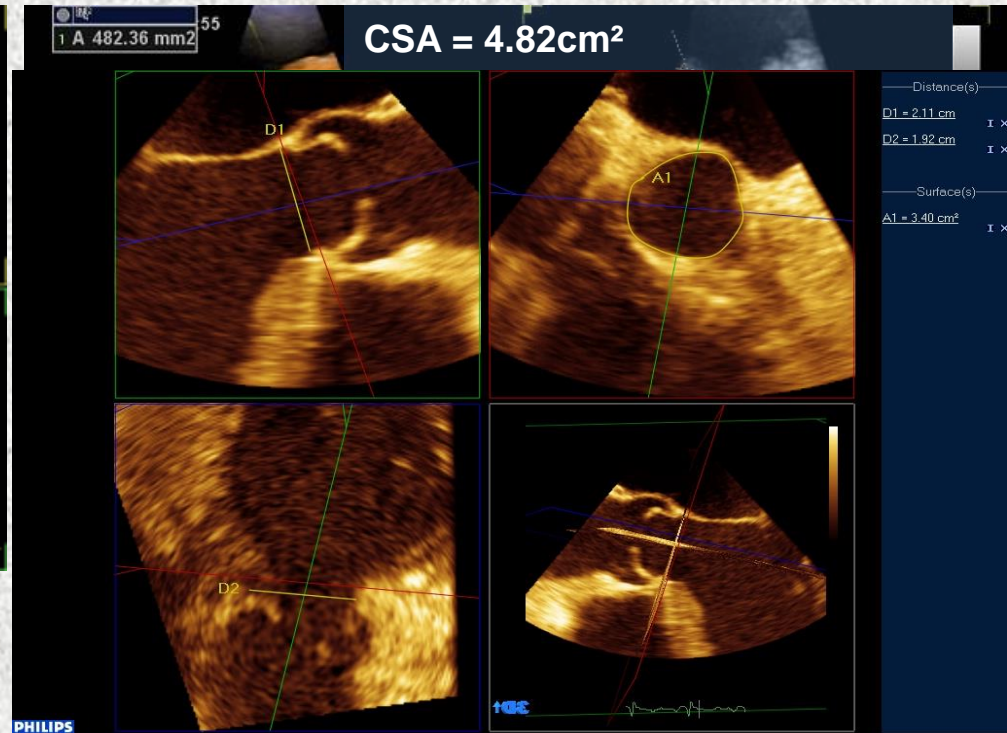
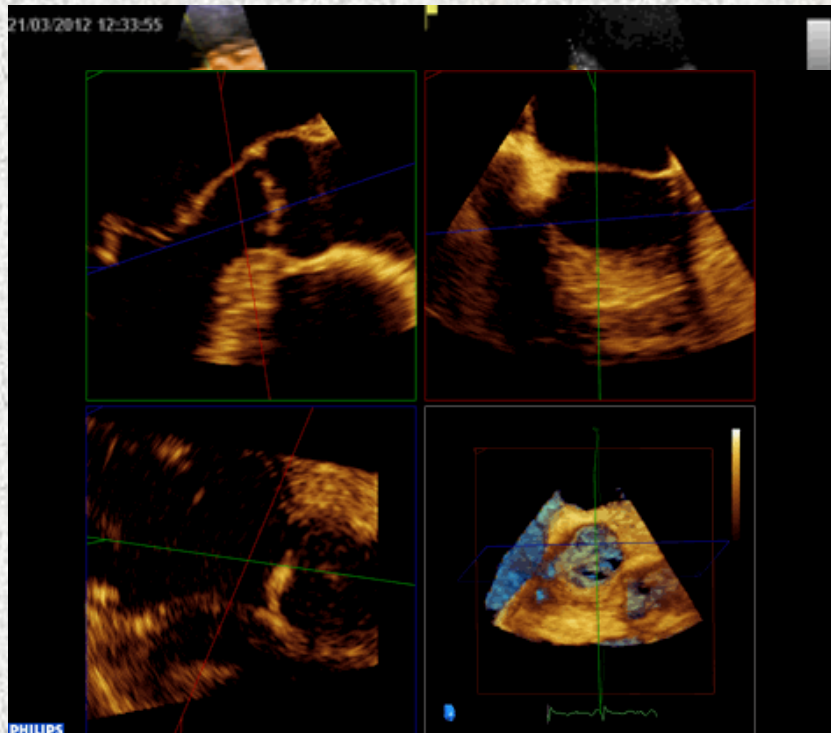


# 3DE -The Aortic Valve

- Improved assessment of AS severity (effective AVA) -
- LVOT Geometry -

3 dimensional imaging techniques say : LVOT is NOT circular !!!!

Off line planimetry of the LVOT cross section without geometrical assumptions



# 3DE -The Tricuspid Valve

## Drawbacks:

### TOE:

- anterior position relative to probe
- oblique incidence of US
- thin cusps

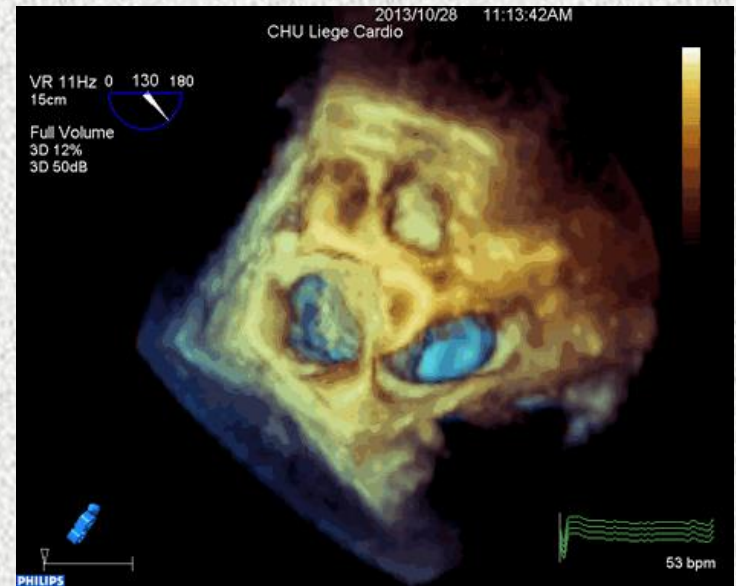
### TEE:

- retrosternal anterior position makes imaging of the lateral aspect of the valve difficult
- oblique incidence of US
- thin cusps

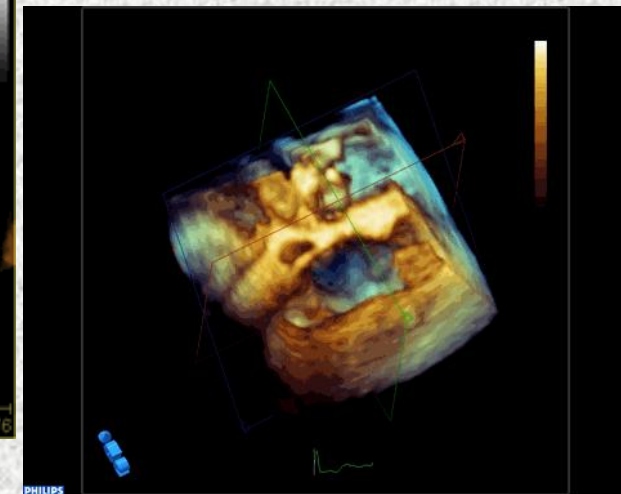
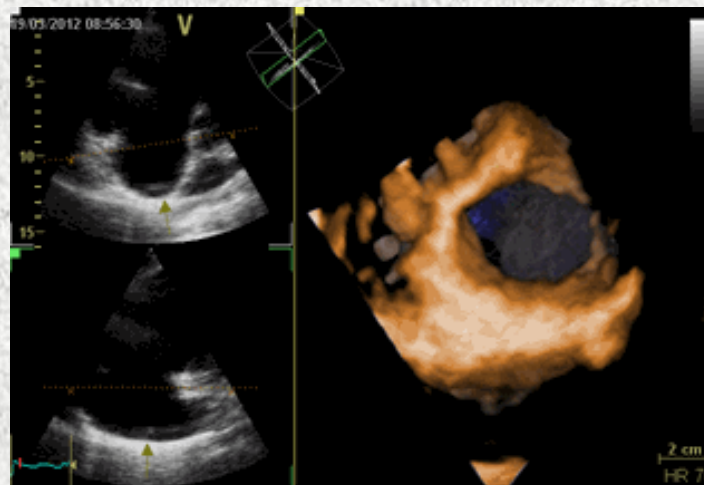
Modified Apical View  
focused on the RV:  
Full Volume

## - Image Acquisition -

Full Volume from mid-oesophageal 4ch view



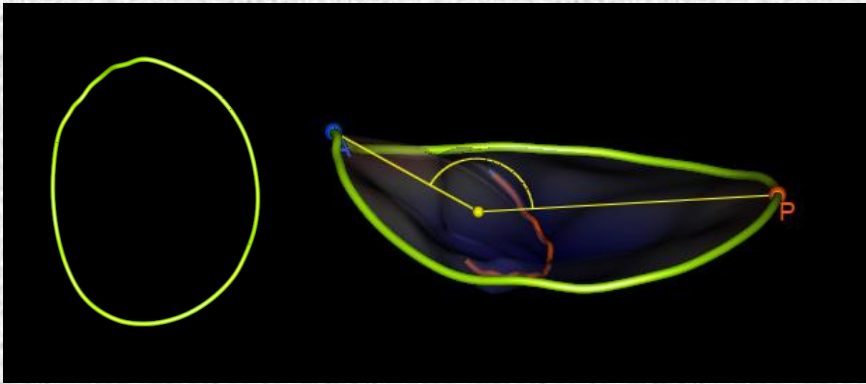
3D Zoom Mode





# 3DE -The Tricuspid Valve

## - Annular Morphology-



Ton-Nu T et al. Circulation 2006

Complex oval, saddle shape

Non-planarity preserved through cardiac cycle, sphincter function

More circular and flattened in secondary TR

## - Leaflets Morphology-

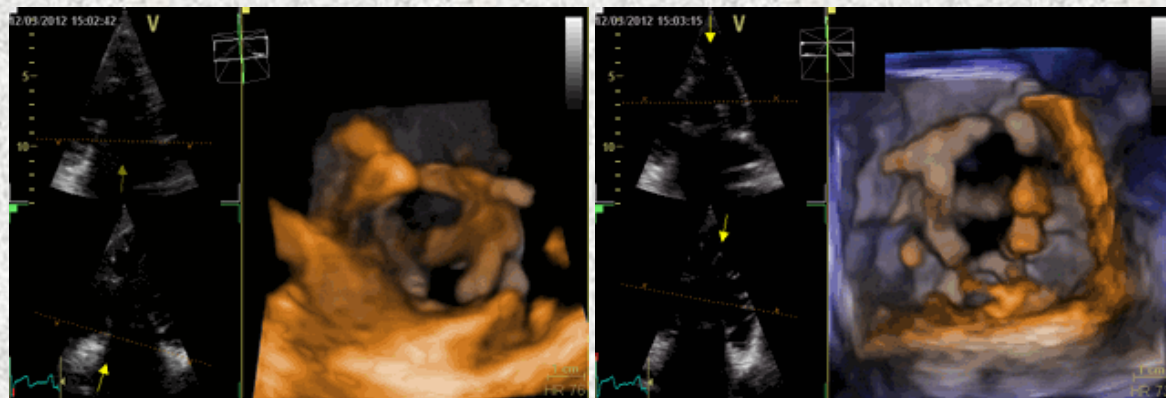
Leaflet restriction

Leaflet thickening

Prolapse

Perforations

Vegetations



# Conclusions

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- **Feasible and valuable in clinical practice, but needs training and experience**
- **For mitral and aortic valve morphology 3D TOE is preferred, especially when planning surgery**
- **Image quality is a trade off between sector size, temporal and spatial resolution**
- **Better understanding of valve dysfunction**
- **Helps in planning surgery**
- **Does not replace 2D echocardiography, but completes the study of valvular morphology**