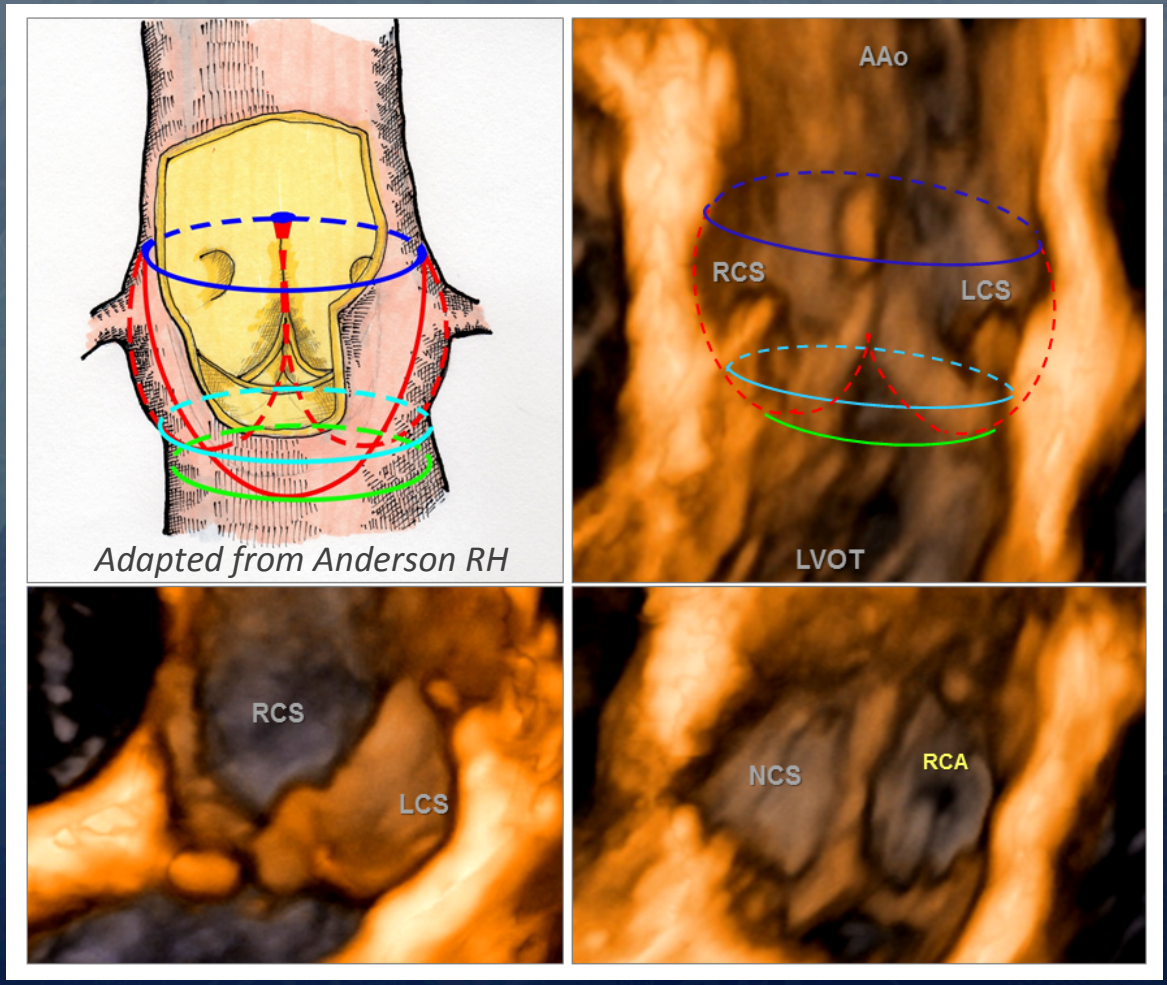
Department of Cardiac, Thoracic and Vascular Sciences
University of Padua

IMPACT OF 3D ECHO ON THE ASSESSMENT OF AORTIC STENOSIS SEVERITY

Denisa Muraru, MD

UPDATE IN VALVULAR DISEASES – EAE/SIEC TEACHING COURSE – MILAN May 8-9th 2012

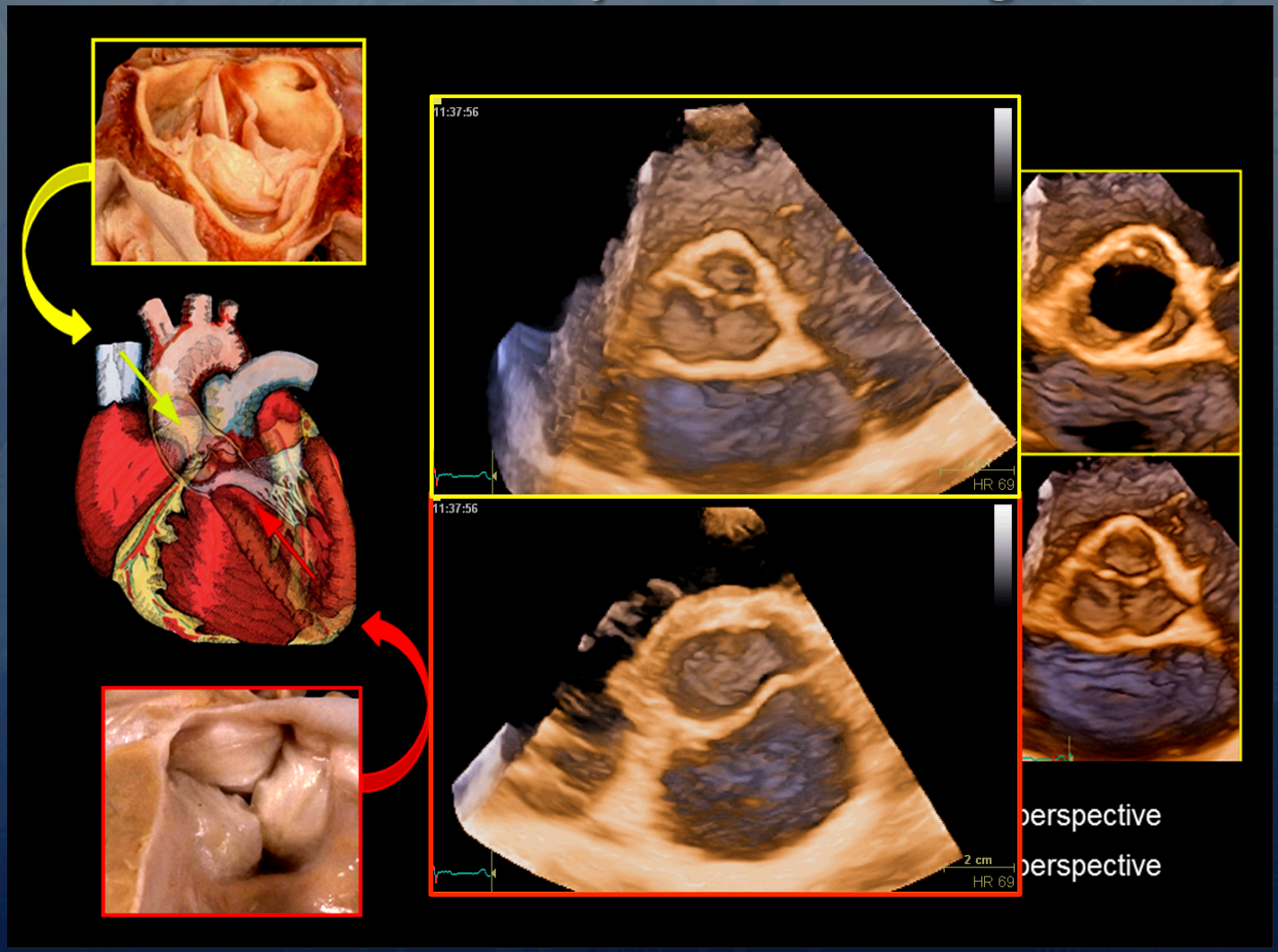
ASSESSING THE 3D GEOMETRY OF AORTIC COMPLEX REQUIRES A 3D METHOD



Muraru D, Badano LP et al. *Eur Heart J Cardiovasc Img* 2012

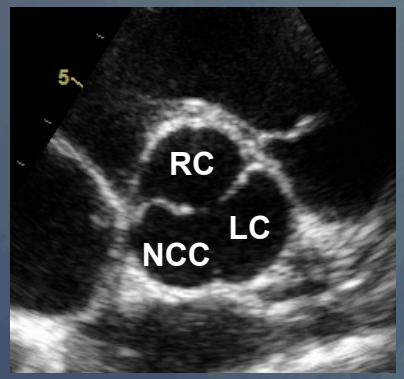
MORPHOLOGY OF AORTIC COMPLEX

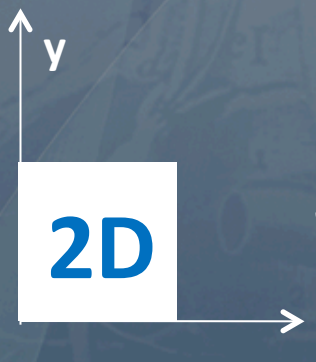
"In vivo" anatomy in the beating heart



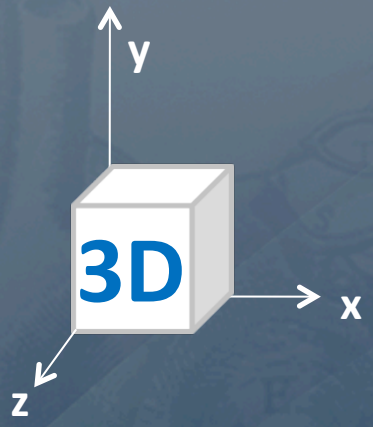
Courtesy of Prof Basso, Cardiovascular Pathology, University of Padua (IT)

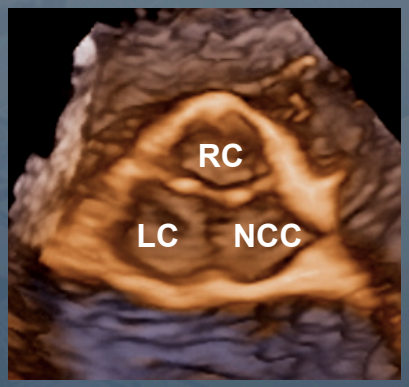
MORPHOLOGY OF AORTIC COMPLEX





versus





- Restricted windows (PSAX +/-subcostal) and perspectives (LVOT)
- Challenging in case of uncommon anatomic position (dextrocardia, lung resection, dilated AA)
- No quantitation of spatial geometry
- Geometric assumptions
- Out-of-plane motion

- More windows and unlimited perspectives (LVOT, Ao, oblique etc)
- Feasible in case of uncommon anatomic position
- Automated aortic root modelling
- No geometric assumptions
- No out-of-plane motion

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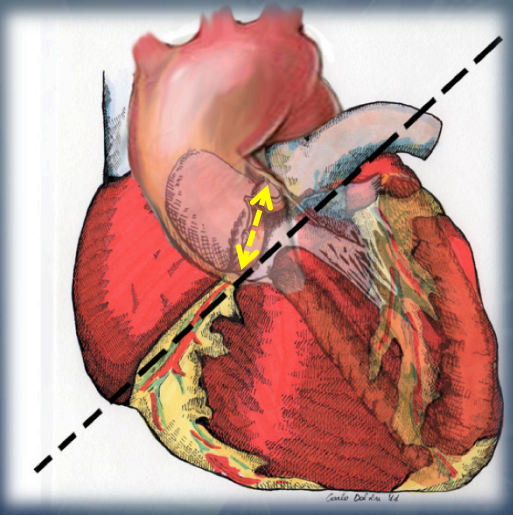
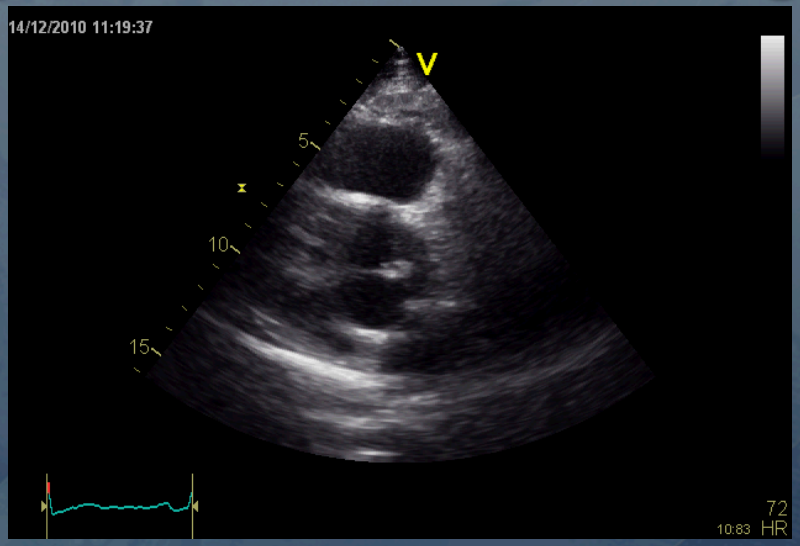
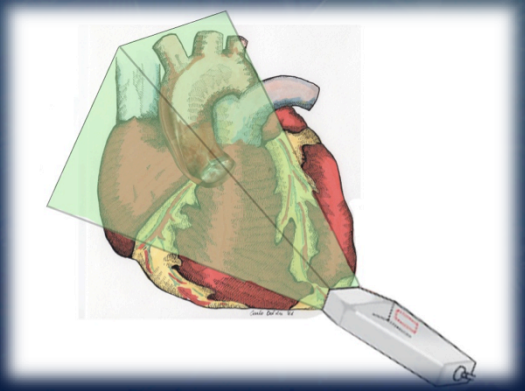
BICUSPID AORTIC VALVE MORPHOLOGY

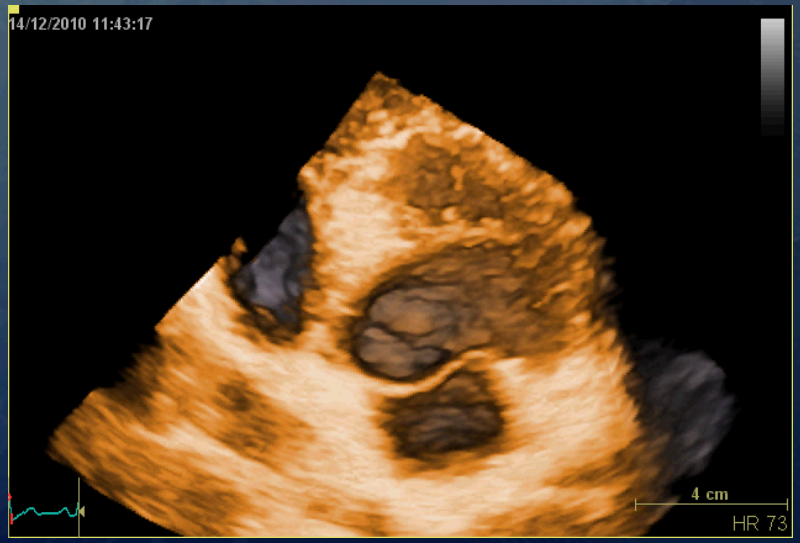
Validation of 3D echo against anatomic findings



Dilated ascending aorta





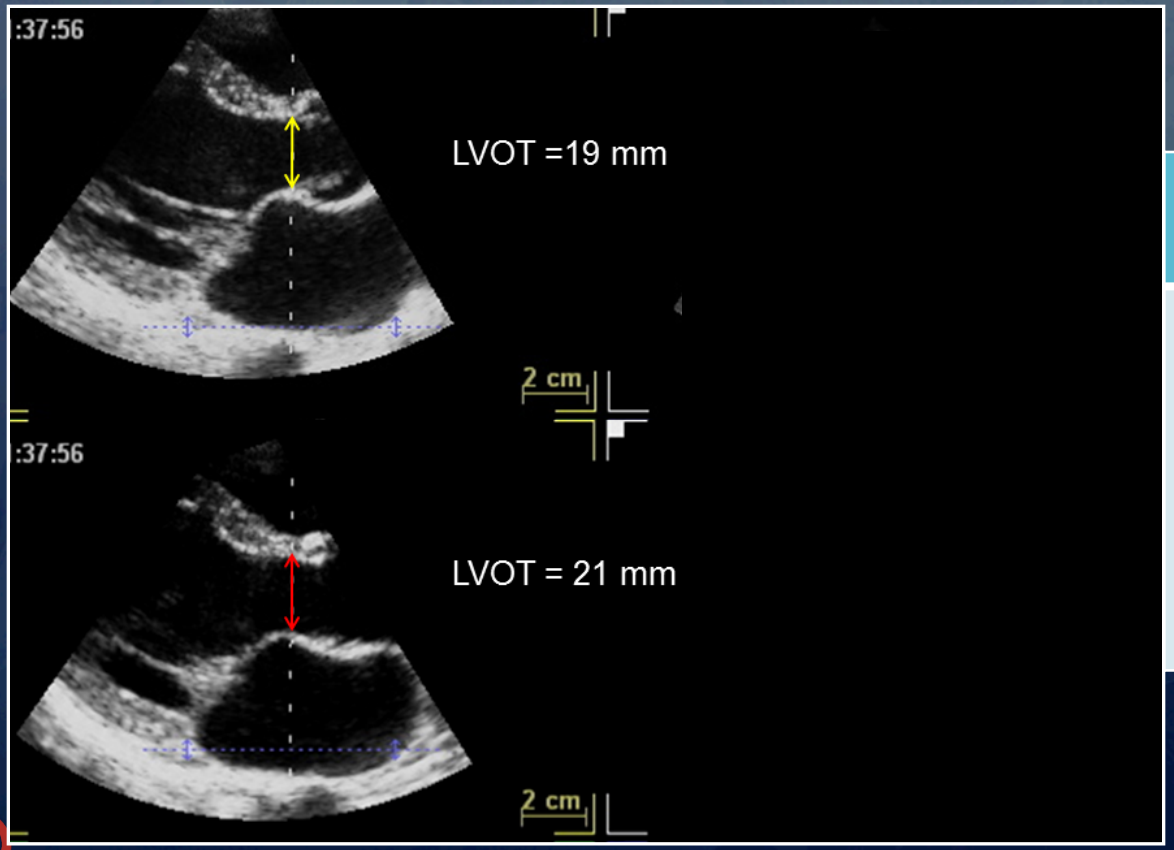


Espinola-Zavaleta N et al. *J Am Soc Echocardiogr* 2003
Sadagopan SN et al. *Cardiol Young* 2006

3D ECHO FOR AS SEVERITY ASSESSMENT

LVOT SIZING

- 2D: lack of anatomical landmarks to verify PLAX plane position to measure LVOT diameter correctly
- biplane imaging by 3DE is superior to single-plane 2D measurement for annulus sizing



	LVOT (mm)	AVA (cm^2)
VTI Ao = 66 cm	19	0.86
	20	0.95
	21	1.05
VTI LVOT = 20 cm	22	1.15
	23	1.26

3D offers bi-plane imaging control

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Altiok E et al. *Heart* 2011

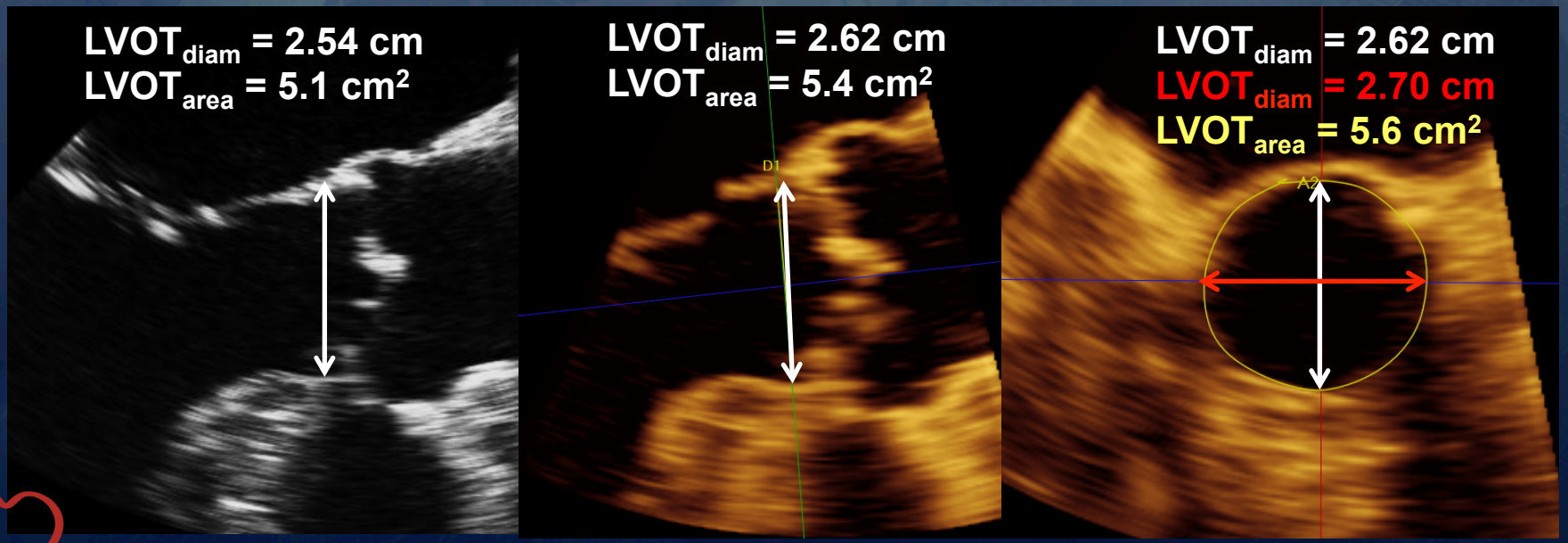
3D ECHO FOR AS SEVERITY ASSESSMENT

LVOT SHAPE

- 2D: Geometric assumption that LVOT is circular
- 3D: LVOT assumes an elliptical configuration

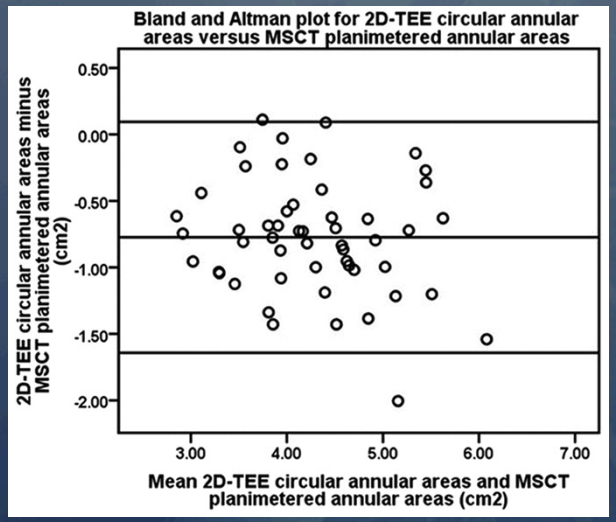
Doddamani S et al. *Echocardiography* 2007

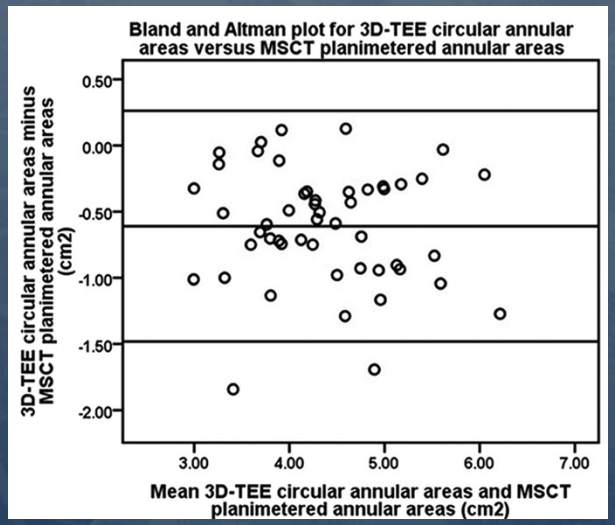
3D enables measurement of LVOT medio-lateral diameter (larger) and LVOT/annulus area planimetry

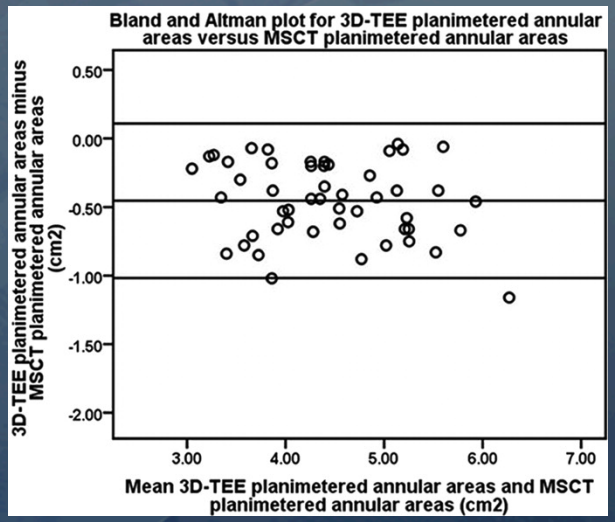


3D ECHO FOR AS SEVERITY ASSESSMENT

Bias from annular/LVOT linear measurement by 2D and 3D TEE vs MSCT planimetered area







2D TEE diameter

Annulus: circular

3D TEE diameter

Annulus: circular

3D TEE planimetered area

Annulus: elliptical

→ ***25% patients reclassified*** *from severe to moderate AS when using 3D TEE planimetered annulus area*

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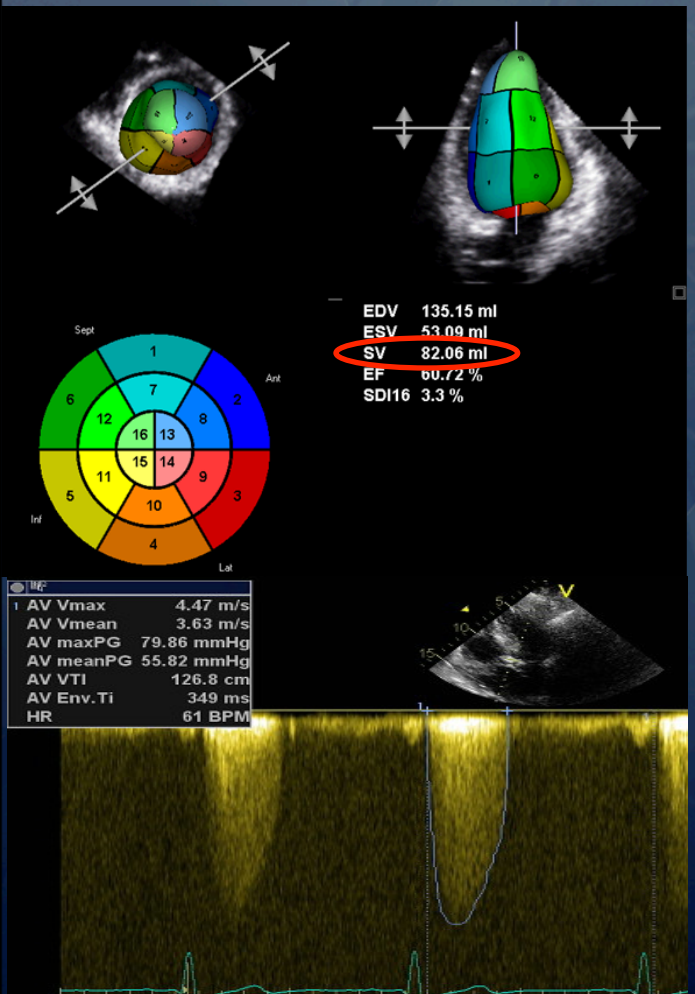
Ng, A.C.T. et al. *Circ Cardiovasc Imaging* 2010

3D ECHO FOR AS SEVERITY ASSESSMENT

LV stroke-volume



- 2D-Doppler: assumptions that LVOT is circular, steady-shaped during systole and PW Doppler tracings of subaortic flow are acquired at the same level of LVOT diameter measurements

$$\text{Aortic valve area (cm}^2\text{)} = \frac{SV_{3D}\ (cm^3)}{VTI_{Ao}\ (cm)}$$

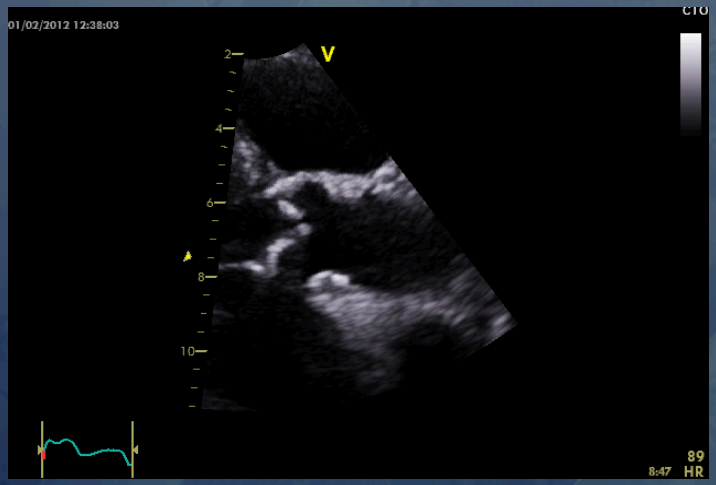
$$\text{Aortic valve area (cm}^2\text{)} = \frac{82.06}{126.8} = 0.65$$

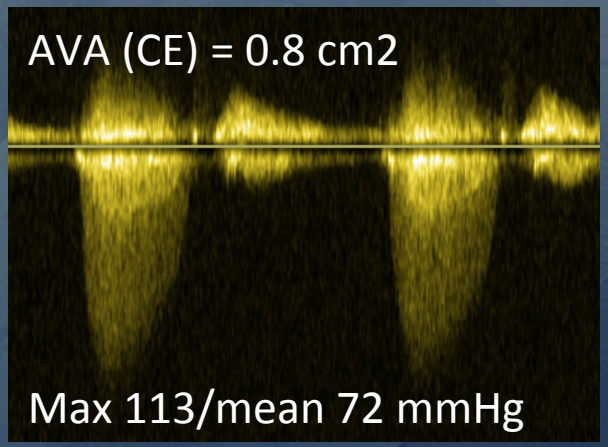
Gutierrez-Chico, J. L. et al. *Eur Heart J* 2007

3D ECHO FOR AS SEVERITY ASSESSMENT

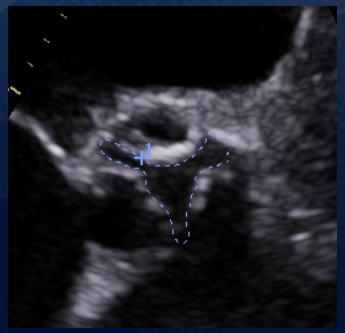
AVA planimetry

- 2D: no real control of plane position at the narrowest orifice, limitations in plane alignment





AVA (planimetry) = 1.2 cm2

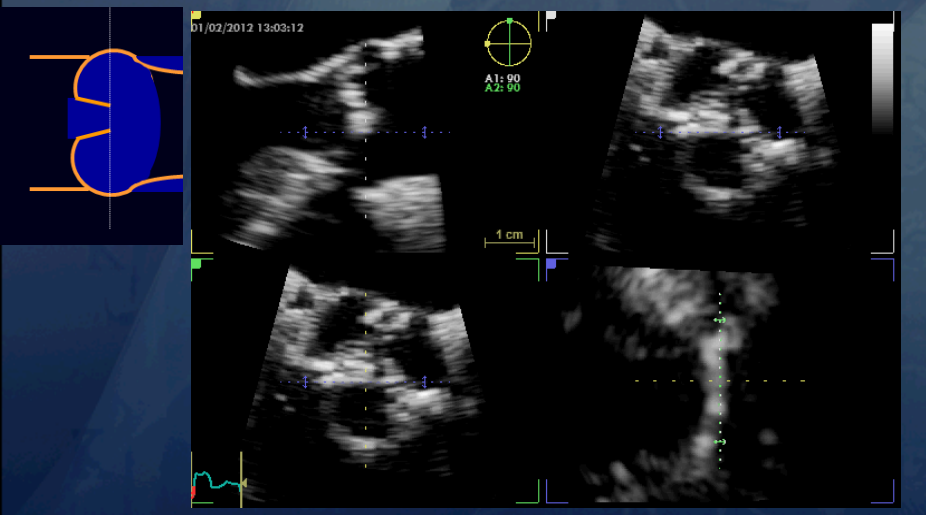


3D ECHO FOR AS SEVERITY ASSESSMENT

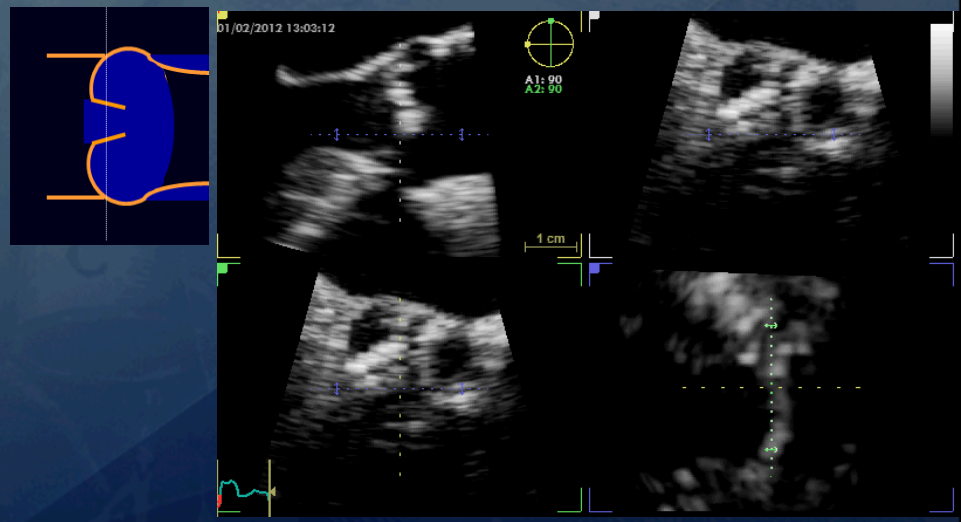
AVA planimetry

- 2D: no real control of plane position at the narrowest orifice, limitations in plane alignment

3D allows plane position control and any change in orientation to capture smallest orifice of stenotic AV



AVA (planimetry) = 0.9 cm2



AVA (planimetry) = 1.1 cm2

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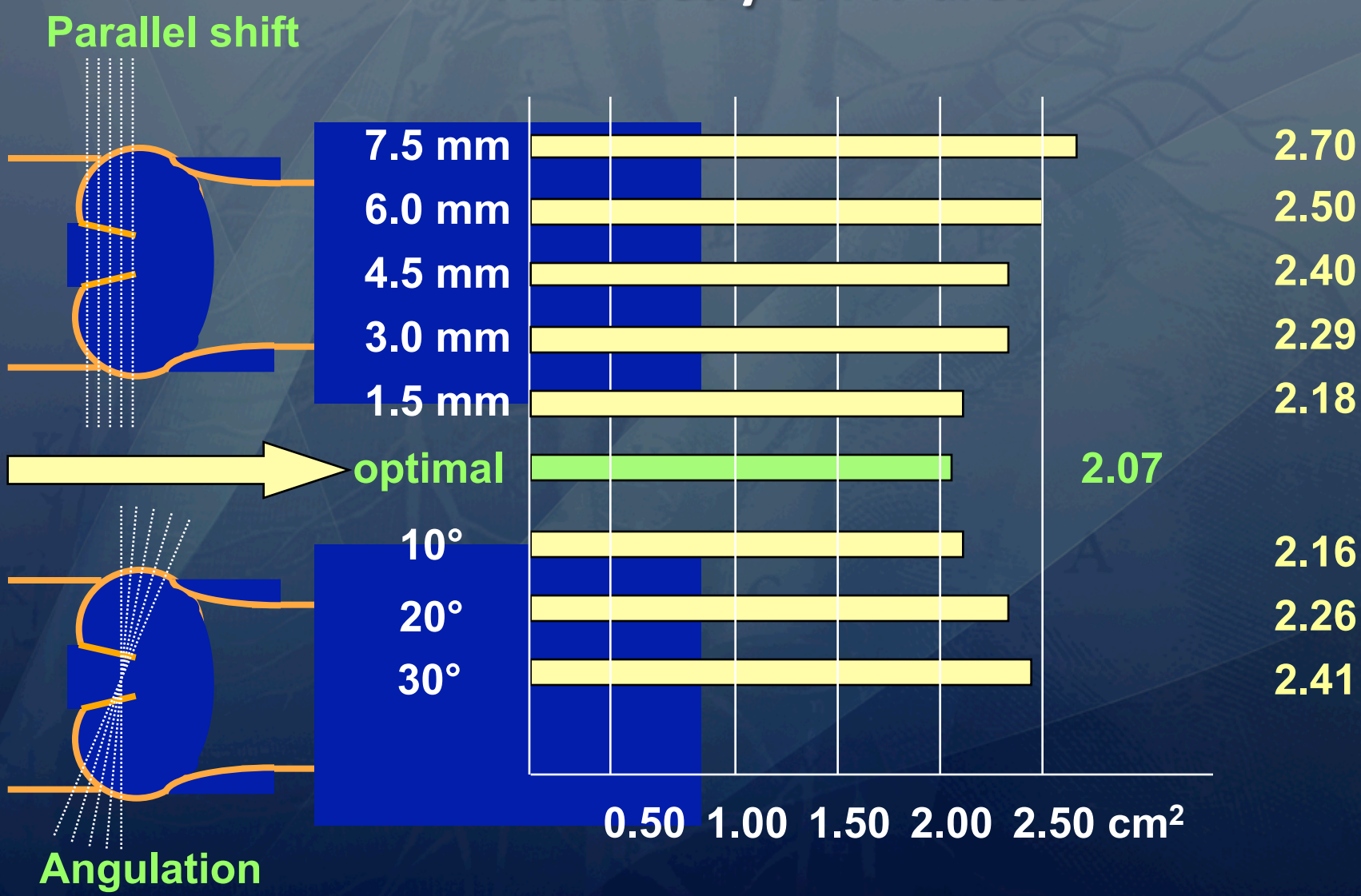
Goland S et al. Heart 2007
Nakai H et al. Eur J Echocardiogr 2010

3D ECHO FOR AS SEVERITY ASSESSMENT

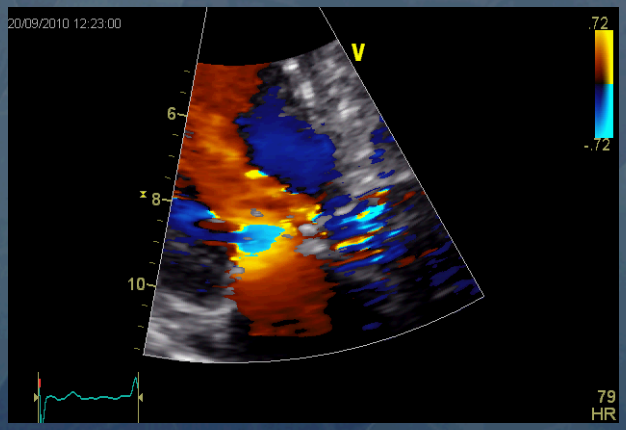


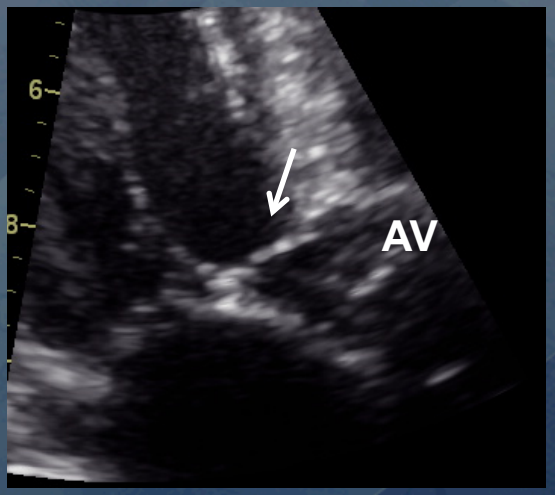
Kasprzak JD et al. Echocardiography 1998

3D ECHO FOR AS SEVERITY ASSESSMENT

AVA planimetry

- Doppler method has limitations particularly for very eccentric jets or when there is an associated subaortic obstruction





SubAVA=0.6 cm2

AVA=1.2 cm2

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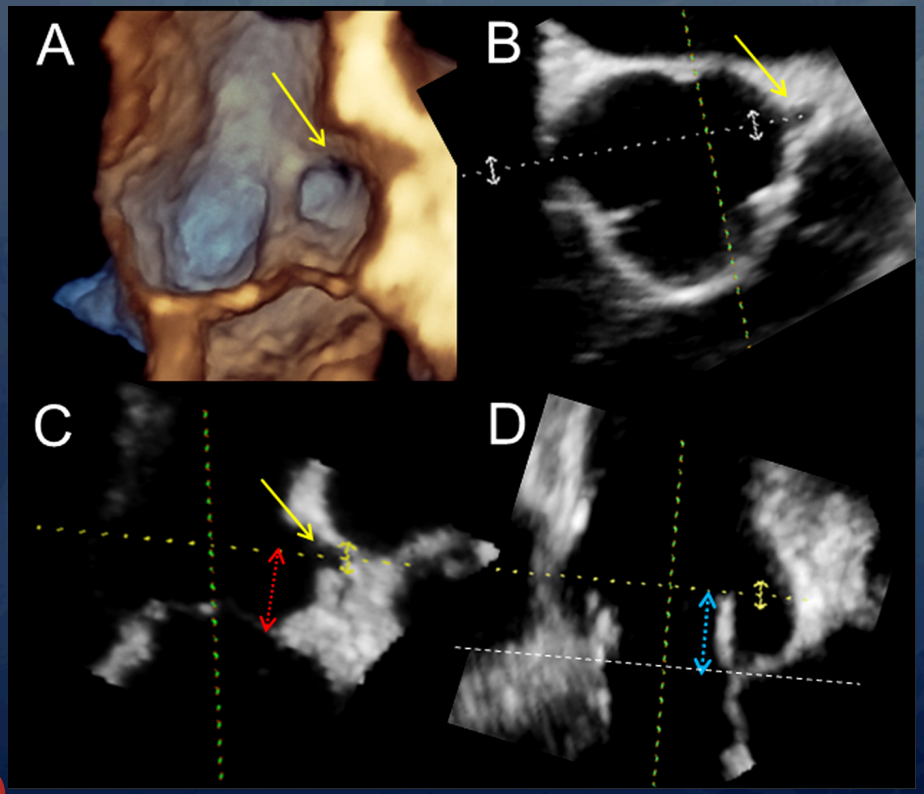
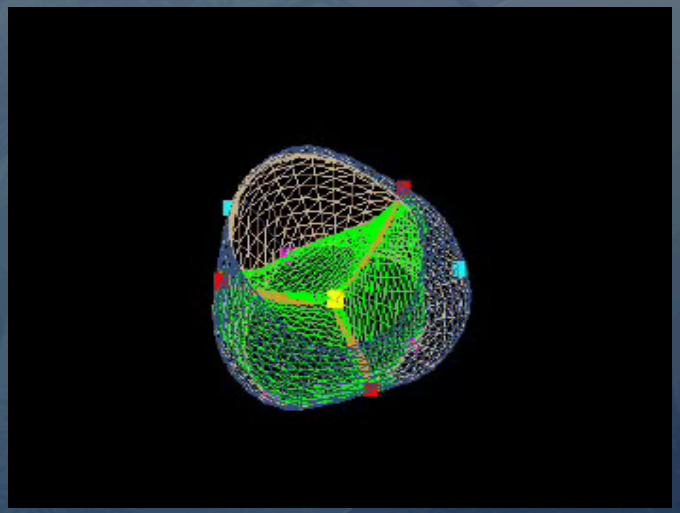
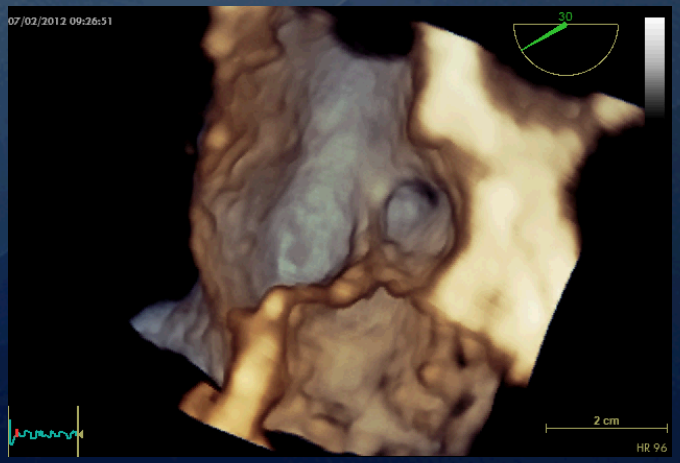
3D TEE FOR AORTIC ROOT ASSESSMENT

UNIQUE OPPORTUNITY FOR QUANTITATION:

- Patient-specific 3D modeling of aortic root morphology
- Hinge-to-coronary ostium distance
- Leaflet height etc.



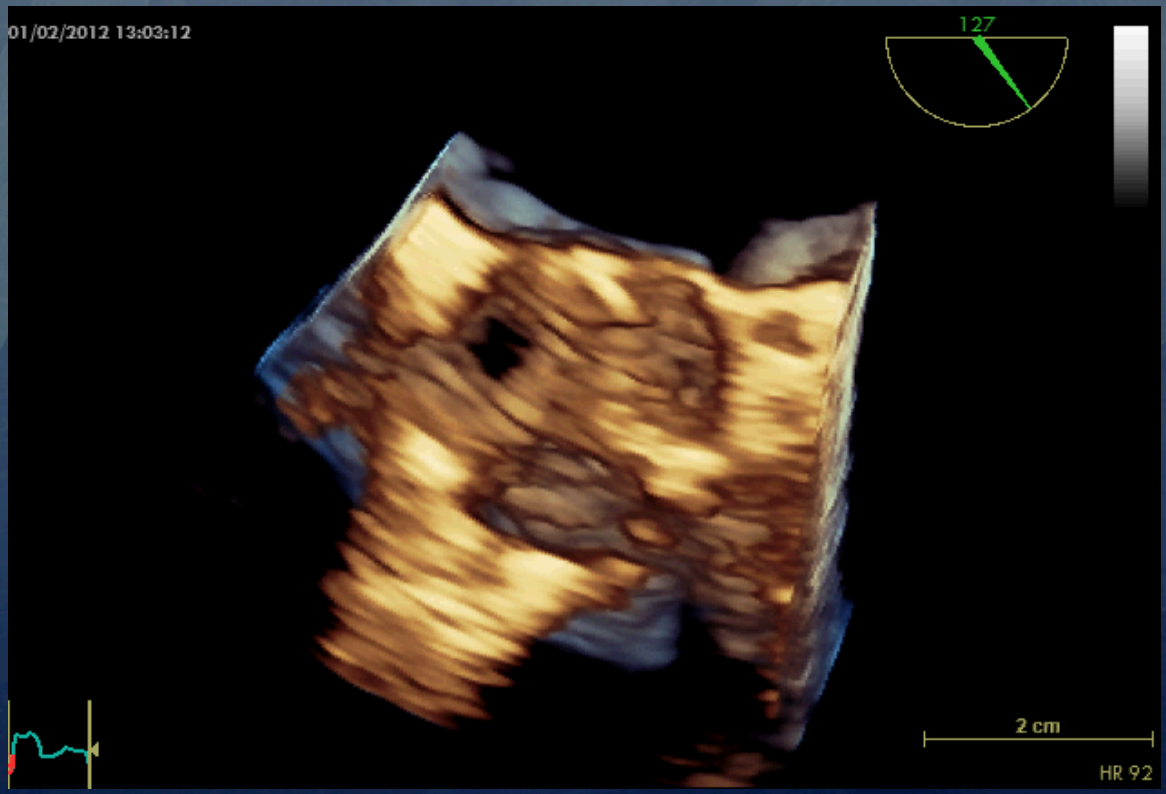




3D ECHO FOR AS SEVERITY ASSESSMENT

Inherent limitations

3D is similarly affected by dropout in heavily calcified valves



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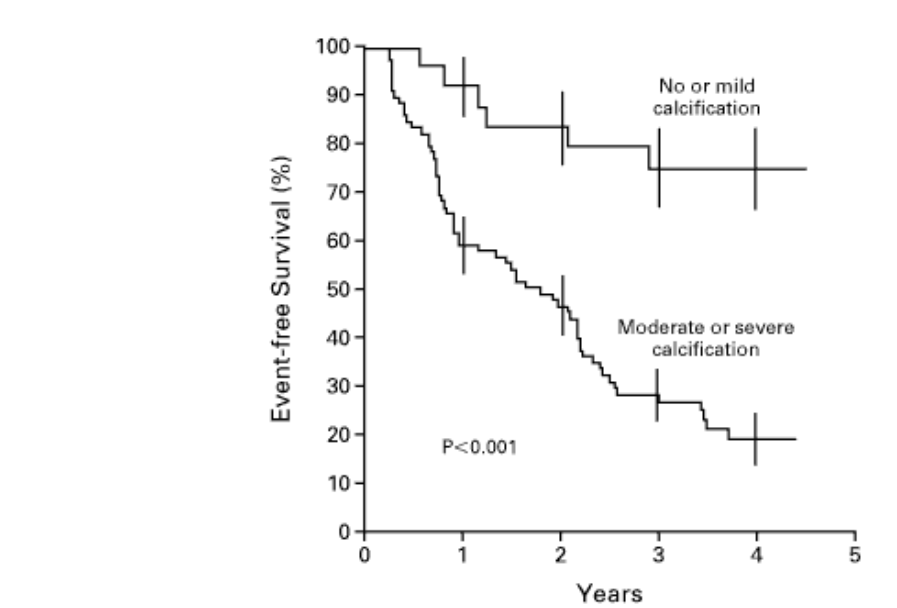
3D ECHO FOR AS SEVERITY ASSESSMENT

Extent of calcifications matters



Class IIa indication for AVR: Asymptomatic patients with severe AS and **moderate-to-severe valve calcification**, and a rate of peak velocity progression 0.3 m/s per year

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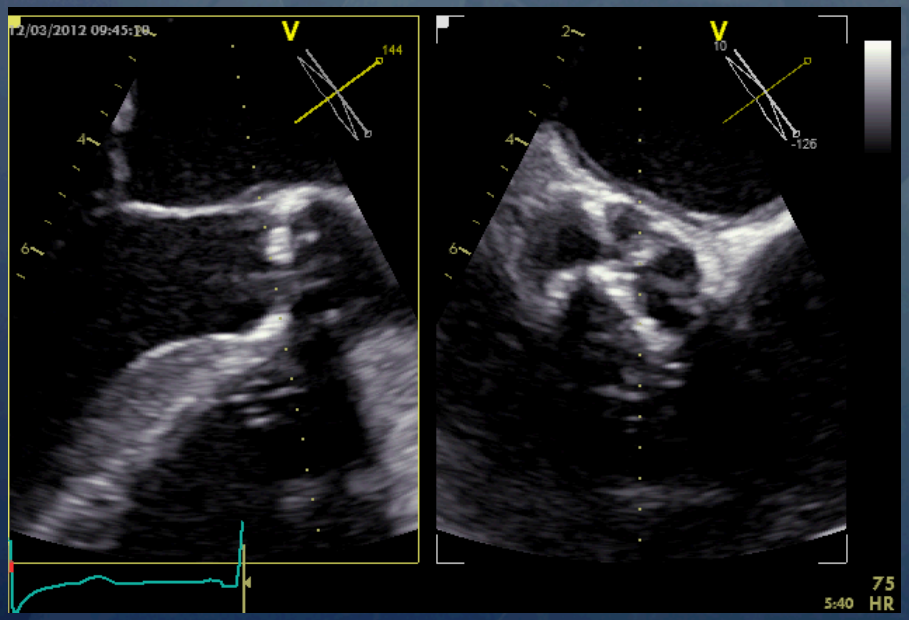
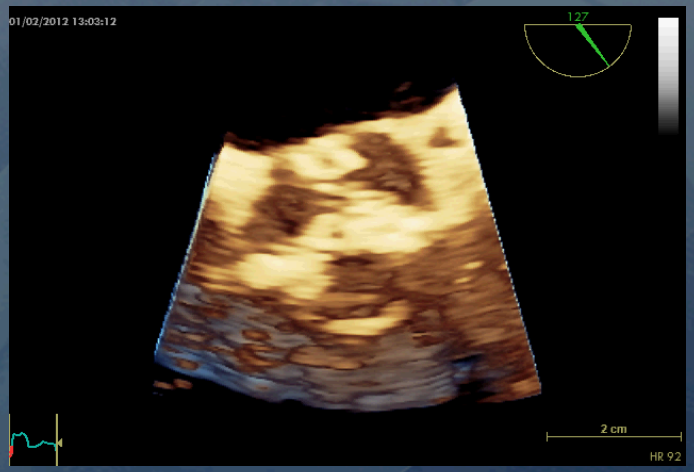
Rosenhek R et al. *N Engl J Med* 2000
Vahanian A et al. *Eur Heart J* 2007

3D ECHO FOR AS SEVERITY ASSESSMENT

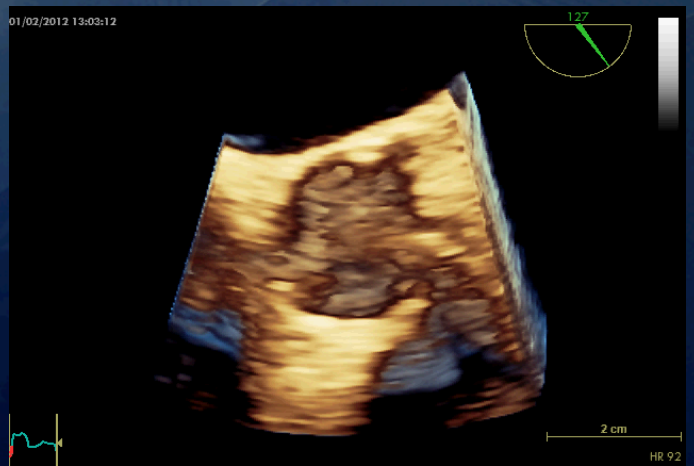
2D is best for tissue characterization; 3D renders depth rather than tissue nature



Cut plane at valvular level



Cut plane above valvular level



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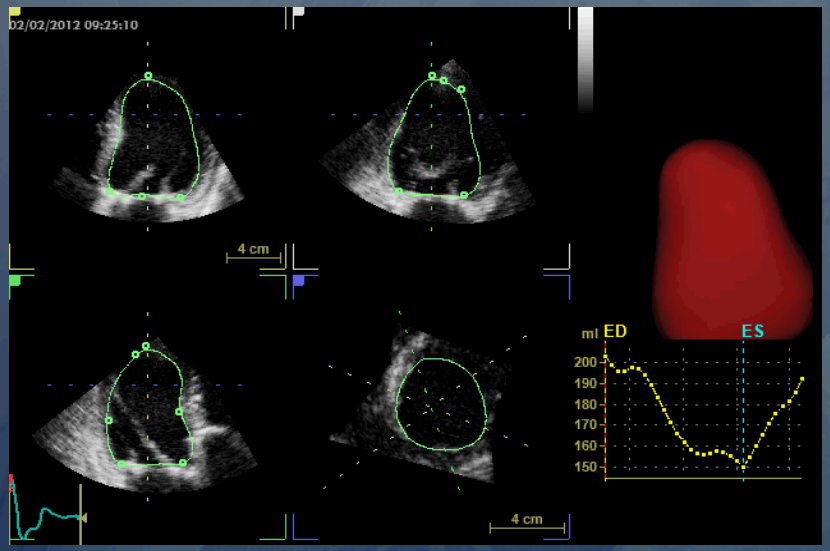
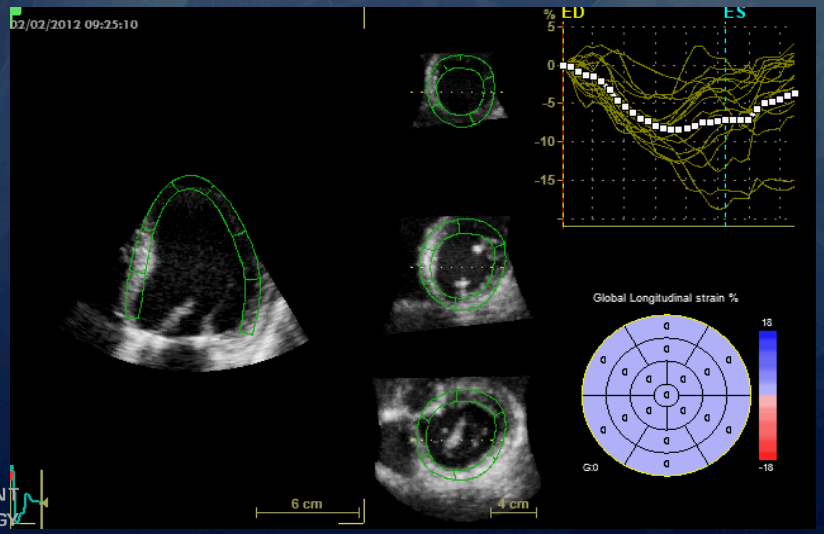
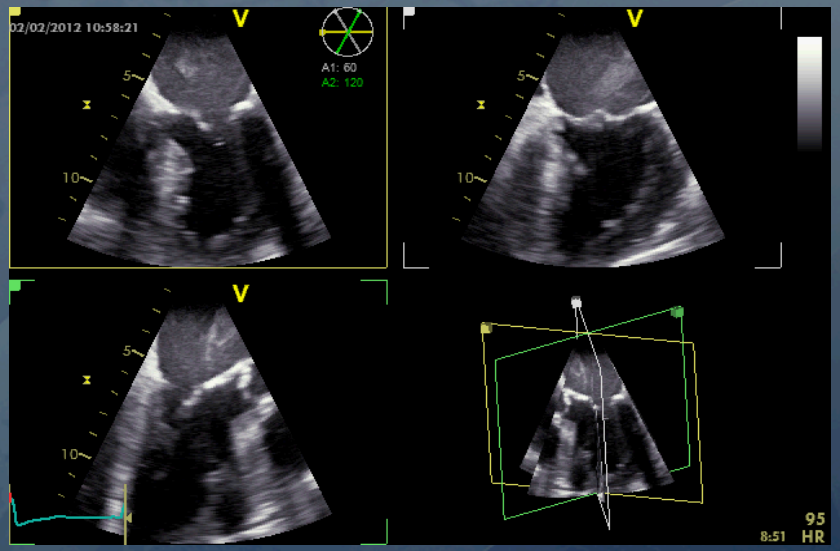
3D ECHO FOR ASSESSING IMPACT OF AS ON LV FUNCTION AND MASS

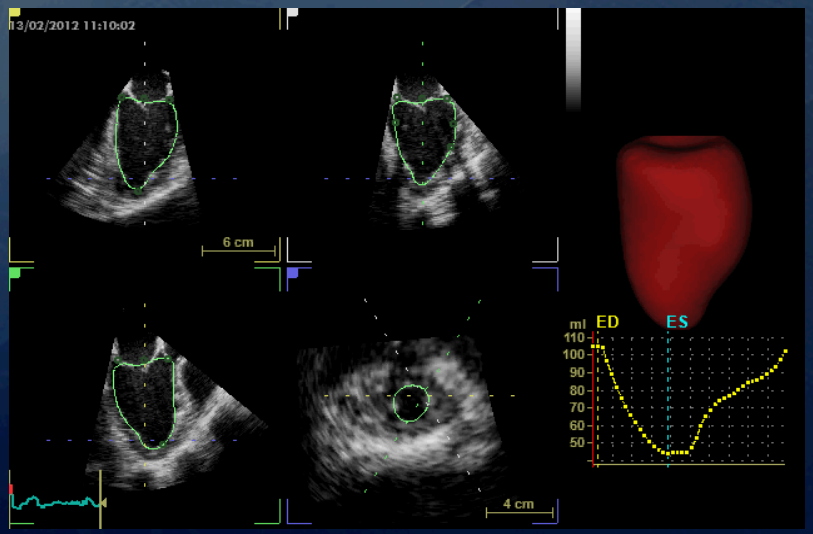
3D TTE





3D TEE





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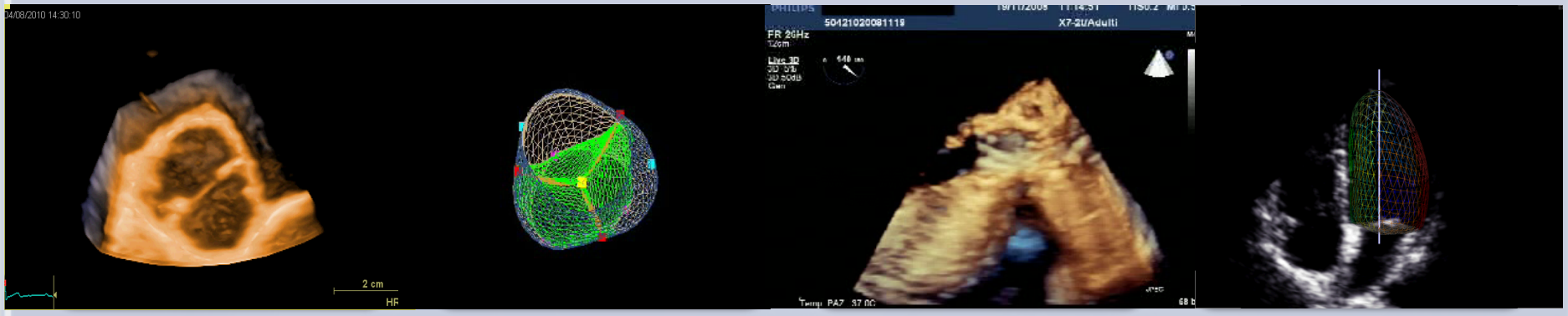
CONCLUSIONS

The added value of the third dimension



- In vivo visualization of AV complex in motion from unlimited, unique perspectives
- Unique automated quantitation of AV morphology and disease severity
- Real-time monitoring of AV interventional procedures
- Accurate quantitation of AV disease consequences on cardiac chambers, competing with CMR

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