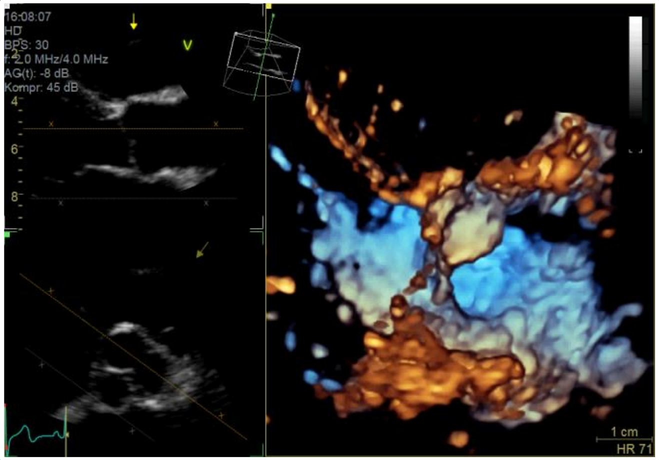
Reconstruction of the Aortic Valve and Root: A practical approach

3-dimensional echo in aortic valve repair

THURSDAY 08 SEPTEMBER 2022
13.45 – 14.00



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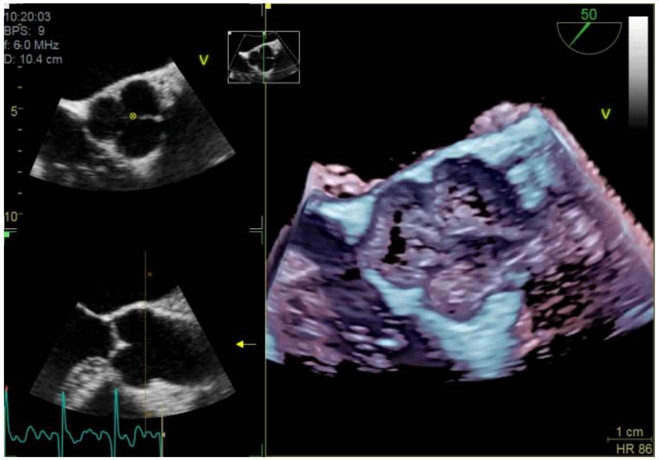

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Declaration of Interests Policy and Rules

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I declare for the last 3 years and the subsequent 12 month the following conflicts of interests:

Section I: Support for Research Activities - grant of the DEGUM
- no other financial research support

Section II: Support for Educational Activities - MIFO, GE Healthcare, Astra Zeneca, Servier, Novartis, Pfizer, Cardiac Dimension, Abbott, Bayer, Canon, Kelcon

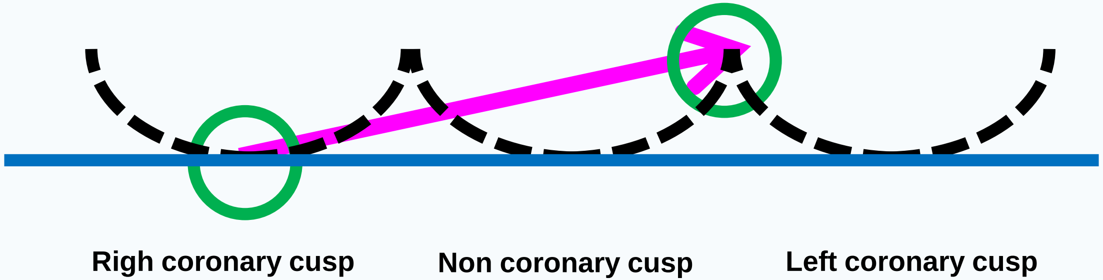
Section III: Honorarium for Promotional Activities - none

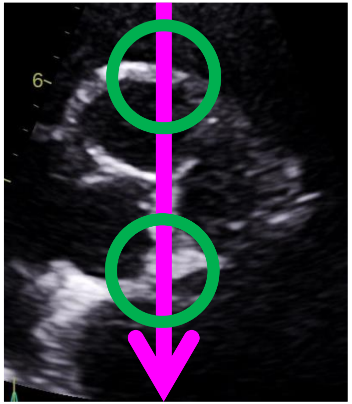
Section IV: Personal Financial Interests in Vommercial Activities - none

IB1; 2A11 - Member of the German Society of Cardiology, the German Society of Ultrasound DEGUM), the German Society of Internal Medicine and the European Society of Cardiology/Cardiovascular Imaging

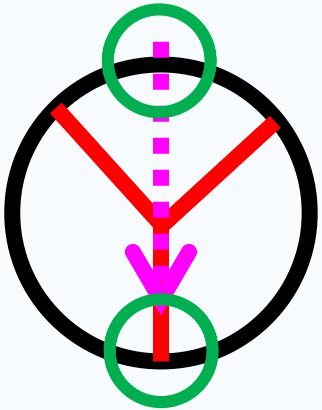
3-dimensional echo in aortic valve repair

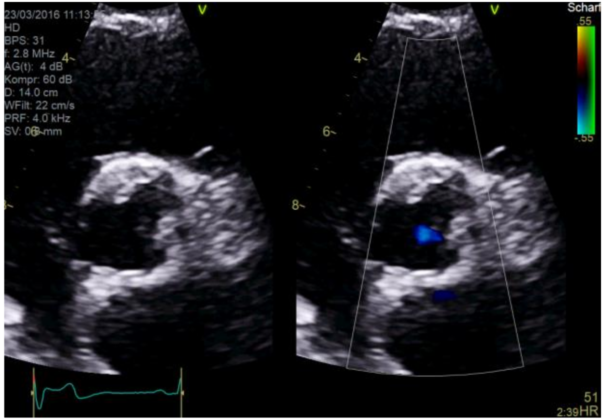
Limitations of 2D echocardiography

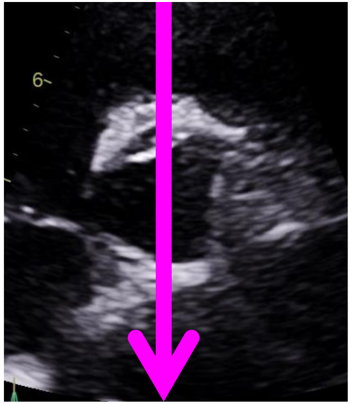




Problem 1:
The connection between cusp and aortic wall is at different levels of the „crown".







Problem 2:
The centerline of the aortic root complex varies during the cardiac cycle.

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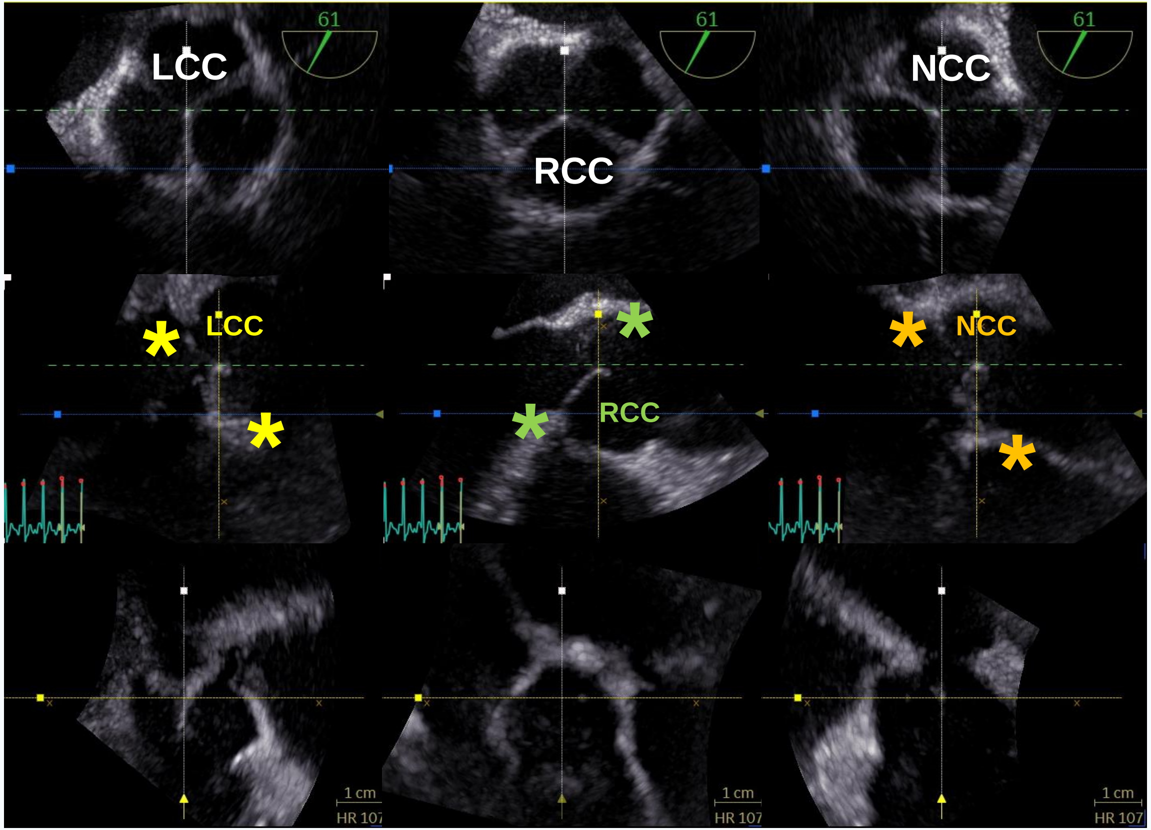
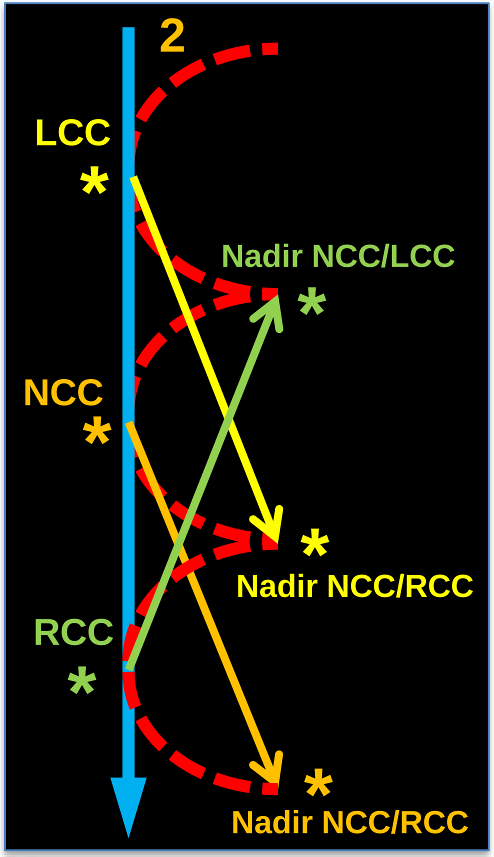
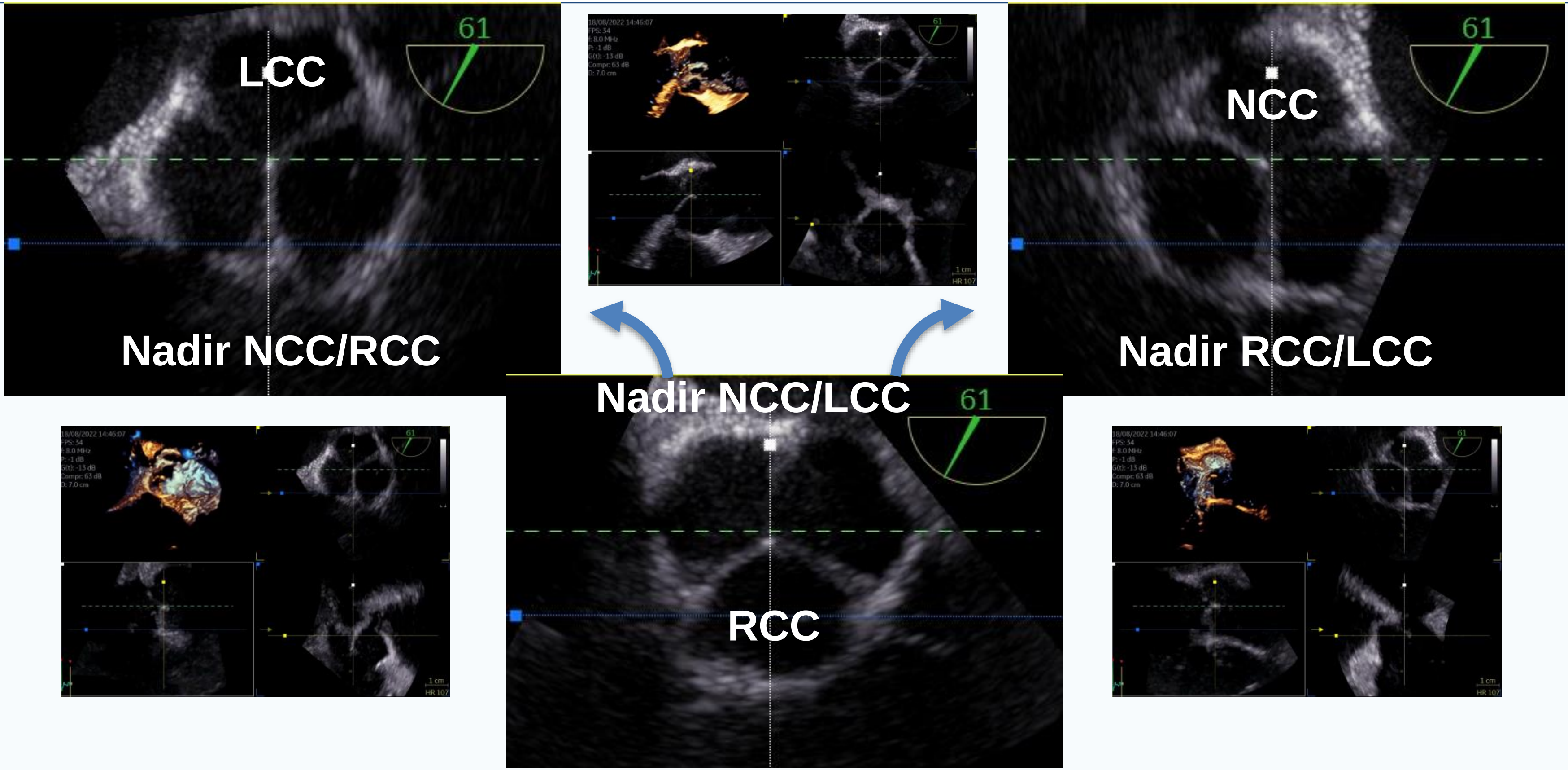
Complex understanding of navigation



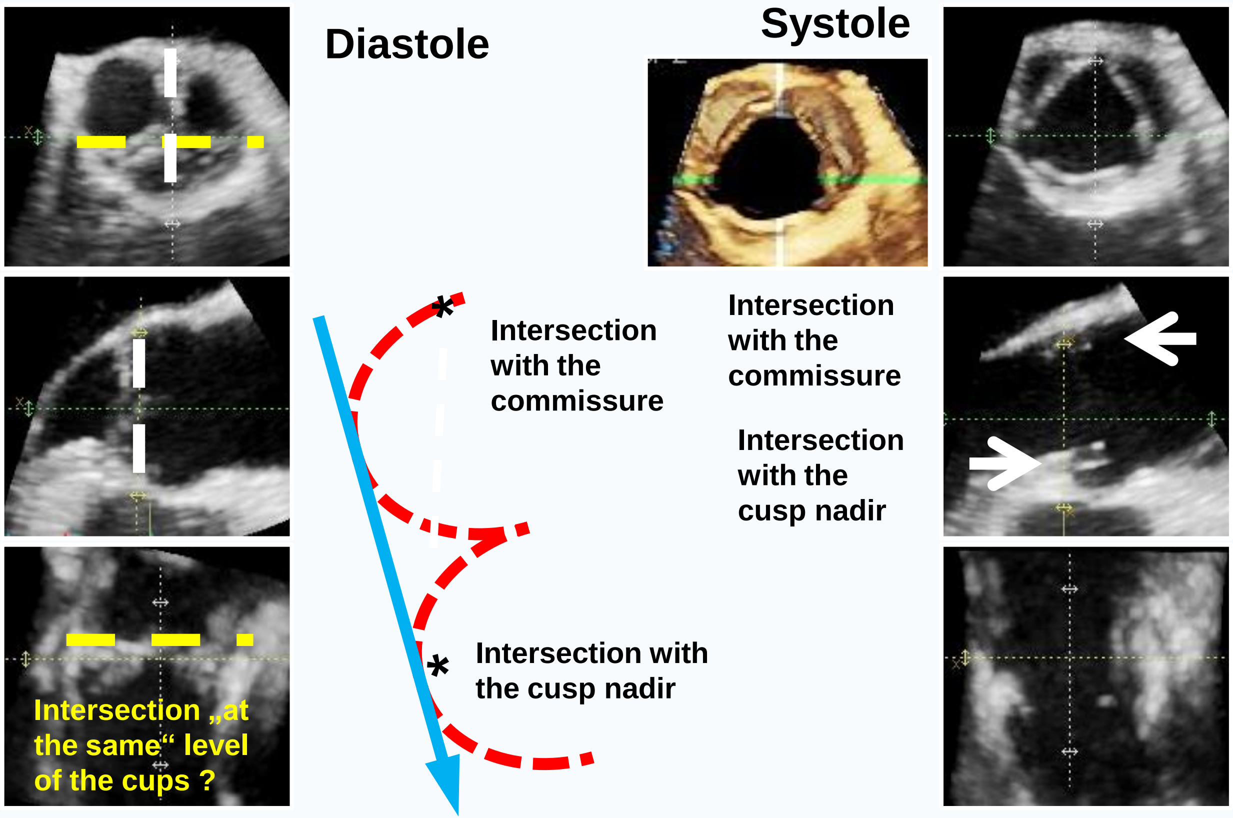


3-dimensional echo in aortic valve repair

EACTS European Association For Cardio-Thoracic Surgery



3-dimensional echo in aortic valve repair
how to visualize properly cardiac structures?



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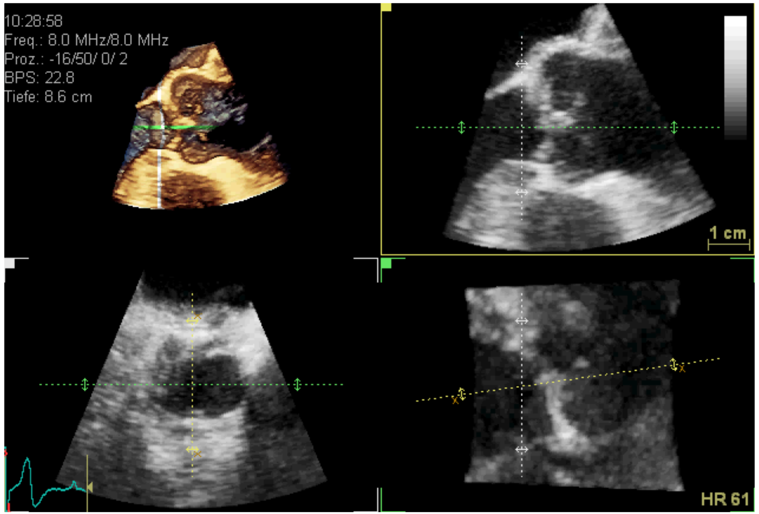

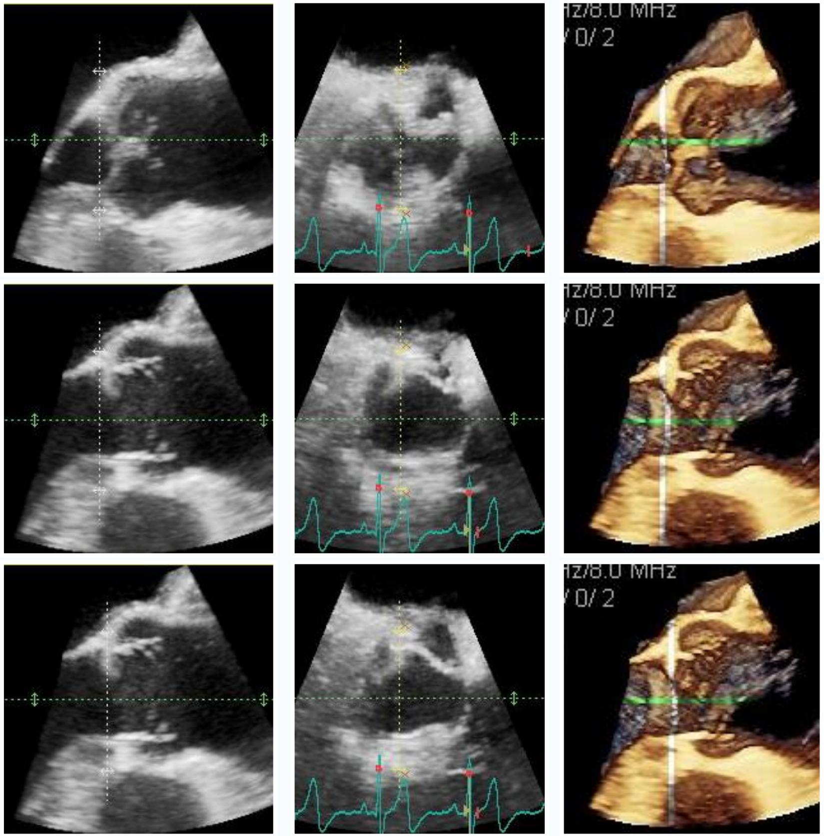

1. step: how adjust the central axis of AV during diastole to label the perpendicular plane through the hinge points
2. step: how to measure the maximum expansion of the LVOT during systole
3. step: how to adjust the plane of the virtual aortic anulus

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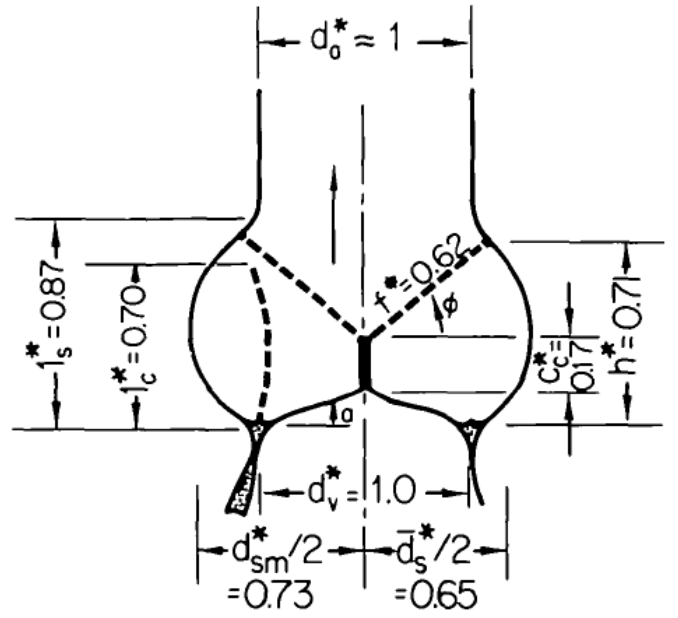
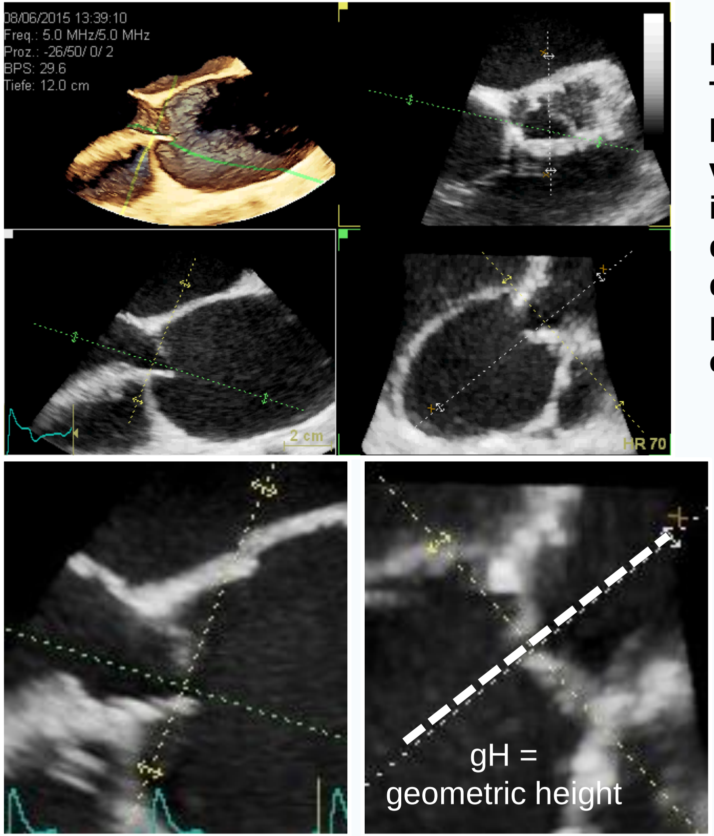


FIGURE 2

Geometry and relative dimensions of aortic valve region. See text for abbreviations.

Circulation Research, Vol. 35, December 1974



Problem 1:
The adaequate level of the virtual anulus is necessary to determine quantitative parameter of cusp anatomy.

3-dimensional echo in aortic valve repair

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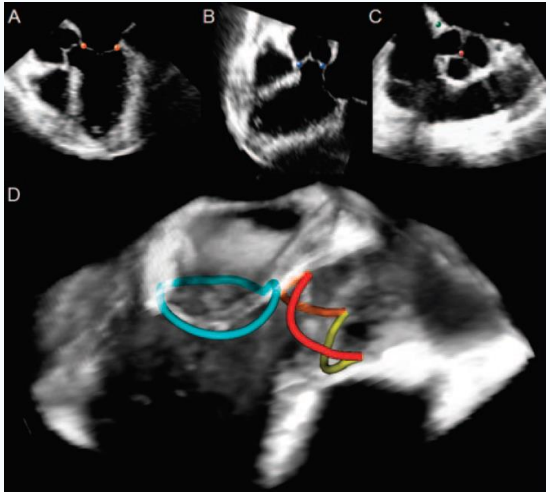
A Study of Functional Anatomy of Aortic-Mitral Valve Coupling Using 3D Matrix Transesophageal Echocardiography

Federico Veronesi, PhD; Cristiana Corsi, PhD; Lissa Sugeng, MD, MPH; Victor Mor-Avi, PhD; Enrico G. Caiani, PhD; Lynn Weinert, BS; Claudio Lamberti, MS; Roberto M. Lang, MD

Conclusions—This is the first study to report quantitative 3D assessment of the mitral and aortic valve dynamics from matrix array transesophageal images and describe the mitral-aortic coupling in a beating human heart. This ability may have impact on patient evaluation for valvular surgical interventions and prosthesis design. (*Circ Cardiovasc Imaging*. **2009;2:24-31.**)



Problem 2:
Timing of the cardiac cycle by a proper ECG is necessary to determine comparable results between modalities (e.g. echo vs. CT).

Figure 2. A, Selection of anterior and posterior MA points on a cut plane representing 3-chamber view. B, Selection of AoA points. C, Automatically displayed aortic valve short axis cut plane on which interatrial (green dot) and coaptation point (red dot) are manually identified. D, Computed MA (cyan) and AoA (red, noncoronary cusp; orange, left cusp; yellow, right cusp) splines on RT3DE volume rendering.

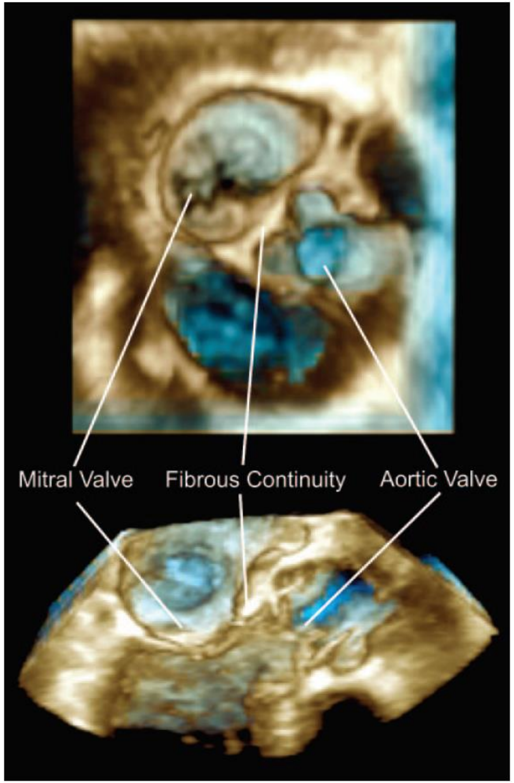


Figure 1. Volume rendering of RT3DE mTEE data visualized from atrium (top) and in a long axis view (bottom).

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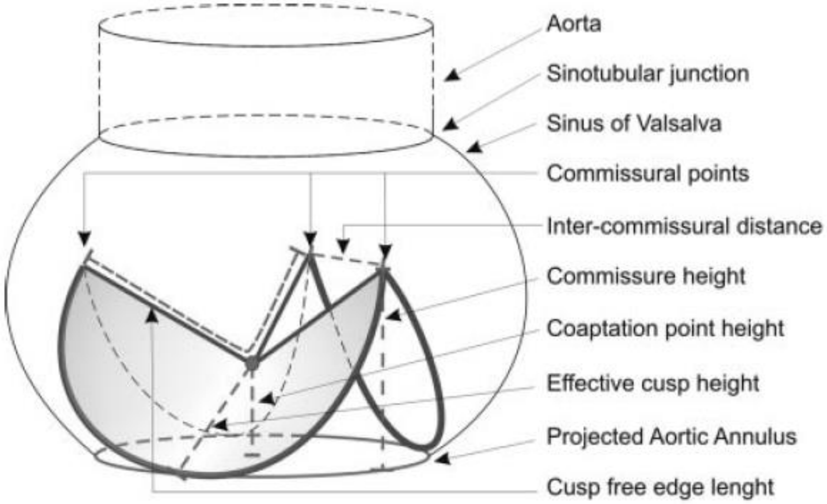

Figure 3. Schematic of automatically extracted AoA measurements.

Problem 2:
A standardisation of the measurements of valvular geometry is necessary. Mostly the enddiastolic time point is chosen.

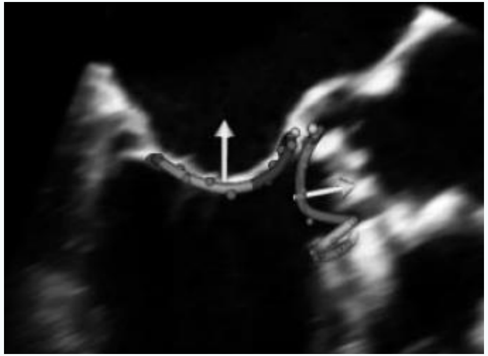

Figure 5. Left, Mitral and aortic annuli computed from a RT3DE data set obtained in a patient with severe sclerocalcific aortic stenosis, shown superimposed on a 3-chamber view. Note that the angle between the 2 valves is severely reduced (93°) compared with normal subjects and also the distance between the 2 valve was just 18 mm and did not changed during cardiac cycle. The aortic stenosis was most likely responsible for the reduced change in projected AoA area during the cardiac cycle, having a negative impact on the aortic-mitral coupling as reflected by a decrease in maximum diastolic area change to only 12%, compared with 25.4% of the ED area in normal subjects (Table 1). Right, Mitral and aortic annuli computed from a RT3DE data set obtained in a patient with implanted mitral ring, shown superimposed on a 2-chamber view. Note the deformation in the shape of the AoA. In this subject, reduced motion of the mitral valve (4.5 mm maximum at ES) and reduced MA height (4.3 mm) at ED was noted. In addition, the intercommissural distances where asymmetrical: the distance between the commissures of the left cusp was smaller (18 mm) compared with the noncoronary and right cusps (28 and 27 mm, respectively). Moreover, the saddle shape of the MA was not preserved because of the rigid ring.

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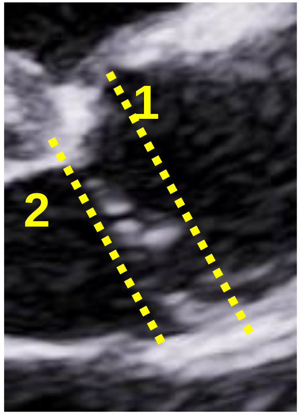
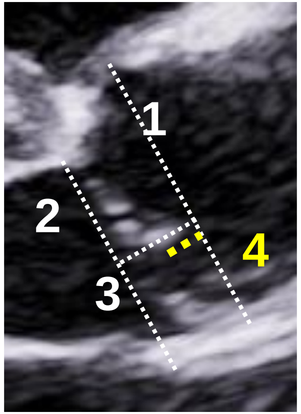
quantitative parameters of cusp geometry

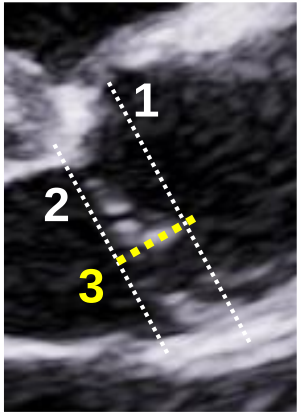




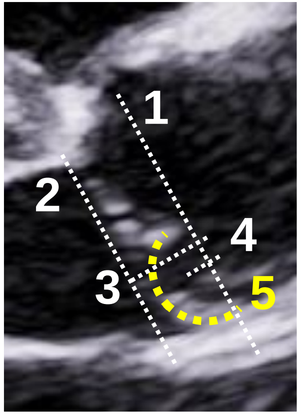
1= orientation line at the level of the tips of the „crown-like“ ring

2= orientation line at the level of the „hinge points“

4 = coaptation-length



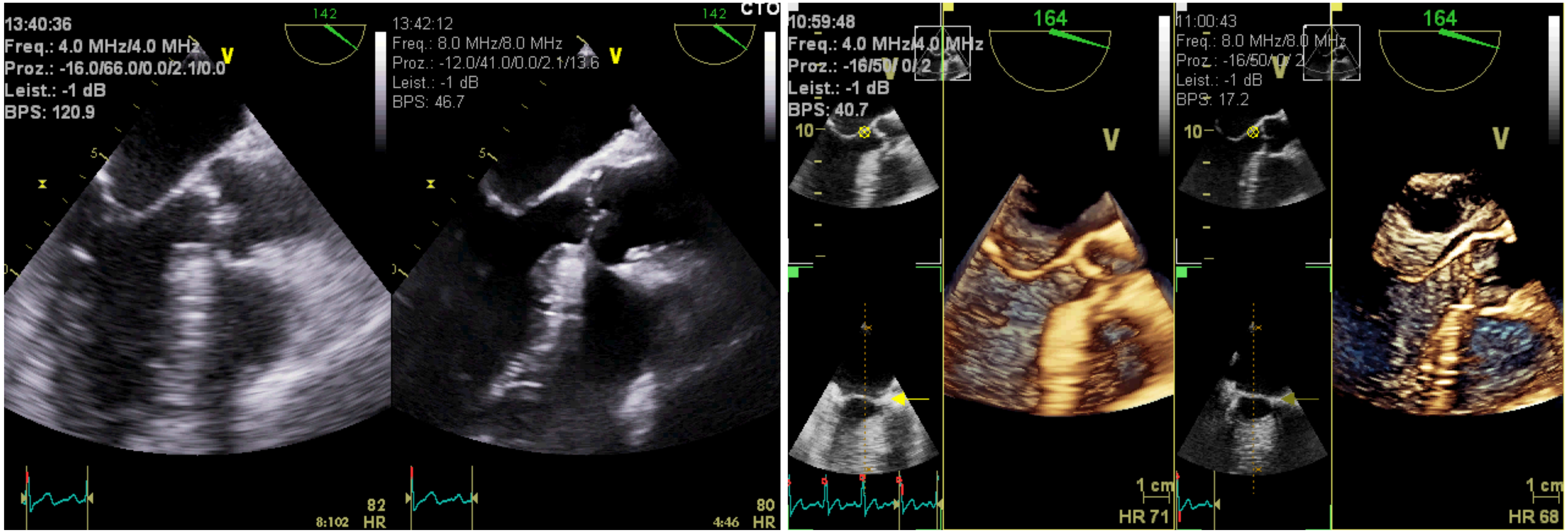
3 = effective height



5 = geometric height of the cusp, if centerline of the cusp is selected (in 2D-echo usually the right coronary cusp

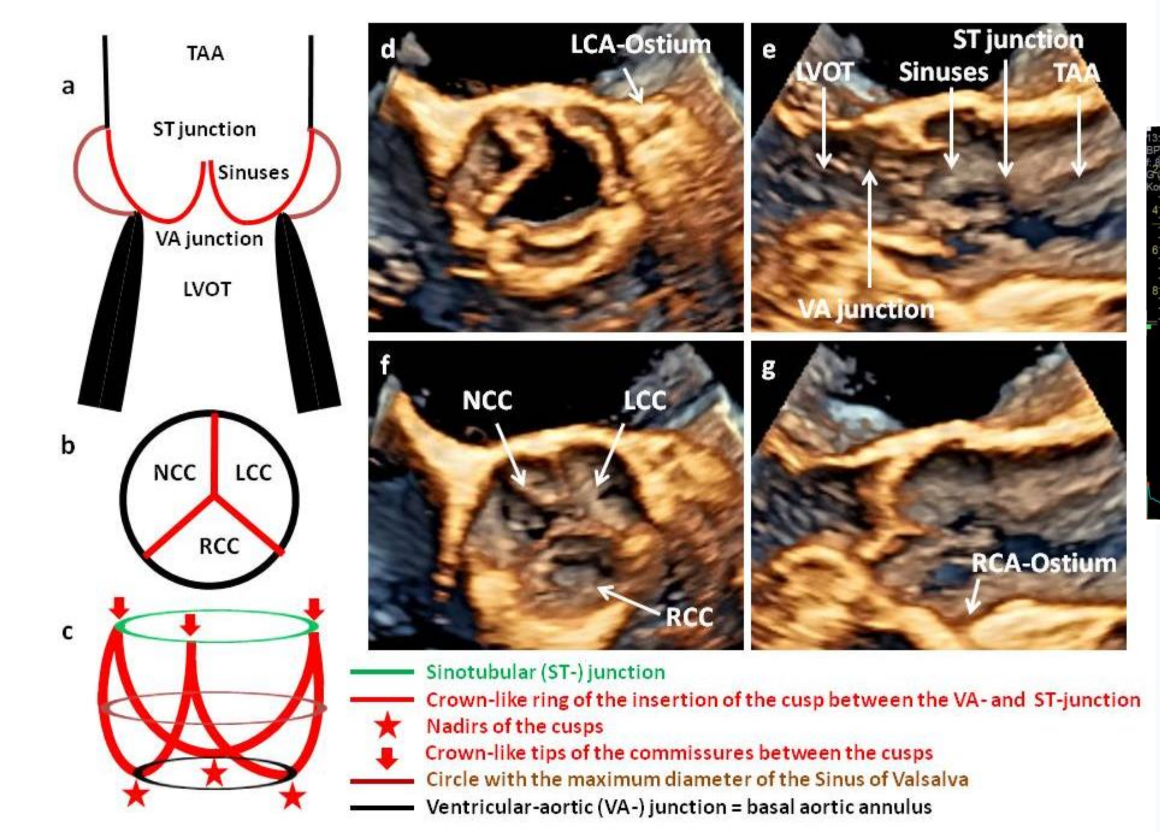
3-dimensional echo in aortic valve repair

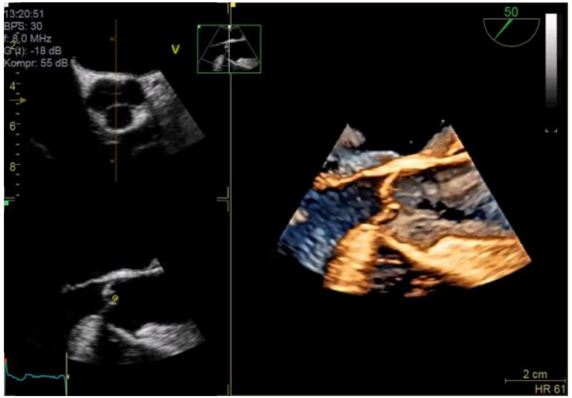
Prerequisite for proper image quality in 2D as well as 3D echocardiography: knowledge about ultrasound physics and implementation of image optimization into the workflow by technical knowledge settings and training for a fast workflow.
Then, detailed analysis of aortic valve and aortic root morphology is possible.
The spatial and temporal resolution of 3D TOE is at least comparable to cardiac-CT.



The same patients: „bad“ settings versus optimized settings in 2D and 3D-TOE.

3-dimensional echo in aortic valve repair

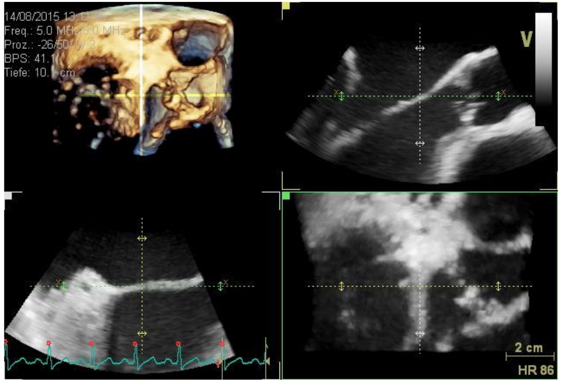




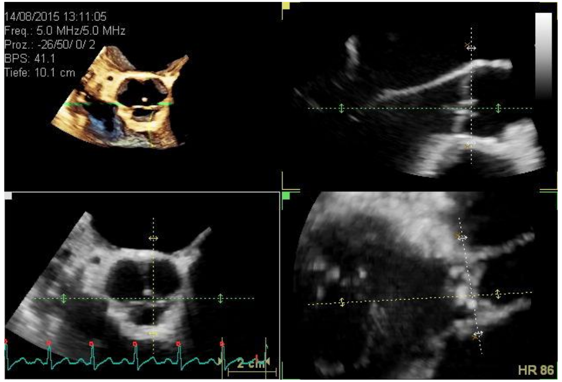
according
Hagendorff A, Evangelista A, Fehske W, Schäfers HJ.
JACC Cardiovasc Imaging. 2019
pii: S1936-878X(19)30172-X.
doi: 10.1016/j.jcmg.2018.06.032

3-dimensional echo in aortic valve repair
steps to measure aortic root morphology

1



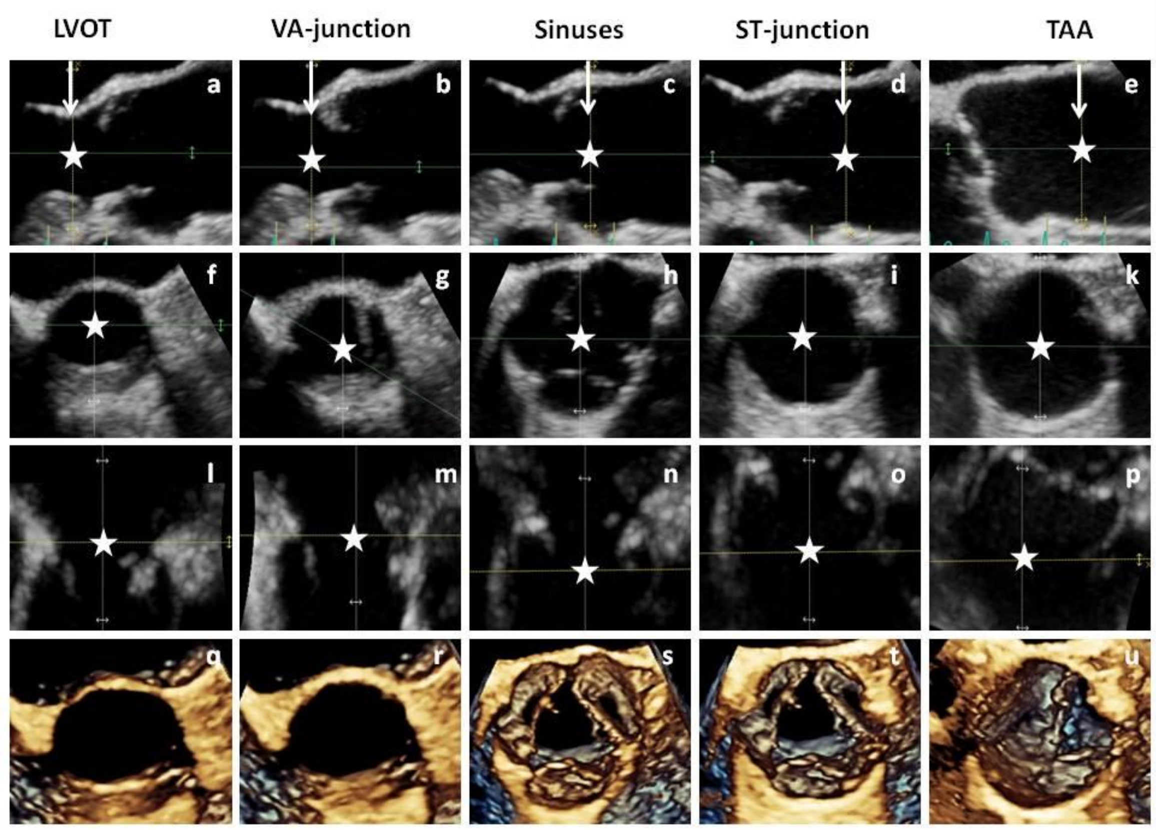
2

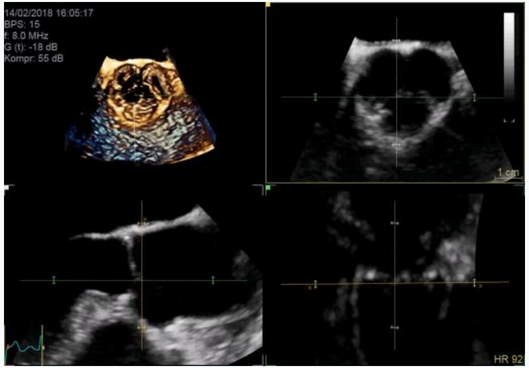


3

1. **Acquire a ZOOM data set - preferrably the complete mitral valve and aortic root complex**
2. **Adjust the central axis of the aortic root in the long axis (systole/diastole)**
3. **Adjust the central axis of the aortic root in the perpendicular axis**
4. **Adjust the short axis to the hindge points by translation during diastole**
5. **Rotate the short axis view to control the sectional short axis plane..**

3-dimensional echo in aortic valve repair





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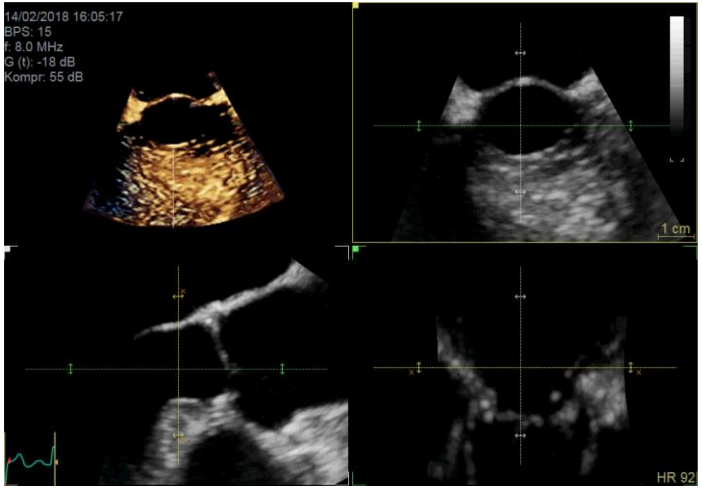
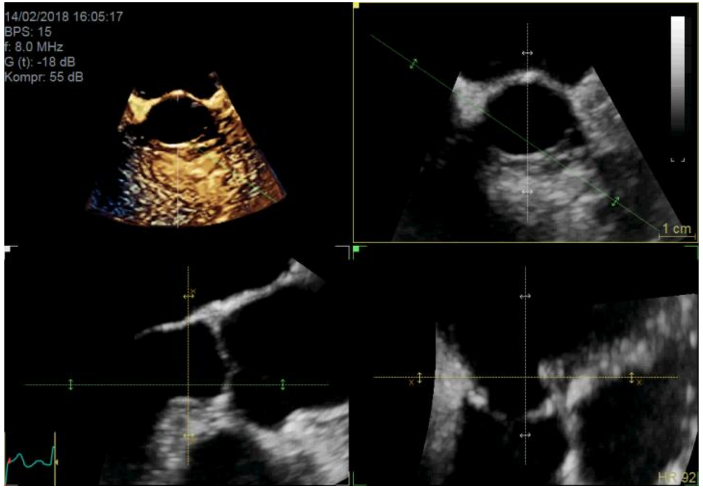
3-dimensional echo in aortic valve repair

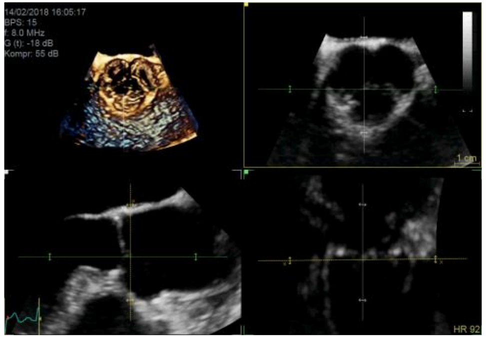
LVOT

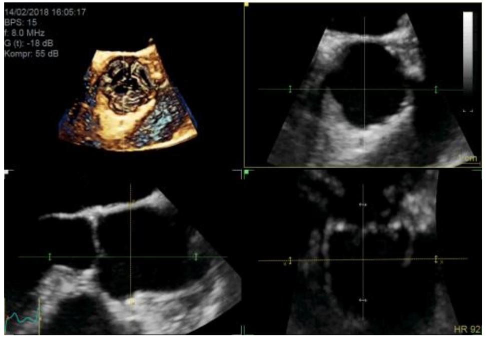




VA-junction

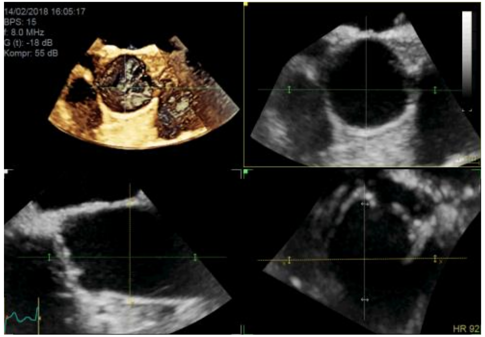
Sinuses





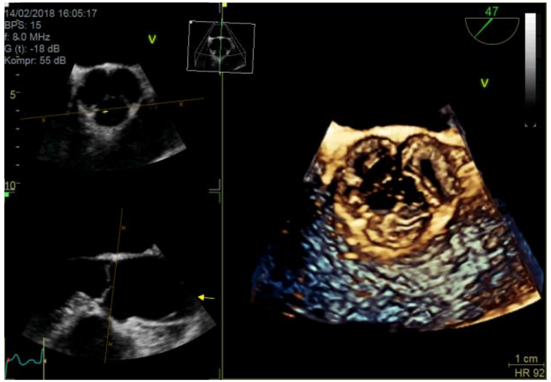
ST-junction

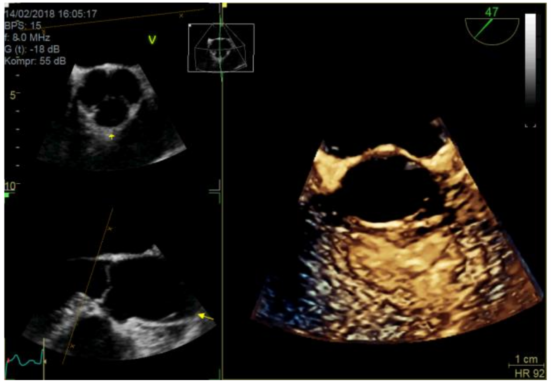
TAA

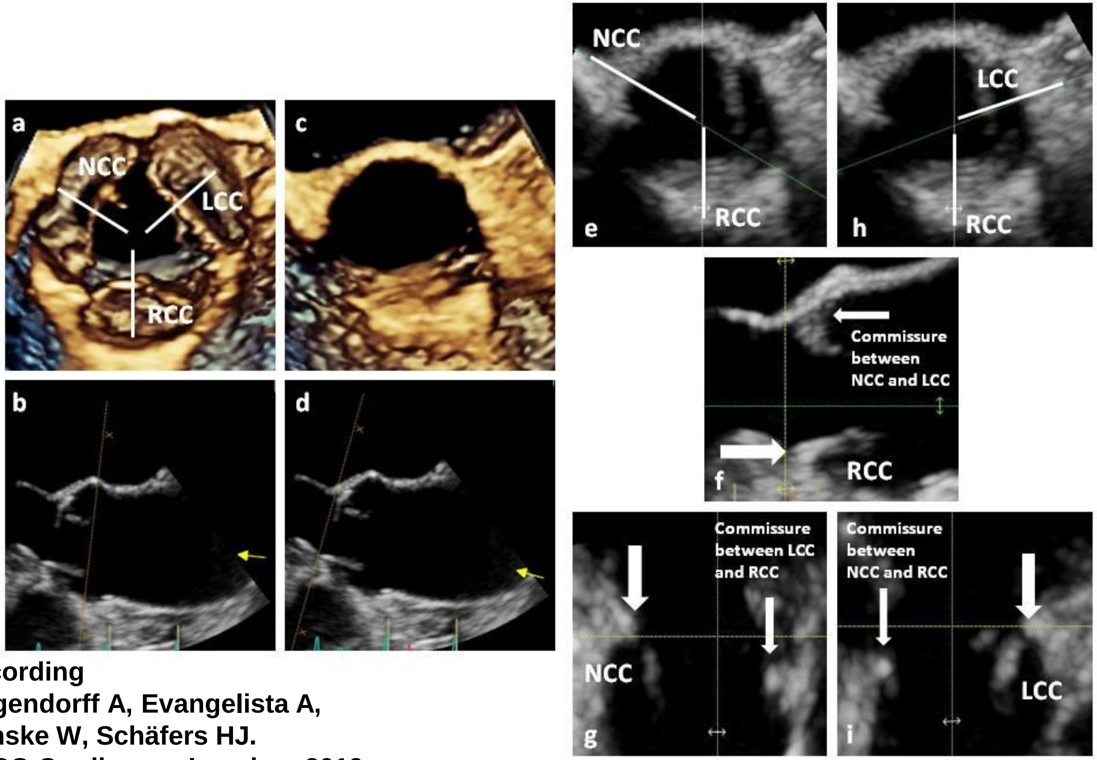


3-dimensional echo in aortic valve repair

adjusting sectional planes of central cusps







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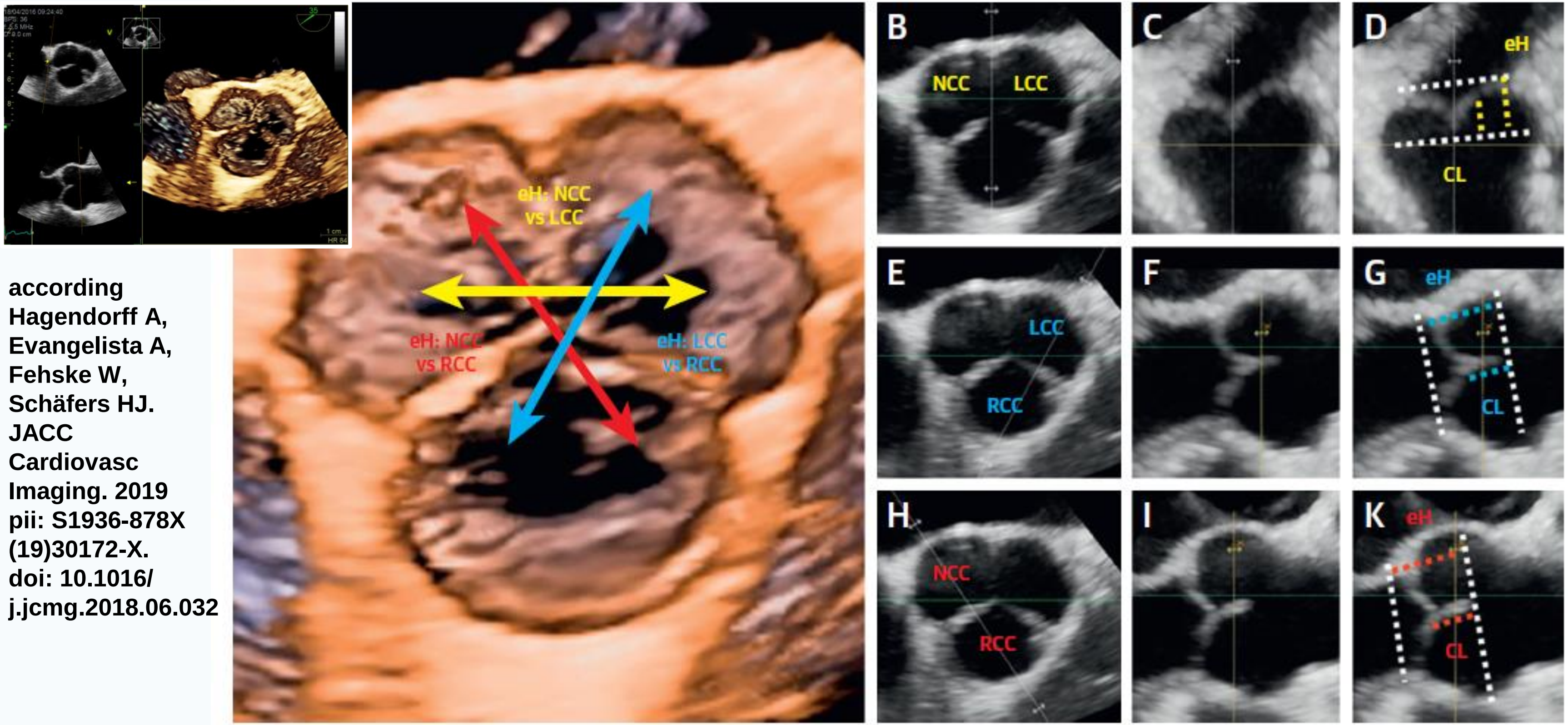
3-dimensional echo in aortic valve repair
assessment of effective height



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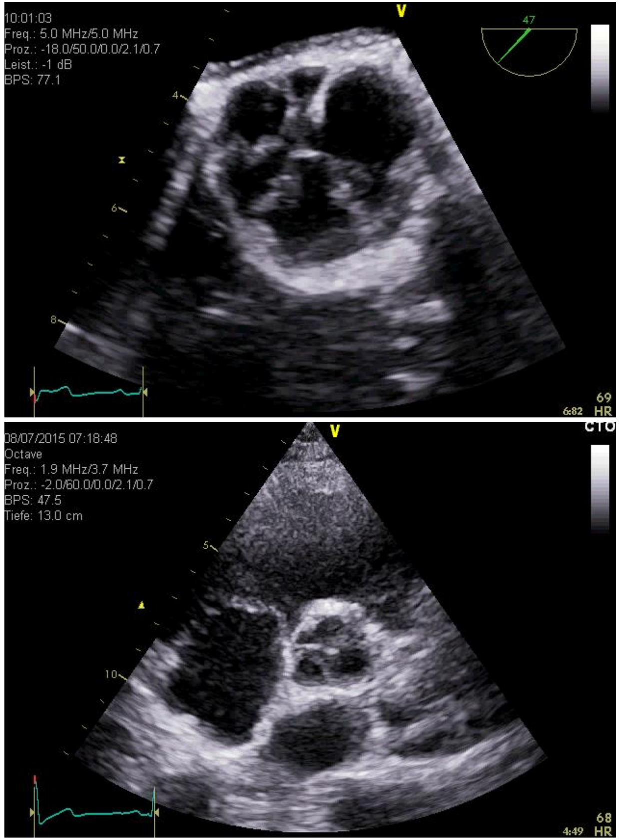
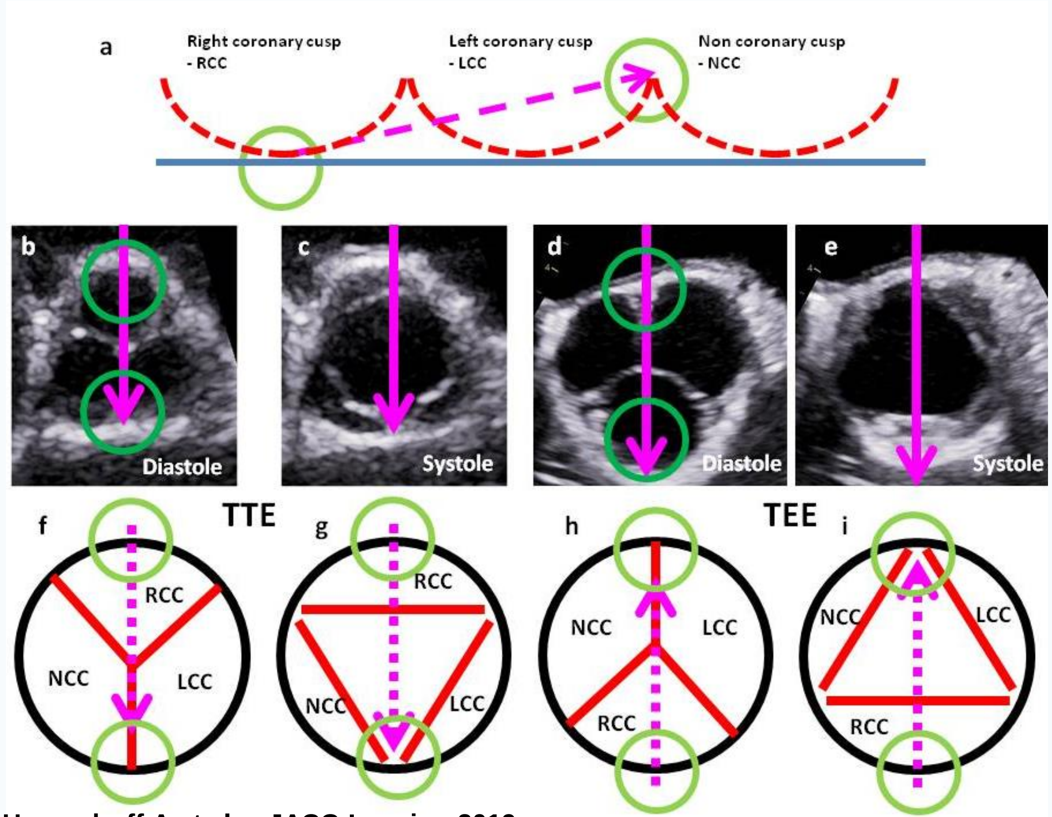
3-dimensional echo in aortic valve repair





Hagendorff A et al. – JACC Imaging 2019

3-dimensional echo in aortic valve repair
assessment of geometric height

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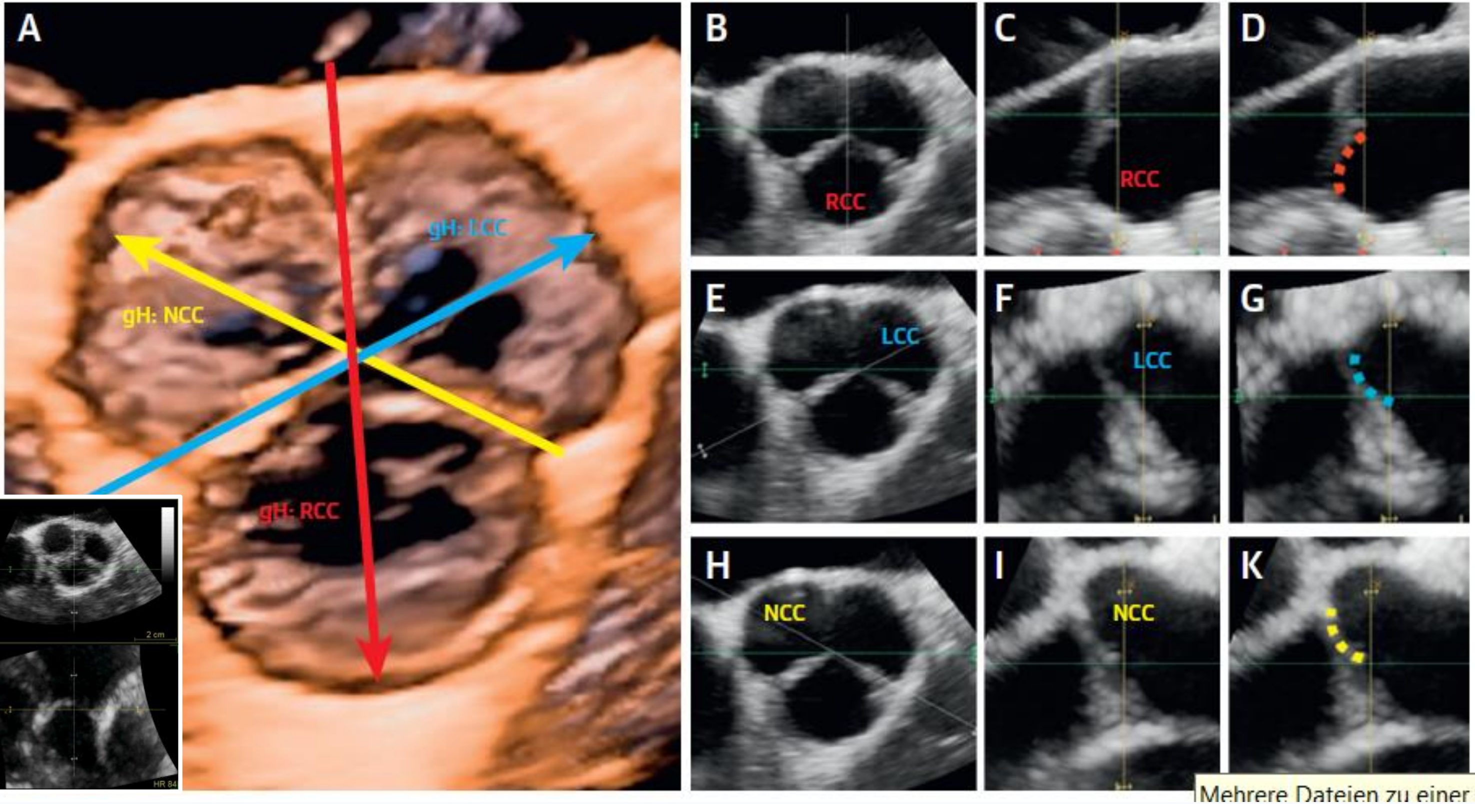
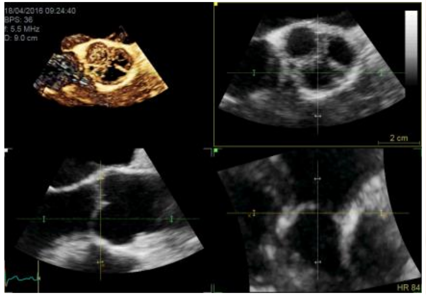
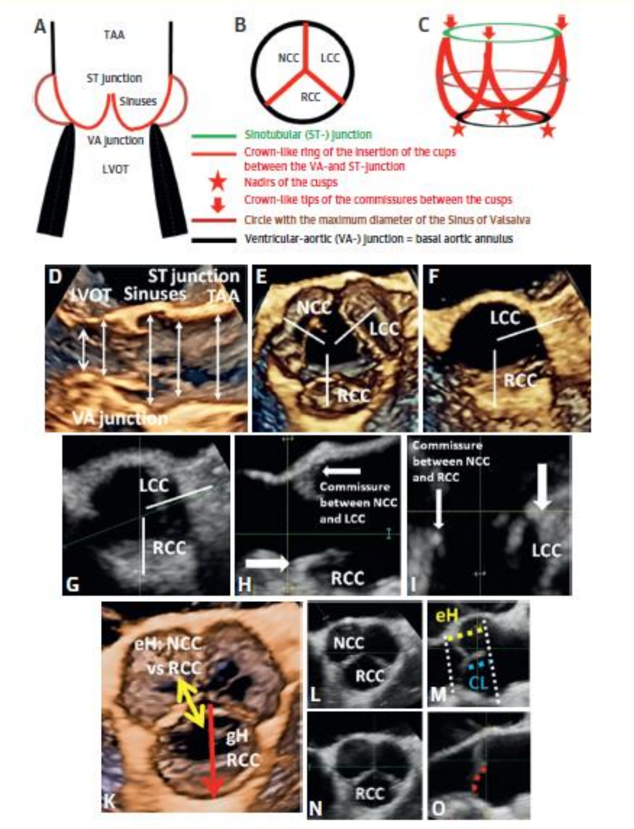
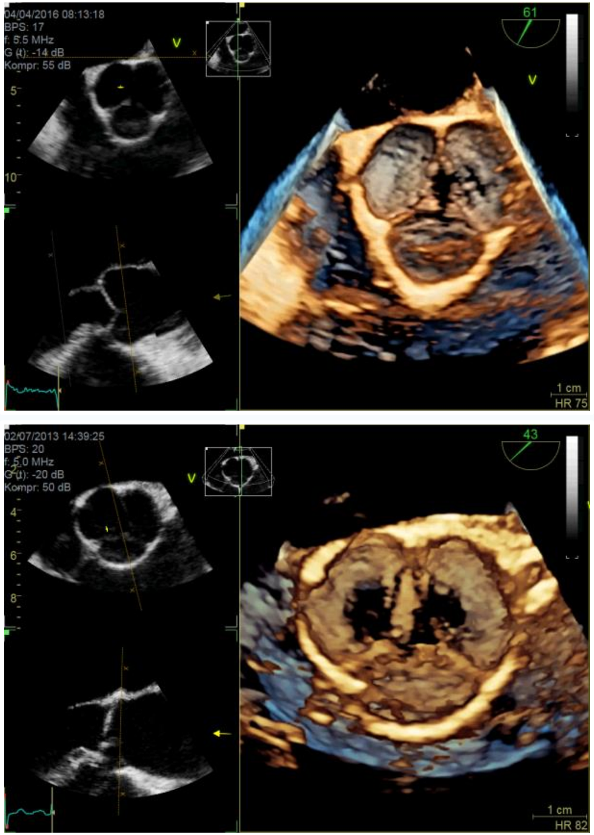




3-dimensional echo in aortic valve repair





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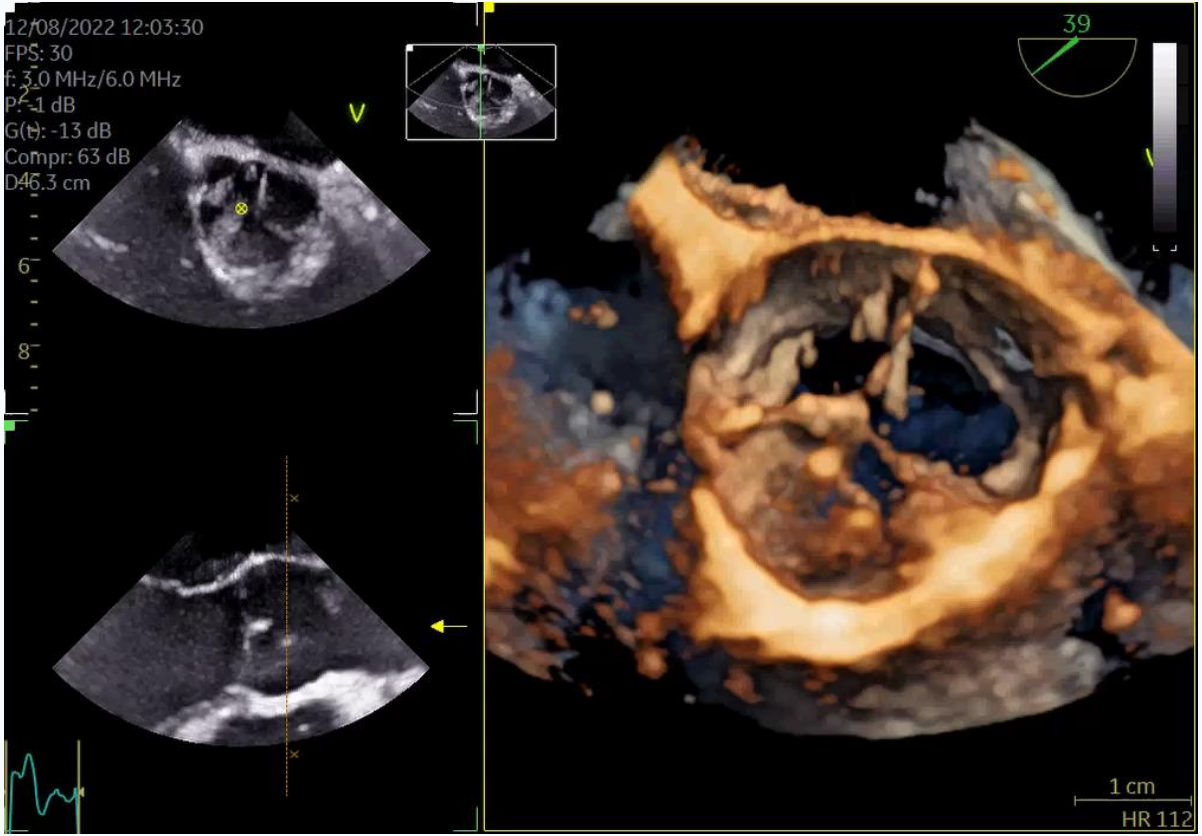
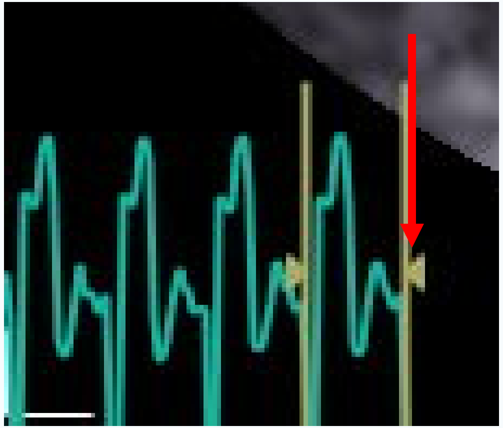
3-dimensional echo in aortic valve repair

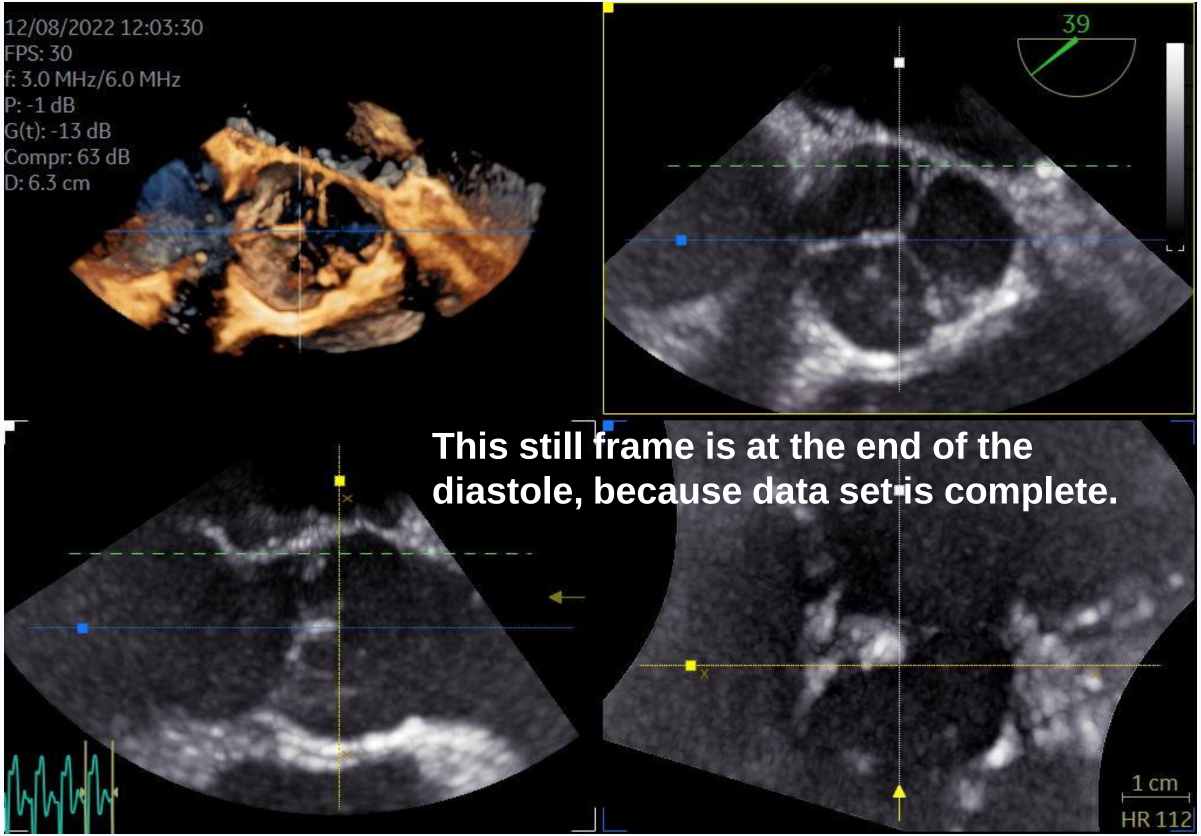
3D-ZOOM-TOE-data set of the aortic root
- 4-beat-near-real-time-full-volume-acquisition -



3-dimensional echo in aortic valve repair

3D-ZOOM-TOE-sata set of the aortic root focus on end-diastole (like CT) - visualization of the comissures and symmetry of cusps

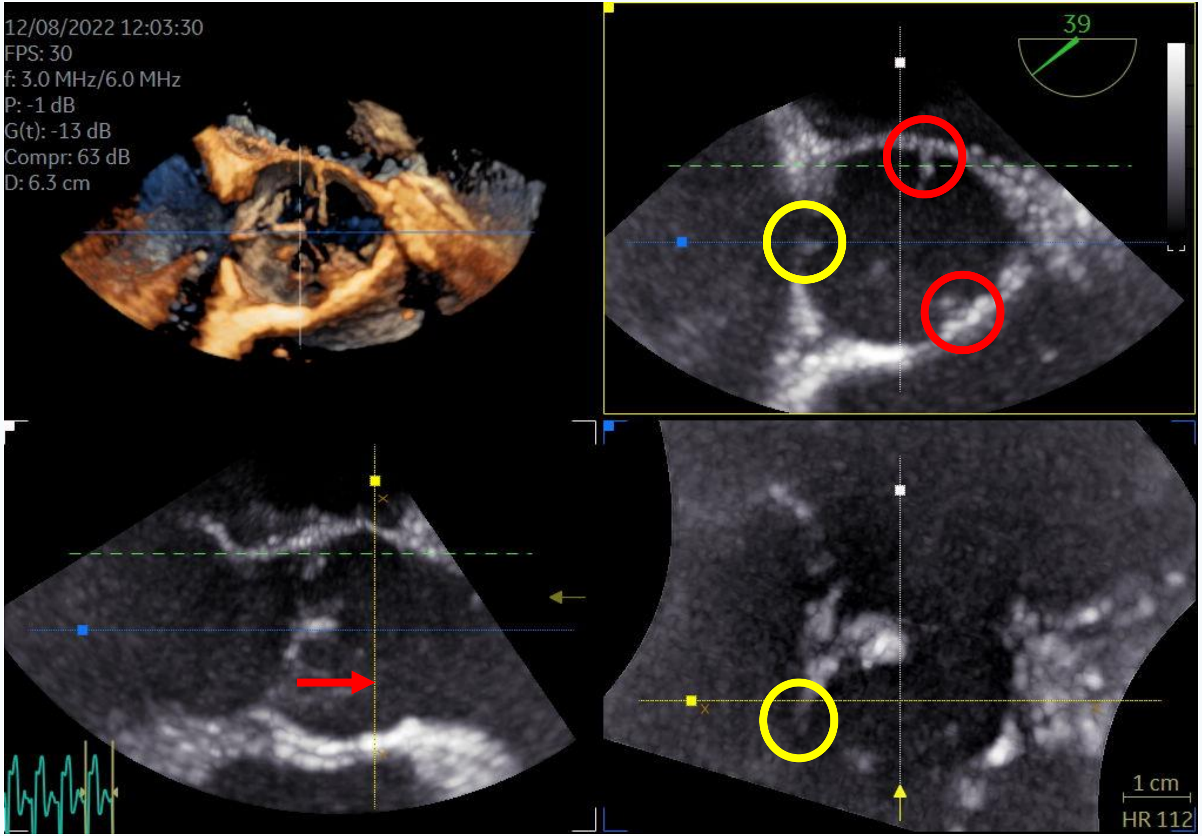




This still frame is at the end of the diastole, because data set is complete.

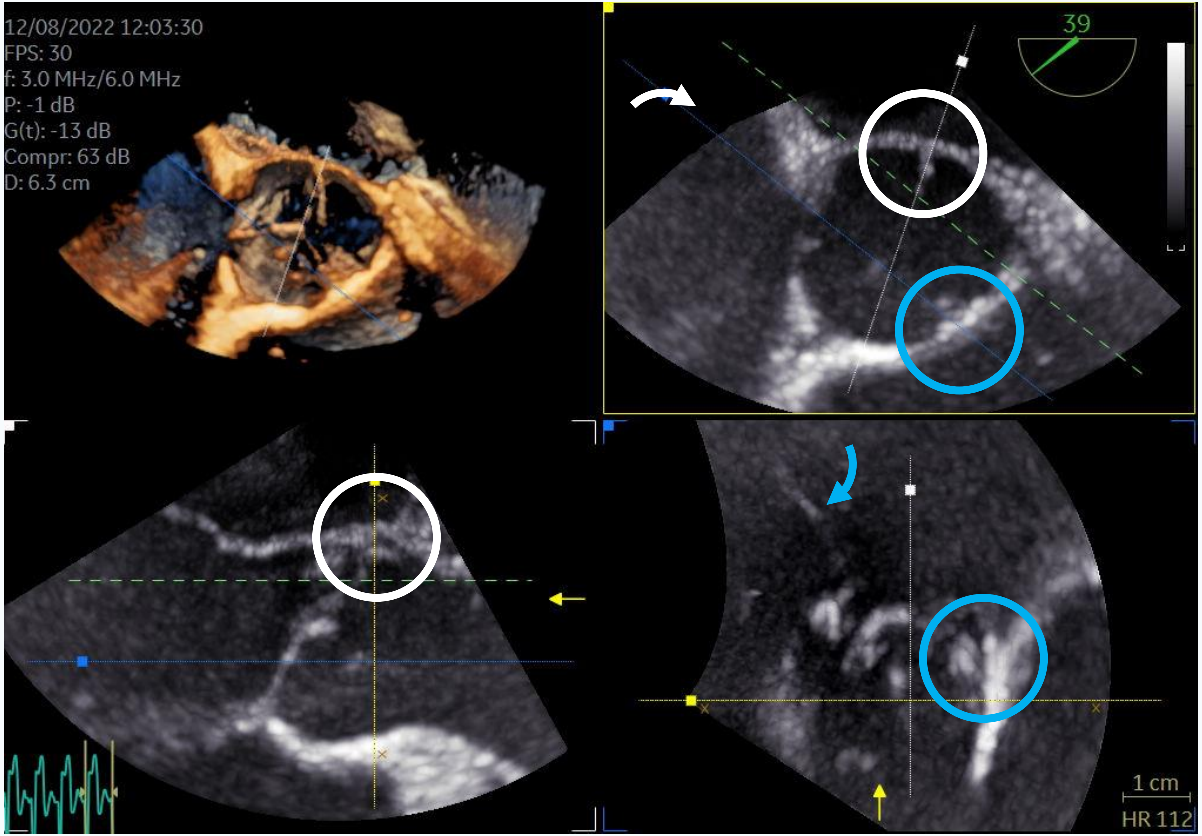
3-dimensional echo in aortic valve repair

3D-ZOOM-TOE-data set of the aortic root
- adjusting the sectional plane of the crown tips by translation – perpendicular sectional plane throu the commissure between NCC and RCC



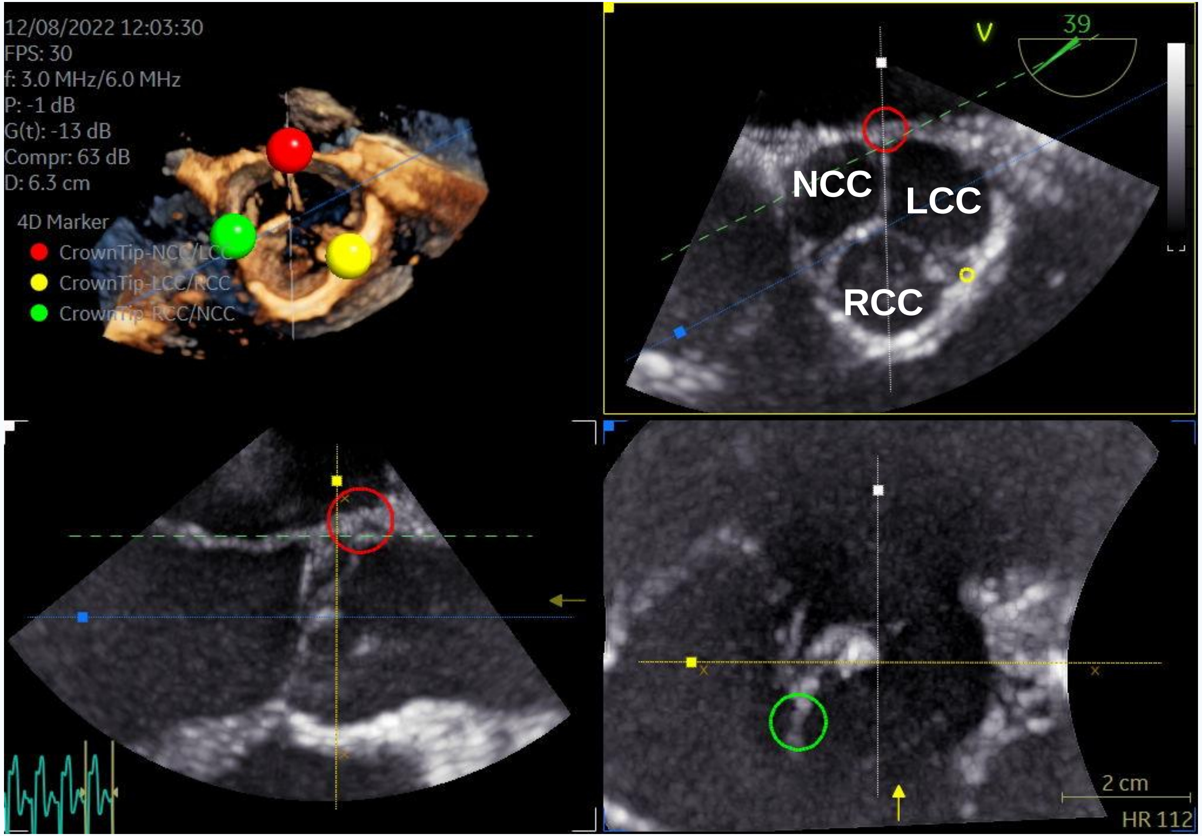
3-dimensional echo in aortic valve repair

3D-ZOOM-TOE-data set of the aortic root
- adjusting the sectional plane of the crown tips by translation – perpendicular sectional plane throu the commissures between NCC/LCC and LCC/RCC



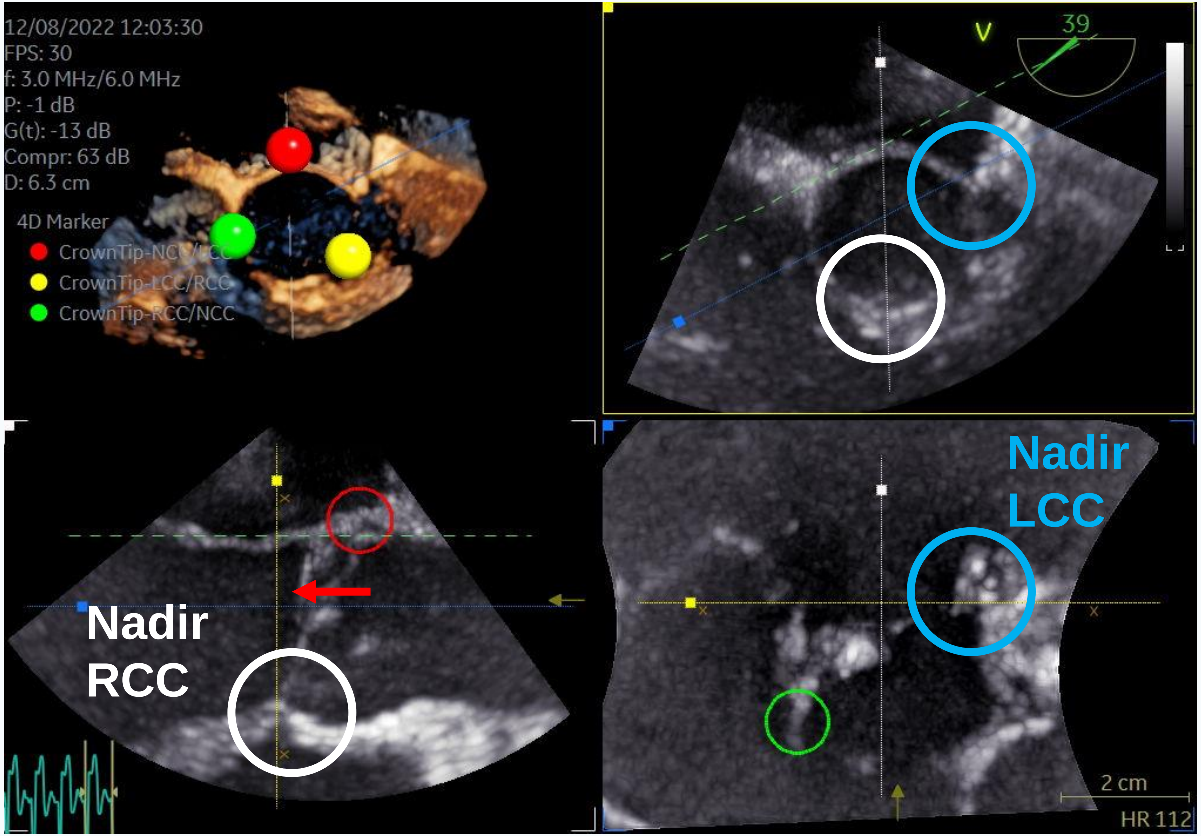
3-dimensional echo in aortic valve repair

3D-ZOOM-TOE-data set of the aortic root
- labeling of the crown tips using markers



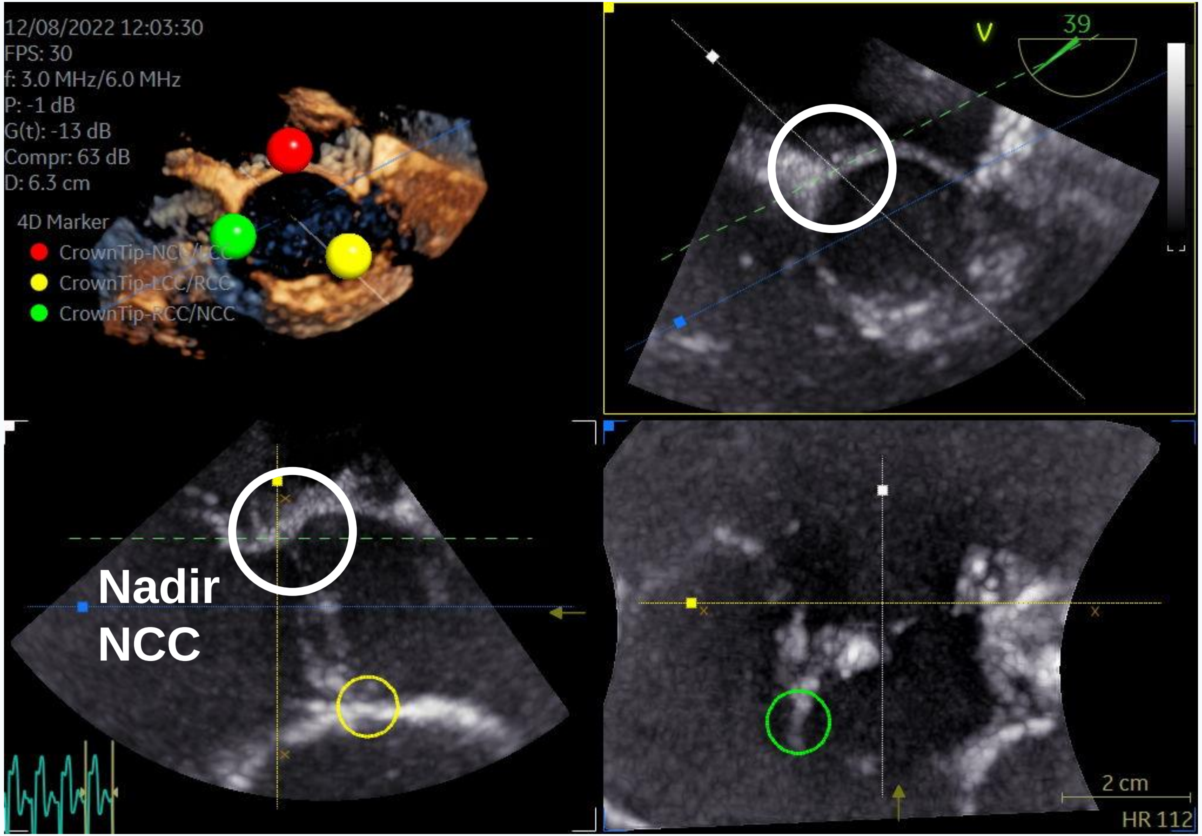
3-dimensional echo in aortic valve repair

3D-ZOOM-TOE-data set of the aortic root - crown tips are labeled by markers, proper alignement of sectional planes to label the nadirs (hindge points) of the RCC and LCC -



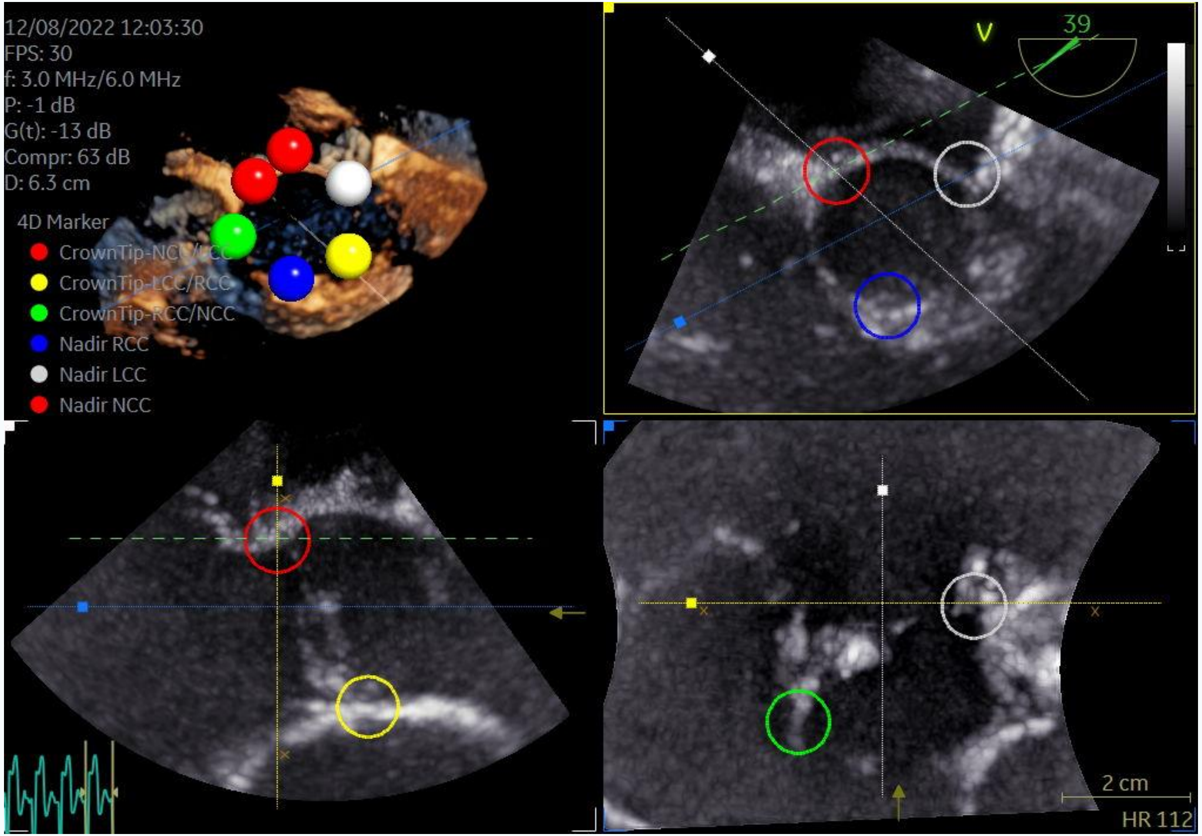
3-dimensional echo in aortic valve repair

3D-ZOOM-TOE-data set of the aortic root
- crown tips are labeled by markers, proper alignement of sectional plane to label the nadir (hindge points) of the NCC -

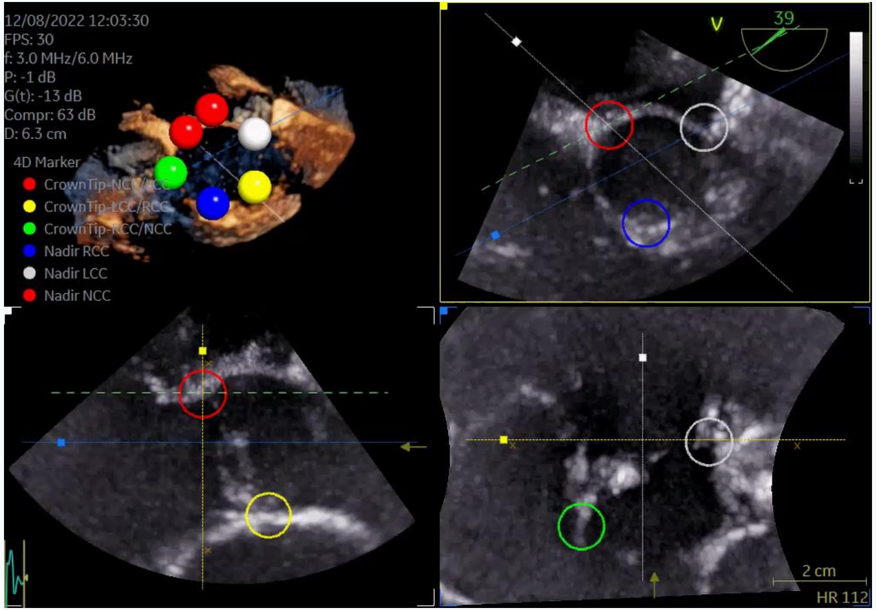


3-dimensional echo in aortic valve repair

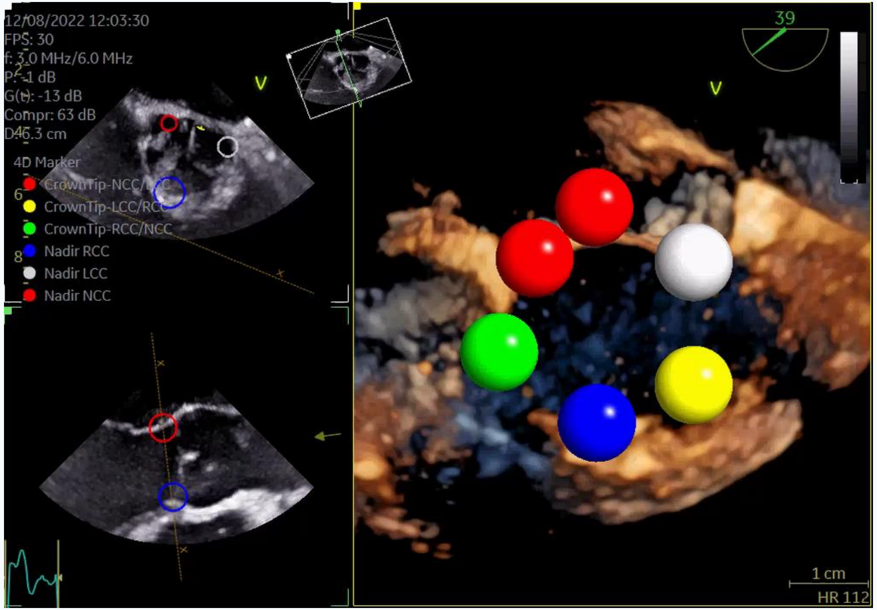
3D-ZOOM-TOE-data set of the aortic root
- labeling of both, the crown tips and the hindge points of the cusps using markers -



3-dimensional echo in aortic valve repair

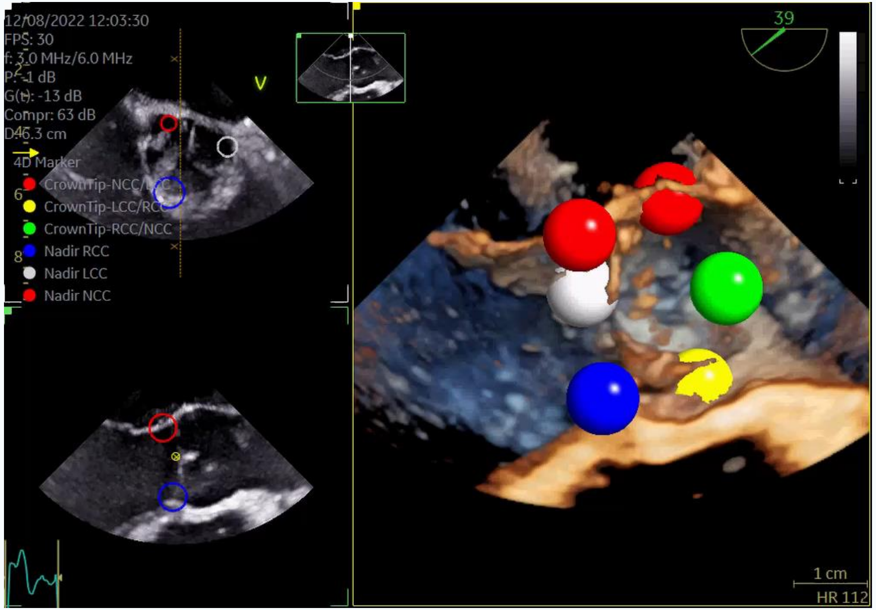


3D-ZOOM-TOE-data set of the aortic root

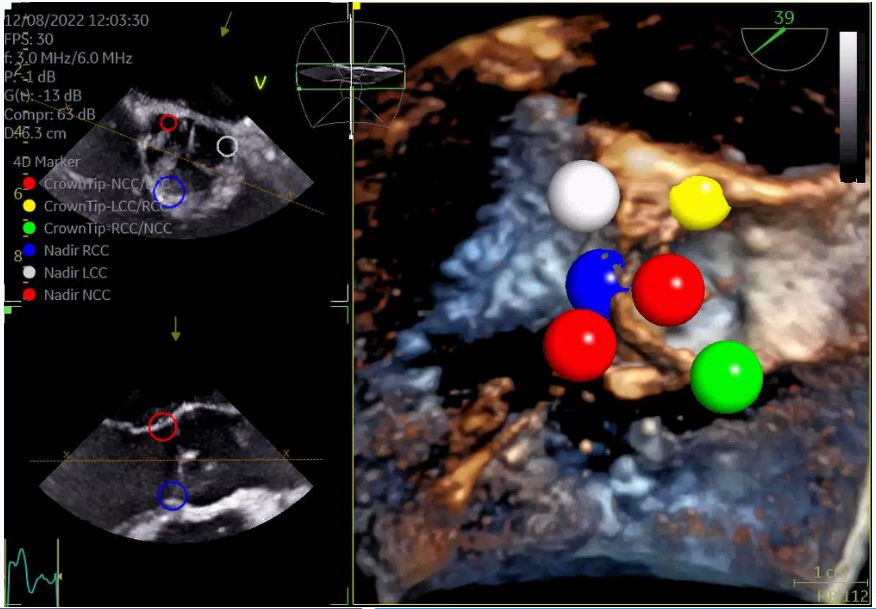


Are the sectional plane of the hindge points parallel to the sectional plane of the crown tips?

3-dimensional echo in aortic valve repair



3D-ZOOM-TOE-data set of the aortic root



Obviously at end-diastole, both sectional planes are not parallel.

3-dimensional echo in aortic valve repair

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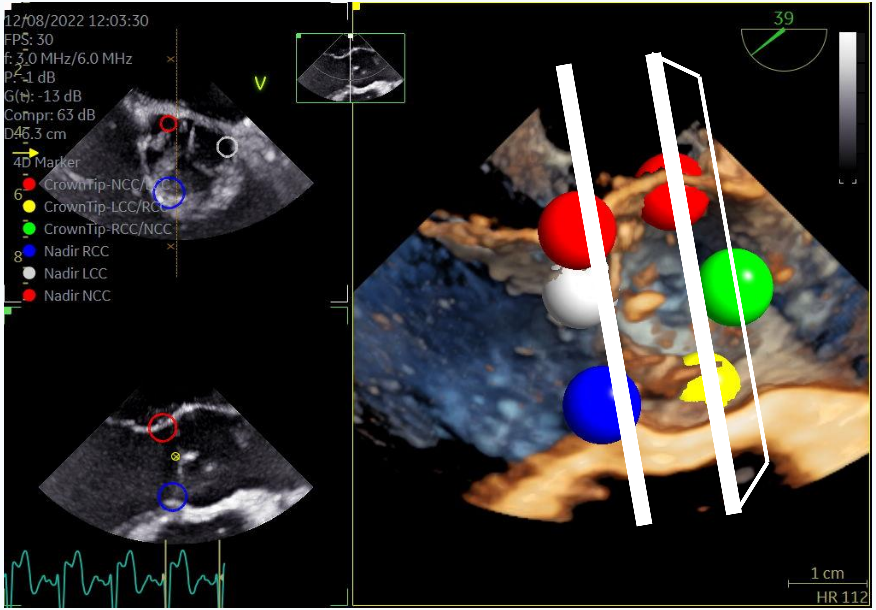
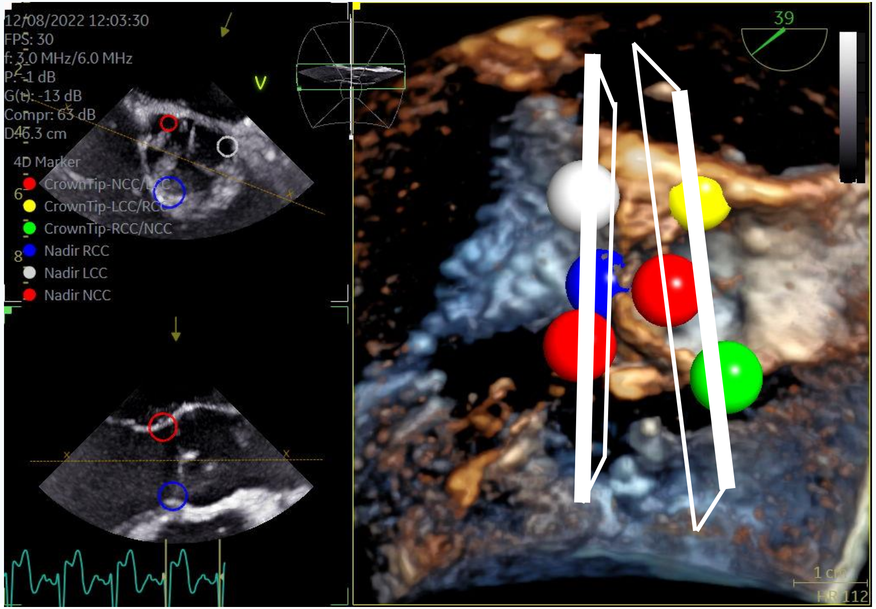


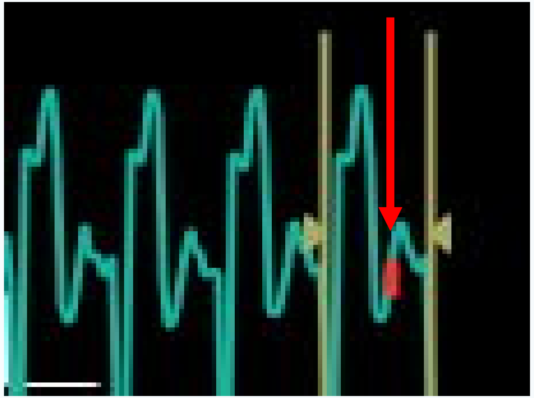
3D-ZOOM-TOE-data set of the aortic root

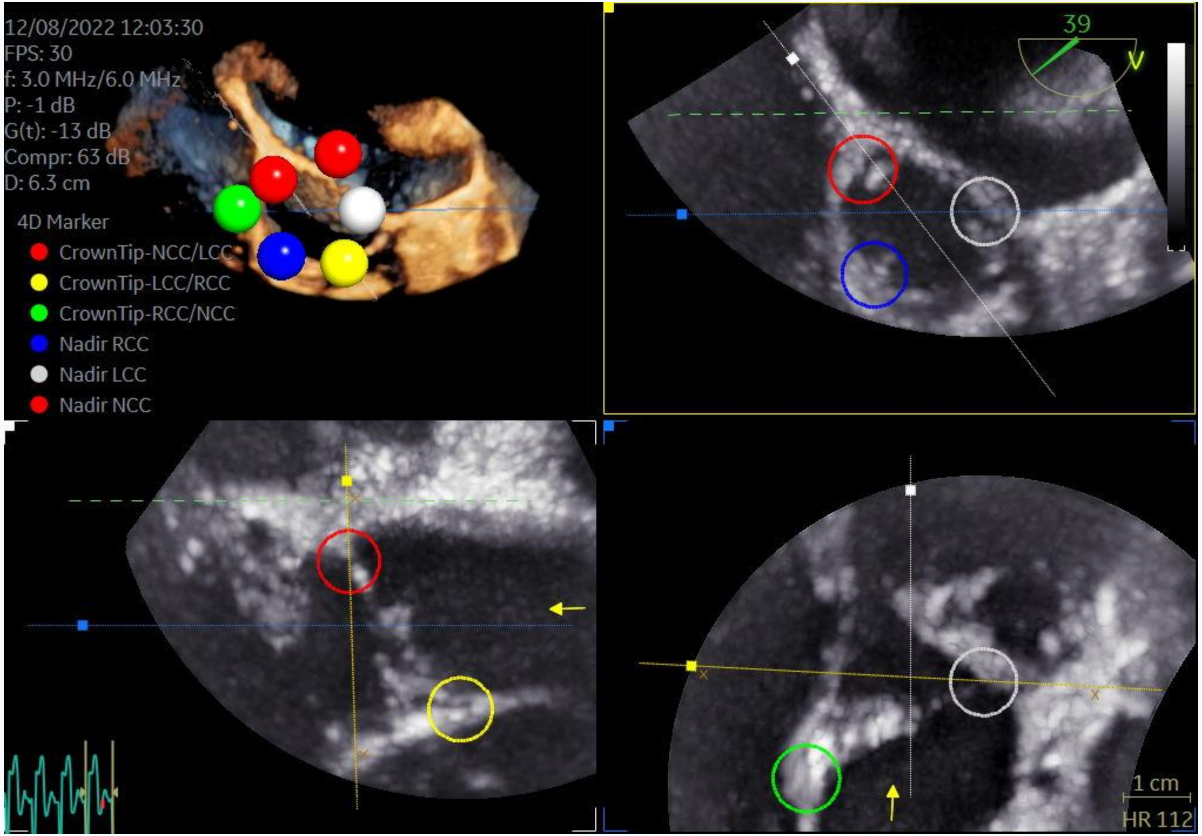


Comparison of both sectional planes at end diastole.

3-dimensional echo in aortic valve repair

3D-ZOOM-TOE-sata set of the aortic root focus on early diastole
- labeling of crown tips and hindge points -





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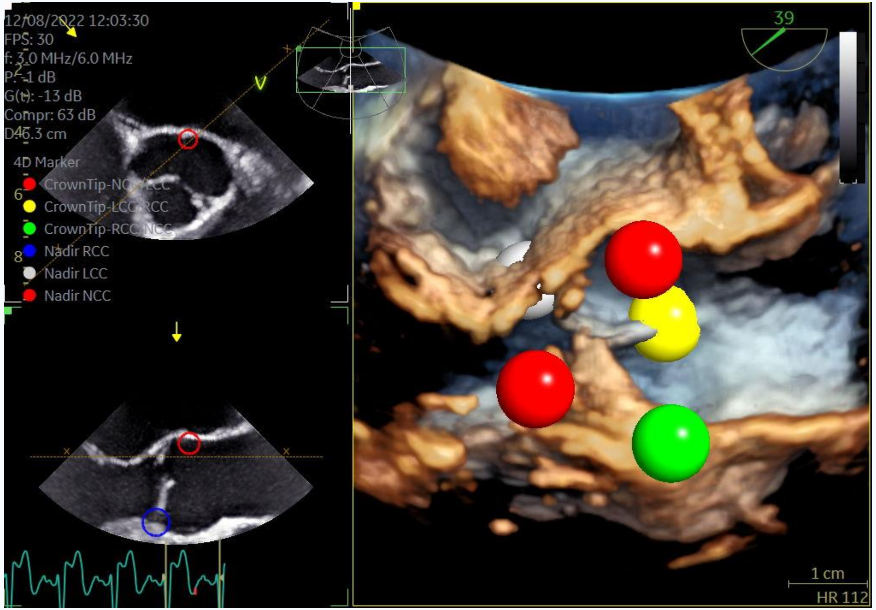
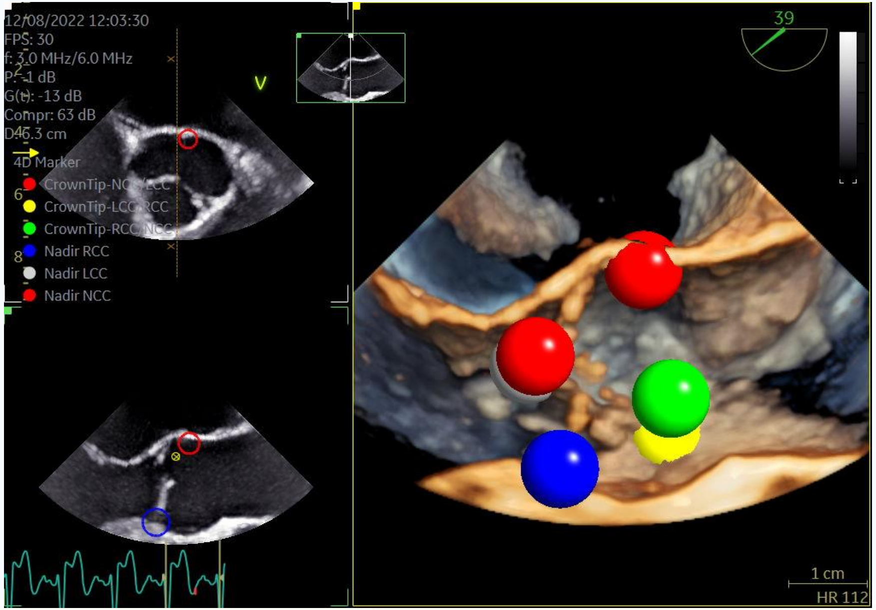


3D-ZOOM-TOE-data set of the aortic root

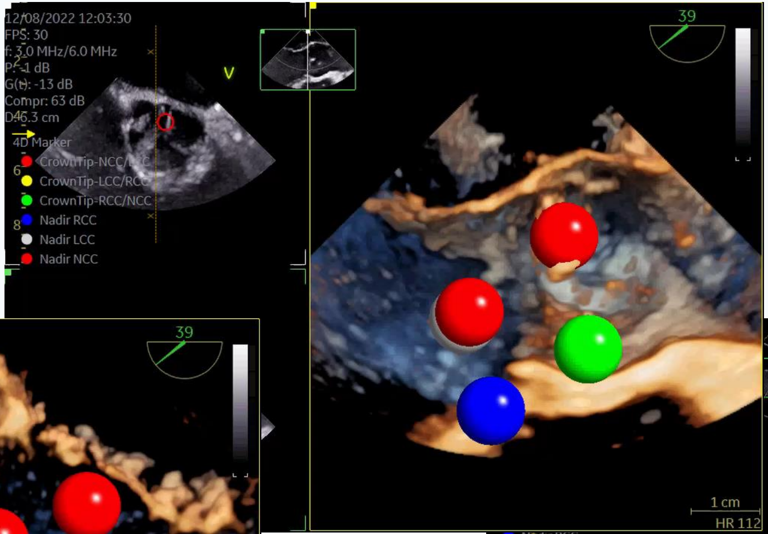


Comparison of both sectional planes at early diastole

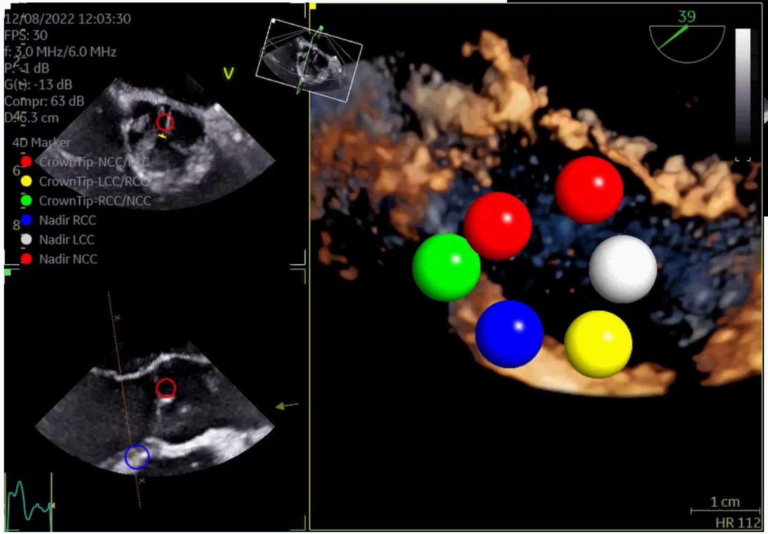
- obviously the planes are almost parallel -

3-dimensional echo in aortic valve repair

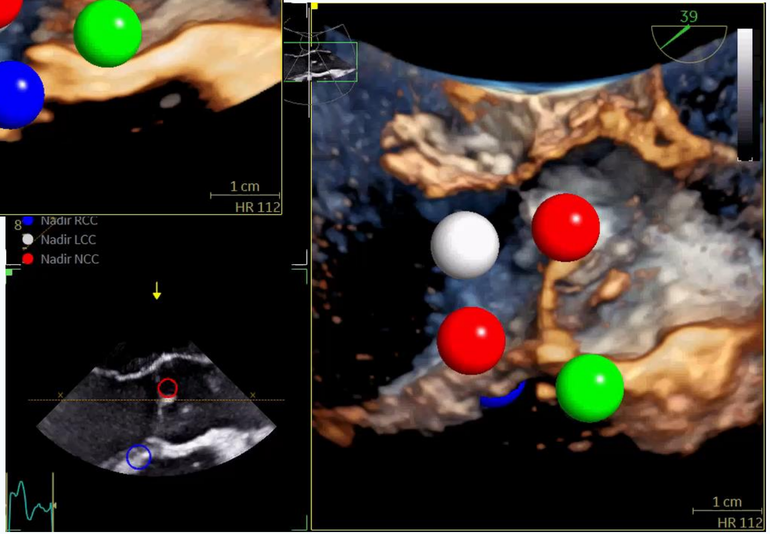
3D-ZOOM-TOE-data set of the aortic root



The relation of both sectinal planes differs during the time period of diastole.

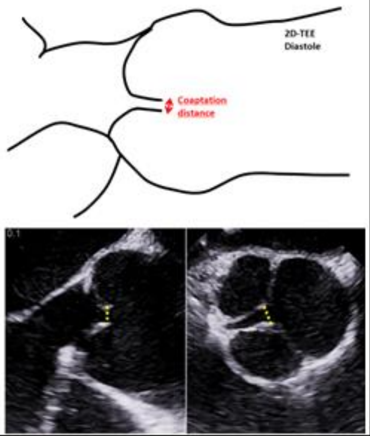
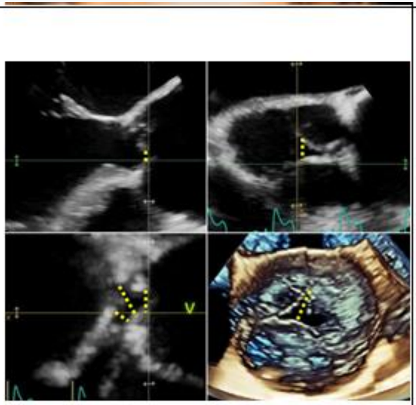
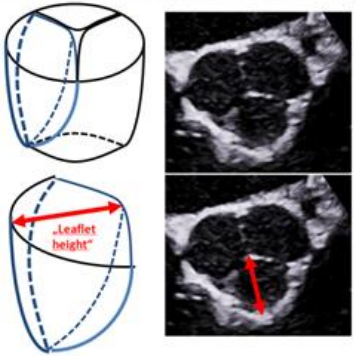
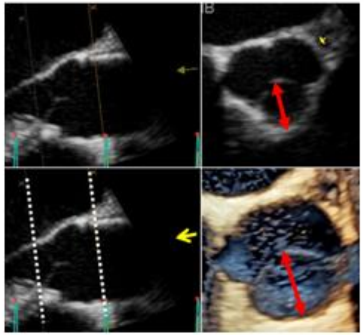


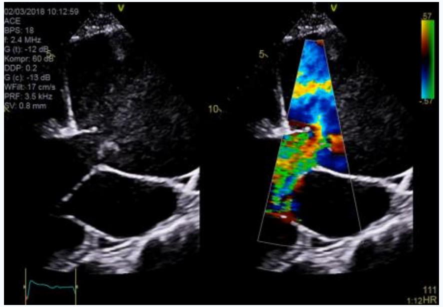
These dynamics can only be assessed by real time imaging.

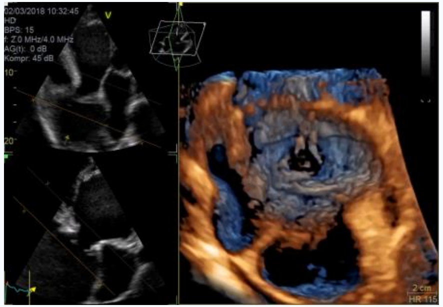


3-dimensional echo in aortic valve repair

- additional parameters -

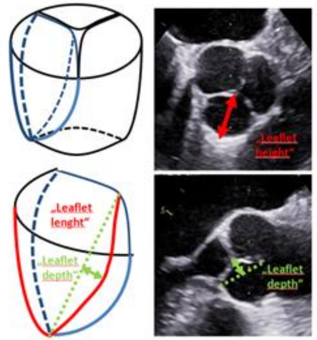
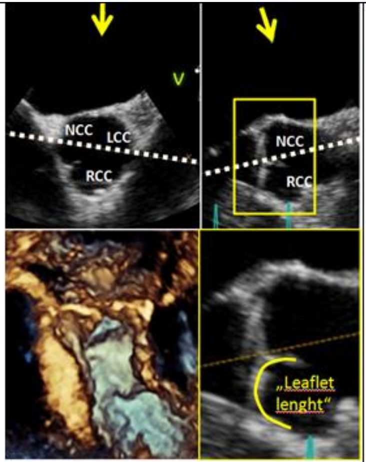
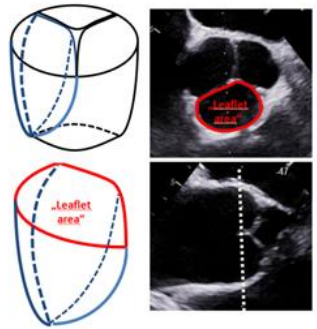
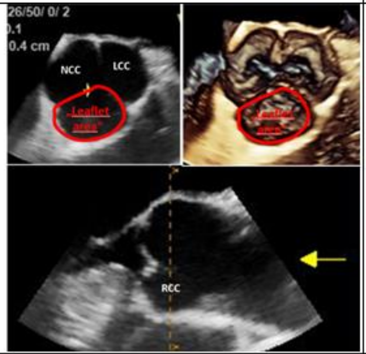
Coaptation distance of the adjacent cusps			The correctness of maximum coaptation distance between the respective cusps cannot be controlled in 2D sectional planes – even if biplane scanning modalities are used. Accurate adjustment of the sectional plane perpendicular to the adjacent cusps in diastole by 3D-echocardiography is necessary to assess maximum coaptation distance.
„Leaflet height“ (LH)			„LH“ should be measured in 2D echocardiography during end diastole in the short-axis view from the internal aortic root border to the free edge of the so-called „leaflet“. If this parameter is measured, a sectional plane parallel to the basal ring has to be chosen by 3D echocardiography. The parameter „LH“ is totally different from the parameter eH.

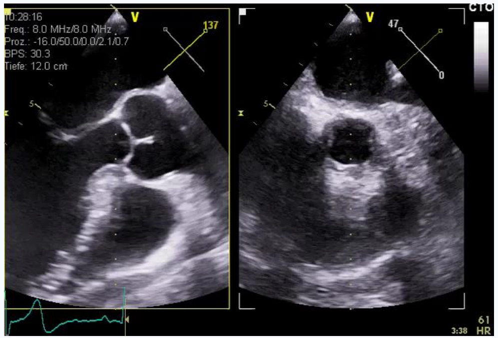


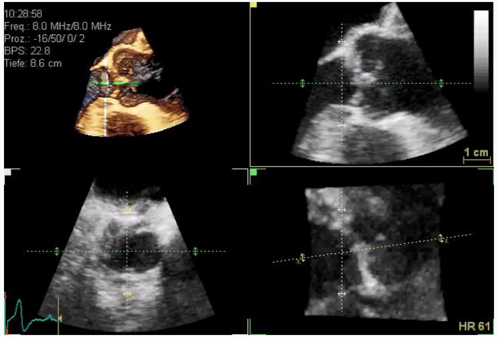


3-dimensional echo in aortic valve repair

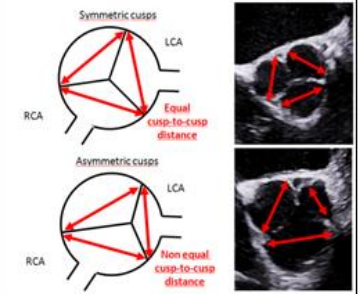
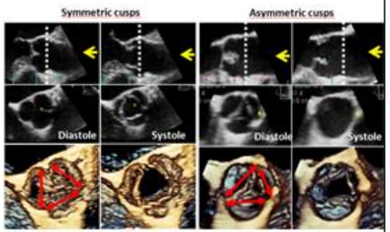
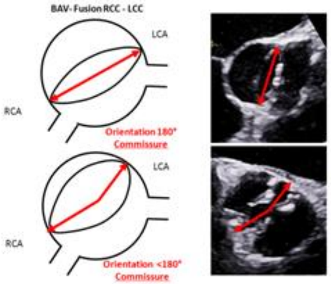
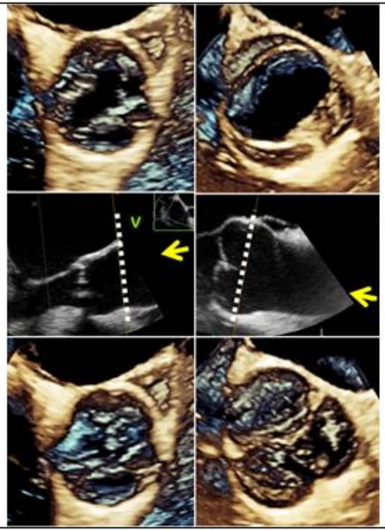
- additional parameters -

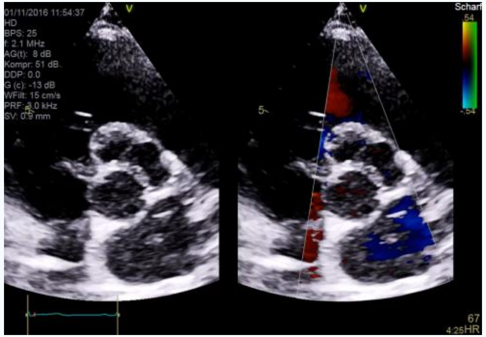
„Leaflet length“ (LL) and „leaflet dephth“ (LD)			The „LL“ over the belly of the leaflet is a calculated parameter, which corresponds to the half perimeter of the ellipse described by the average „LH“ as major axis and twice the „LD“ as minor axis. The „LD“ is measured in the long-axis view as the distance between the line from the „leaflet“ insertion to the „leaflet“ tip and the most convex point of the „leaflet“. It is possible to measure „LL“ for each cusp by 3D echocardiography. However, the parameter „LL“ is totally different from the parameter „geometric height“.
„Leaflet area“			„Leaflet area“ is also a parameter measured by 2D echocardiography during end diastole in the short-axis view. In 3D echocardiography this area can be determined exactly parallel to the basal AV annulus. This parameter was used in conventional echocardiography to characterize cusp size.

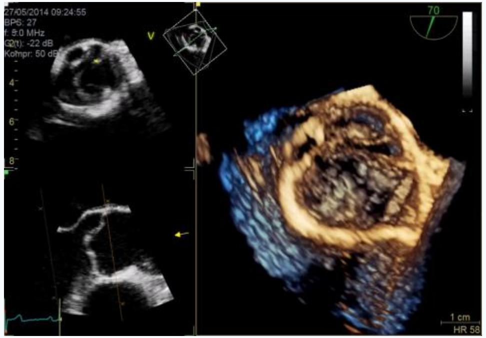




3-dimensional echo in aortic valve repair
- additional parameters -

Cusp-to-cusp distance			Cusp-to-cups distance has to be measured at the level of the cusps during diastole exactly in a sectional plane parallel to the basal AV annulus to characterize symmetry of the aortic root. The exact orientation of this sectional plane can only be controlled by 3D echocardiography.
Orientation of the commissure in bicuspid aortic valve			The impression of the orientation commisure can vary between diastole and systole as well as with respect to the sectional plane. The en-face-view or the sectional plane through the cusps during diastole have to be exactly parallel to the plane of the basal AV annulus which can only be controlled by 3D echocardiography.





3-dimensional echo in aortic valve repair

- additional parameters -

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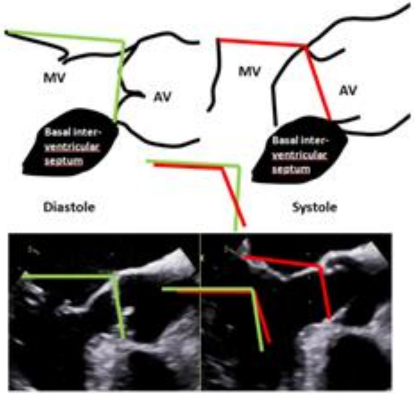
<td>Aortic annulus excursion and the angle between mitral and aortic annulus</td>
<td>
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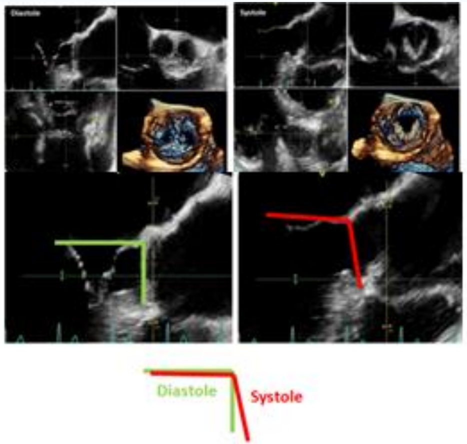
<td>
</td>
<td>The correctness of the 2D sectional plane of the standardized long axis view throug the center of the mitral valve and the AV can be exactly controlled by 3D echocardiography. The deviation of the exact long axis between diastole and systole due to out-of-plane movement during the cineloop can exactly be corrected by adjustment of the sectional planes in 3D-data sets.</td>
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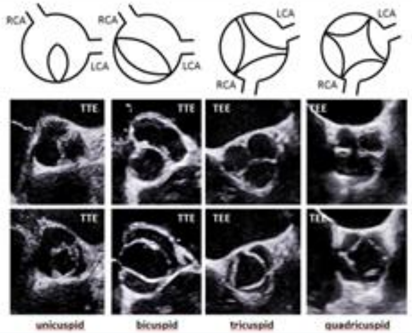
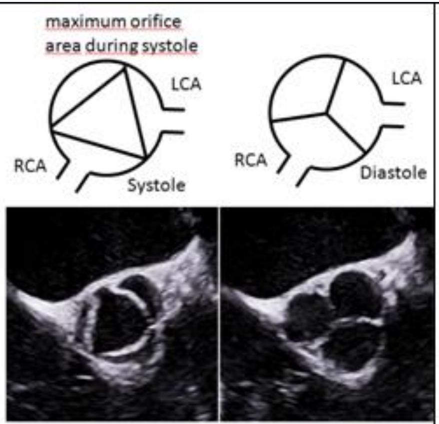
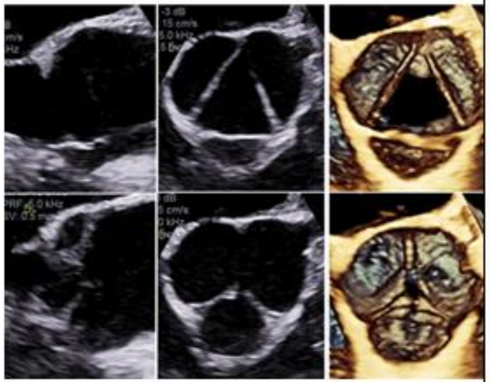
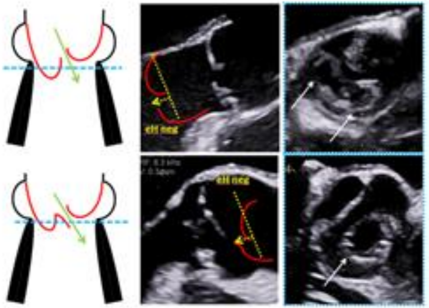
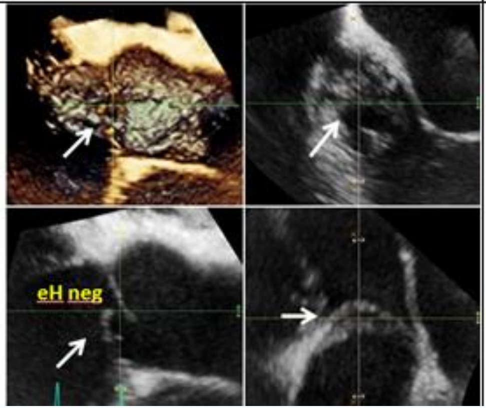
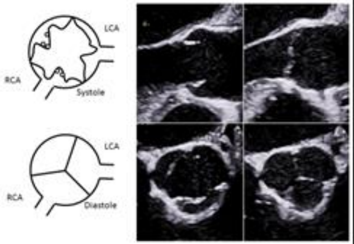
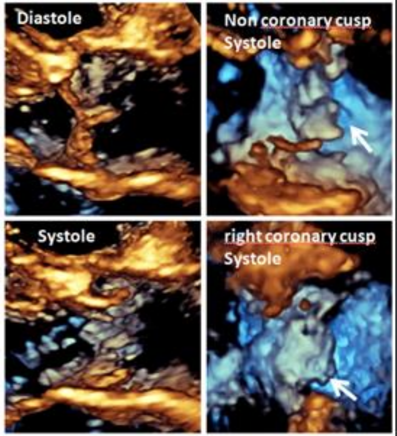
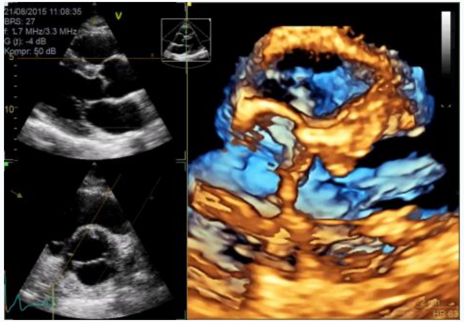
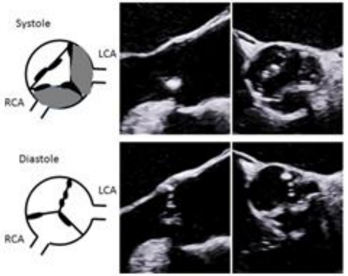
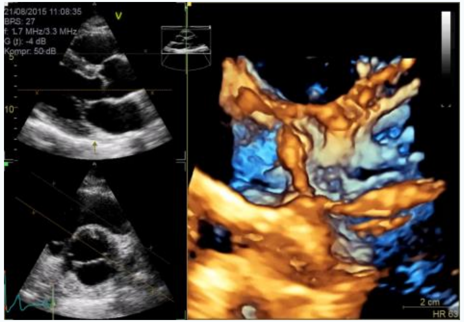
<tr>
<td>Cuspidity</td>
<td>
</td>
<td>
</td>
<td>Cuspidity and the accurate characterization of the commissures can be better analyzed and characterized in 3D en-face views of the aorticc valve.</td>
</tr>
</table>

3-dimensional echo in aortic valve repair
- additional parameters -

Cusp tethering and retraction			Illustration of cusp tethering and functional restriction of the cusps due to dilatation of the ST-junction can be better analyzed and characterized in 3D en-face views parallel to the basal annulus. Thethering is additionally described by a reduced gH.
Cusp billowing and prolapse			Illustration of cusp billowing and prolapse can be objectifyed in 3D echocardiography by the perpendicular sectional planes within a 3D data set. The negativ eH documents the protusion of the free margin into the LVOT.

3-dimensional echo in aortic valve repair

- additional parameters -

Cusp fenestrations			Fenestrations cannot be documented in sectional 2D planes. Especially in 2D echocardiography sectional planes normally will not display the area of one cusp during systole. In 3D echocardiography the free margin of each cusp during systole can be displayed with special en-face-views.	
Cusp calcification			Calcifications can be displayed by marked echogeneities in 2D sectional planes. The extent and the affection of the cusps by the calcification pattern can be better visualized by en-face-views from the aortic root in diastole and systole. Severe calcification, however, is a limitation of 3D echocardiography due to shadowing.	

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Final recommendations according to the authors` experience and literature (1)

- The results of echocardiographic measurements of the AV and aortic root strongly depend on the time point of the cardiac cycle.
- The maximum anterior-posterior diameter of the LVOT, AV annulus, SV, ST junction and TAA obviously vary between systole and diastole.
- These dimensions are larger during systole than diastole, especially in younger patients with preserved compliance of the aortic root.
- These dimensions are important for decision making in AV reconstruction, which is generally performed in younger patients.
- Given these considerations, we strongly feel that the AV complex measurements should be performed in mid-systole.

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Final recommendations according to the authors` experience and literature (2)

- In addition, spatial resolution of the external aortic wall using 3D TTE and 3D TOE may be limited.
- Owing superior demarcation of the inner aortic wall – especially using 3D TOE – we believe that I-I measurements are superior to L-L measurements when using 3D echocardiography.
- Finally, underestimation is unavoidable in 2D TOE for the reasons stated.
- Thus, correct determination of these important diameters can best be achieved by I-I measurements during mid-systole using standardized sectional planes within the 3D data sets by postprocessing.
- This creates a contradiction regarding proposed mid-systolic measurements and current guideline recommendations.
- Current guidelines, however, do not address the specific aspects of AV repair. Furthermore, several studies showed that using I-I convention underestimation was compensated for by measuring aortic diameters mid-end-systole.

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Final recommendations according to the authors` experience and literature (3)

- Measurements of cusp morphology and geometry – especially CL, eH and gH – obviously have to be performed during diastole when the cusps are stretched by diastolic pressure.
- All findings and parameters for the assessment of the AV root complex which are relevant and mandatory according to our experience, are highlighted in table 1.

TABLE 1 Illustrations of the Anatomic Structures and the Parameters Determined by 2- and 3-Dimensional Echocardiography With Comments on the Advantages and Disadvantages of the Echocardiographic Techniques

Anatomic Structure/ Parameter	2D Echocardiographic Scheme and 2D Image	3D Echocardiographic Simultaneous Sectional Planes Within the 3D Dataset: En Face Views	Comments: Advantages/Disadvantages

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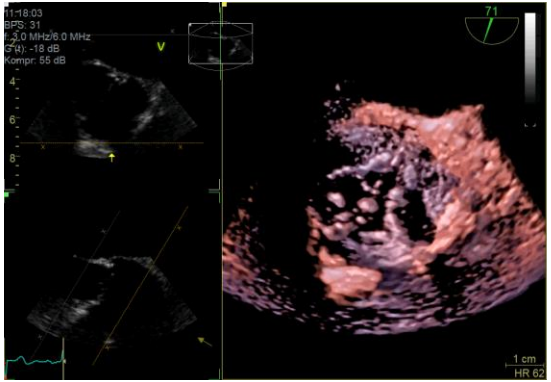

Review article

A systematic approach to 3D echocardiographic assessment of the aortic root

Andreas Hagendorff[1], Stephan Stoebe[1], Bhupendar Tayal[2]

[1] Dep. of Cardiology, University Hospital Leipzig, Germany
[2] Dep. of Cardiology, Aalborg University Hospital, Denmark
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Hagendorff et al., Global Cardiology Science and Practice 2018:12 http://dx.doi.org/10.21542/gcsp.2018.12

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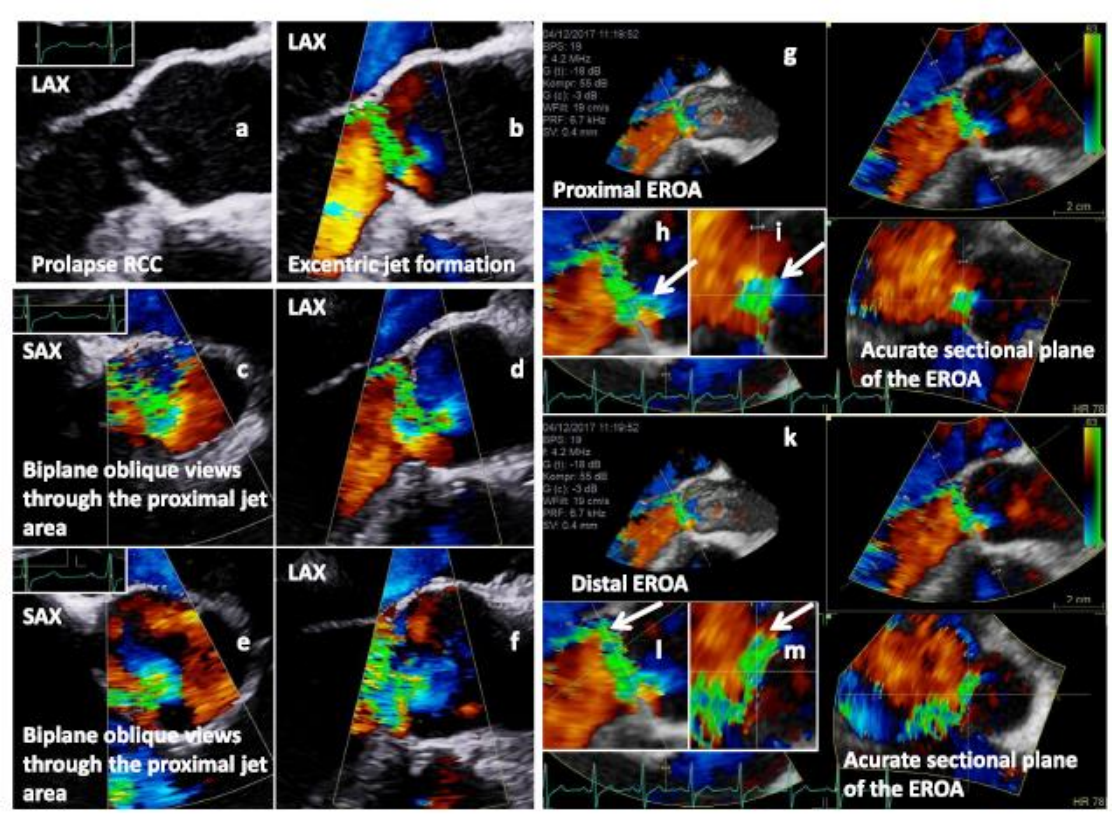

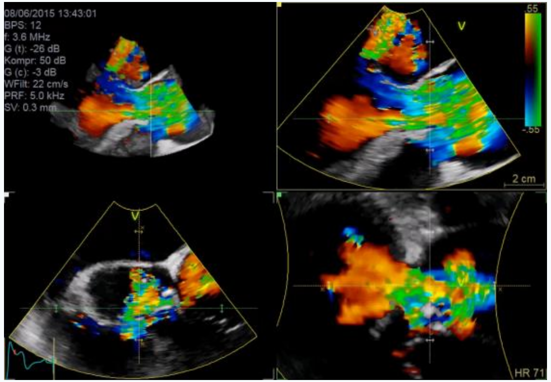

Hagendorff et al., Global Cardiology Science and Practice 2018:12 http://dx.doi.org/10.21542/gcsp.2018.12

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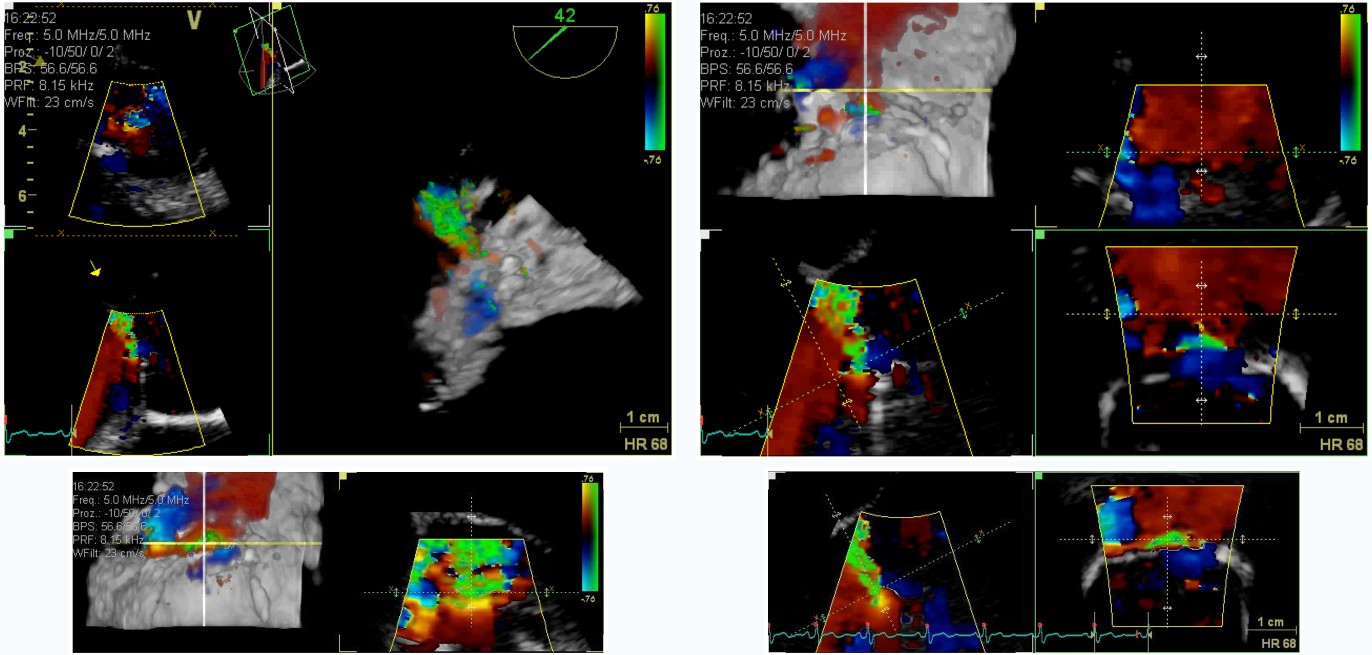
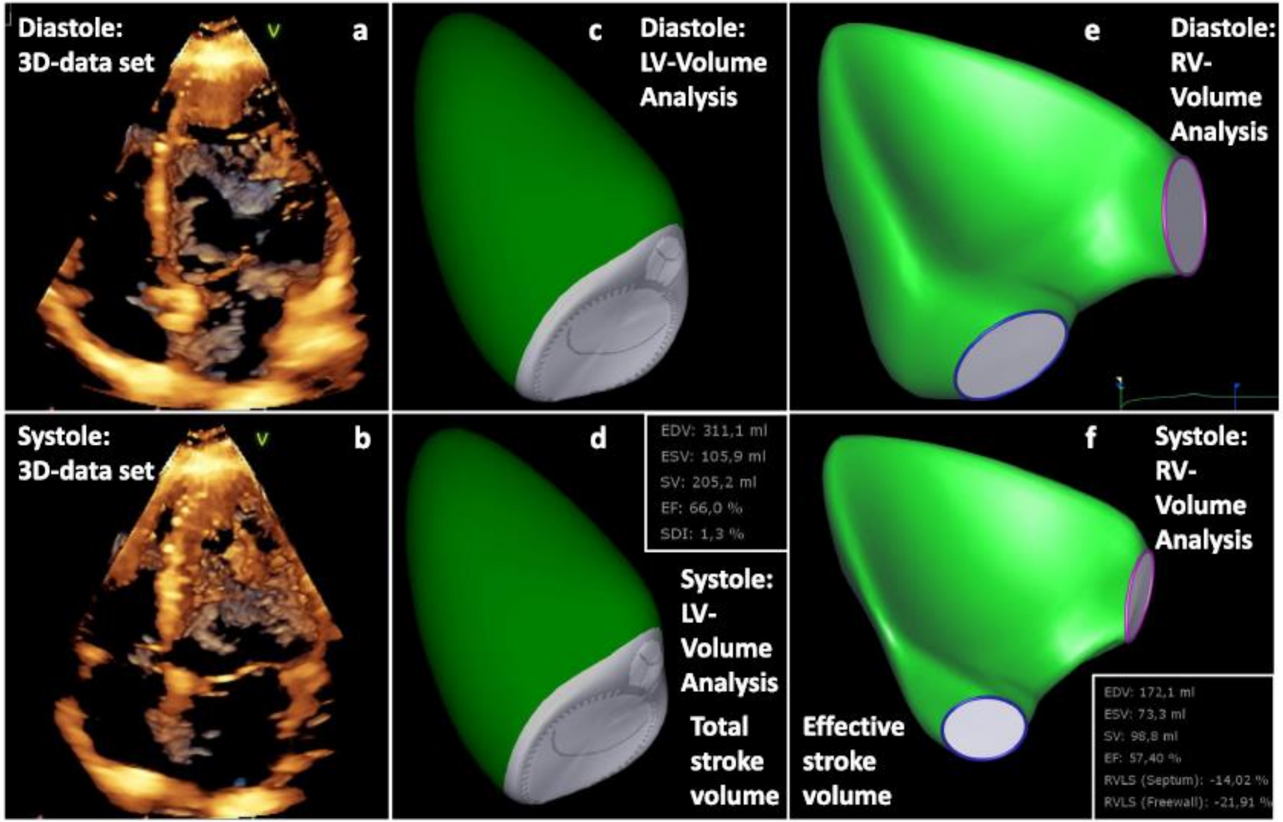
Additional information and better diagnostic impact:
Quantification of an excentric regurgitation in biscuspid aortic valve
ERO - 0.1-0.2 cm^2



3-dimensional echo in aortic valve repair



3D-analysis of left and right ventricular volumes to determine total, effective and regurgitant volume by 3D echocardiography

Hagendorff et al., Global Cardiology Science and Practice 2018:12 http://dx.doi.org/10.21542/gcsp. 2018.12

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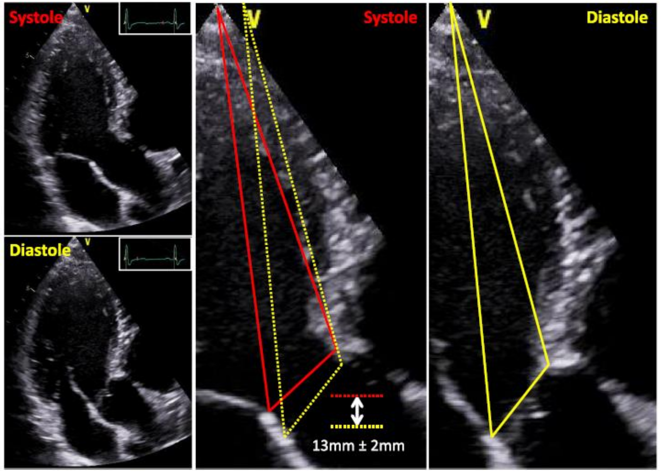

Figure 10. Caudal-cranial aortic annulus excursion between systole and diastole. Due to LV filling during diastole the distance between apex and AV-junction is more cranial in comparison to end-systole. Changes of aortic annulus position are illustrated by yellow lines during diastole and red lines during systole.

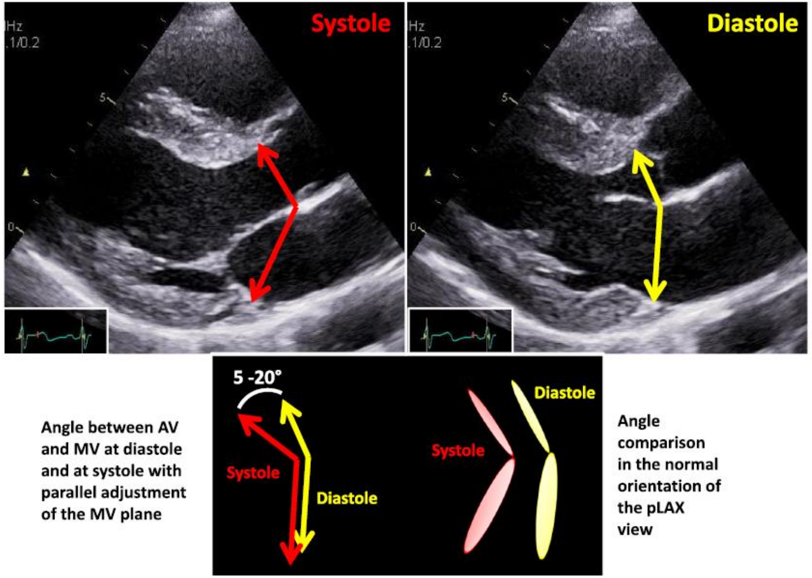

Figure 11. Angle differences between mitral and aortic annulus during systole (red) and diastole (yellow) including a scheme showing the angle difference of the mitral valve during systole and diastole (left below) with parallel adjustment in comparison to normal orientation of the annulus planes (right below).

Documentation of the dynamics between the mitral and aortic annulus between systole and diastole

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3-dimensional echo in aortic valve repair

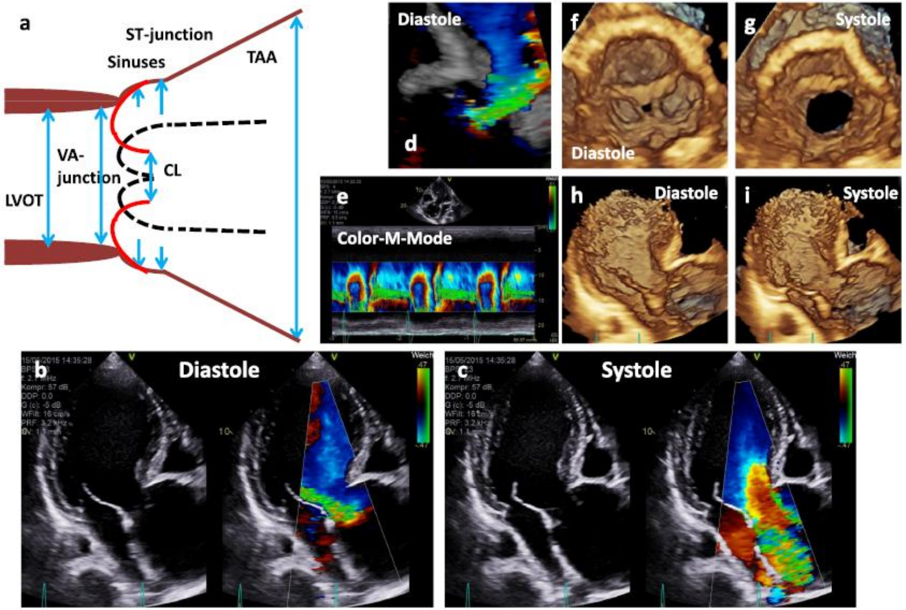
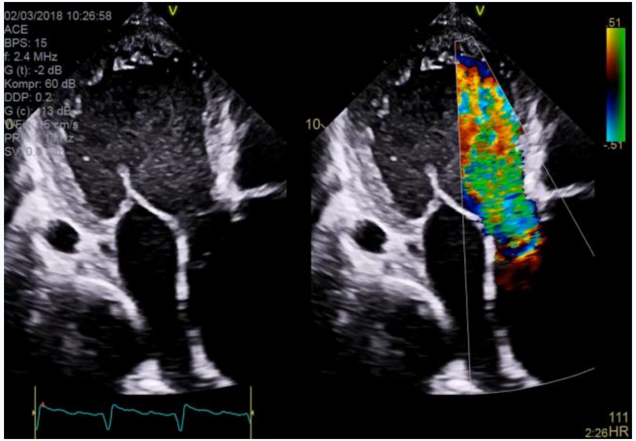


Figure 16. The scheme shows an ectasia of the sinuses of Valsalva and a severe aneurysm of the proximal TAA (a). Below native and color-coded 2D transthoracic images are shown during diastole (b) and systole (c). In addition, 3D TTE image of the aortic regurgitation during diastole (d), color M-Mode of the regurgitation (e), en-face views of the aortic annulus during diastole (f) and systole (g) and 3D transthoracic images of long axis views during diastole (h) and systole (i) are shown.

Documentation of different types of aortic regurgitation by 3D-echocardiography



Hagendorff et al., Global Cardiology Science and Practice 2018:12 http://dx.doi.org/10.21542/gcsp.2018.12

3-dimensional echo in aortic valve repair

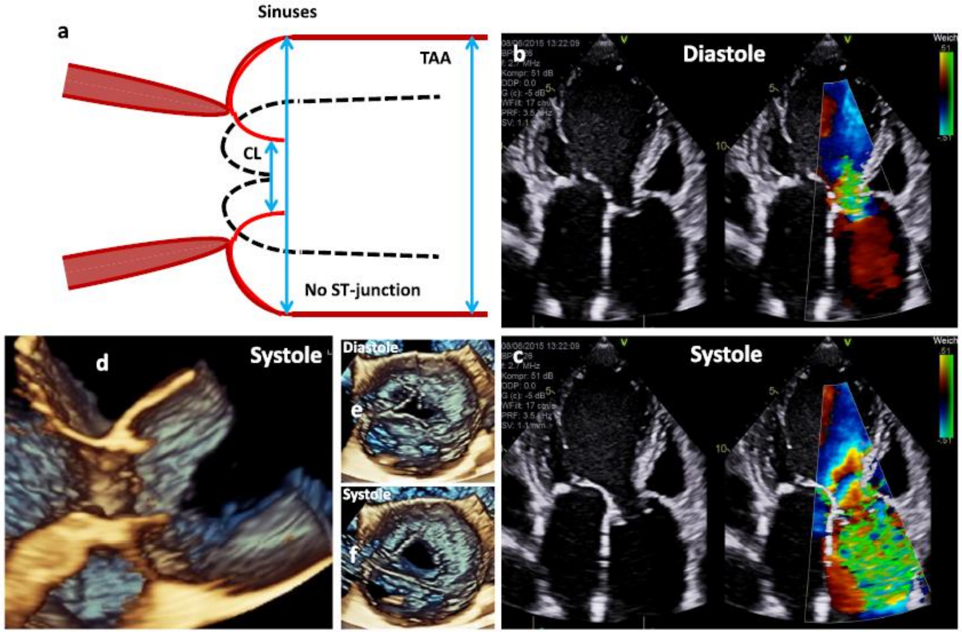
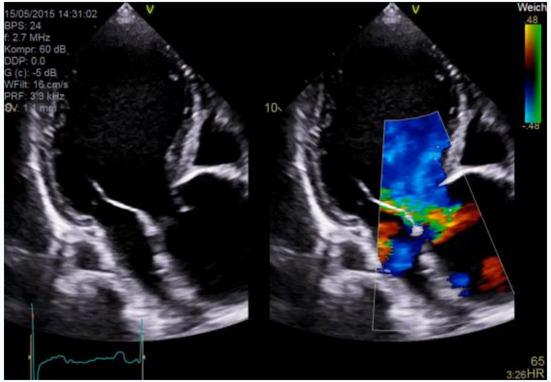


Figure 17. The scheme shows an aneurysm of the sinuses of Valsalva with an ectasia of the proximal ascending aorta and disappearance of the ST-junction and the direct transition of the sinuses into the proximal TAA (a). Further, native and color-coded 2D transthoracic images during diastole (b) and systole (c), 3D transthoracic long axis view during systole (d) and 3D transesophageal en-face views of the AV during diastole (e) and systole (f) are shown.

Documentation of different types of aortic regurgitation by 3D-echocardiography



Hagendorff et al., Global Cardiology Science and Practice 2018:12 http://dx.doi.org/10.21542/gcsp.2018.12

3-dimensional echo in aortic valve repair

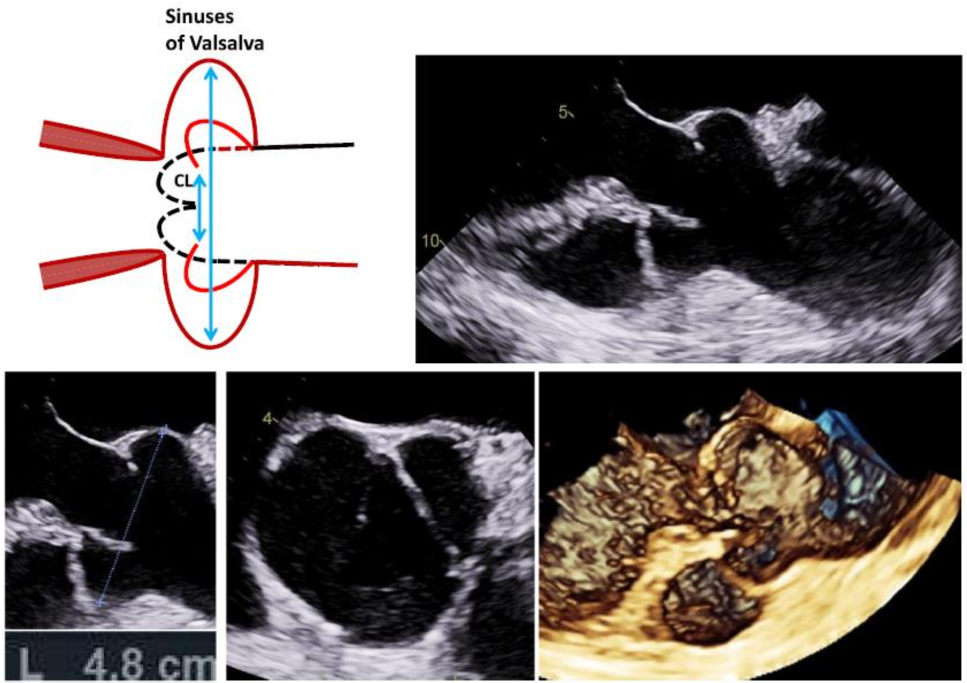
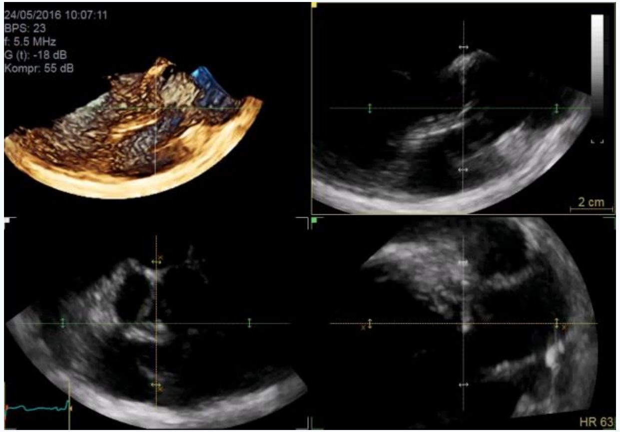


Figure 18. The scheme shows an isolated aneurysm of the sinuses of Valsalva. On the right side and below 2D and 3D transesophageal images during systole as well as the measurement of the aortic root diameter are shown.

Documentation of different types of aortic regurgitation by 3D-echocardiography



Hagendorff et al., Global Cardiology Science and Practice 2018:12 http://dx.doi.org/10.21542/gcsp.2018.12

3-dimensional echo in aortic valve repair

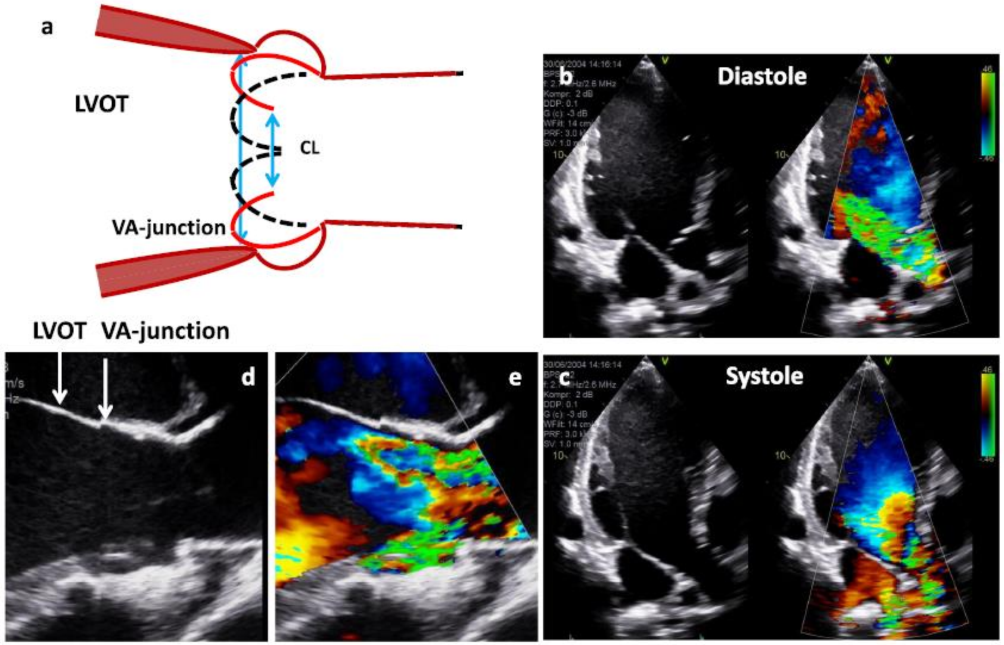
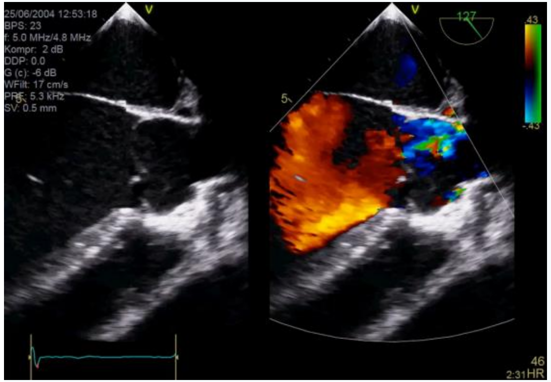


Figure 19. The scheme shows LV dilatation with dilatation of the LVOT and the basal aortic annulus and consecutive severe aortic regurgitation (a). Further, native and color-coded 2D transthoracic images during diastole (b) and systole (c) as well as native (d) and color-coded (e) 2D long axis views of the LVOT and the VA-junction during systole are shown.

Documentation of different types of aortic regurgitation by 3D-echocardiography



Hagendorff et al., Global Cardiology Science and Practice 2018:12 http://dx.doi.org/10.21542/gcsp.2018.12

3-dimensional echo in aortic valve repair

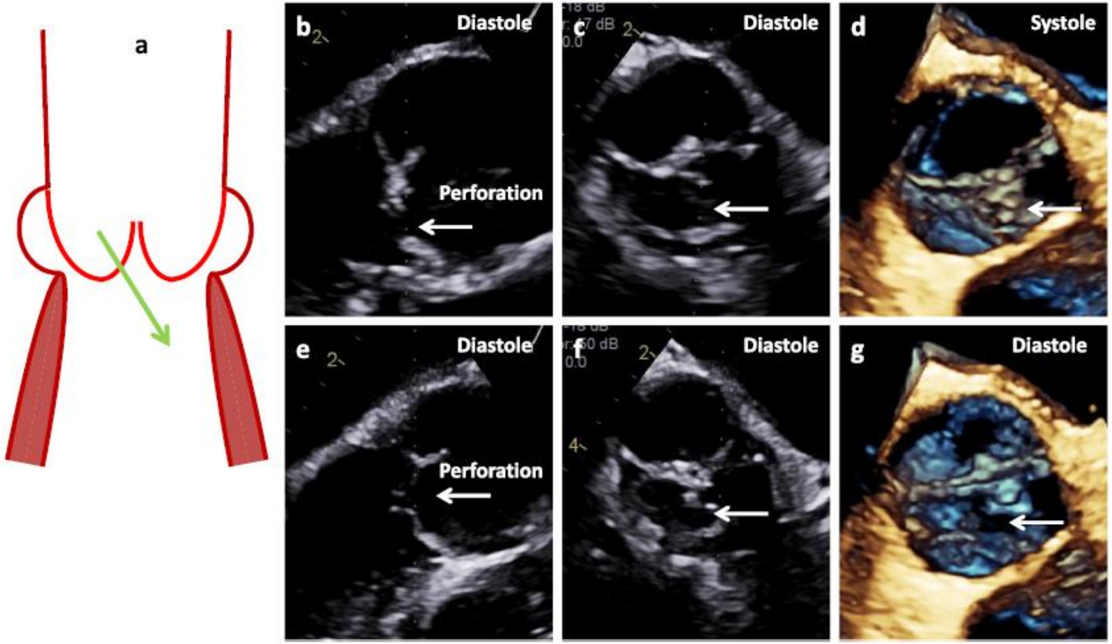
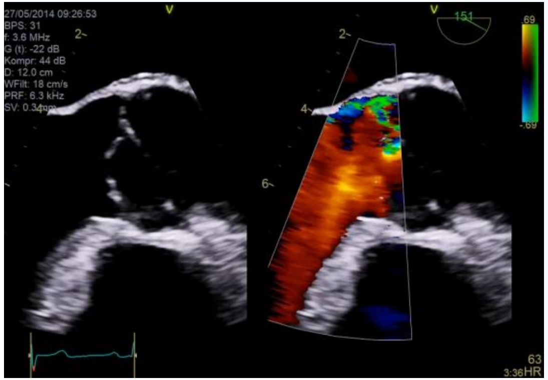


Figure 20. The scheme shows cusp perforation (a). 2D- and 3D images of long axis views (b, e), short axis views (c, f) and 3D-en-face views of the AV (d, g) show perforation of the RCC labeled by white arrows.

Documentation of different types of aortic regurgitation by 3D-echocardiography



Hagendorff et al., Global Cardiology Science and Practice 2018:12 http://dx.doi.org/10.21542/gcsp.2018.12

3-dimensional echo in aortic valve repair

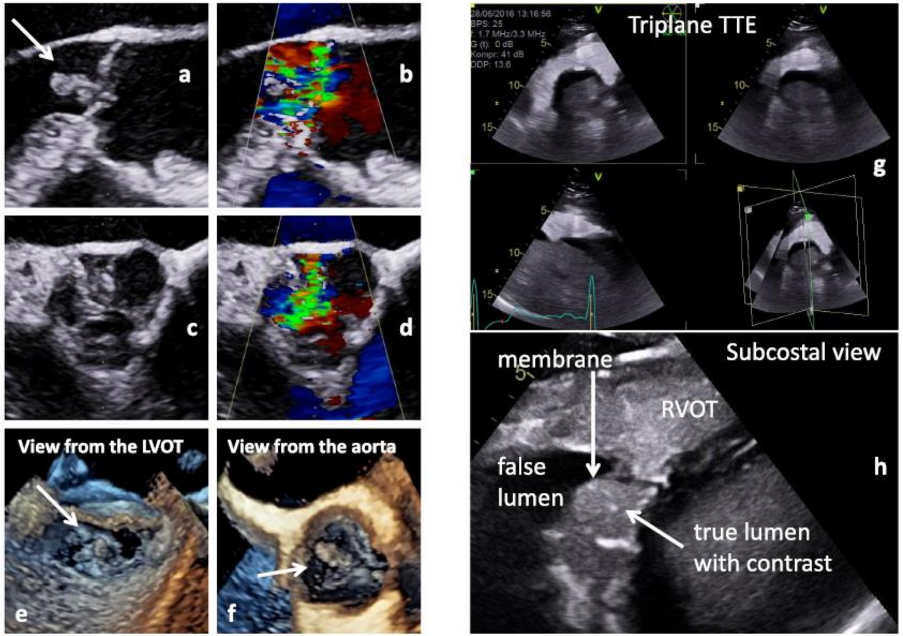
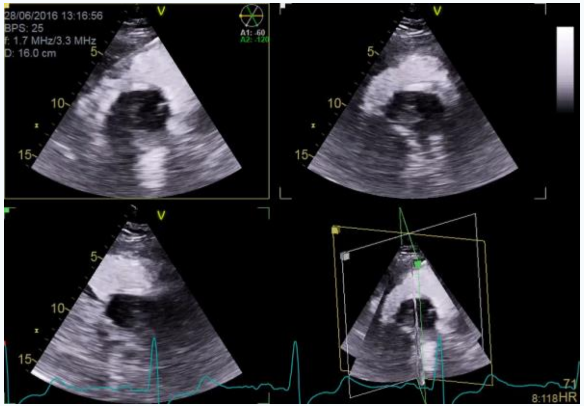


Figure 22. Documentation of vegetations due to endocarditis in native and color-coded 2D transthoracic long axis views (a, b) and 2D transesophageal short axis views (c, d) as well as 3D transesophageal en-face views of the AV from the LVOT (e) and the tubular ascending aorta (f). On the right side aortic dissection (Stanford A) is documented in a triplane subcostal view using contrast echocardiography (g) and in a zoom view of the dissection membrane (h).

Documentation of complications (endocarditis, aortic dissection) by 3D-echocardiography and contrast echocardiography



Hagendorff et al., Global Cardiology Science and Practice 2018:12 http://dx.doi.org/10.21542/gcsp. 2018.12

3-dimensional echo in aortic valve repair

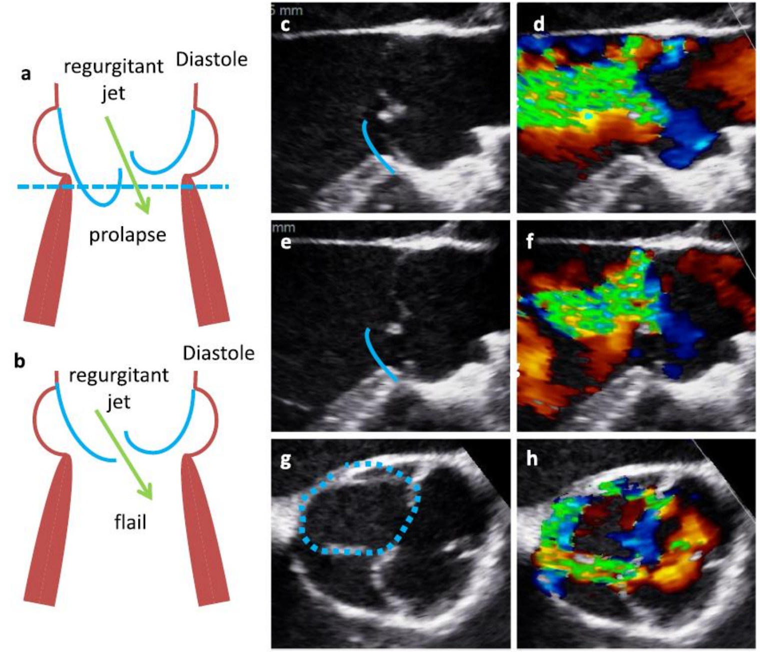
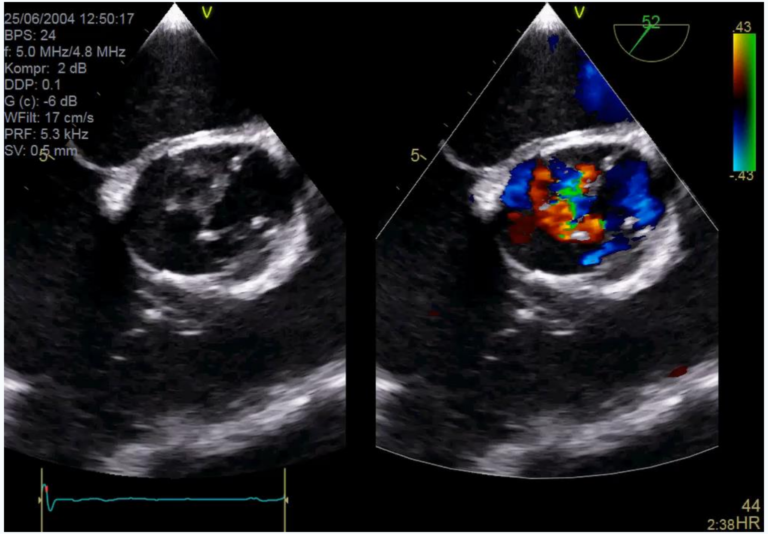


Figure 25. In the scheme a prolapse (a) and a flail (b) are shown in long axis views. On the right side native (c) and color-coded 2D transesophageal long axis view is shown documenting the free margin of the RCC in the LVOT during diastole and the regurgitant jet. Below oblique corresponding views are shown. The course of the RCC and the prolapse are labeled by the blue lines in the native 2D transesophageal images. In (g), (h) color coded 2D transesophageal short axis views show the prolaps by the colored contour displayed by the blue dotted line.

Documentation of cusp prolapses by 2D-echocardiography



Hagendorff et al., Global Cardiology Science and Practice 2018:12 http://dx.doi.org/10.21542/gcsp. 2018.12

3-dimensional echo in aortic valve repair

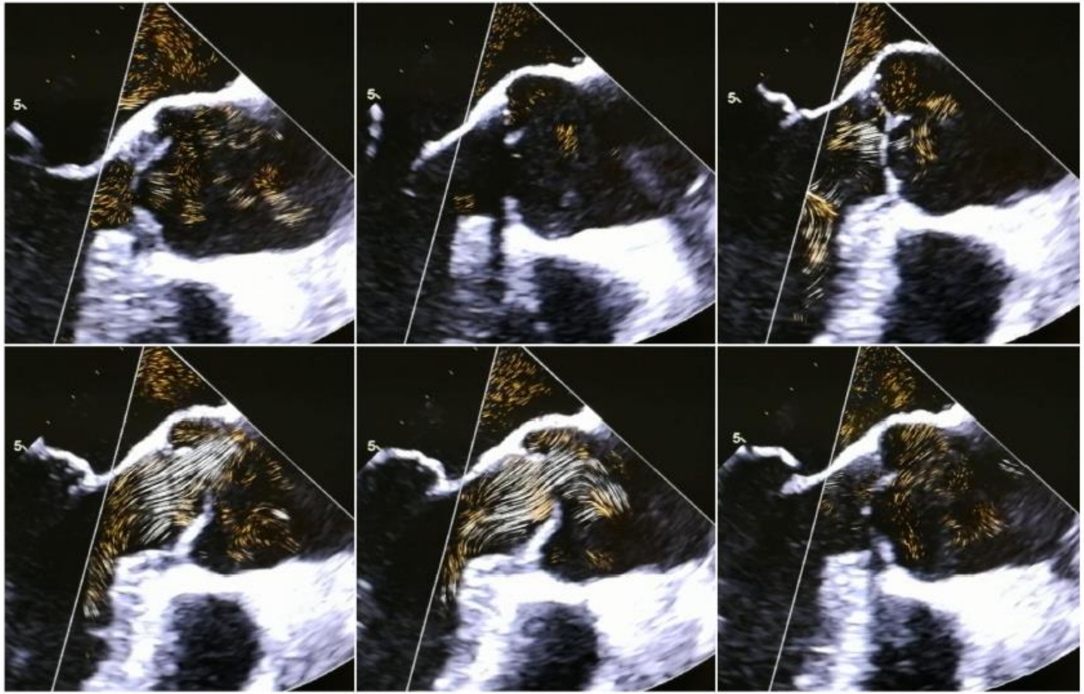
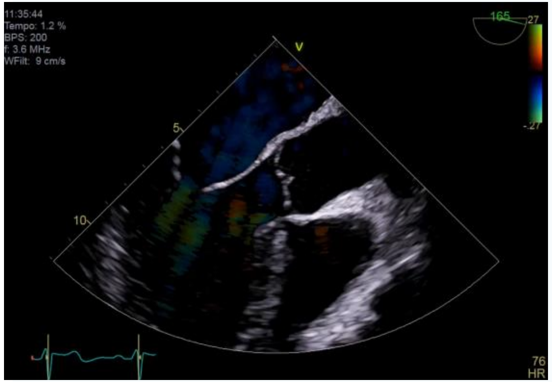


Figure 26. 2D transesophageal long axis views within one cardiac cycle showing the blood flow by blood flow speckle tracking. This new technique permits the visualization of the flow vortex.

Visualization of blood flow turbulences by blood flow speckle tracking



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3-dimensional echo in aortic valve repair

Summary

- 3D Echocardiography is the best imaging technique for patient selection for surgical AV repair and AV-sparing surgery.
- 2D-TTE and 2D-TOE are inferior to 3D-echocardiography owing to misleading measurements in non-standardized, oblique sectional planes.
- 3D echocardiography should include analysis of AV morphology, aortic root dimensions and AR severity.
- Cusp morphology and commissures and measurements of coaptation length, eH and gH parameters should be described in a systematic approach using mainly 3D TTE and 3D TOE.
- Complete and concise analysis by 3D echocardiography enables correct decision-making and planning of surgical procedures in patients with AR and aortic valve/root abnormalities. It can be assumed that automatic quantification of the aortic root complex will facilitate the dynamic analysis of the aortic root complex in the future.

3-dimensional echo in aortic valve repair

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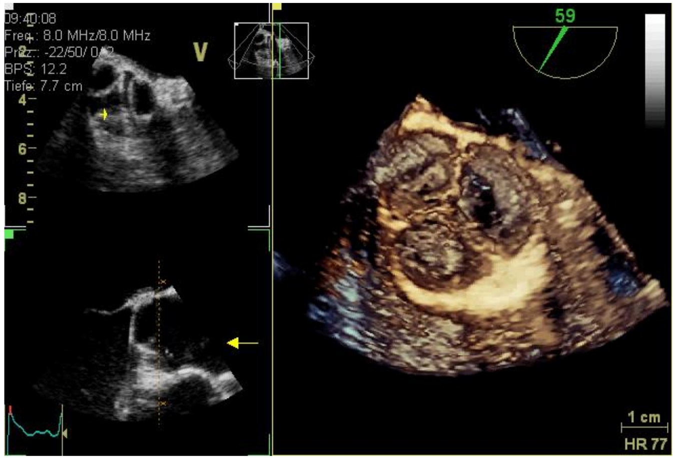
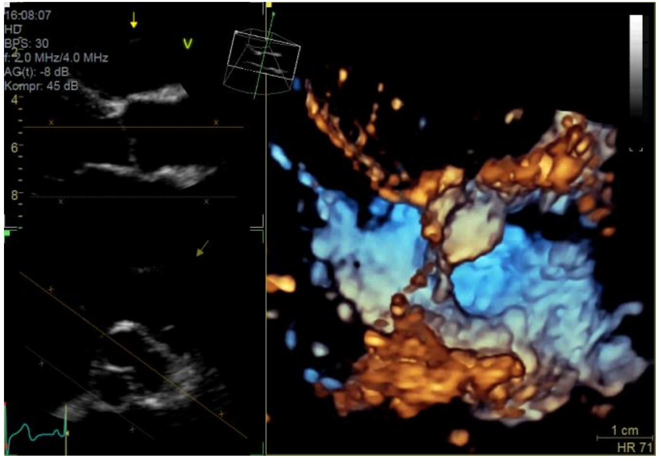


Siegel der
Universität Leipzig



Thank You for Your Attention

3-dimensional echo in aortic valve repair

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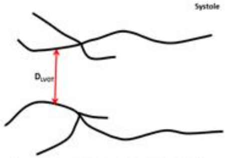
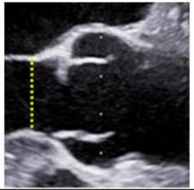
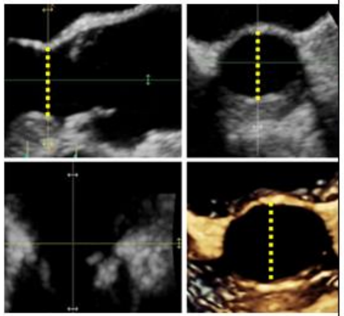
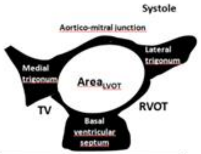
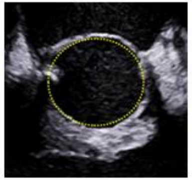
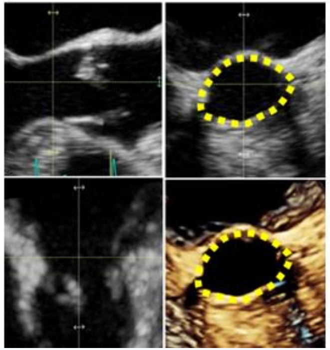
<table>
<tr><th colspan="4">Table</th></tr>
<tr><th>Anatomic Structure/ Parameter</th><th>2D-Echocardiography Scheme and 2D-Image</th><th>3D- Echocardiography Simultanious sectional planes within the 3D data set – en face views</th><th>Comments – Advantages/ Disadvantages</th></tr>
<tr><td>Diameter of the left ventricular outflow tract (LVOT)</td><td>

</td><td></td><td>Accurate adjustment of the perpendicular sectional planes for measurement of LVOT-diameter is only possible by 3D-echocardiography. Reference values: ♂: 2.6 ±0.3, ♀: 2.3±0.2 [37].</td></tr>
<tr><td>Area of the LVOT</td><td>

</td><td></td><td>The correctness of the 2D sectional planes for measurements of the LVOT area cannot be controlled. Accurate adjustment of the perpendicular sectional planes for measurement of LVOT-area is only possible by 3D-echocardiography.</td></tr>
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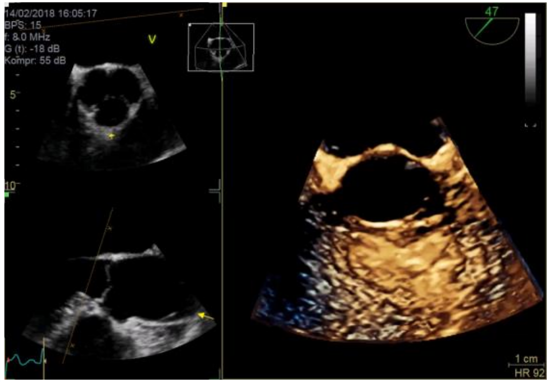

according Hagendorff A, Evangelista A, Fehske W, Schäfers HJ. JACC Cardiovasc Imaging. 2019 pii: S1936-878X (19)30172-X. doi: 10.1016/ j.jcmg.2018.06.032

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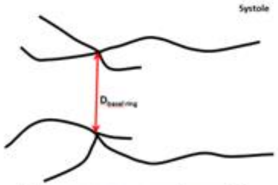
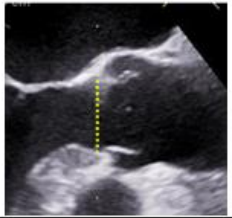
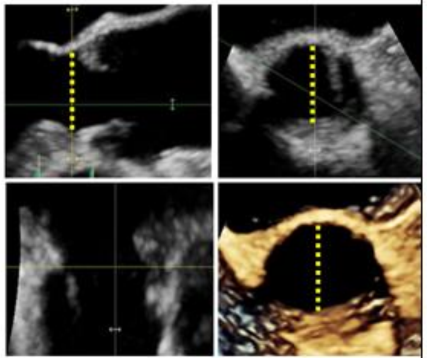
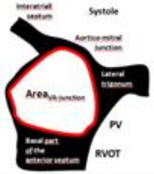
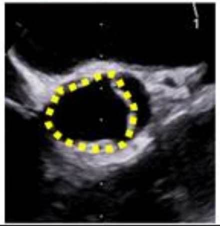
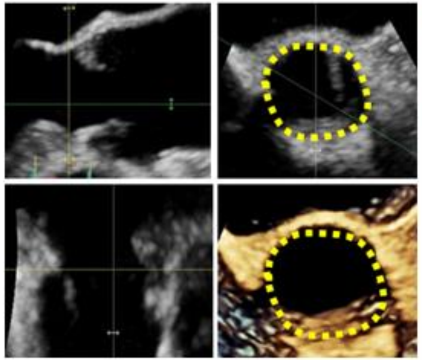
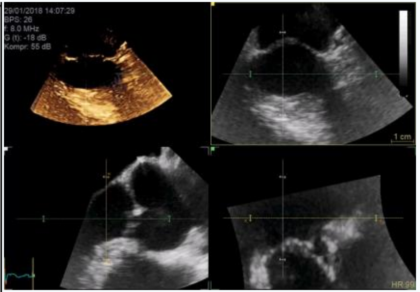
Diameter of the ventricular-aortic (VA) junction = virtual basal ring	 		Accurate adjustment of the perpendicular sectional planes for measurement of AV junction , which is determined by the nadirs of all three cusps in a normal aortic valve, is only possible by 3D-echocardiography. Reference values: ♂: 2.6 ±0.3, ♀: 2.3±0.2 [37].
Area of the VA-junction = virtual basal ring	 		Accurate adjustment of the sectional plane of all three nadirs for measurement of the VA-Junction-area is only possible by 3D-echocardiography.



according Hagendorff A, Evangelista A, Fehske W, Schäfers HJ. JACC Cardiovasc Imaging. 2019 pii: S1936-878X(19)30172-X. doi: 10.1016/j.jcmg.2018.06.032

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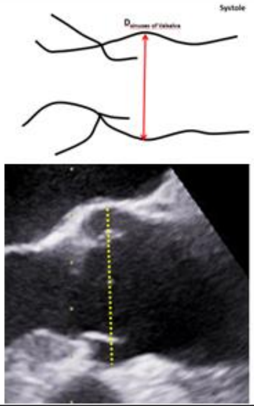
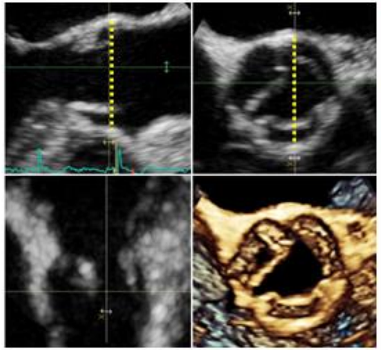
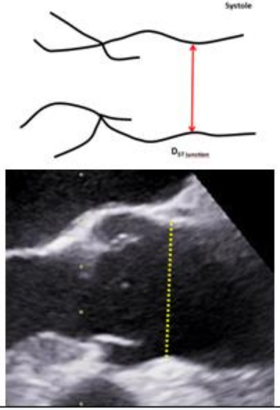
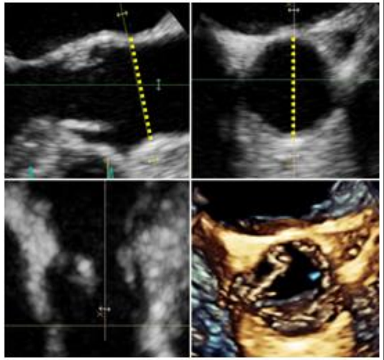
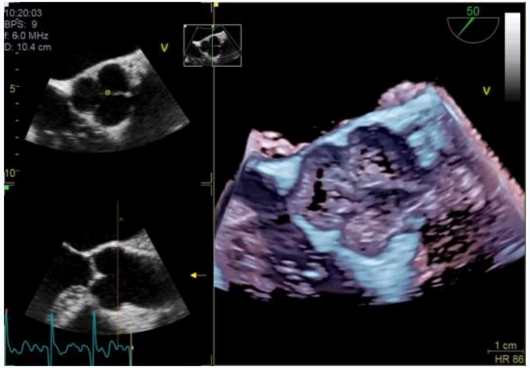
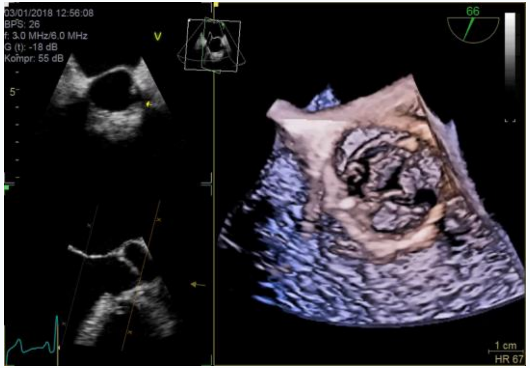
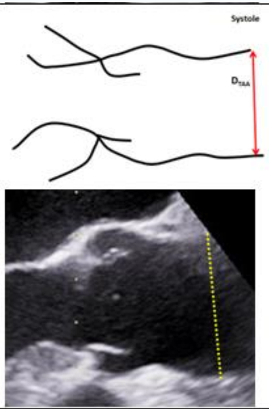
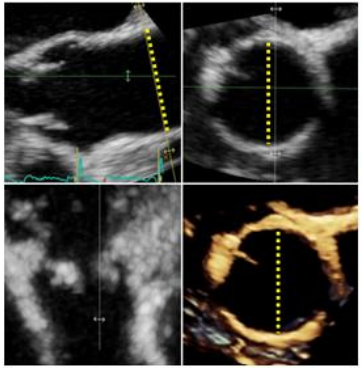
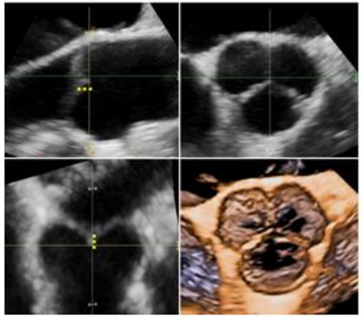
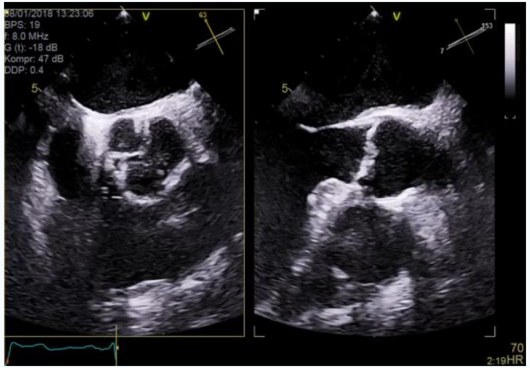
Diameter of the Sinus of Valsalva			The adjustment of the perpendicular sectional planes for measurement of the diameter of the sinus of Valsalvae can only be performed using 3D-echocardiography. Reference values: ♂: 3.4 ±0.3, ♀: 3.0±0.3 [37].
Diameter of the sinotubular (ST) junction			The correctness of the 2D sectional planes for measurements of the ST junction cannot be acurately controlled. The diameter of the ST-junction can only adequately assessed by 3D-echocardiography. Reference values: ♂: 2.9 ±0.3, ♀: 2.6±0.3 [37].

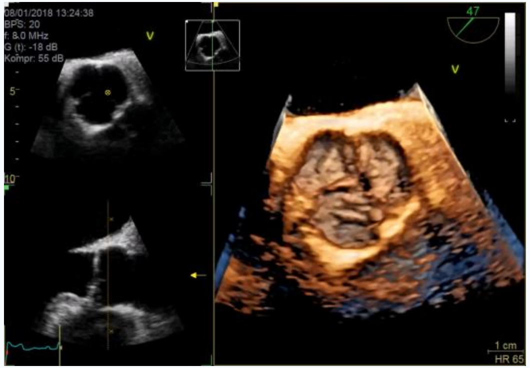




3-dimensional echo in aortic valve repair

Diameter of the proximal tubular ascending aorta (TAA)			Accurate adjustment of sectional planes perpendicular to the central axis of the proximal ascending aorta for the correct measurement of the diameter of the TAA can only be performed using 3D-echocardiography. Reference values: ♂: 3.0 ±0.4, ♀: 2.7±0.4 [37].
Coaptation length (CL) at the central point of AV			Accurate adjustment of the perpendicular sectional planes for measurement of the CL at the central point of the AV in diastole is only possible by 3D-echocardiography.





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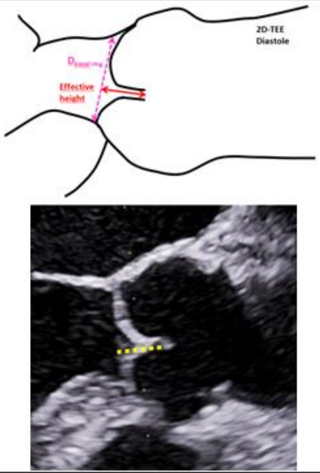
<td>Effective height (eH) between right coronary cusp (RCC) and the left (LCC) or non coronary cusp (NCC)</td>
<td>
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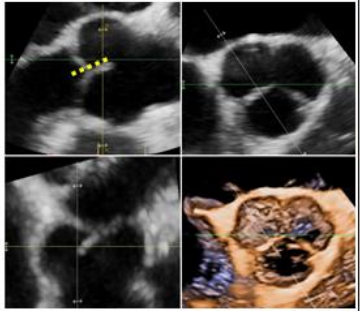
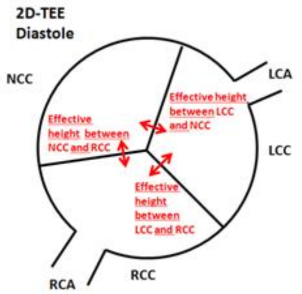
<td></td>
<td>In 2D echocardiography only the eH between the RCC and the LCC or NCC can only be determined depending on the correct orientation of the commissures. To distinguish between LCC and NCC biplane scanning is necessary. Accurate adjustment of the perpendicular sectional planes for measurement of each eH in diastole is only possible by 3D-echocardiography.</td>
</tr>
<tr>
<td>eH between NCC and RCC, LCC and RCC, and LCC and NCC</td>
<td>
</td>
<td>
</td>
<td>Accurate determination of each eH between the respective cusps in diastole is only possible by postprocessing in 3D-data sets.</td>
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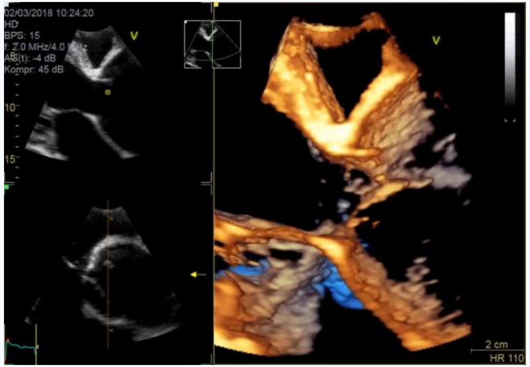

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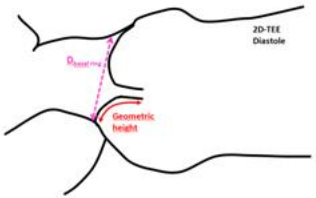
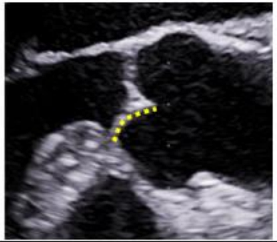
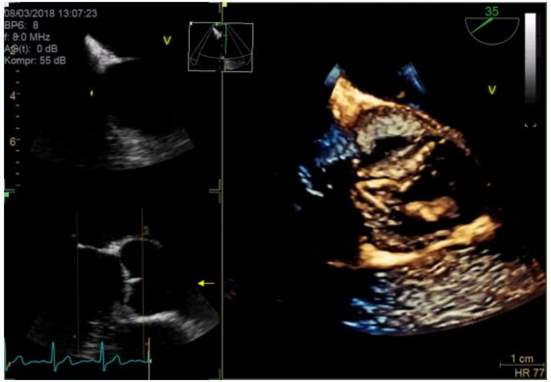
Geometric height (gH) of the RCC

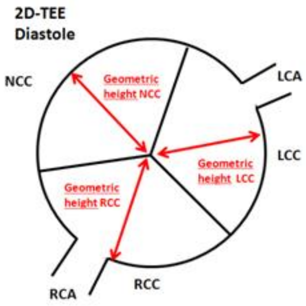


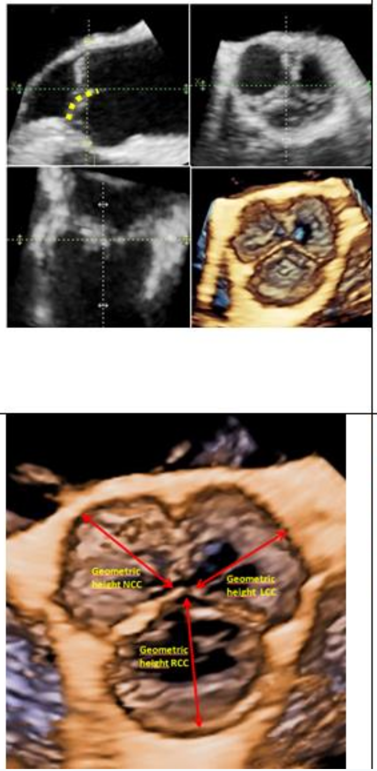


The correctness of the 2D sectional planes for measurements of gH of the RCC cannot be exactly controlled by 2D echocardiography. Accurate adjustment of the perpendicular sectional planes for measurement of gH of each cusp in diastole is only possible by postprocessing in 3D-data sets.

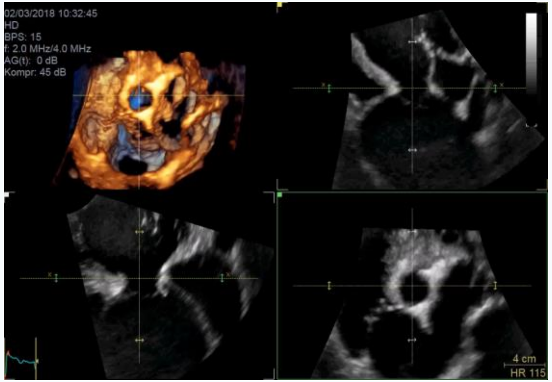


gH of the NCC, LCC, and RCC





Accurate determination of each gH of the respective cusps in diastole is possible by 3D-echocardiography adjusting the sectional planes perpendicular to the center of each commissure in 3D data sets.



3-dimensional echo in aortic valve repair

Final Summary:

1. **3D echocardiography enables a completely new modality of imaging in echocardiography – the visualization of surfaces (endocardium and the cusps).**
2. **Biplane and triplane simultaneous sectional planes enables a better and more acurate standardization of imaging with improvement of measurements of anatomical structures.**
3. **Postprocessing in 3D data sets offers the possibility of new views (e.g. en-face view of the coronary ostia, etc.)**
4. **Especially for the decicion making and the planning of the surgical strategy 3D echocardiography can provide important informations.**
5. **The higher the image quality, the better the information.**
6. **Thus, training and expertise in 3D echocardiography is a prerequisite for a better diagnosis.**