Aortic valve: evaluation using 4-D echocardiography

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Aortic valve

- Anatomically simple structure; **rapid motion!**
- Low echogenicity of normal valve
- Fibrosis improves 3-D presentation
- Calcification worsens 3-D presentation

- TEE provides optimal quality
  - 59% excellent, 22% adequate
- 3d TTE is improving!
Aortic valve

- Anatomically simple structure?
- Now considered a functional unit comprising the:
  - aortic annulus
  - cusps
  - sinuses of Valsalva
  - commissures
  - tubular junction
- Rapid motion during cardiac cycle!
- Low echogenicity of normal valve
  - Fibrosis improves 3-D quality
  - Calcification worsens 3-D quality

Anderson RH, Heart 2000
Aortic valve – RT 3D imaging

- Parasternal window
  - From AV – cusps number and orifice
  - From LVOT – vegetations, prolapse, SAS

- Apical window - LVOT
  - Worse resolution, use when no other available
  - Long axis view - motion

- Anyplane/paraplane
  - Measurements, eg. area or LVOT planimetry

- Volume rendering
  - 3-D relationships and anatomy; planimetry?
AV 3D

B. Full Volume

C. PV, AV, TV, MV

A. Full Volume

AV 3D
3D of aortic valve - expectations

- Definitive anatomical characterization (number of cusps)
- Better localization of pathoanatomy
- Planimetry of aortic valve orifice
  - Improved interobserver variability vs TEE
- Additional information on prosthetic valves (disc mobility) with overall poorer quality
- Additional relevant information in 31% of studies (TEE, *Eur Heart J* Kasprzak 1996)
Aortic valve planimetry

- excellent agreement vs Gorlin area values (Menzel et al.) as well as TEE planimetry and continuity equation (Kasprzak et al.)
- feasibility of TEE planimetry 88% - 96%

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N=27; Kasprzak et al., AHJ 1998
Real-time three-dimensional echocardiography in aortic stenosis: a novel, simple, and reliable method to improve accuracy in area calculation

Juan Luis Gutiérrez-Chico, José Luis Zamorano, Elsa Prieto-Moriche, Rosa Ana Hernández-Antolín, Marisol Bravo-Amaro, Leopoldo Pérez de Isla, Marcelo Sanmartín-Fernández, José Antonio Baz-Alonso, and Andrés Iníguez-Romo
Prosthetic valves - continuity equation / triplane

- Alunni G, Echocardiography 2011
- EOA of prosthetic aortic valves were measured in 23 consecutive patients requiring periodical follow up. EOA was calculated using Doppler continuity equation (DCE) and the RT3P method by replacing Doppler-derived SV with SV measured with real time triplane echocardiography.
- RT3P revealed an inverse correlation between functional area and mean gradient that was better than DCE (P = 0.0359).
3D valve shape determines EOA

- Domed valves (E,F) cause 14% and 40% less gradient as compared to intermediate (C,D) or flat (A,B) valves, respectively.
Aortic regurgitation

- Direct visualization of regurgitant jet easy, but imaging of AV orifice rarely possible
- 3-D color regurgitant jets can be analyzed
  - Direct VC width / PISA volume > jet volume
- Orifice – flow correlation
- Functional analysis of excentric jets
3-D vena contracta in AR

- 56 consecutive adult patients who underwent echo for evaluation of aortic insufficiency.

- Aortographic or surgical grading
  - correlated well with 2D TTE measurements of VCW \( (r=0.92) \)
  - and, better with 3D TTE measurements of VCA \( (r=0.95) \),
  - with improved dispersion between angiographic grades demonstrated by the 3D TTE technique.

- Live 3D TTE color Doppler measurements of VCA are comparable to assessment by aortography.

Fang L, Echocardiography 2005
32 consecutive patients – AR assessed with 3DCDE and their results were compared with those obtained by means of CMR.

Mean age was 63.0±13.5 years. Compared with the traditional echo-Doppler methods, 3DCDE evaluation had the best linear association with CMR results (3D vena contracta cross sectional area method: \( r=0.88; \) \( r \text{ square}=0.77; \) \( p<0.001 \). 3D vena contracta cross sectional area/left ventricular outflow tract cross sectional area method: \( r=0.87; \) \( r \text{ square}=0.75; \) \( p<0.001 \)).

The ROC analysis for detection of severe CAR (3D vena contracta cross sectional area method=0.97; 3D vena contracta cross sectional area/left ventricular outflow tract cross sectional area method=0.98).

variability for the 3DCDE evaluation was good (ICC=0.89 and ICC=0.91 for inter and intra observer variability respectively).

Aortic valve – complex morphology

- Endocarditis
  - vegetations
  - destruction
  - abscesses

- Tumors

- Prosthetic valves

- Anatomical relationships

- Mobility

- Size
Paravalvular leaks

• vena contracta planimetry was larger in patients with moderate AR than in mild AR (0.30 ± 0.12 vs 0.09 ± 0.07 cm², P = .001).
• Vena contracta planimetry on 3D TTE was better correlated with AR volume than on 2D TTE (Kendall’s t = 0.82 [P < .001] vs 0.66 [P < .001]).
• The AOC were 0.96 for VC planimetry and 0.35 for VCW. Goncalves JASE 2012
Bicuspidity

Sizing

Monitoring
- Positioning
- Complications:
  - Prosthesis displacement
  - Prosthesis instability
  - Aortic regurgitation
  - Trauma

Marcos-Alberca P et al., Rev Esp Cardiol 2009
EAE/ASE Recommendations for Image Acquisition and Display Using Three-Dimensional Echocardiography

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![Table of Recommendations](image)

*mitral clips, mitral valvuloplasty, transcatheter aortic valve implantation, paravalvular leak closure, atrial septal defect closure, ventricular septal defect closure and left atrial appendage closure.
AV assessment of the future?

- Automated detection and extraction of AV complex from 3-D datasets,
- Integration with 3-D flow data and shape quantification

courtesy of - Siemens Healthcare- Ultrasound division
Szczecin 2012