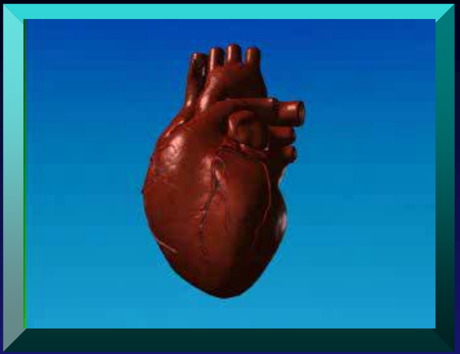
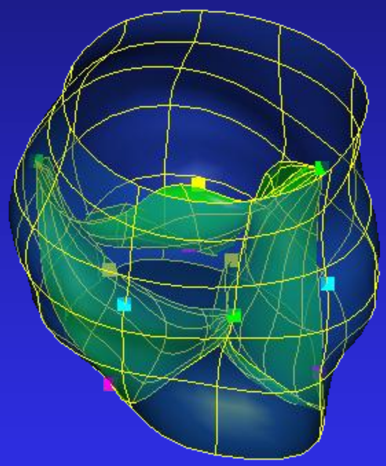
Jaroslaw D. Kasprzak, FESC, FACC





Aortic valve: evaluation using 4-D echocardiography

2nd Chair and Dept. of Cardiology
Medical University of Łódź, Poland

UNIWERSYTET MEDYCZNY W ŁODZI

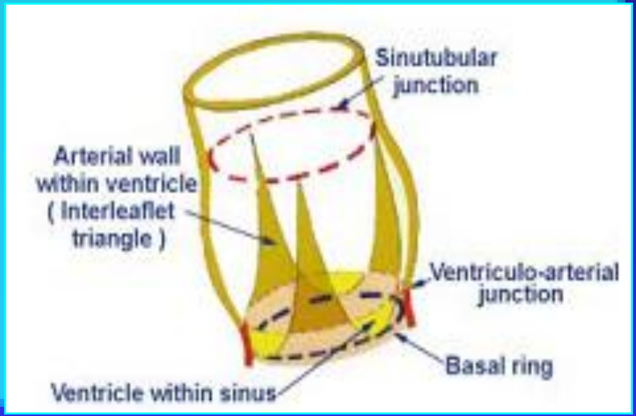
Aortic valve

- 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



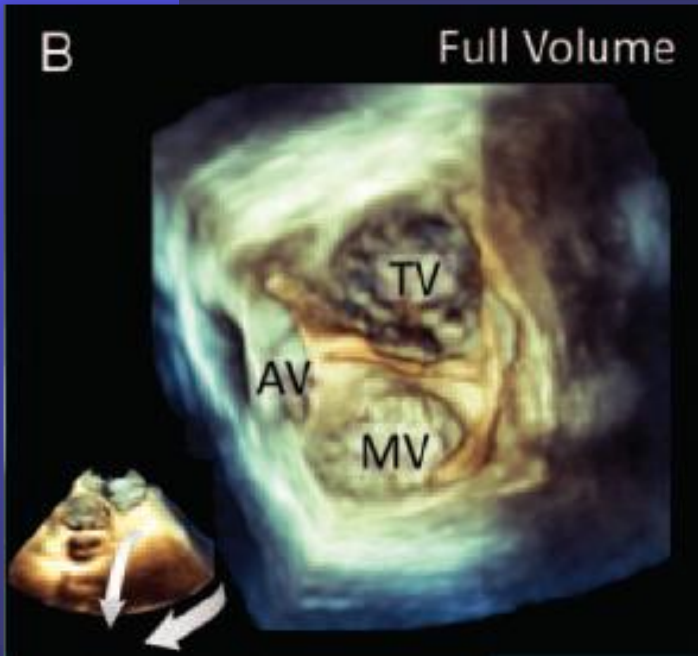
Anderson RH, Heart 2000

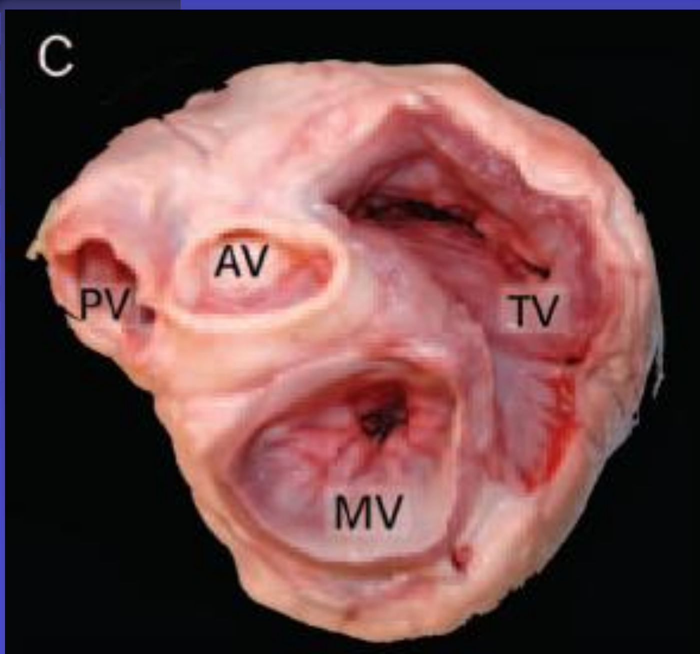
- Rapid motion during cardiac cycle!
- Low echogenicity of normal valve
  - Fibrosis improves 3-D quality
  - Calcification worsens 3-D quality

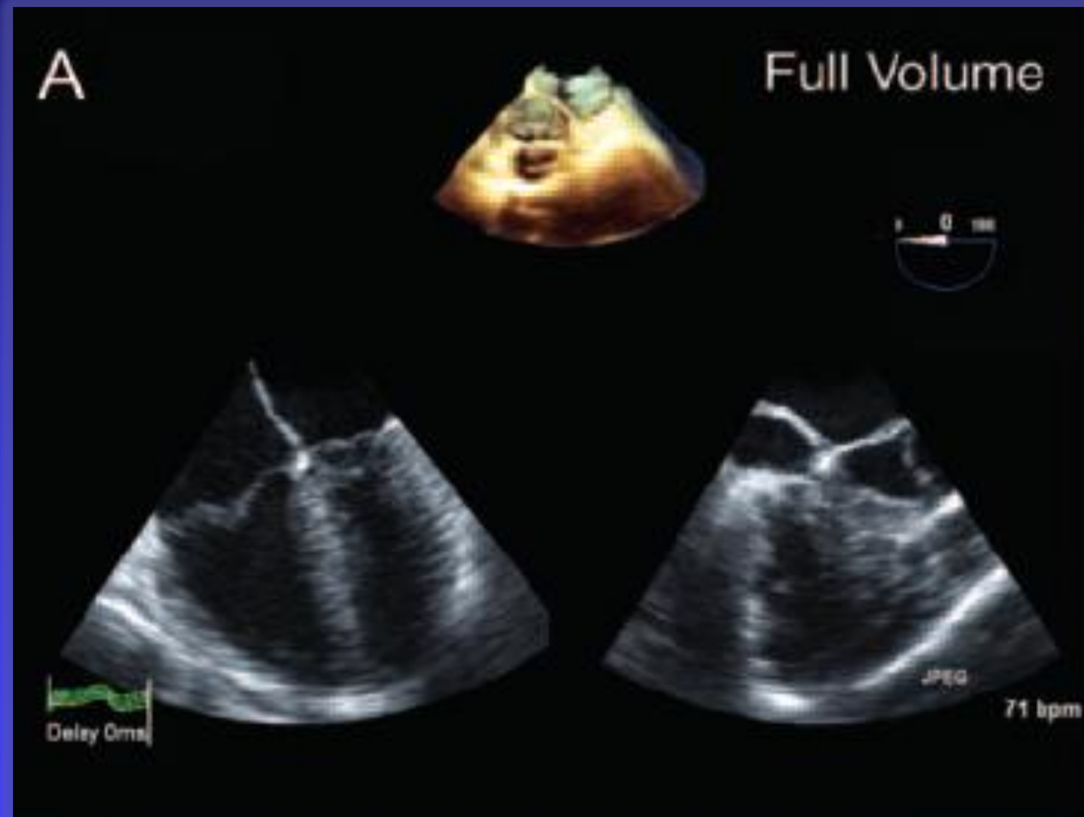
Aortic valve – RT 3D imaging

- 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
TV
AV
MV


C
AV
PV
TV
MV

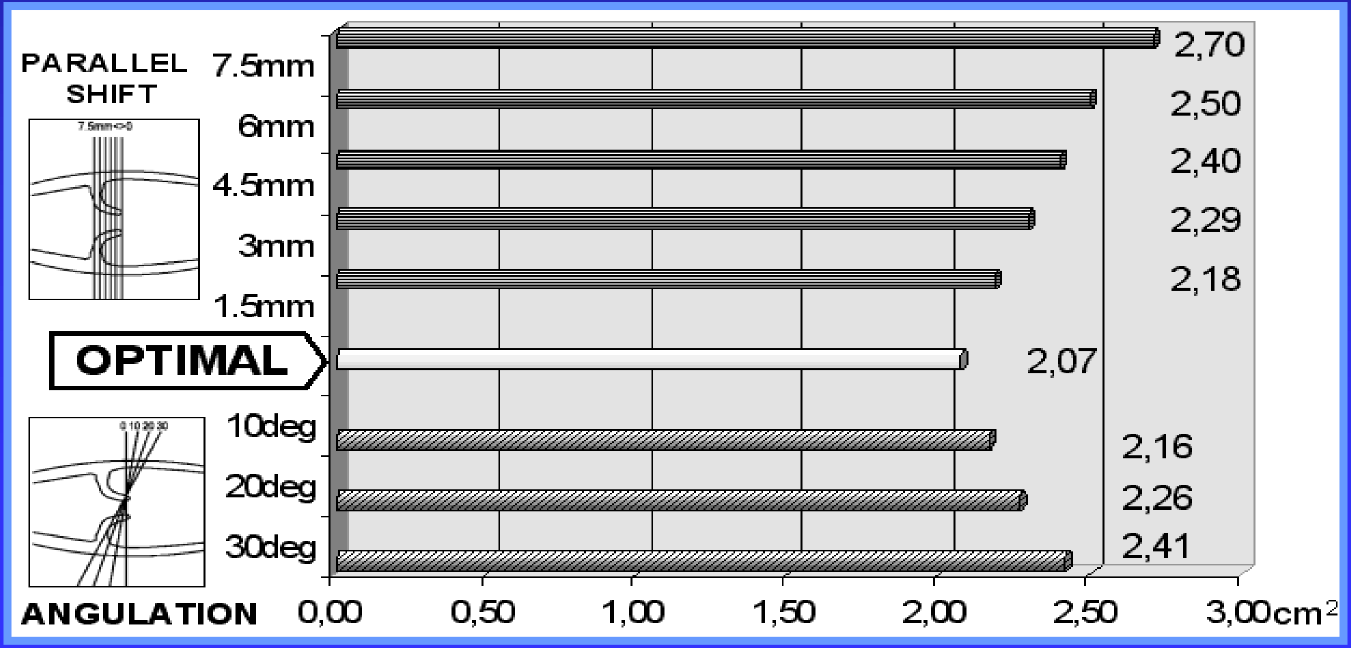

A
Full Volume
Delay 0ms
JPEG
71 bpm

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%



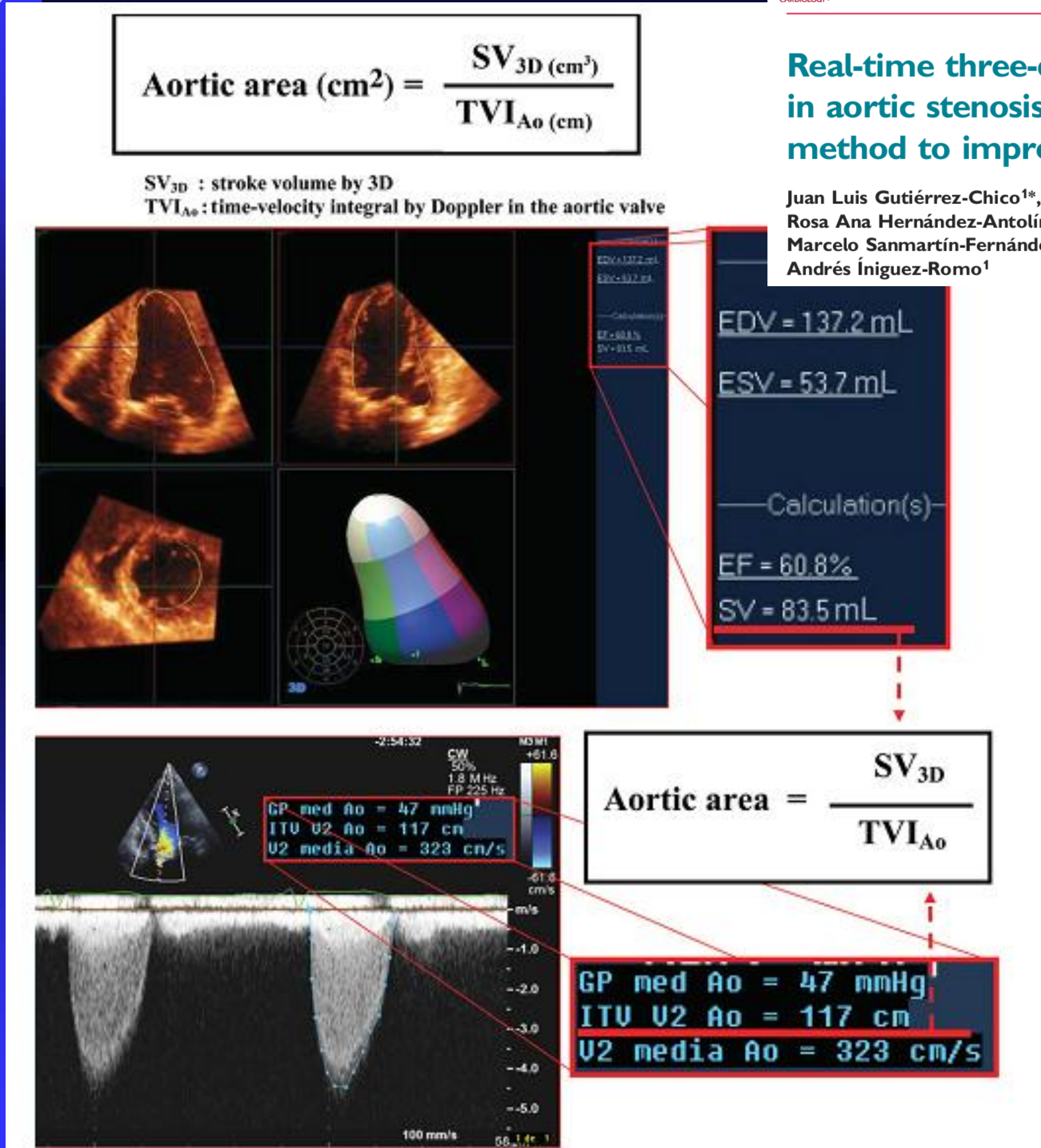
N=27; Kasprzak et al., AHJ 1998

European Heart Journal (2008) **29**, 1296–1306
doi:10.1093/eurheartj/ehm467

CLINICAL RESEARCH
Imaging

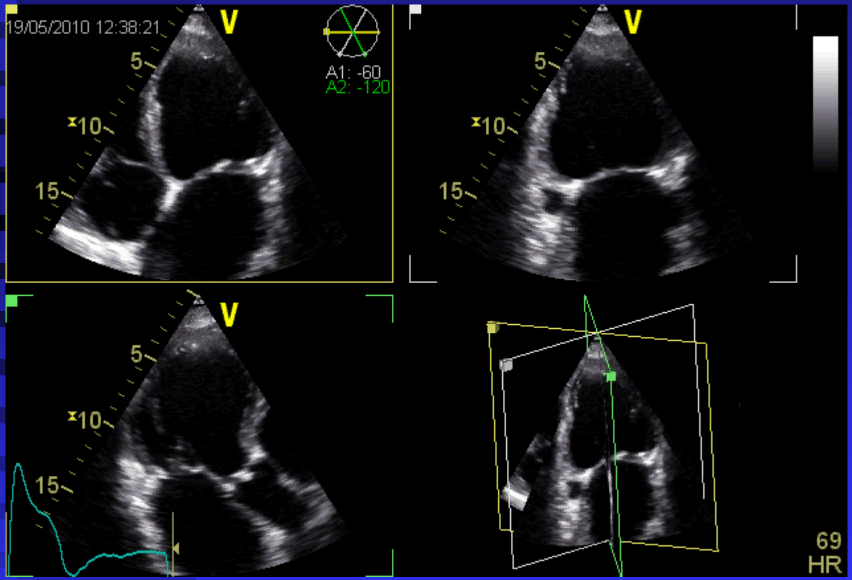
Real-time three-dimensional echocardiography in aortic stenosis: a novel, simple, and reliable method to improve accuracy in area calculation

Juan Luis Gutiérrez-Chico[1]*, José Luis Zamorano[2], Elsa Prieto-Moriche[2], Rosa Ana Hernández-Antolín[2], Marisol Bravo-Amaro[1], Leopoldo Pérez de Isla[2], Marcelo Sanmartín-Fernández[1], José Antonio Baz-Alonso[1], and Andrés Íniguez-Romo[1]



Chico JL, Eur Heart J 2008

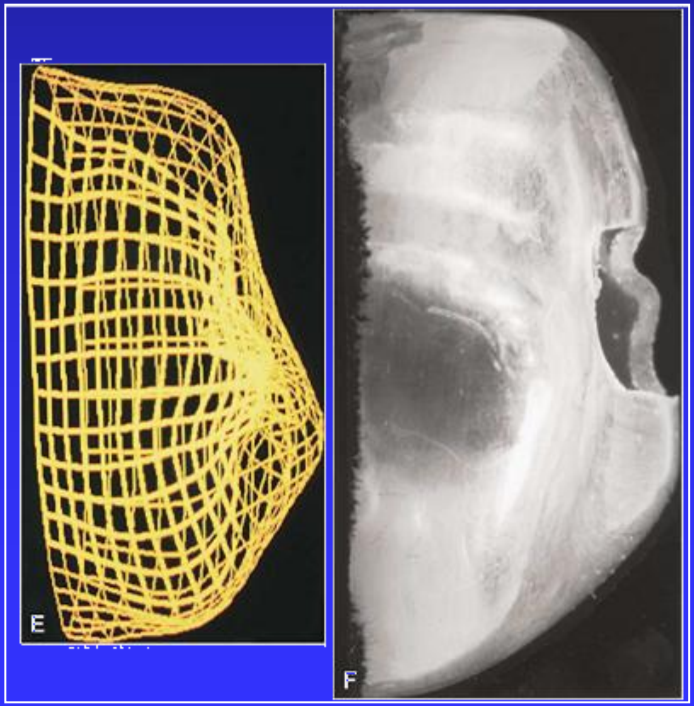
Prosthetic valves - continutiy equation / triplane

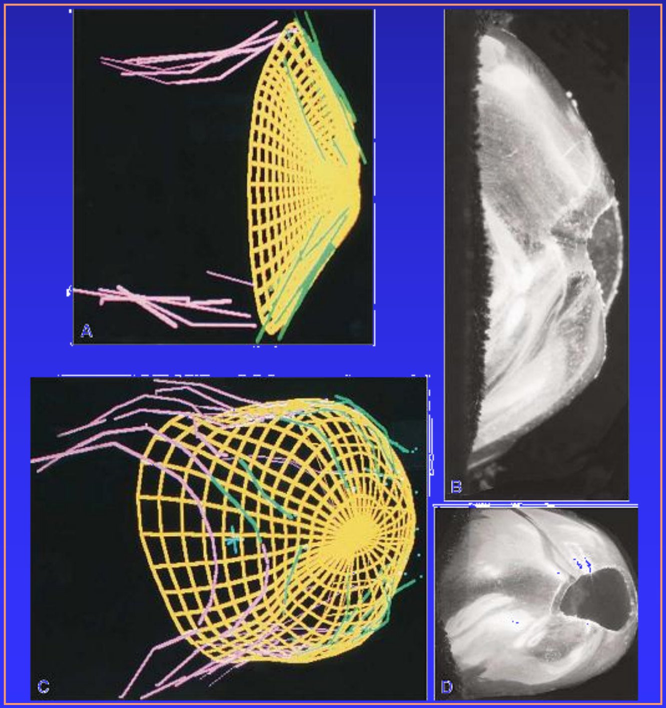


- Alunni G, Echocardiography 2011
- EOA of prosthetic aortic valves were measured in 23 consecutive patients requiring periodical follow up. EOA was calculated using Doppler continuity equation (DCE) and the RT3P method by replacing Doppler-derived SV with SV measured with real time triplane echocardiography.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

3D valve shape determines EOA

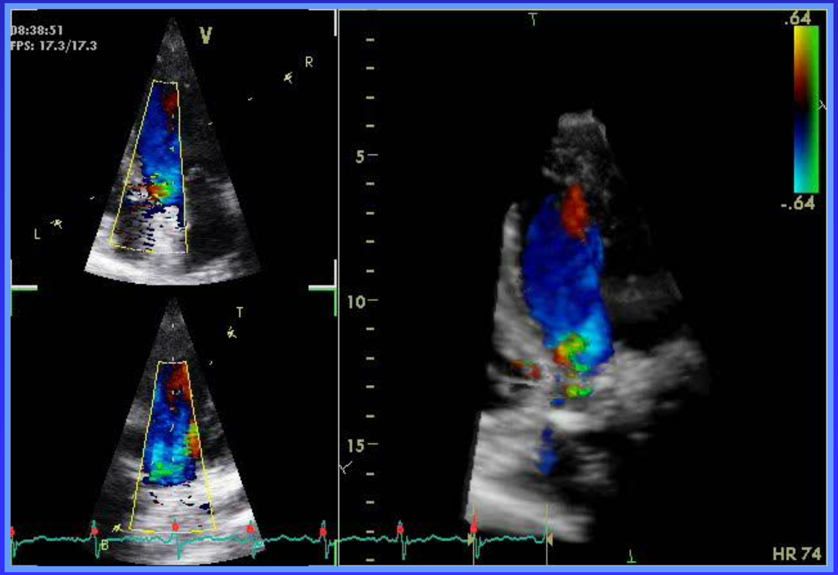
- Domed valves (E,F) cause 14% and 40% less gradient as compared to **intermediate** (C,D) or **flat** (A,B) valves , respectively





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

AR quantfication

- 32 consecutive patients – AR assessed with 3DCDE and their results were compared with those obtained by means of CMR.
- Mean age was 63.0±13.5years. 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 square=0.77; $p<0.001$. 3D vena contracta cross sectional area/left ventricular outflow tract cross sectional area method: $r=0.87$; r 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).

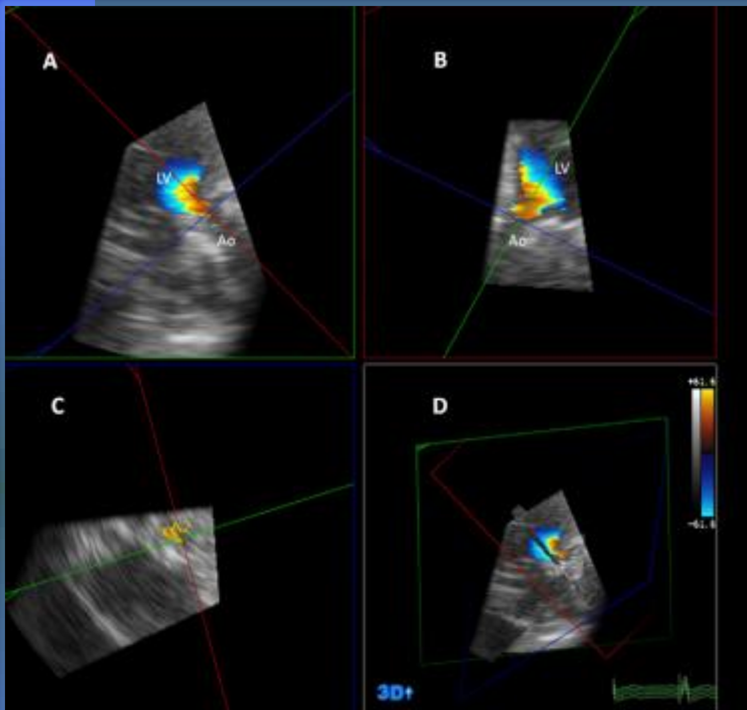
Perez de Isla L, Int J Cardiol 2011 - ***3D color-Doppler echocardiography and chronic aortic regurgitation: A novel approach for severity assessment.***

Aortic valve – complex morphology

- Endocarditis
  - vegetations
  - destruction
  - abscesses
- Tumors
- Prosthetic valves

- Anatomical relationships
- Mobility
- Size

Paravalvular leaks



Journal of the American Society of Echocardiography
Volume 25 Number 1

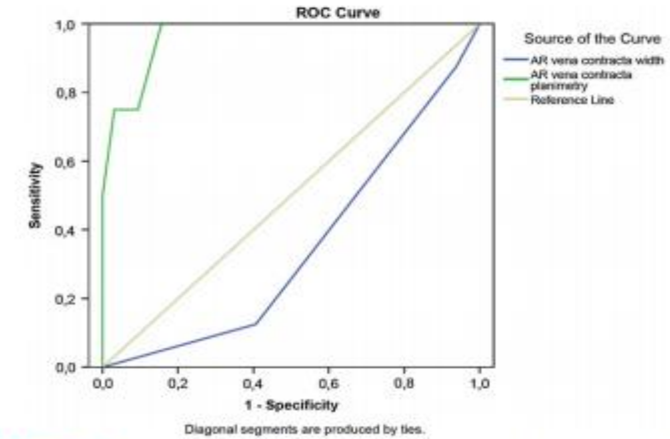


Figure 7 Receiver operating characteristic (ROC) curves for vena contracta width by 2D TTE (area under the curve, 0.35; 95% confidence interval, 0.15–0.55) and vena contracta planimetry by 3D TTE (area under the curve, 0.96; 95% confidence interval, 0.91–1.0) for the diagnosis of moderate AR.

Aortic valvular area (cm^2)	1.9 ± 0.6	2.0 ± 0.6	.605	1.9 ± 0.6	.680
AR volume (mL)	–	22.2 ± 5.5	–	41.3 ± 6.4	<.001
Vena contracta width (mm)	–	2.3 ± 0.6	–	2.0 ± 0.5	.139
Vena contracta planimetry (cm^2)	–	0.09 ± 0.06	–	0.29 ± 0.1	.001

- vena contracta planimetry was larger in patients with moderate AR than in mild AR (0.30 6 0.12 vs 0.09 6 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*

TAVI and RT3D

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

Marcos-Alberca P et al.., Rev Esp Cardiol 2009

GUIDELINES AND STANDARDS

EAE/ASE Recommendations for Image Acquisition and Display Using Three-Dimensional Echocardiography

Roberto M. Lang, MD, FASE,[*,‡] Luigi P. Badano, MD, FESC,[†,‡] Wendy Tsang, MD,[*] David H. Adams, MD,[*] Eustachio Agricola, MD,[†] Thomas Buck, MD, FESC,[†] Francesco F. Faletra, MD,[†] Andreas Franke, MD, FESC,[†] Judy Hung, MD, FASE,[*] Leopoldo Pérez de Isla, MD, PhD, FESC,[†] Otto Kamp, MD, PhD, FESC,[†] Jaroslaw D. Kasprzak, MD, FESC,[†] Patrizio Lancellotti, MD, PhD, FESC,[†] Thomas H. Marwick, MBBS, PhD,[*] Marti L. McCulloch, RDCS, FASE,[*] Mark J. Monaghan, PhD, FESC,[†] Petros Nihoyannopoulos, MD, FESC,[†] Natesa G. Pandian, MD,[*] Patricia A. Pellikka, MD, FASE,[*] Mauro Pepi, MD, FESC,[†] David A. Roberson, MD, FASE,[*] Stanton K. Shernan, MD, FASE,[*] Girish S. Shirali, MBBS, FASE,[*] Lissa Sugeng, MD,[*] Folkert J. Ten Cate, MD,[†] Mani A. Vannan, MBBS, FASE,[*] Jose Luis Zamorano, MD, FESC, FASE,[†] and William A. Zoghbi, MD, FASE[*], *Chicago and Oak Lawn, Illinois; Padua and Milan, Italy; New York, New York; Essen and Hannover, Germany; Lugano, Switzerland; Boston, Massachusetts; Madrid, Spain; Amsterdam and Rotterdam, The Netherlands; Lodz, Poland; Liege, Belgium; Cleveland, Ohio; Houston, Texas; London, United Kingdom; Rochester, Minnesota; Charleston, South Carolina; New Haven, Connecticut; Morrisville, North Carolina*

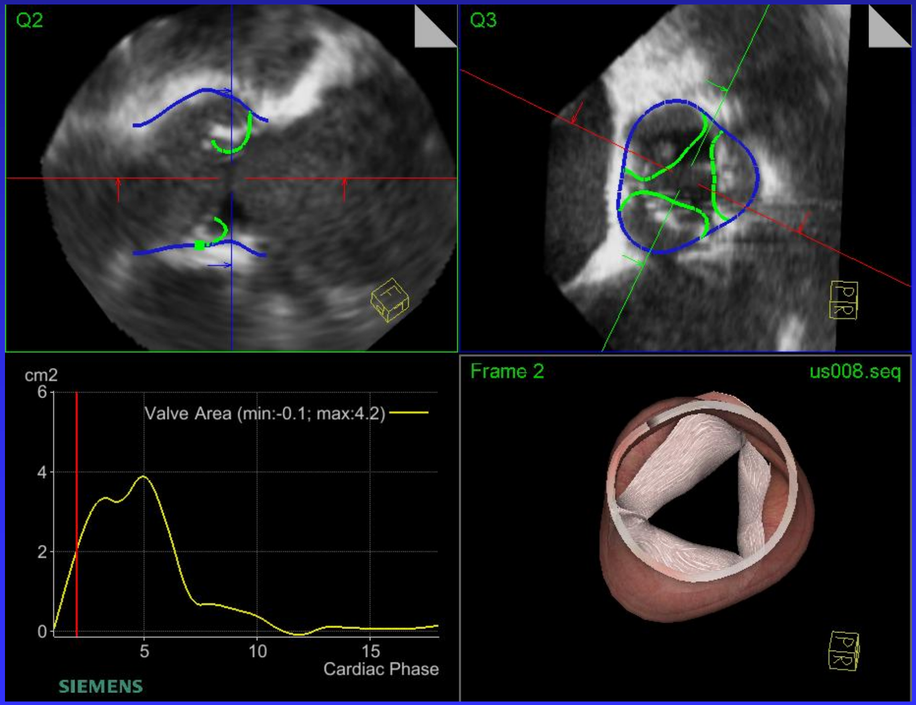
(J Am Soc Echocardiogr 2012;25:3-46.)

	Recommended for Clinical Practice	Promising Clinical Studies	Areas of Active Research	Unstudied
Aortic Valve Assessment				
Anatomy		✔		
Stenosis		✔		
Regurgitation				✔
Infective Endocarditis				✔
Prosthetic Valves			✔	
Guidance of Transcatheter Procedures*	✔			

* 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

UNIWERSYTET
MEDYCZNY
W ŁODZI