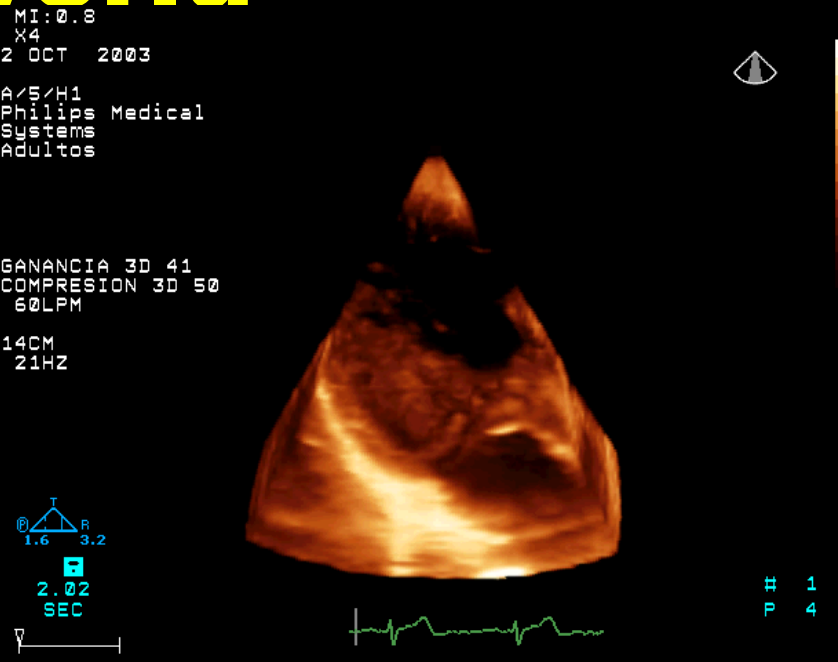
Three-dimensional echocardiography in the clinical world



Dr. JL Zamorano

Director CV Institute

University Clinic SC, Madrid

Advantages of 3D.

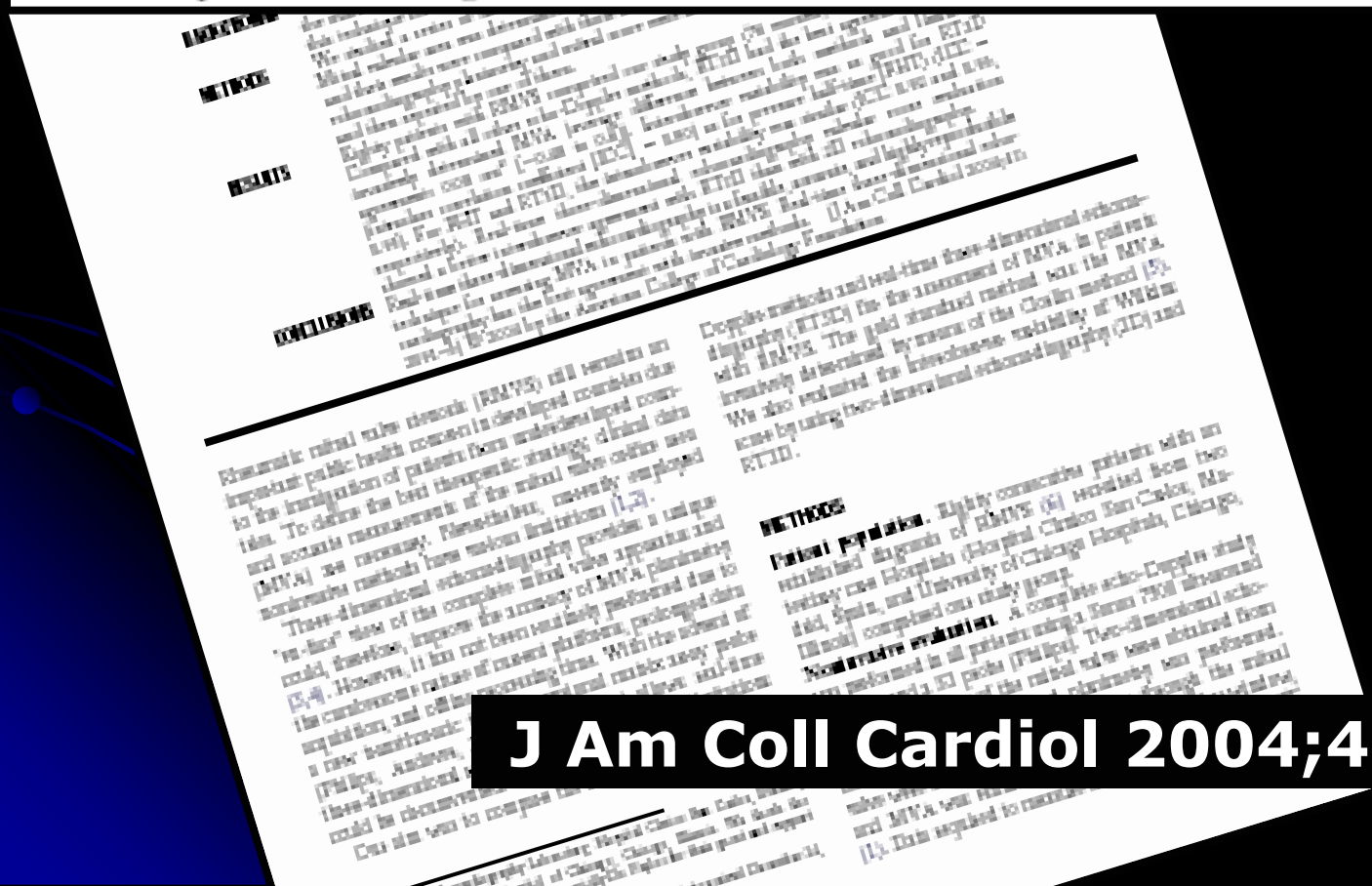
- **Spatial manipulation.**
  - **Optimal alineation of structures.**
  - **Views and planes impossible to get in 2D.**
- **Single acquisition, multiple information.**
- **Easy approach to complex problems.**
- **Volumes calculation.**
  - **No geometrical assumption (Right ventricle).**
  - **Precision ≅ MRI, (but faster and cheaper).**

Real-Time Three-Dimensional Echocardiography for Rheumatic Mitral Valve Stenosis Evaluation

An Accurate and Novel Approach

José Zamorano, MD,* Pedro Cordeiro, MD,* Lissa Sugeng, MD,† Leopoldo Perez de Isla, MD,*
Lynn Weinert, MD,† Carlos Macaya, MD,* Enrique Rodríguez, MD,* Roberto M. Lang, MD†

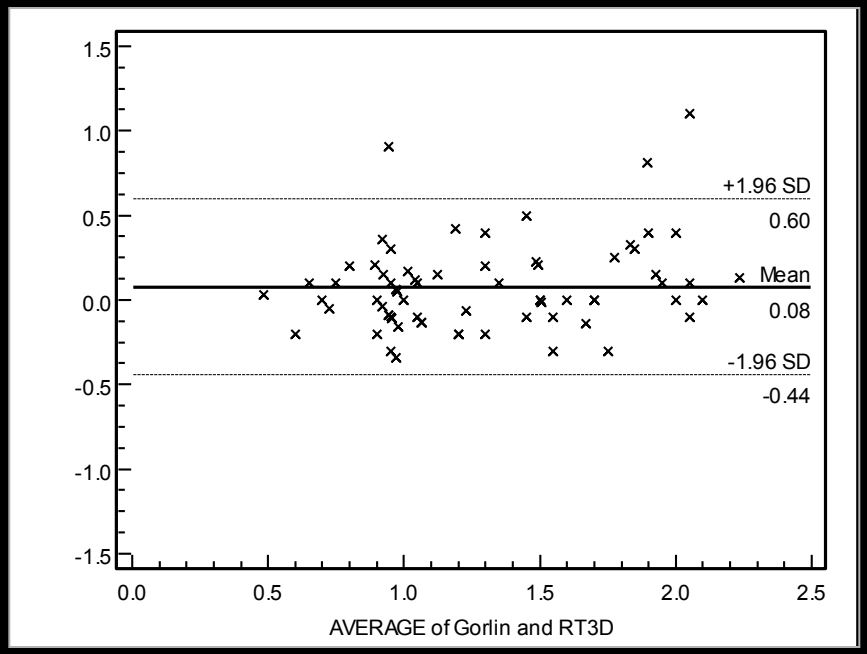
Madrid, Spain; and Chicago, Illinois



J Am Coll Cardiol 2004;43: 2091–6

Evaluation of Mitral valve area

- MVA estimated by:
  - 2D Echo :
    - PHT
    - Planimetry
    - PISA
  - 3D
  - Gorlin
- **Conclusions**:
  - 3D RT is very accurate in assessing MVA
  - 3D RT showed better agreement.



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European Heart Journal (2004) 25, 1086–1091

Clinical research

Non-invasive assessment of mitral valve area during percutaneous balloon mitral valvuloplasty: role of real-time 3D echocardiography

José Zamorano[a,*], Leopoldo Perez de Isla[a], Lissa Sugeng[b], Pedro Cordeiro[a], José Luis Rodrigo[a], Carlos Almeria[a], Lynn Weinert[b], Ted Feldman[b], Carlos Macaya[a], Roberto M. Lang[b], Rosana Hernandez Antolin[a]

[a] *Echocardiography Laboratory of the Hospital Clínico de San Carlos, Instituto Cardiovascular, 28040 Madrid, Spain*
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Received 13 May 2004; revised 3 September 2004; accepted 9 September 2004

See page 2073 for the editorial comment on this article (doi:10.1016/j.ehj.2004.10.001)

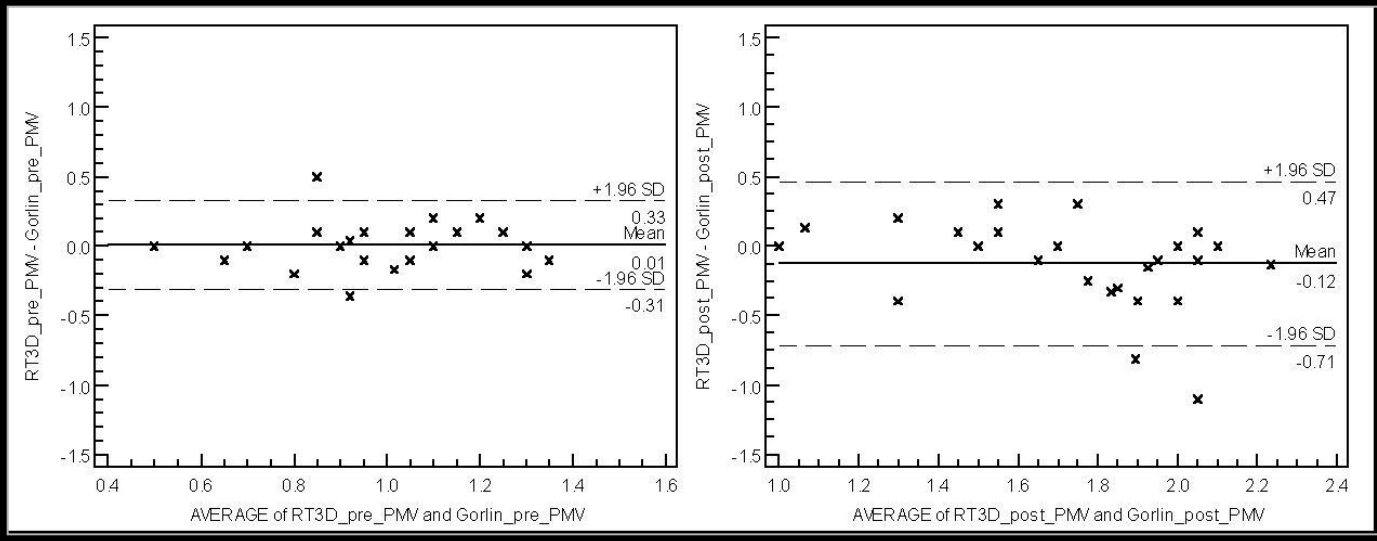
KEYWORDS
Mitral valve;
Echocardiography;
Three-dimensional;
Mitral stenosis;
Real time

Background In the last decade, multiple studies depicted discrepancies between mitral valvular orifice area (MVA) measurements obtained with the pressure half-time (PHT) method and invasive methods during the immediate post-percutaneous mitral valvuloplasty (PMV) period. Our aim was to assess the accuracy of Real-Time 3D echo (RT3D) to measure the MVA in the immediate post-PMV period. The invasively determined MVA was used as the gold standard.

Methods and results We studied 29 patients with rheumatic mitral stenosis from two centres (27 women; mean age 48.2 ± 11.3 years), all of which had undergone PMV. MVA was calculated before and after PMV using the PHT method, 2D echo planimetry, RT3D echo planimetry and invasive determination (Gorlin's method). The RT3D MVA assessment showed a better agreement with the invasively derived MVA before and in the immediate post-PMV period (Bland-Altman analysis: Average difference between both methods and limits of agreement: 0.01 (−0.31 to 0.33) cm^2 and −0.12 (−0.71 to 0.47) cm^2) before and immediately after the PMV, respectively.

Conclusions RT3D is a feasible and accurate technique for measuring MVA in patients with RMVS. It has the best agreement with the invasively determined MVA, particularly in the immediate post-PMV period.

MV pre – post MVP



Conclusion: 3D RT better correlation with Gorlin, after MVP

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Mitral valve.

3D: Best diagnostic tool for structural mitral evaluation.

- **Mitral stenosis.**
  - **Anatomy of leaflets, comissures, subvalvular apparatus.**
  - **Planimetry of oriffice: superior to 2D.**
  - **Guide for balloon valvulotomy.**
    - **Score.**
    - **Oriffice post-valvuloplastia.**
    - **Complications.**

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European Heart Journal (2004) 25, 1073–1074

Editorial

Should mitral valve area assessment in patients with mitral stenosis be based on anatomical or on functional evaluation? A plea for 3D echocardiography as the new clinical standard

Herman F.J. Mannaerts*, Otto Kamp, Cees A. Visser

VU University Medical Center, Amsterdam, The Netherlands

Received 1 October 2004; revised 1 October 2004; accepted 5 October 2004

This makes 3D echocardiography and especially real-time 3D echocardiography a new clinical standard, which offers more than the conventionally used ultrasound indices for assessment of the severity of mitral stenosis: a fast and reproducible technique with detailed anatomical information and orifice area assessment, relatively independent of confounding haemodynamic variables.

and limitations. Pressure half-time-derived MVA can be obtained easily, but may to a great extent, be influenced

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† doi:10.1016/j.ehj.2004.09.041.

ity of the method of transthoracic 3D MVA assessment has been described previously.[2,3,6,7] Binder et al. used a first generation real-time 3D echocardiography machine (Volumetrics®), in which 3D planimetry proved to be a fast, easy, accurate, and reproducible technique in comparison to 2D planimetry and pressure half-time-derived MVA.[2] In that study, however, it was not applied to the setting of PMV, in contrast to the present study by

Mitral valve.

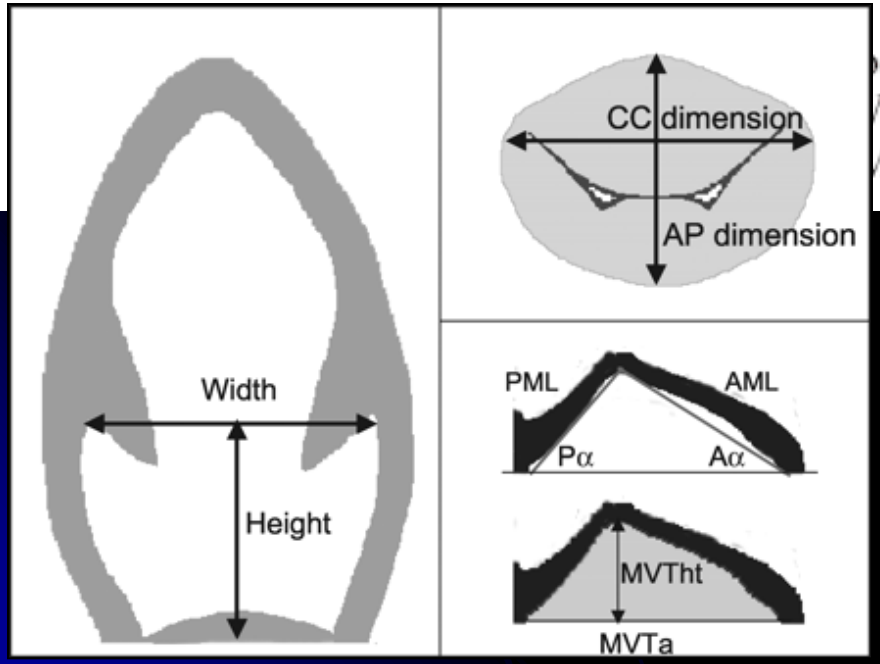
- **Mitral regurgitation.**

Geometric Differences of the Mitral Apparatus Between Ischemic and Dilated Cardiomyopathy With Significant Mitral Regurgitation

Real-Time Three-Dimensional Echocardiography Study

borah A. Agler, RDCS; Zoran B. Popović, MD;
William J. Stewart, MD; Delos M. Cosgrove, MD;
MD; James D. Thomas, MD

Circulation, March 2003



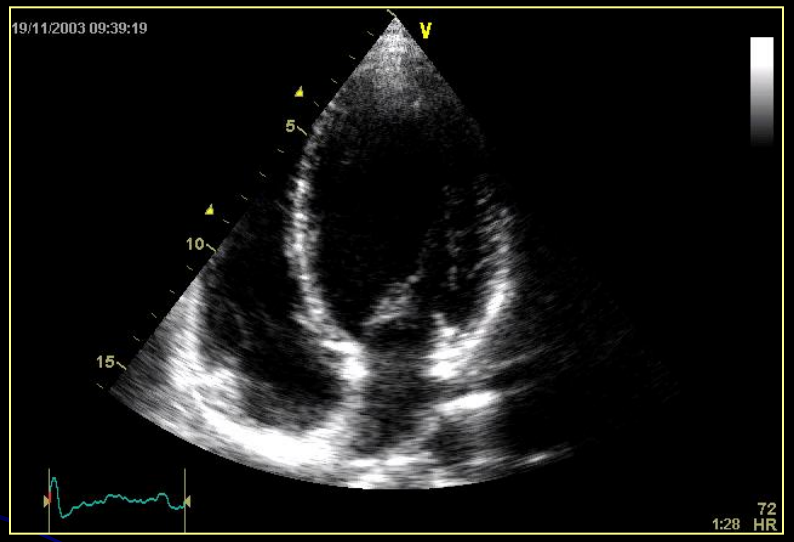
- **Mechanism of Mi regurgitation**

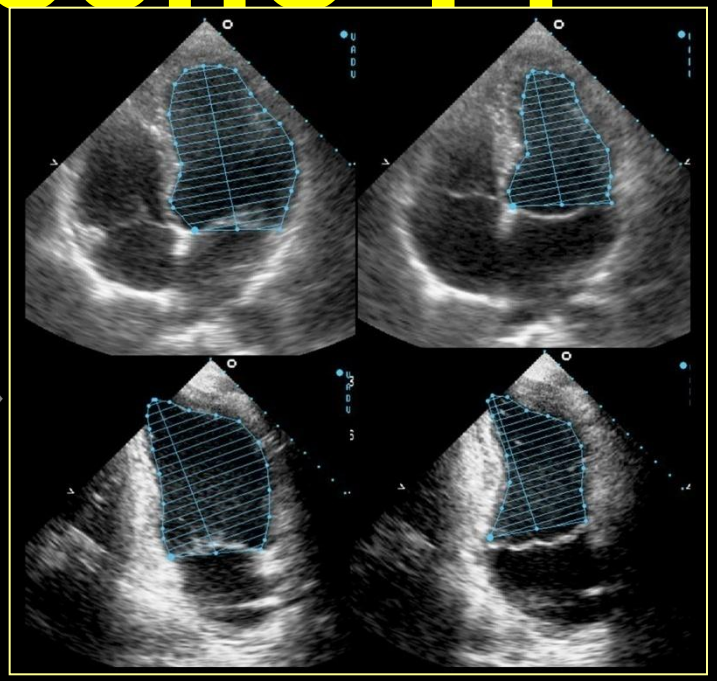
Mitral valve.

- **Mitral regurgitation.**
  - **Volumes quantification.**
  - **3D colour doppler quantification: promising perspectives.**
  - **Mechanism of Mi regurgitation.**

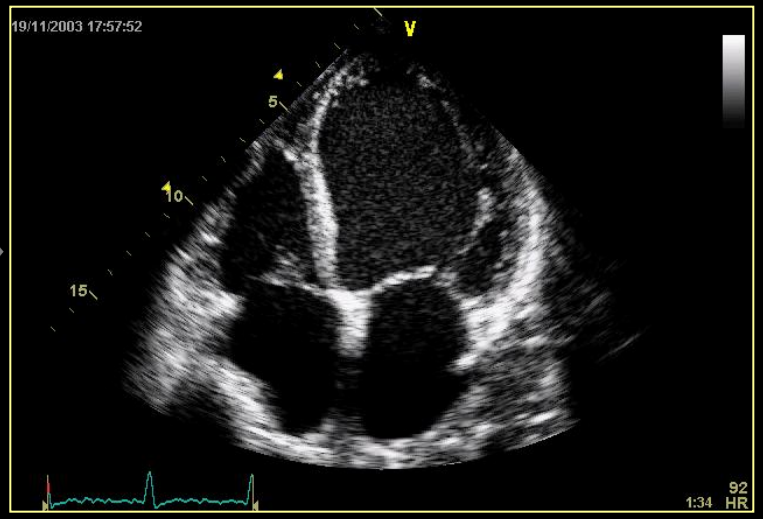
Volumes. 2D echo ??

- 2D: Simpson





- Problems:
  - ¿Optimal alignement ?
  - Geometric asumptions



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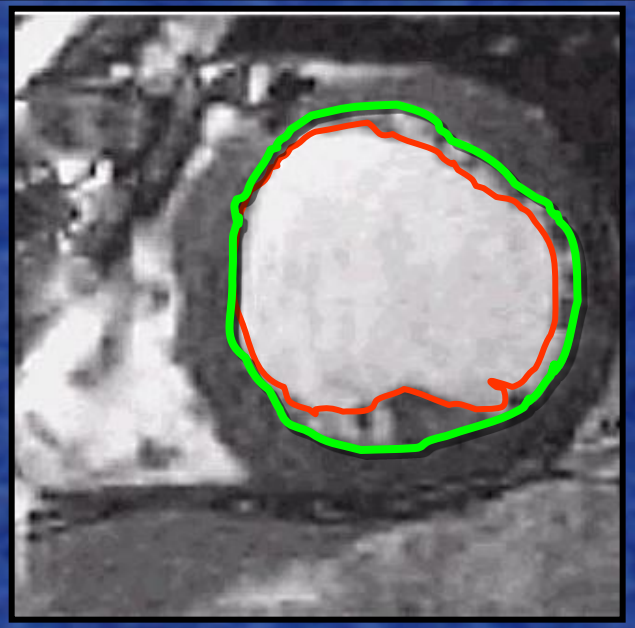
3D: Volumes calculation

Quantification of left ventricular volumes and ejection fraction using freehand transthoracic three-dimensional echocardiography: comparison with magnetic resonance imaging.

Mannaerts HF, Van Der Heide JA, Kamp O, Papavassiliu T, Marcus JT, Beek A, Van Rossum AC, Twisk J, Visser CA. **JASE 2003**

3D underestimates volumes



Comparison of Left Ventricular Volumes and Ejection Fractions Measured by Three-Dimensional Echocardiography Versus by Two-Dimensional Echocardiography and Cardiac Magnetic Resonance in Patients With Various Cardiomyopathies

Juan Luis Gutiérrez-Chico, MD, José Luis Zamorano, MD, Leopoldo Pérez de Isla, MD, Miguel Orejas, MD, Carlos Almería, MD, José Luis Rodrigo, MD, Joaquín Ferreirós, MD, Viviana Serra, MD, and Carlos Macaya, MD

End-diastolic volume and end-systolic volume were measured in 35 consecutive patients with cardiomyopathy using 2-dimensional (2-D) and 3-dimensional (3-D) echocardiography (2, 4, and 8 planes) and cardiac magnetic resonance imaging. Three-dimensional echocardiography correlates better with magnetic resonance imaging than does 2-D echocardiography. Its accuracy improves with the increase in the number of planes used. Two-dimensional echocardiography underestimates volumes, mainly in the subgroup with an ejection fraction of <50%, whereas 3-D echocardiography does not, if enough planes are used. However, in patients with an end-diastolic volume ≥150 ml, the underestimation of 3-D echocardiography is statistically significant. Increasing the number of planes to 8 reduces this bias. Conversely, patients with an end-diastolic volume <150 ml are accurately studied with just 4 planes.

(Am J Cardiol 2005;95:809–813)

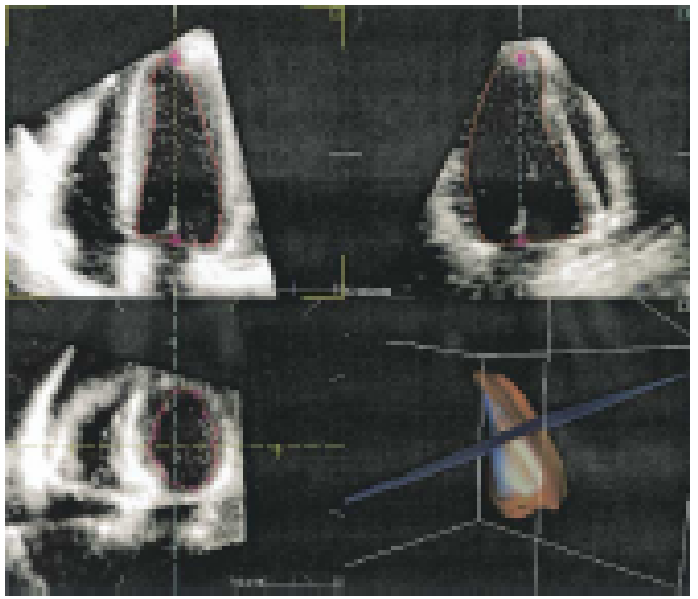


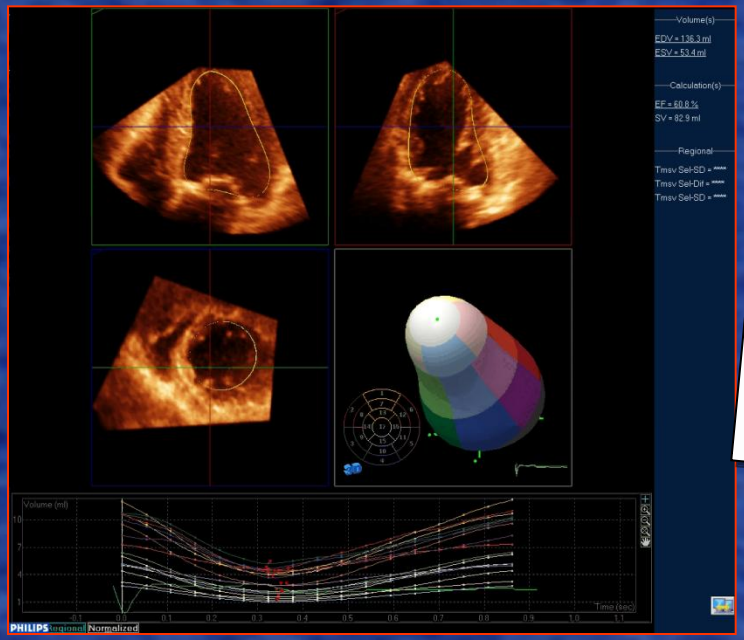
FIGURE 1. Tracing of the endocardial border in end-diastole with TomTec software, and 3-D reconstruction of the LV cavity in end-diastole and end-systole.

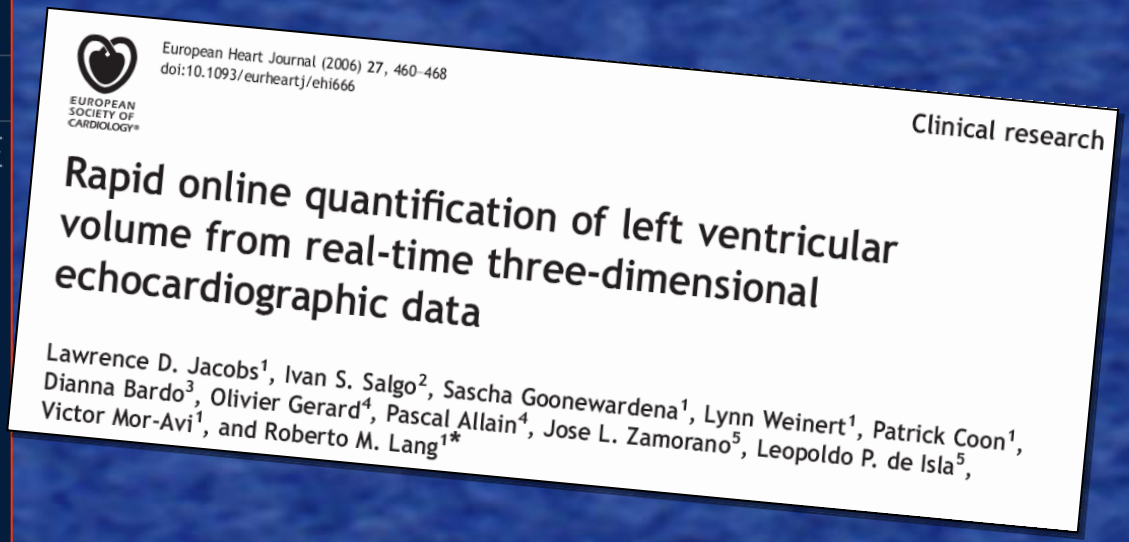
hypertrophic cardiomyopathy, as well as secondary to

RT3D: Semiautomated border detection

Improved semiautomated quantification of LV volumes and EF using 3D echocardiography with a full matrix-array transducer: comparison with magnetic resonance imaging.

Caiani EG, Corsi C, Zamorano JL, Sugeng L, MacEneaney P, Weinert L, Battani R, Gutiérrez-Chico JL, Koch R, Pérez de Isla L, Mor-Avi V, Lang RM. **JASE 2005 Aug**




European Heart Journal (2006) 27, 460–468
doi:10.1093/eurheartj/ehi666

EUROPEAN SOCIETY OF CARDIOLOGY®

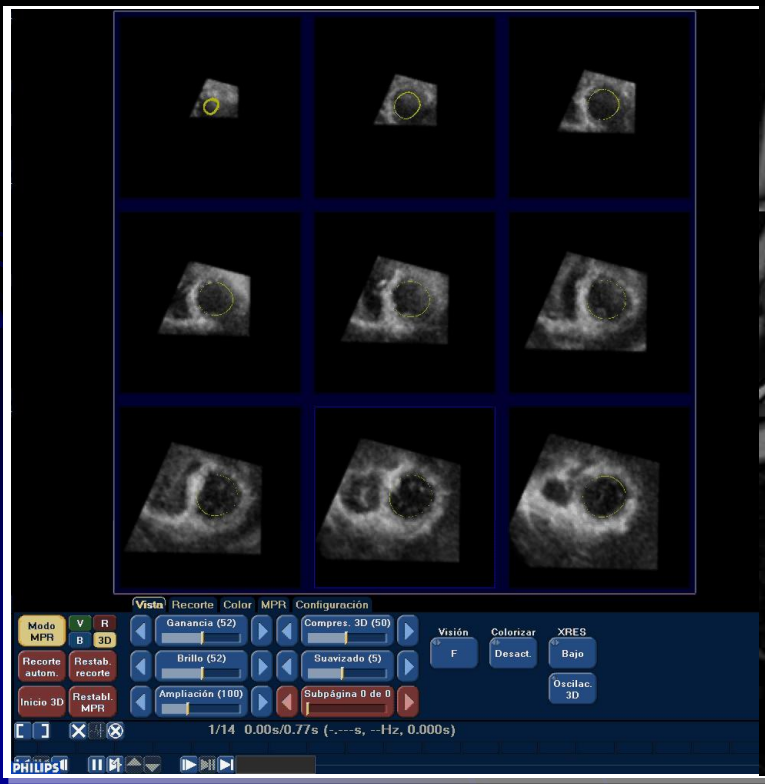
Clinical research

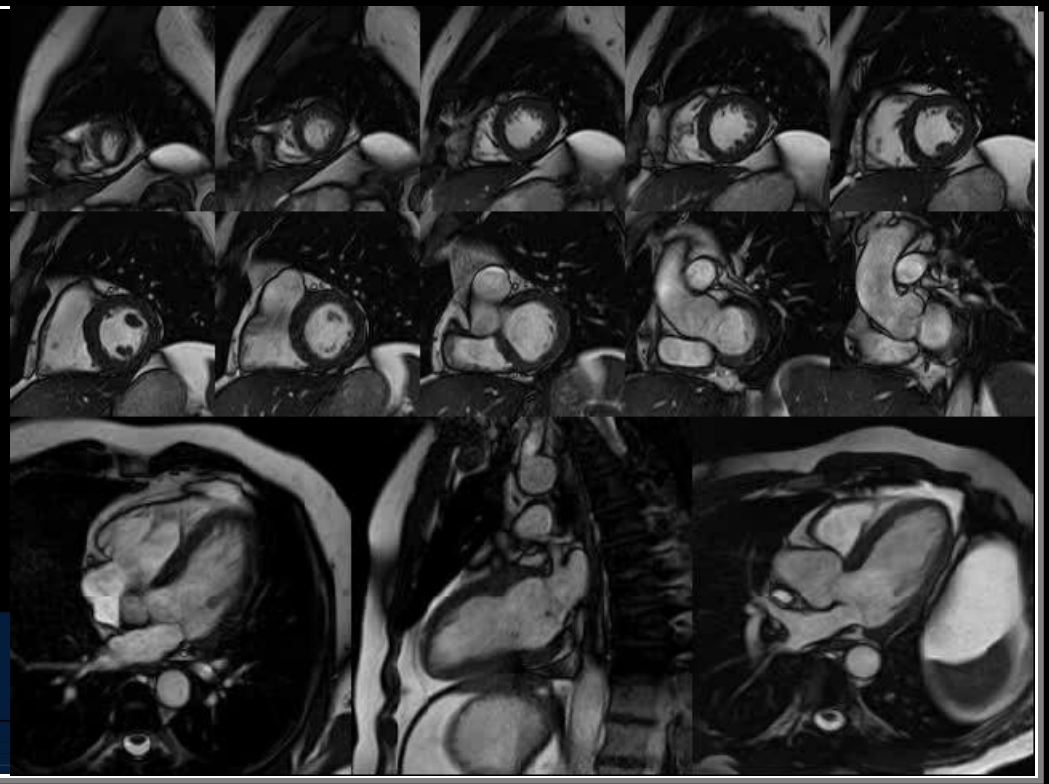
Rapid online quantification of left ventricular volume from real-time three-dimensional echocardiographic data

Lawrence D. Jacobs[1], Ivan S. Salgo[2], Sascha Goonewardena[1], Lynn Weinert[1], Patrick Coon[1], Dianna Bardo[3], Olivier Gerard[4], Pascal Allain[4], Jose L. Zamorano[5], Leopoldo P. de Isla[5], Victor Mor-Avi[1], and Roberto M. Lang[1]*

Volumes in 3D

- Volumes calculation – **Slice view**
  - **Direct comparison with gold standard**





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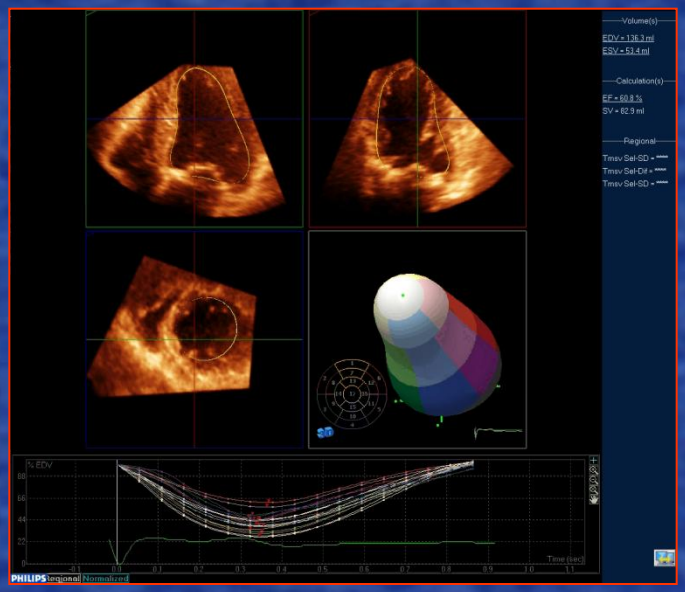
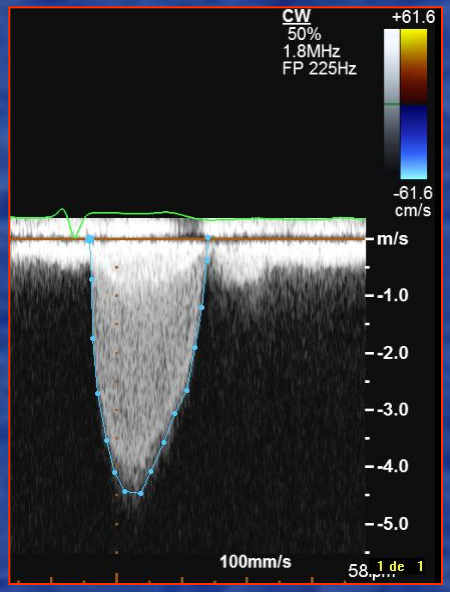
Aortic area with RT 3D echo ?





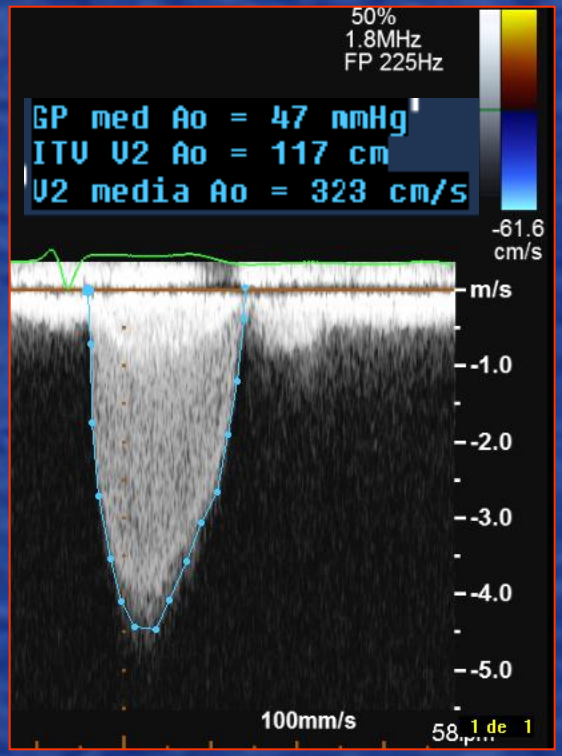
Aortic stenosis: Continuity equation

- Cumulative error in several parameters
- Depending on good parasternal & apical acoustic windows

TSVI

IVT TSVI

$$A_{Ao} = \pi \left(\frac{D_{TSVI}}{2}\right)^2 \frac{IVT_{TSVI}}{IVT_{Ao}}$$



Aortic stenosis: Continuity equation

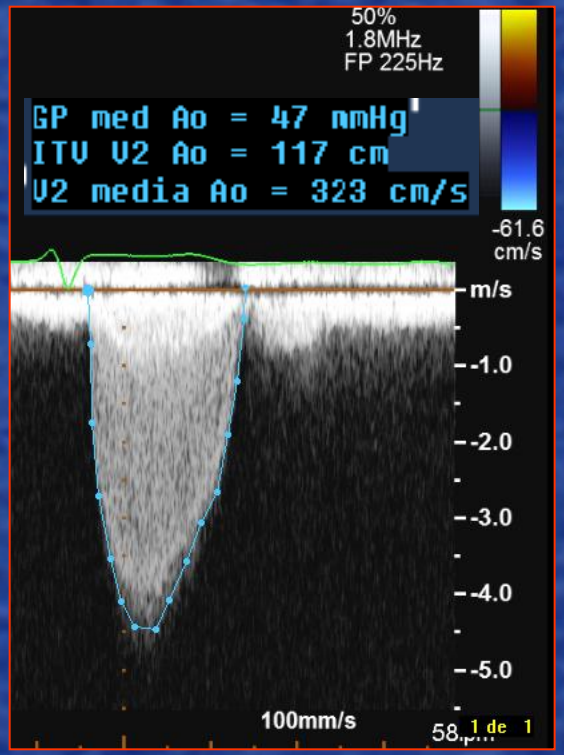
- Cumulative error in several parameters
- Depending on good parasternal & apical acoustic windows

TSVI

IVT TSVI

$$A_{Ao} = \pi \left(\frac{D_{TSVI}}{2}\right)^2 \frac{IVT_{TSVI}}{IVT_{Ao}}$$

STROKE VOLUME



Aortic stenosis: Continuity equation

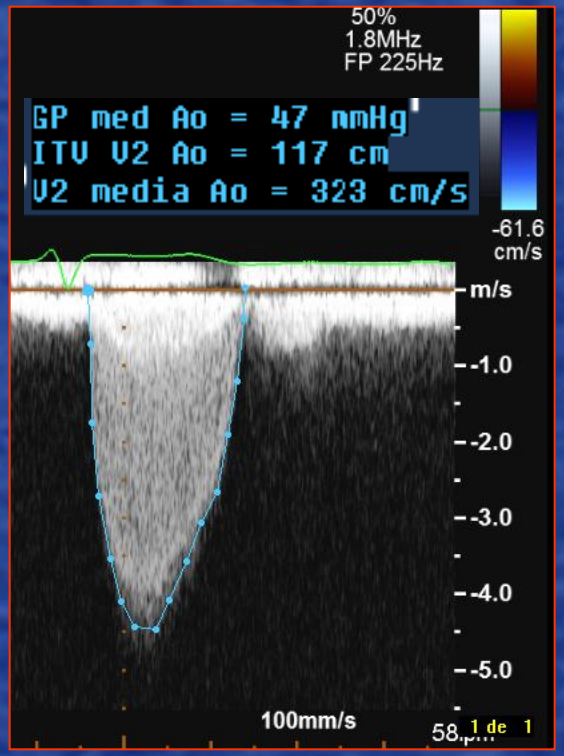
- Cumulative error in several parameters
- Depending on good parasternal & apical acoustic windows

TSVI

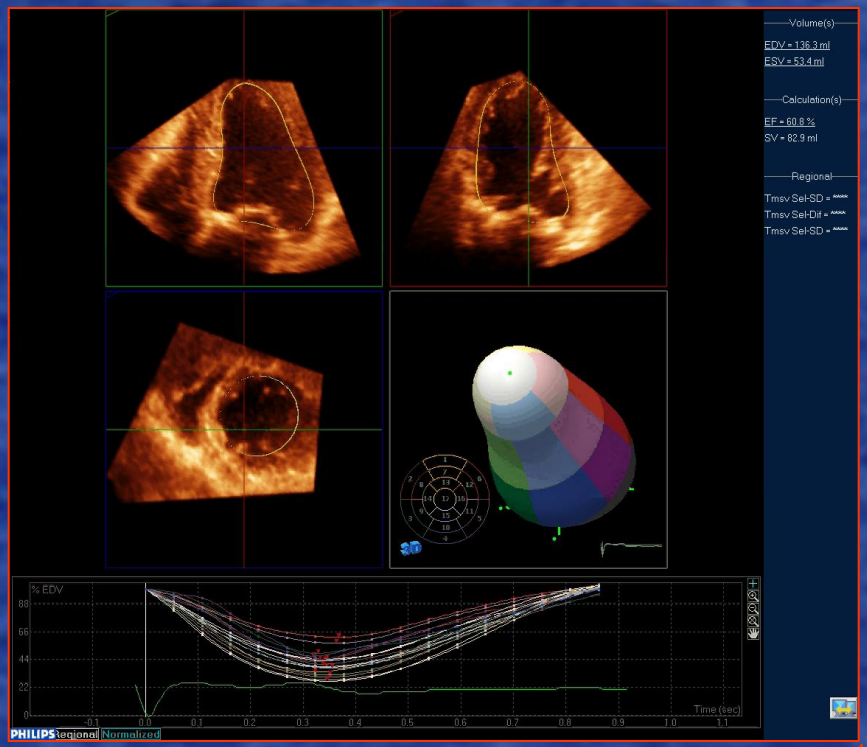
IVT TSVI

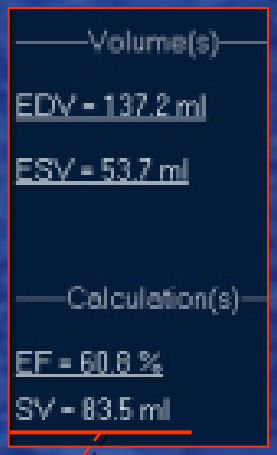
$$A_{Ao} = \frac{SV}{IVT_{Ao}}$$

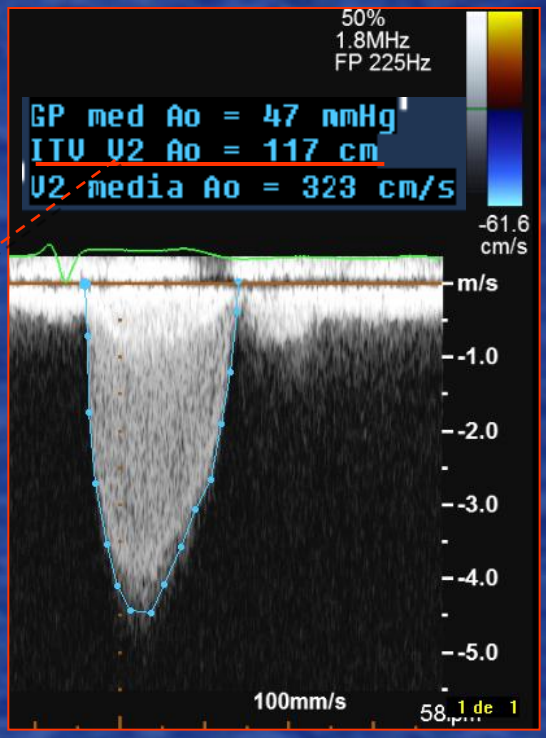
STROKE VOLUME



Aortic area: RT3D-Doppler hybrid approach







$$\text{Aortic area} = \frac{SV_{3D}}{TVI_{Ao}}$$

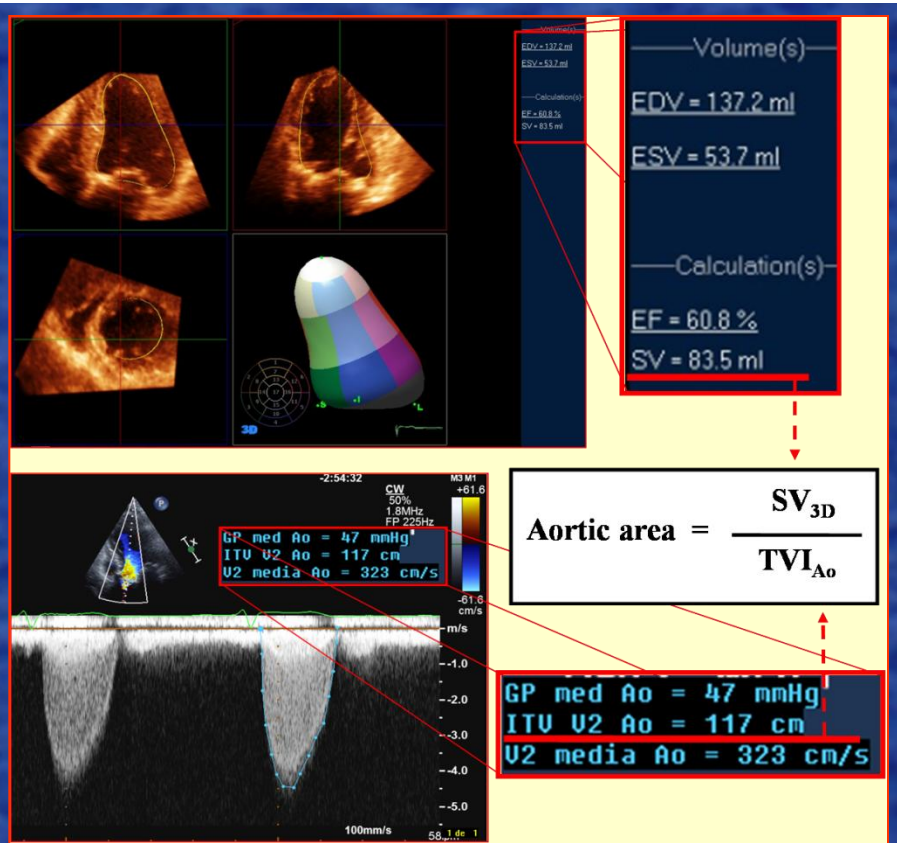
European Heart Journal Advance Access published November 6, 2007

European Heart Journal
doi:10.1093/eurheartj/ehm467

Clinical research

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 Íñiguez-Romo[1]



- **Aortic area:**
  - **Invasive:**
    - **Gorlin**
    - **Hakki**
  - **Echo:**
    - **Continuity equation**
    - **Volumetric Simpson**
    - **RT 3D**

Leak closure. Echo info

Utility of Real-Time Three-Dimensional Transesophageal Echocardiography in Evaluating the Success of Percutaneous Transcatheter Closure of Mitral Paravalvular Leaks

Miguel Angel García-Fernández, PhD, MD, Marcelino Cortés, PhD, MD, Jose A. García-Robles, MD, Jose J. Gomez de Diego, MD, Esther Perez-David, PhD, MD, and Eulogio García, MD, *Madrid, Spain*

Background: The percutaneous closure of mitral paravalvular leaks has been reported in patients who are poor operative candidates. Unsuccessful percutaneous closure of leaks may be related to morphologic characteristics of the defects.

Methods: Ten patients were selected from a database for mitral dehiscence closure, in whom 2-dimensional transesophageal echocardiography revealed inadequate leak closure. Another 4 patients with optimal results were also selected. Real-time 3-dimensional transesophageal echocardiography (3DTEE) was performed in all of them.

Results: Real-time 3DTEE enabled the determination of the locations and number of the leaks, as well as their shapes, lengths, widths, areas, and extent. We were also able to observe the position of the device (or devices) implanted during percutaneous closure.

Conclusion: According to this preliminary study, 3DTEE can improve understanding of the causes underlying failure of these techniques to reduce regurgitation secondary to a defect. This could improve patient selection and procedure results, but further studies are needed. (J Am Soc Echocardiogr 2009;■:■-■.)

Keywords: 3D echocardiography, Transesophageal, Cardiac catheterization, Mitral valve dehiscence

Perivalvular dehiscence is a complication that may occasionally occur in patients with prosthetic valves, especially if these are mechanical. They occur in approximately 2% to 17% of cases[1,2] and in up to 10% of cases of prosthetic valve reoperation,[2,3] with a prevalence of approximately 10% to 15% in follow-up studies using standard 2-dimensional (2D) transesophageal echocardiography (2DTEE).[4] The surgical closure of paravalvular leaks is usually advised in severely symptomatic patients and in those requiring blood transfusions for persistent hemolysis. Operative mortality is 6% to 14%.[5,6] The percutaneous closure of severe periprosthetic leaks has been reported in patients who are poor operative candidates, with different devices and techniques.[7-15] Our group recently published results from the longest series of cases presented in the literature of periprosthetic mitral valve leak closure, in which total or a highly significant reduction in the severity of regurgitation was shown.[16] Unsuccessful percutaneous closure of leaks may be related to their large sizes and shapes, which prevent closure using simple devices.[17] Two-dimensional TEE allows only an approximate assessment of the morphology and extent of a leak. However, the recently developed real-time 3-dimensional (3D) TEE (3DTEE) offers excellent imaging of the different cardiac structures, basically (being a transesophageal technique) of the mitral valve, left atrium, and prosthetic mitral valves.[18,19]

The purpose of this study was to evaluate the utility of 3DTEE in analyzing the underlying causes of unsuccessful leak closure. To do this, the technique was used to analyze a cohort of patients who were found to have unsuccessful periprosthetic leak closure with persistent severe regurgitation at a 2-month postoperative follow-up study.

From the Department of Medicine I, Universidad Complutense de Madrid, Madrid, Spain (M.A.G.-F.); the Department of Cardiology, Gregorio Marañón General University Hospital, Madrid, Spain (M.C., J.A.G.-R., J.J.G.D., E.P.-D.); and the Department of Cardiology, Clínico San Carlos Hospital, Madrid, Spain (E.G.).

Reprint requests: Miguel Angel García-Fernández, Departamento de Medicina I, Facultad de Medicina de la Universidad Complutense, Ciudad Universitaria, Ramon y Cajal s/n, 28040 Madrid, Spain (E-mail: garciafernandez@ecocardio.com).

0894-7317/$36.00

doi:10.1016/j.echo.2009.09.028

METHODS

Study Population

The database of our group for percutaneous prosthetic mitral valve closure currently consists of 52 patients, 27 of whom formed part of the previous study.[16] All percutaneous interventions were performed at the same institution and by the same operator (E.G.). The devices used in all interventions were patent ductus arteriosus occluders (Amplatzer; AGA Medical Corporation, Minneapolis, MN). All paravalvular leak closure procedures were performed under general anesthesia with radiographic and 2D transesophageal echocardiographic guidance. Monitoring with 2DTEE was used to locate the optimal region of the interatrial septum for transseptal puncture

Conclusions

- 3D is the best imaging for Mitral valve.
  - New approach to mitral anatomy and mitral prolapse.
  - 3D planimetry: Best non-invasive methode for Mi stenosis.
  - Mechanism of Mi regurgitation.
  - Best option for complex problems, MVP, surgical repair.
- 3D colour Doppler: promising perspectives for quantification of valvular regurgitations.
- MONITOR INTERVENTIONS
- Volume estimation… similar to MRI