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 \( \approx \) 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
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.
Non-invasive assessment of mitral valve area during percutaneous balloon mitral valvuloplasty: role of real-time 3D echocardiography

José Zamorano, Leopoldo Perez de Isla, Lissa Sugeng, Pedro Cordeiro, José Luis Rodrigo, Carlos Almería, Lynn Weinert, Ted Feldman, Carlos Macaya, Roberto M. Lang, Rosana Hernandez Antolin

Echocardiography Laboratory of the Hospital Clinico de San Carlos, Instituto Cardiovascular, 28040 Madrid, Spain
University Hospital of Chicago, Chicago, USA

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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 ± 15.3 years), all of whom had underwent 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: 0.02 (-0.31 to 0.33) cm² and -0.12 (-0.71 to 0.47) cm² before and immediately after the PMV, respectively. Conclusions RT3D is a feasible and accurate technique for measuring MVA in patients with PMVS. It has the best agreement with the invasively determined MVA, particularly in the immediate post-PMV period.

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

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

3D: Best diagnostic tool for structural mitral evaluation.
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
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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.

* Correspondence to: Dr. Herman FJ Mannaerts, Department of Cardiology, VU University Medical Center, P.O. Box 7057, 1007 MB Amsterdam, The Netherlands. Tel.: +31 204442846; fax: +31 204442846.
E-mail address: f.f.j.mannaerts@vumc.nl (H.F.J. Mannaerts).

3D echocardiography has been described previously. 1,3,4,7 Binder et al. used a first generation real-time 3D echocardiography machine (Volumentrics®), 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. 3 In that study, however, it was not applied to the setting of PAV, 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

Thorah A. Agler, RDCS; Zoran B. Popović, MD; William J. Stewart, MD; Delos M. Cosgrove, 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 assumptions
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
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. ©2005 by Excerpta Medica Inc.

(Fig 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.

(Am J Cardiol 2005;95:809–813)
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.


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

Lawrence D. Jacobs¹, Ivan S. Salgo², Sascha Gunewardena³, Lynn Weinert¹, Patrick Coon¹, Dianna Bardo⁴, Olivier Gérard⁴, Pascal Allain⁴, Jose L. Zamorano⁵, Leopoldo P. de Isla⁶, Victor Mor-Avi⁷, and Roberto M. Lang⁷
Volumes in 3D

- Volumes calculation – Slice view
- Direct comparison with gold standard
Aortic area with RT 3D echo?
Aortic stenosis: Continuity equation

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

\[ A_{Ao} = \pi \left( \frac{D_{TSVI}}{2} \right)^2 \frac{IVT_{TSVI}}{IVT_{Ao}} \]
Aortic stenosis: Continuity equation

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

\[ A_{Ao} = \pi \left( \frac{D_{TSVI}}{2} \right)^2 \frac{IVT_{TSVI}}{IVT_{Ao}} \]
Aortic stenosis: Continuity equation

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

\[ A_{Ao} = \frac{SV}{IVT_{Ao}} \]
Aortic area: RT3D-Doppler hybrid approach

\[
\text{Aortic area} = \frac{SV_{3D}}{TVI_{Ao}}
\]
Real-time three-dimensional echocardiography in aortic stenosis: a novel, simple, and reliable method to improve accuracy in area calculation

Juan Luis Gutiérrez-Chico¹*, José Luis Zamorano², Elsa Prieto-Moriche², Rosa Ana Hernández-Antolín², Marisol Bravo-Amaro¹, Leopoldo Pérez de Isla², Marcelo Sanmartín-Fernández¹, José Antonio Baz-Alonso¹, and Andrés Íñiguez-Romo¹

Aortic area:

- Invasive:
  - Gorlin
  - Hakki

- Echo:
  - Continuity equation
  - Volumetric Simpson
  - RT 3D
Utility of Real-Time Three-Dimensional Transesophageal Echocardiography in Evaluating the Success of Percutaneous Transcatheter Closure of Mitral Paravalvular Leaks

Miquel Angel Garcia-Penadés, PhD, MD, Marcelino Correa, PhD, MD, Jose A. Garde-Robles, MD, Jose J. Cano de Diego, MD, Javier Ponce-David, PhD, MD, and Esteban Garcia, MD, Madrid, Spain

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

Methods: Ten patients were selected from a database for mitral dichance closure, in whom 2-dimensional transesophageal echocardiography revealed no adequate 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, area, and extent. We were able to observe the position of the device projected 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; [Epub ahead of print].

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

Perforation of the valve appears to be a complication that may occasionally occur in patients with prosthesis valves, especially if these are mechanical. They occur in approximately 2% to 17% of cases and in up to 10% of cases of prosthesis valve reoperation, with a prevalence of approximately 1% to 15% in follow-up studies using standard echocardiography. Two-dimensional transesophageal echocardiography (2DTEE) allows only an approximate assessment of the morphology and extent of the leak, the recently developed real-time 3-dimensional transesophageal echocardiography (3DTEE) offers excellent imaging of the different cardiac structures, basically being a transesophageal technique of the mitral valve, left atrium, and prosthetic mitral valves.

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

METHODS

Study Population

The database of our group for percutaneous prosthetic mitral valve closure currently consists of 52 patients, 17 of whom formed part of the previous study. All percutaneous interventions were performed at the same institution and by the same operator. The devices used in all interventions were para-aortic aortic occluders (Amplatz AGA Medical Corporation, Minneapolis, MN). All paravalvular leak closure procedures were performed using a general anesthesia with transcatheter angiographic and 3D transesophageal echocardiographic guidance. Monitoring with 3DTEE 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 method for Mitral stenosis.
  - Mechanism of Mitral 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