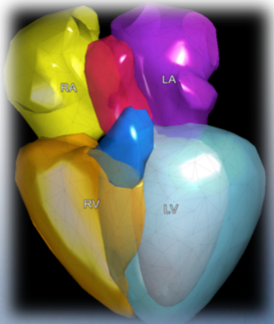
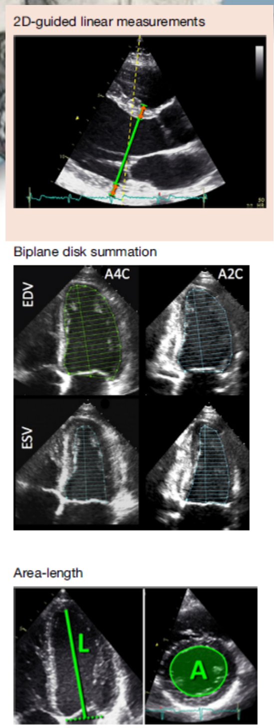


Heart Model
The future of quantiative Echocardiography

Prof. J Zamorano. Ramón y Cajal University Hospital. Madrid. Spain.

INTRODUCTION

What is the accepted practice today



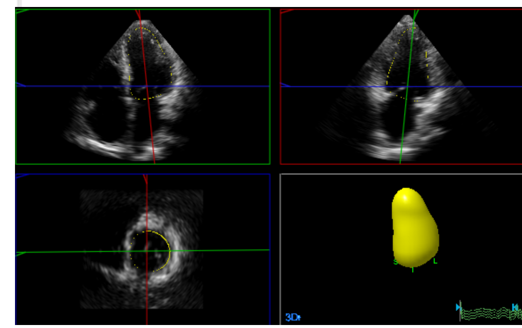
GUIDELINES AND STANDARDS

Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging

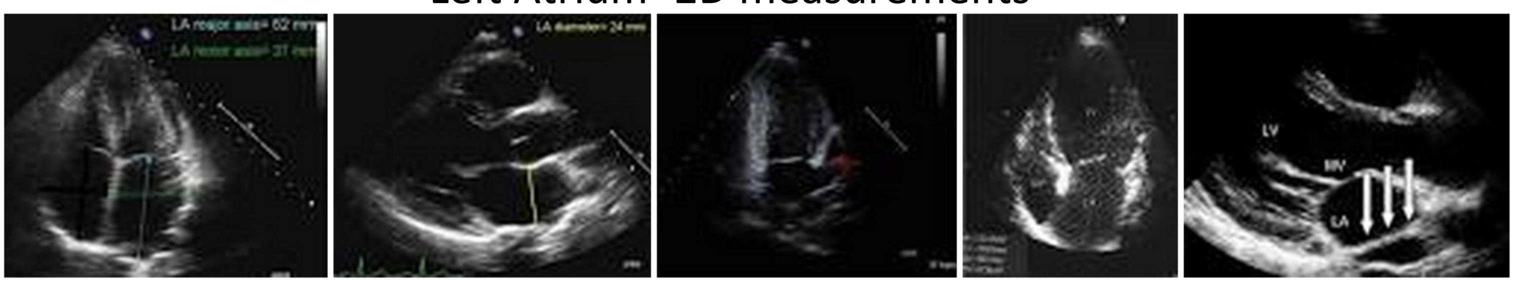
Roberto M. Lang, MD, FASE, FESC, Luigi P. Badano, MD, PhD, FESC, Victor Mor-Avi, PhD, FASE, Jonathan Afilalo, MD, MSc, Anderson Armstrong, MD, MSc, Laura Ernande, MD, PhD, Frank A. Flachskampf, MD, FESC, Elyse Foster, MD, FASE, Steven A. Goldstein, MD, Tatiana Kuznetsova, MD, PhD, Patrizio Lancellotti, MD, PhD, FESC, Denisa Muraru, MD, PhD, Michael H. Picard, MD, FASE, Ernst R. Rietzschel, MD, PhD, Lawrence Rudski, MD, FASE, Kirk T. Spencer, MD, FASE, Wendy Tsang, MD, and Jens-Uwe Voigt, MD, PhD, FESC, *Chicago, Illinois; Padua, Italy; Montreal, Quebec and Toronto, Ontario, Canada; Baltimore, Maryland; Créteil, France; Uppsala, Sweden; San Francisco, California; Washington, District of Columbia; Leuven, Liège, and Ghent, Belgium; Boston, Massachusetts*

LV- 3D

- No geometrical assumption
- Unaffected by foreshortening
- More accurate and reproducible compared to other imaging modalities



Left Atrium- 2D measurements

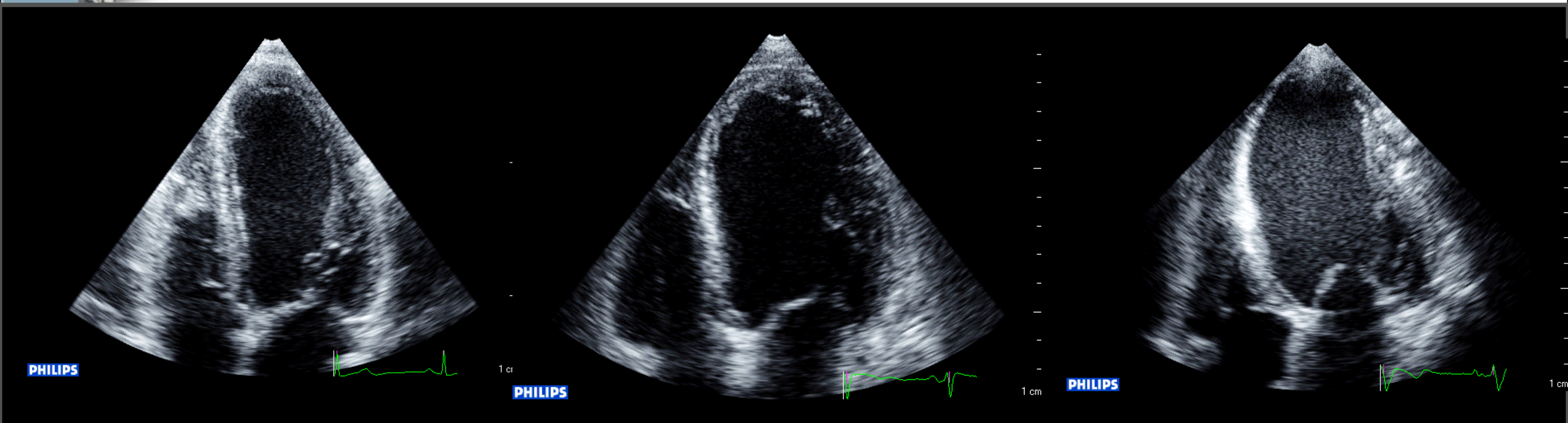


2D is the accepted practice for volume analysis today with acknowledgement that 3D is superior


Image quality
Reproducibility
Time

How do we assess LV Function?

Eye ball



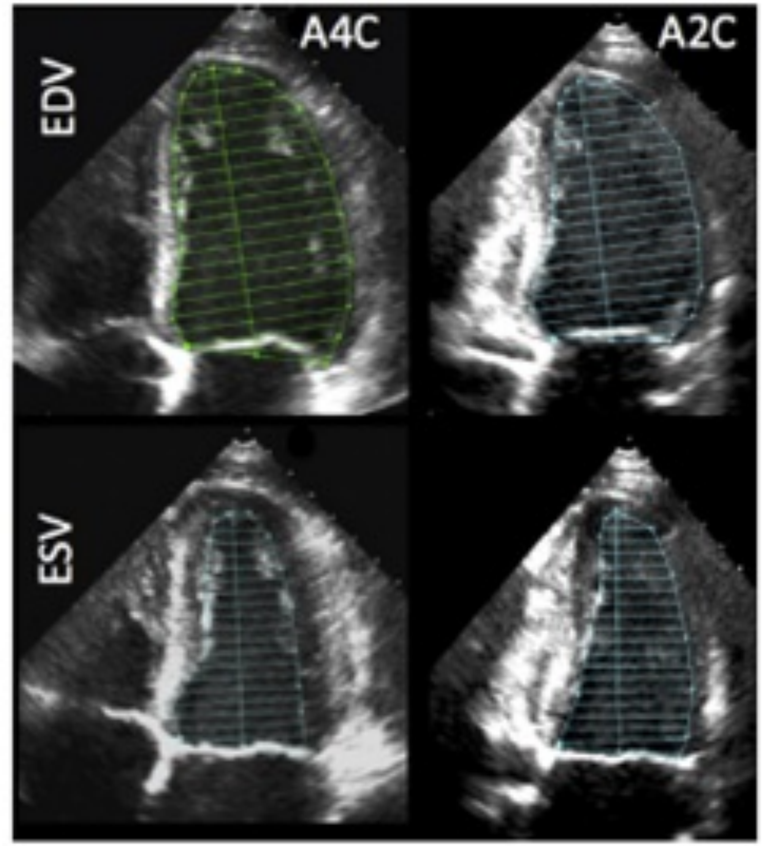
Limitations

- **Subjective**
- **Experience dependent**
- **Lack of standardization**
- **Large inter- and intra-observer variability**

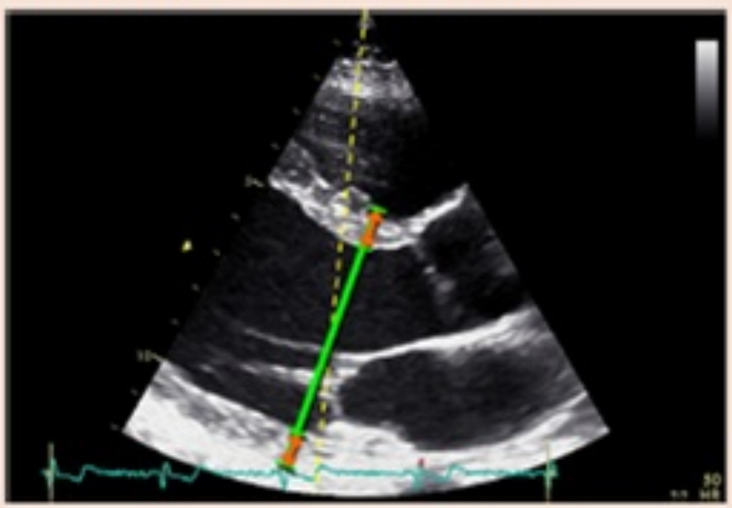
Lang RM, J Am Soc Echocardiogr 2015;28:1-39

2D LV assessment

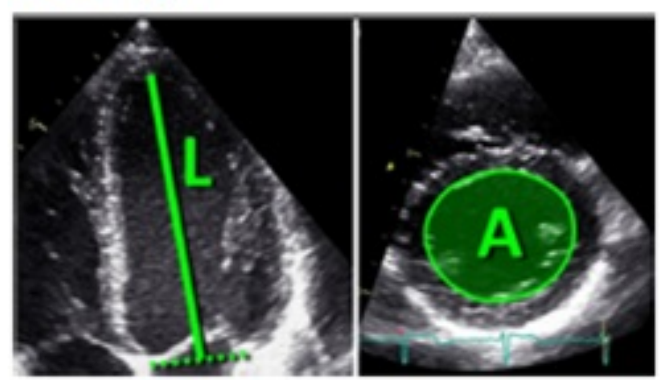
Biplane disk summation



2D-guided linear measurements

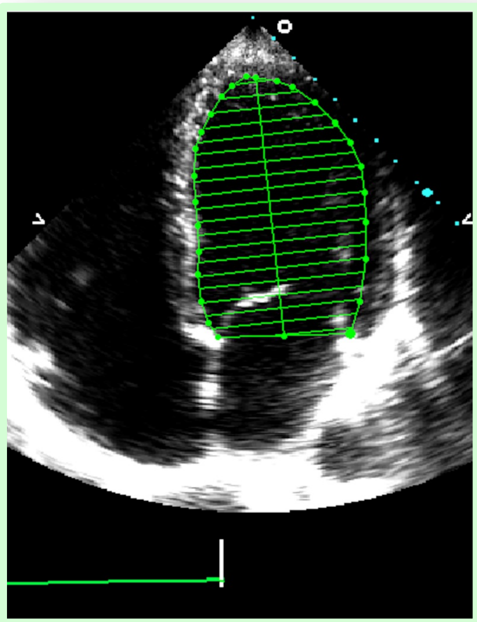


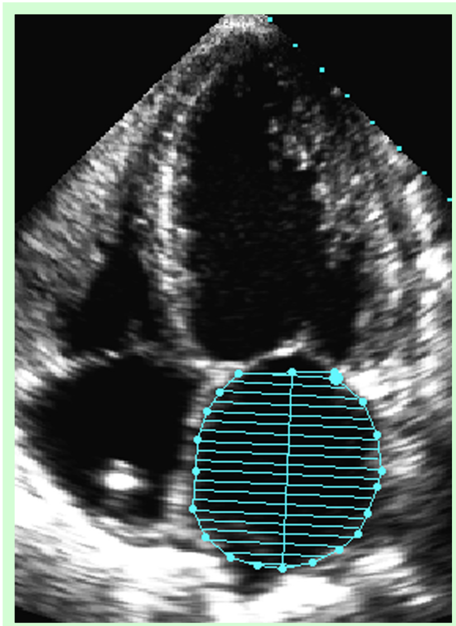
Area-length



Foreshortening

Tracing errors

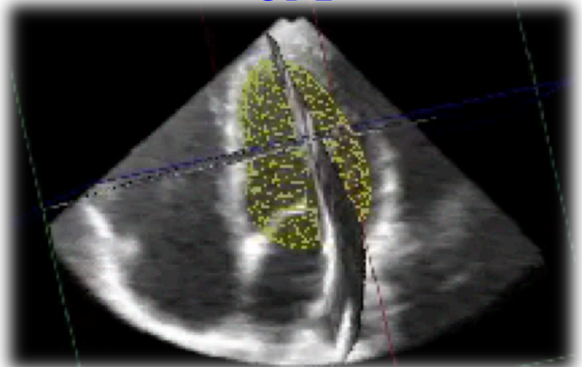


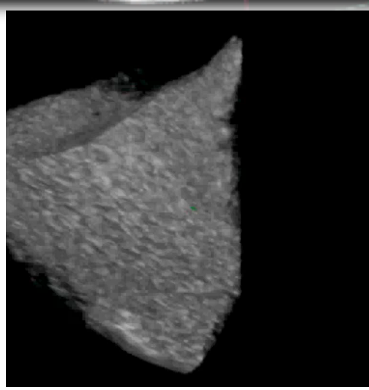


Geometry dependent

3DE Measurements Are More Accurate

3DE





MRI

LAV

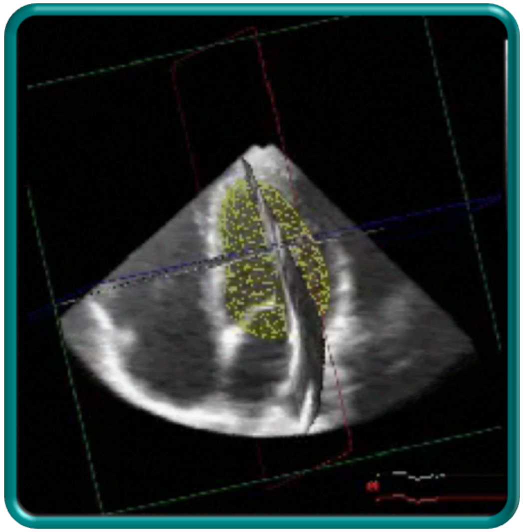
LV EDV

LV ESV

- Excellent correlation (r^2>0.85)
- Small biases
- Narrow limits of agreement

Ahmad M, et al. *JACC 2001; 37:1303-9*
Qin JX, et al. *JACC 2000; 36:900-7*
Arai K, et al. *AJC 2004; 94:552-8*
Jenkins C, et al. *JACC 2004; 44:878-86*
Kuhl HP, et al. *JACC 2004; 43:2083-90.*
Gutierrez-Chico JL, et al. *AJC 2005; 95:809-13*
Mor-Avi V, et al. JACC: CV Img 2012;5:769

Validation by MRI

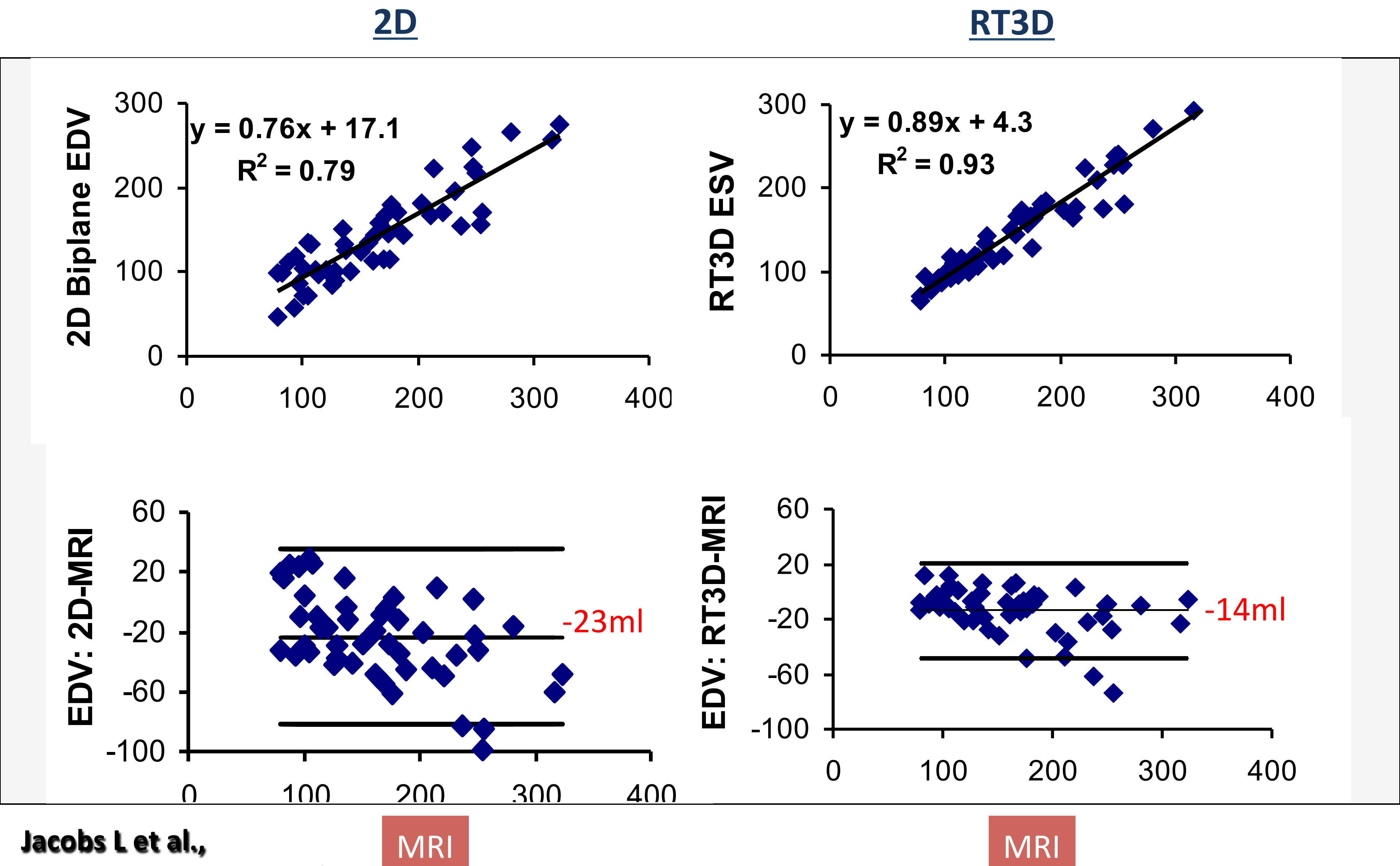


EDV, ESV

Excellent correlation
($r^2>0.85$)

- **Ahmad M, et al. *J Am Coll Cardiol 2001; 37:1303-9***
- **Qin JX, et al. *J Am Coll Cardiol 2000; 36:900-7***
- **Arai K, et al. *Am J Cardiol 2004; 94:552-8***
- **Jenkins C, et al. *J Am Coll Cardiol 2004; 44:878-86***
- **Kuhl HP, et al. *J Am Coll Cardiol 2004; 43:2083-90.***
- **Gutierrez-Chico JL, et al. *Am J Cardiol 2005; 95:809-13***

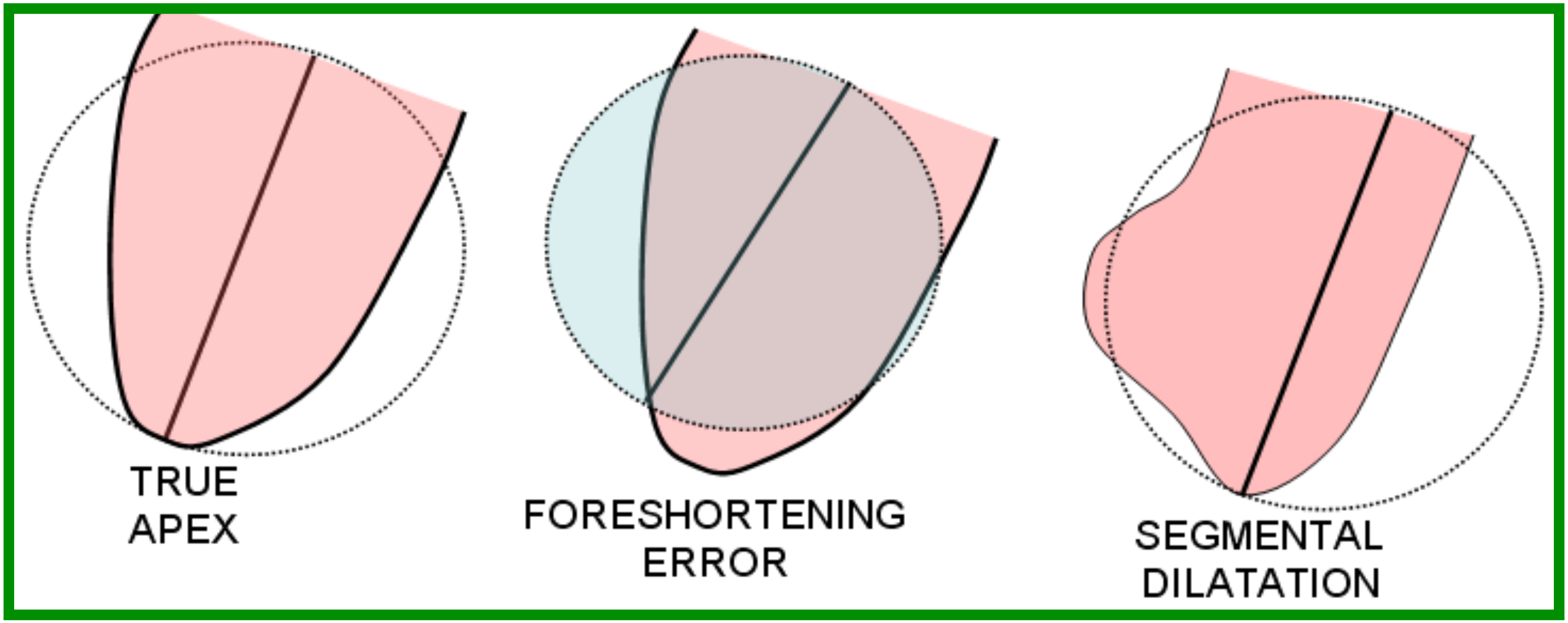
End Diastolic Volume



Jacobs L et al.,
European Heart Journal
27: 460-468, 2006

Why is 3D More Accurate?

- No geometrical assumption
- Unaffected by foreshortening
- More accurate and reproducible compared to other imaging modalities



Limitations to clinical integration of 3D TTE LV assessment

Limitations	Solutions
Separate 2/3D transducers	→ **Integrated transducer**
Manual reconstruction	→ **'real-time' 3D images**

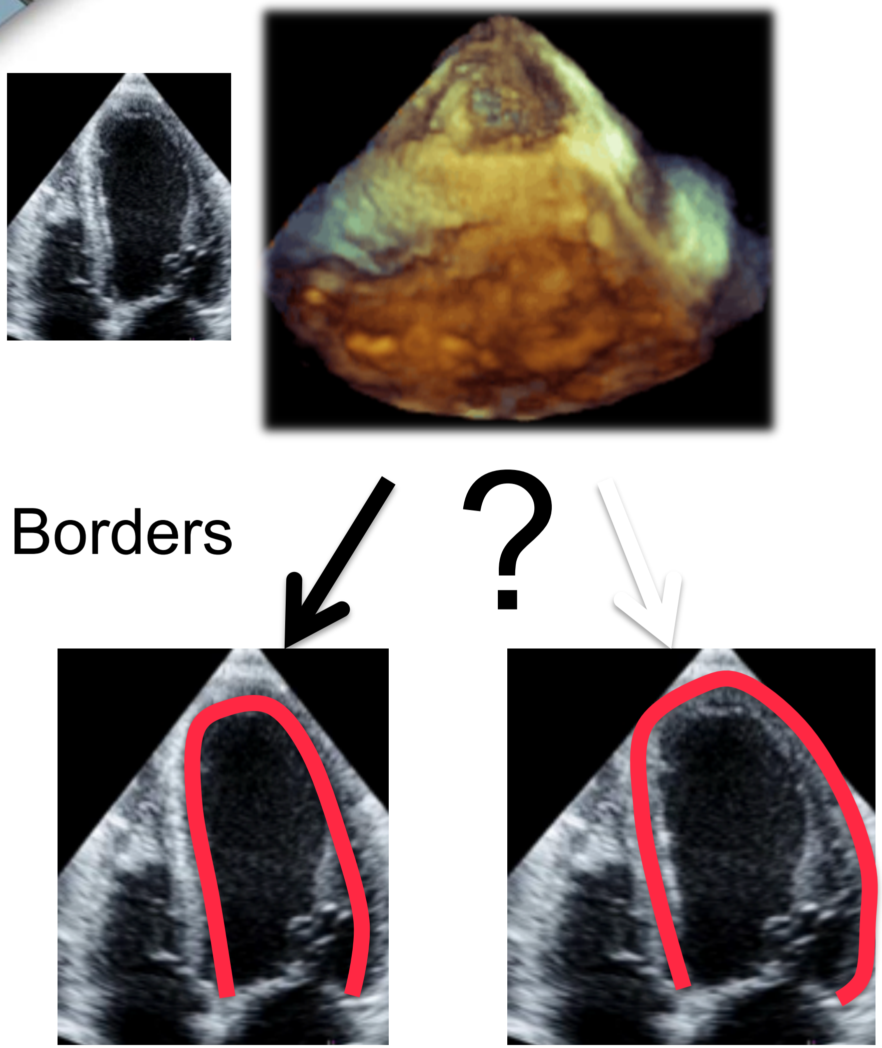
Off-line, off-cart analysis

Training

Time-consuming

Automation

Problems with 3D Echo –where is the true border?



Time Consuming

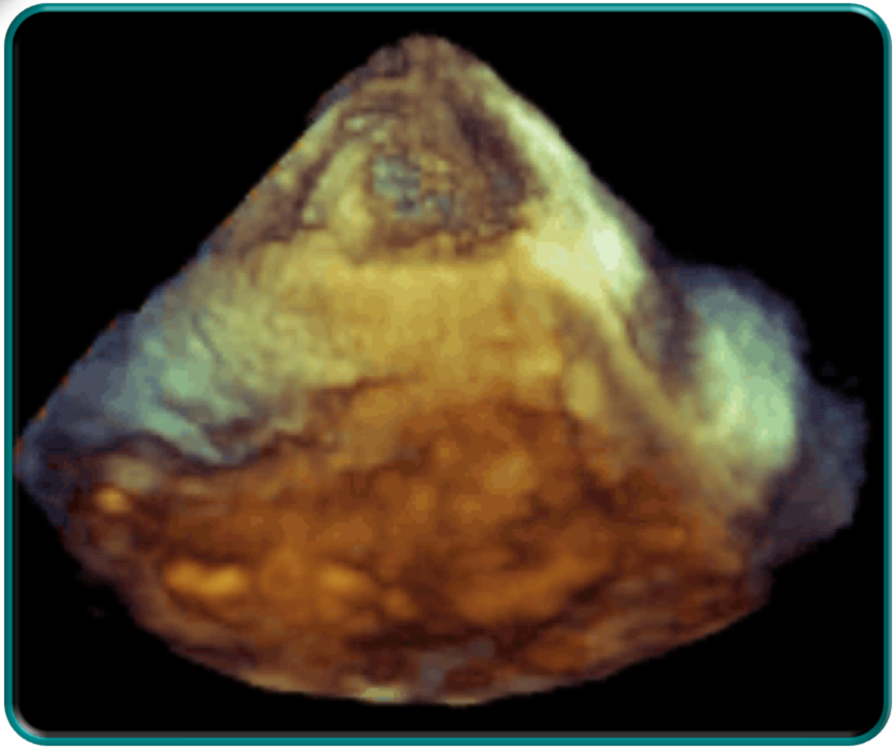
↓

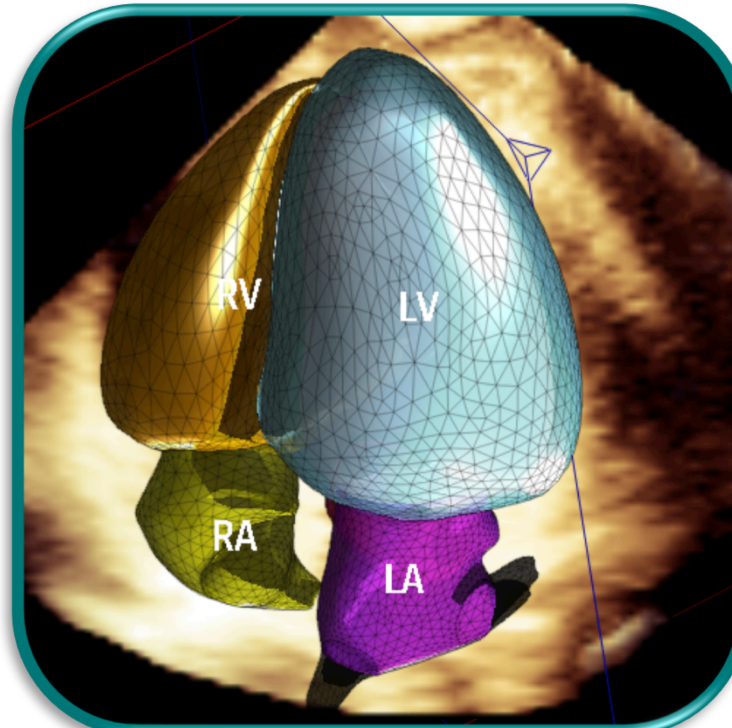
3 min and 30 sec

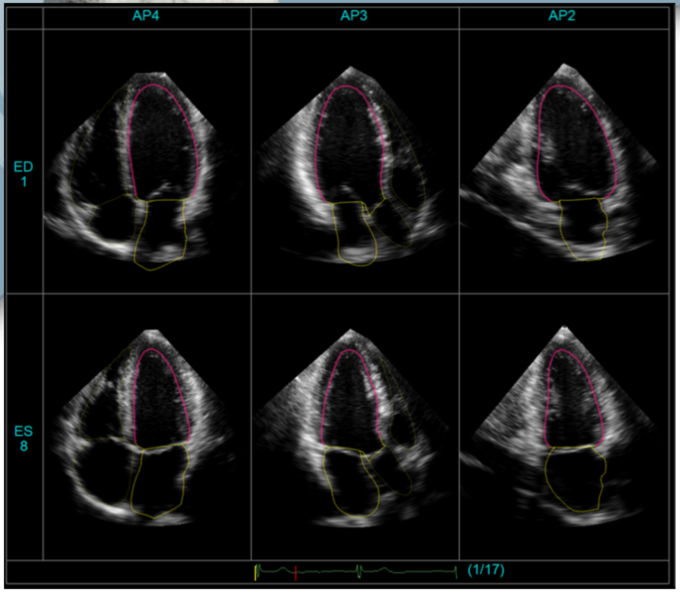
↓

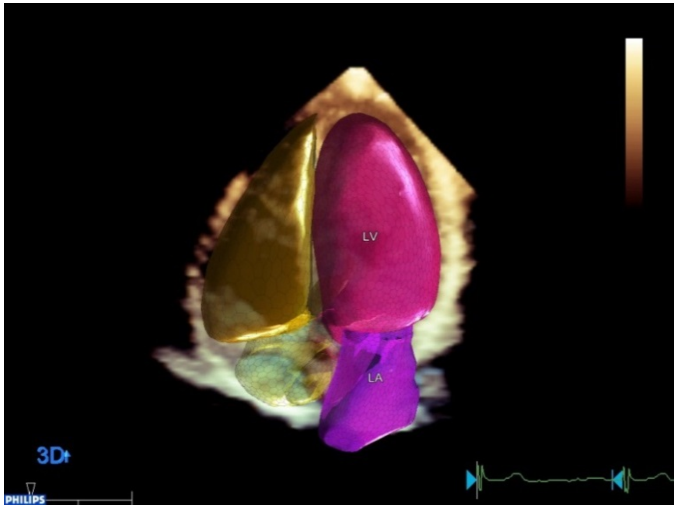
≈ 3 hours for 50 patients

Fully Automated Cardiac Chamber Quantification







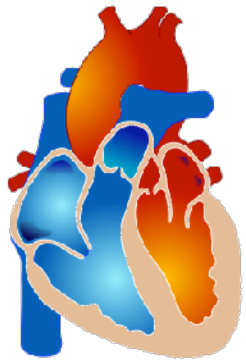


.With one-button simplicity, **HeartModel** overcomes the complexity and time it takes to perform 3D TTE. HeartModel brings robust 3D quantification to everyday clinical practice.

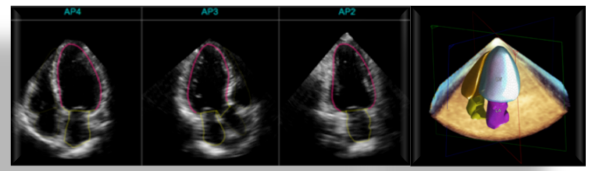
This anatomically intelligent cardiac application **automatically detects, segments, and quantifies the left ventricle (LV) and left atrium (LA) from a Live 3D volume.**

Technical solution:
Anatomical Intelligence for Ultrasound

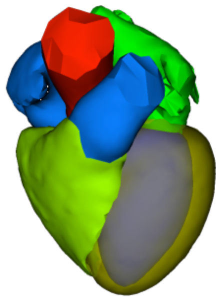
Training of AIUS



+

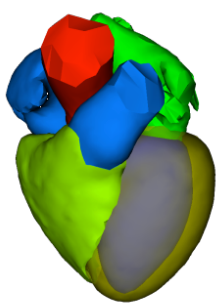


⇒



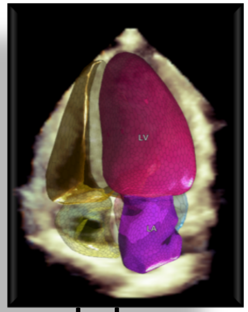
Anatomical knowledge | Sample 3D images | Generic Model

Use of AIUS



+

⇒



Generic Model | Dataset | Adapted model

Knowledge Based Identification

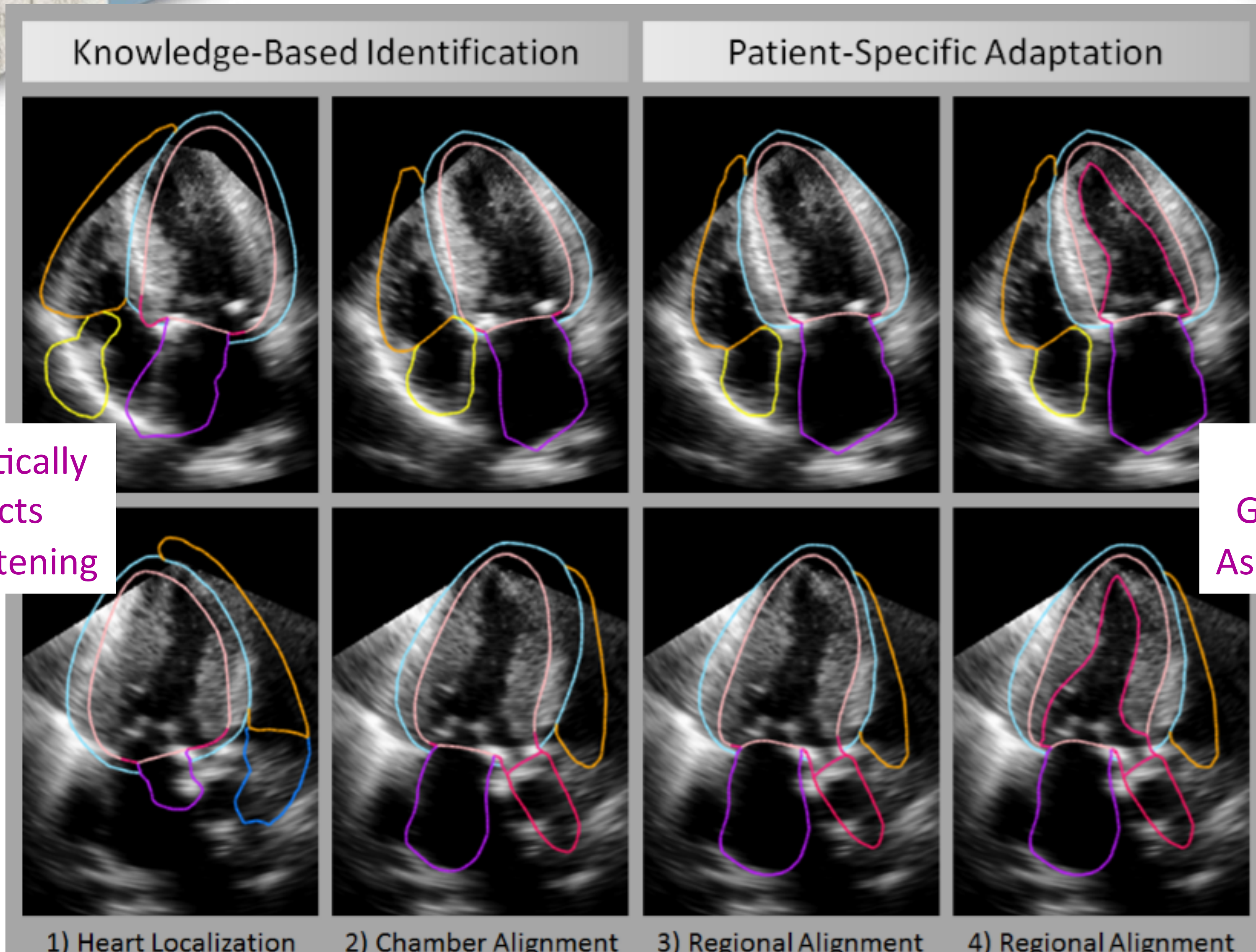
Patient Specific Adaptation

How it works

HeartModel$^{A.I.}$ Algorithm

Align & Orient <u>Model</u>

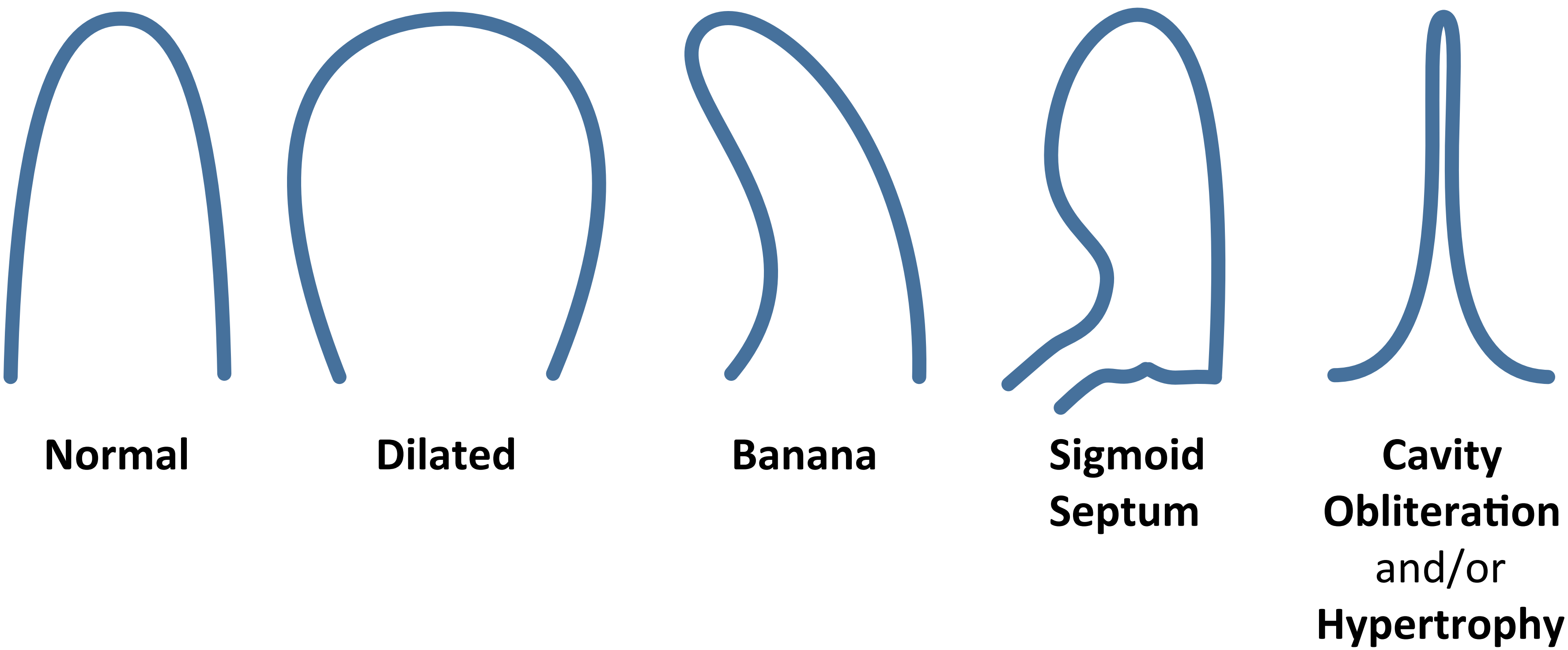
Adjust Local Borders



Automatically Corrects Foreshortening

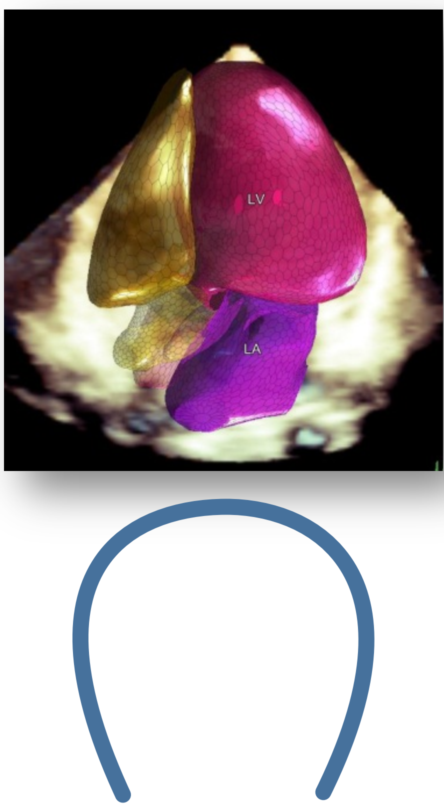
Avoids Geometric Assumptions

Model Requires Training: different heart shapes



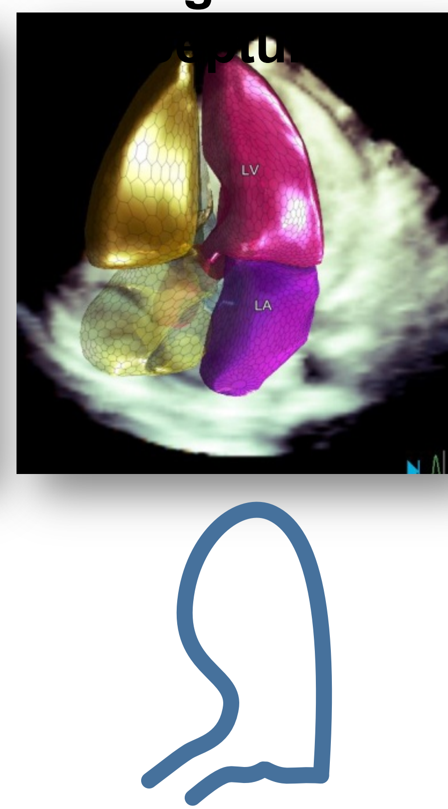
Real-Time Automated Transthoracic Three-Dimensional Echocardiographic Left Heart Chamber Quantification using an Adaptive Analytics Algorithm

Dilated

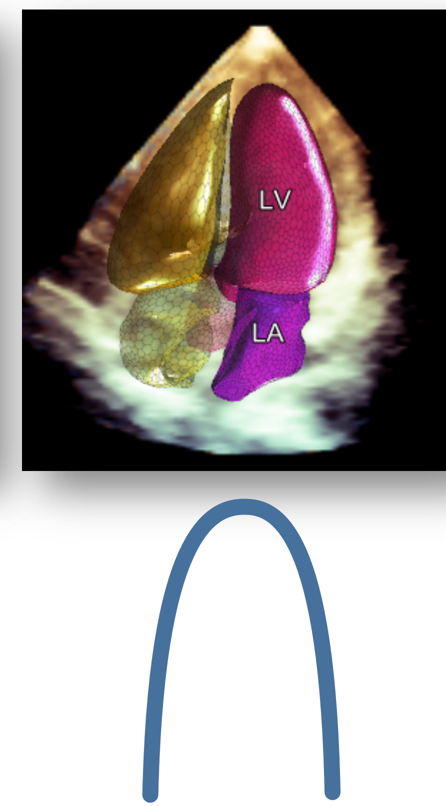


Banana

Sigmoid

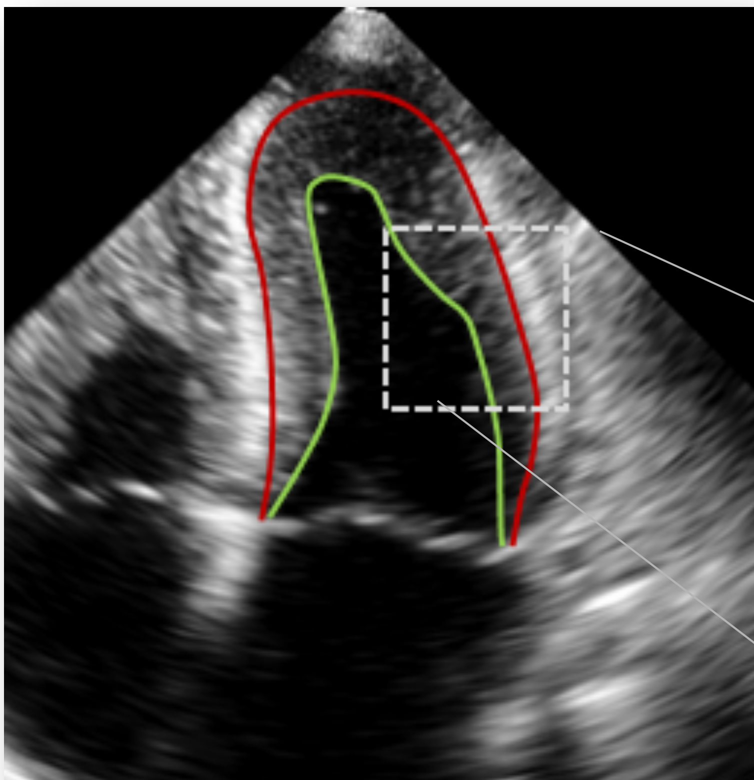


Normal



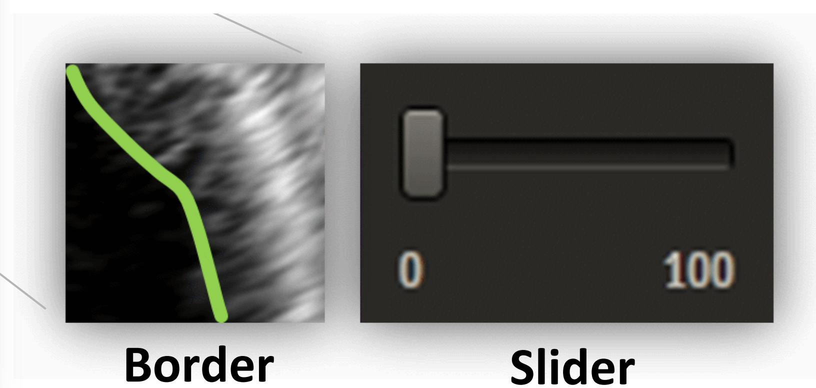
HeartModel algorithm detects 2 borders: Inner and Outer

- Inner border located at blood/tissue interface
- Outer border located at compacted myocardium interface



User-Configured 3D GLOBAL Border Position

- User-adjustable slider moves final border between inner and outer border
- Default slider position can be preset to user's preference
- Provides consistent behavior



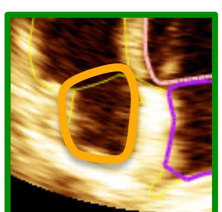
Fully Automated Cardiac Chamber Quantification

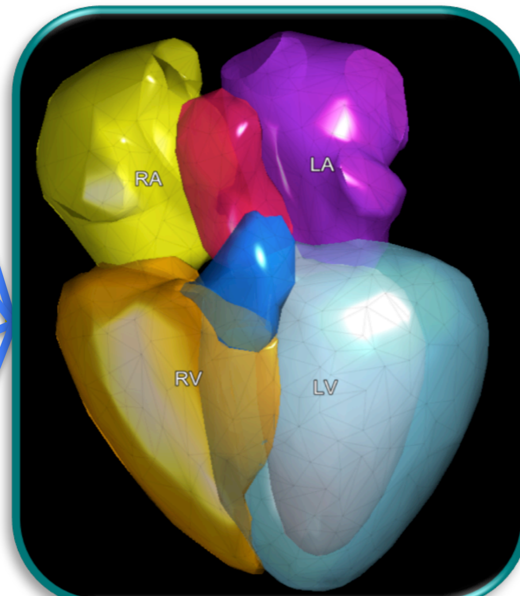
3D RV End-Diastolic Volume

3D RV End-Systolic Volume

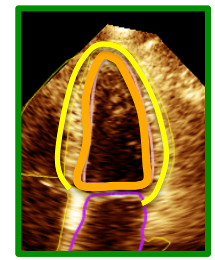
3D RV Ejection Fraction

3D RA Volume at LV End-Systole



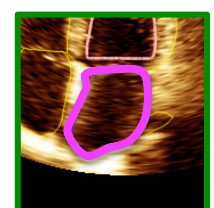


3D LV End-Diastolic Volume



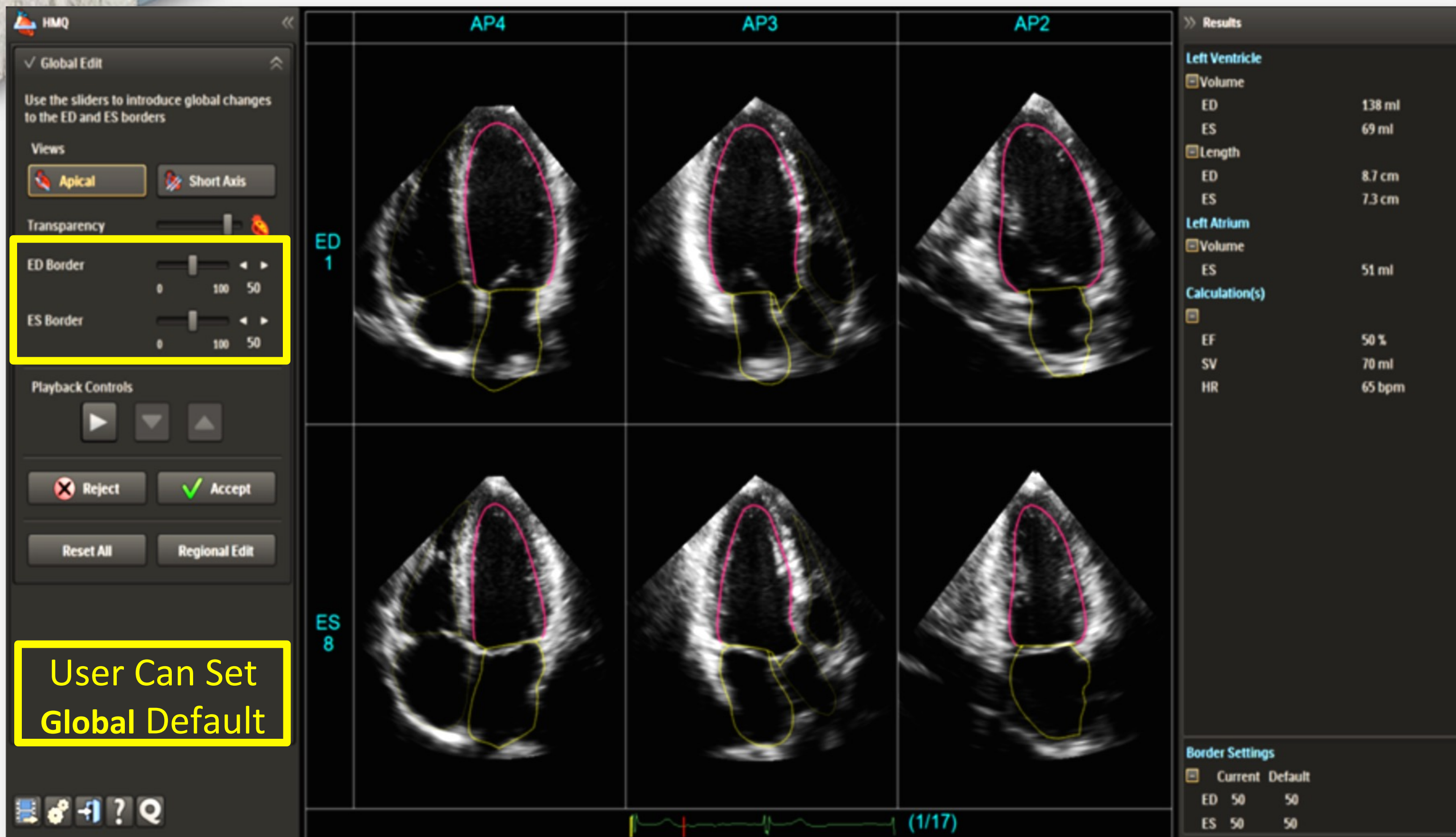
3D LV End-Systolic Volume

3D LV Ejection Fraction



3D LA Volume at LV End-Systole

Global Editing



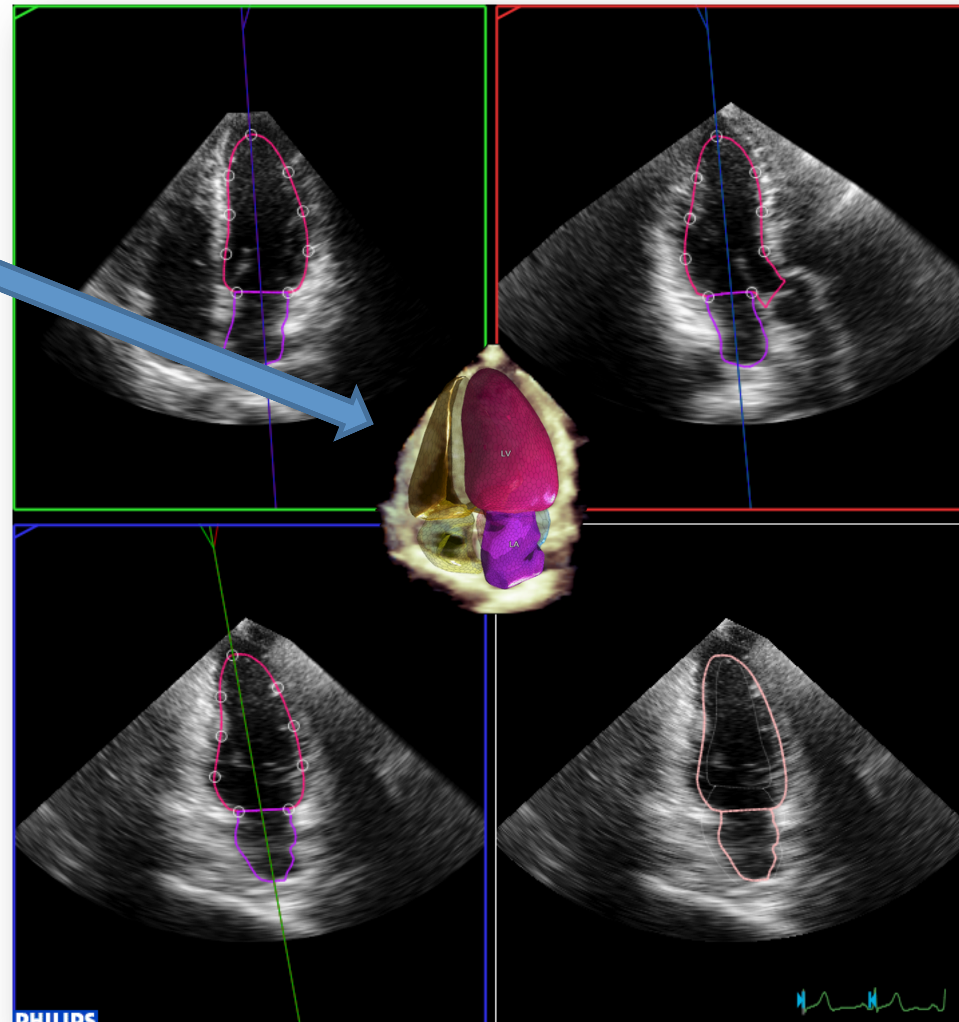
Edit Stage 1: Automated Views & Global Editing

- HeartModel 6-up display shows aligned Ap4, Ap3 and Ap2 views at ED and ES
- User can adjust “slider” at ED and ES to adjust global position of borders

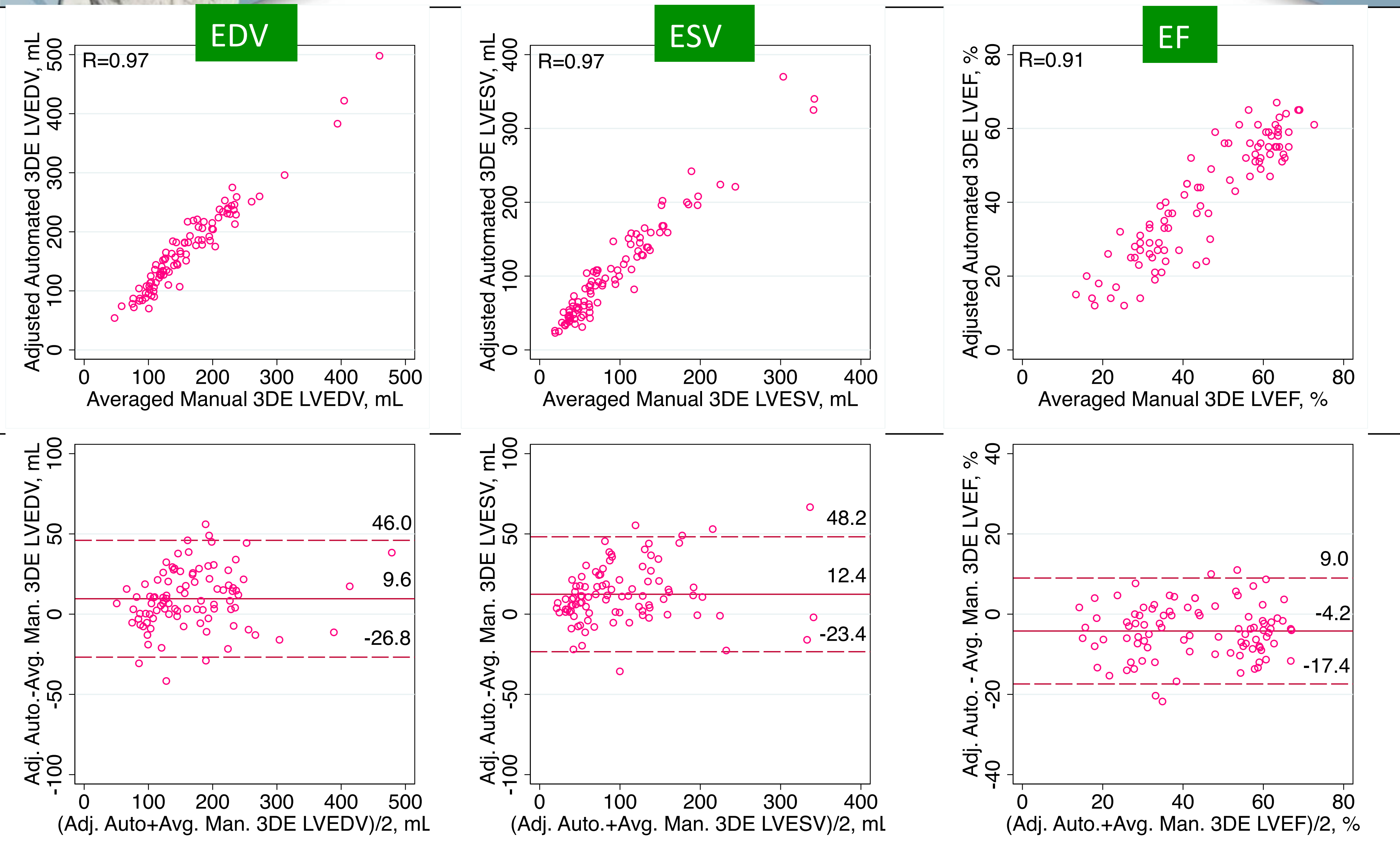
3D Regional Editing

Edit Stage 2: Regional Editing

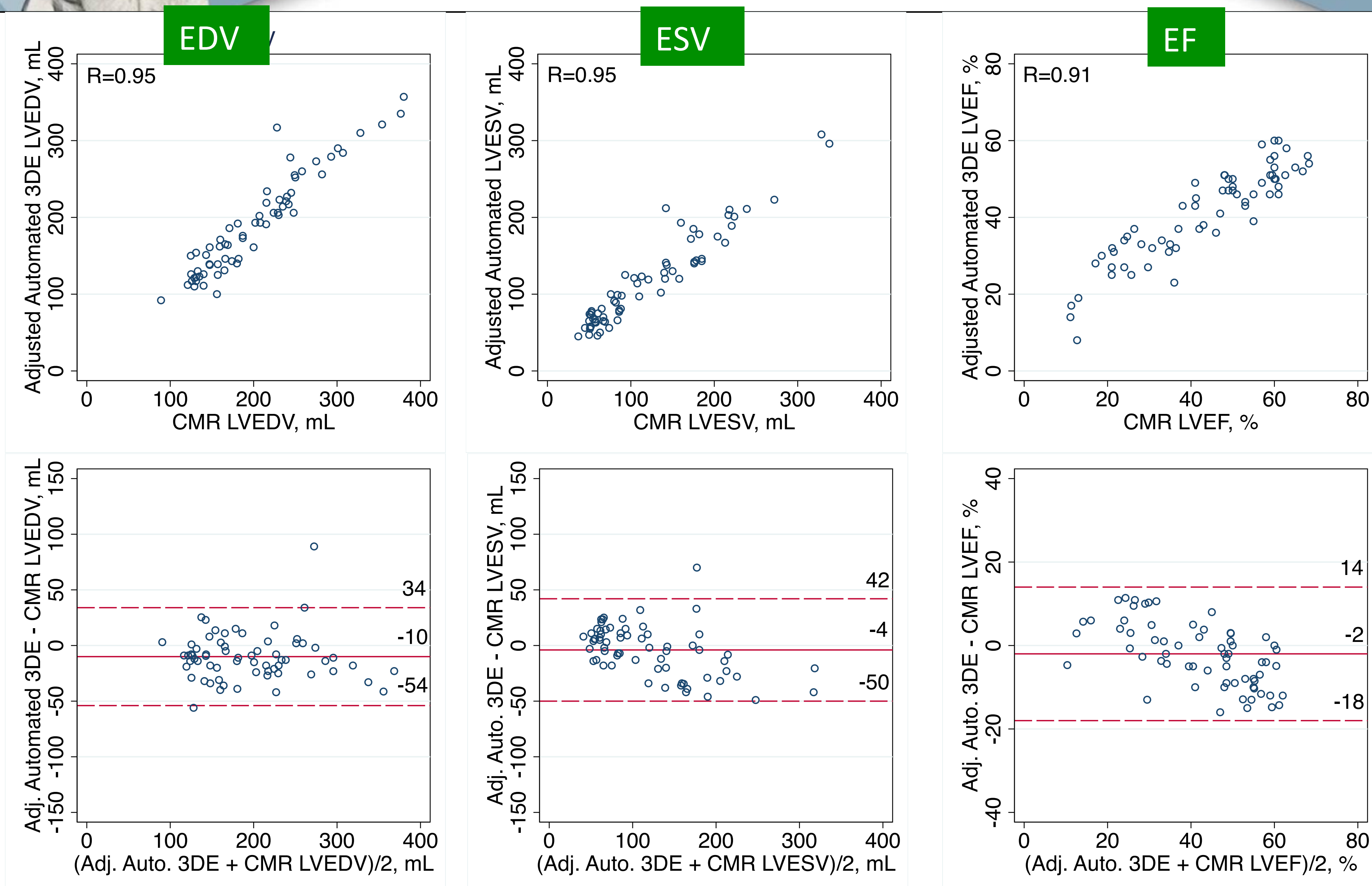
- **Edit impacts the entire 3D mesh**
- There may be heart shapes that require a regional edit to properly place the border
- Editing is done on 3 MPR views showing the Ap2, Ap3, and Ap4 views
- ***SMALL EDITS HAVE A MINOR IMPACT ON THE VOLUMES AND EF***



LV: Manual 3DE vs. Model with adjustments

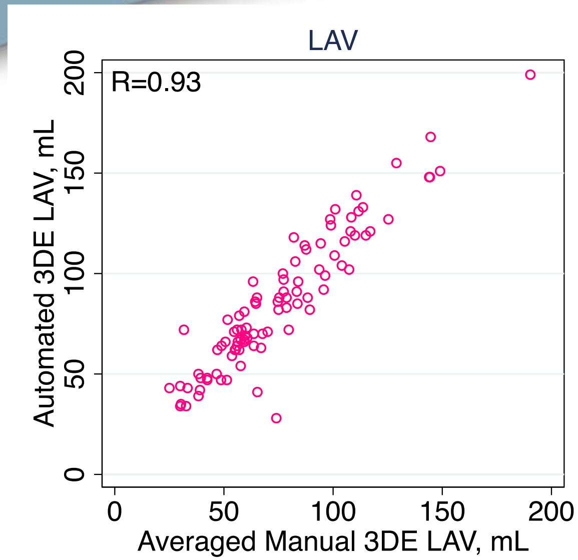


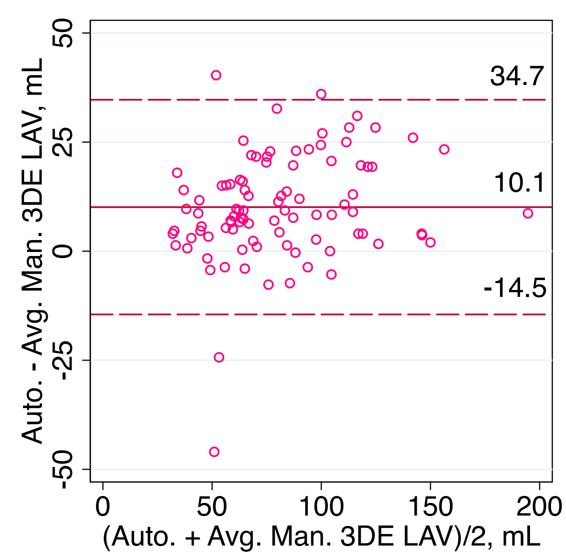
LV: Cardiac MRI vs. Model with adjustments

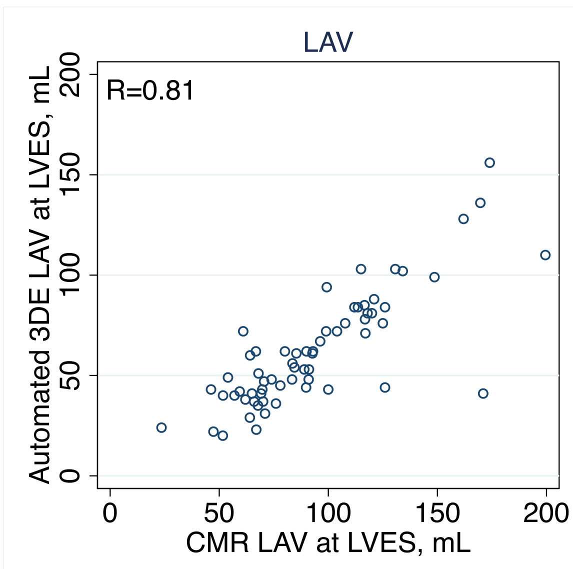


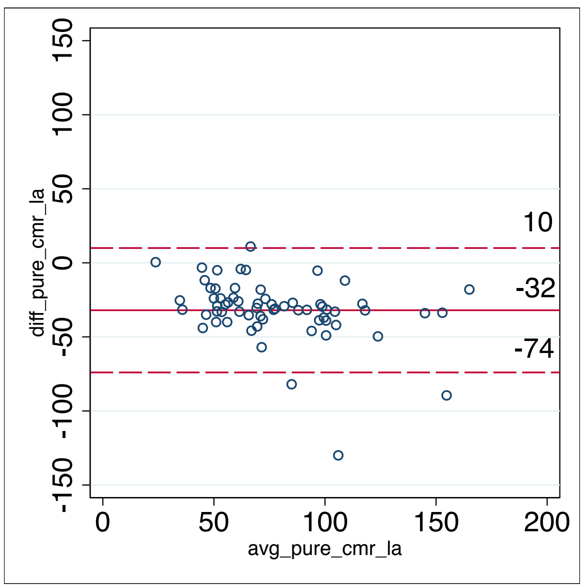
LA

Manual 3DE vs. Model









Model vs. CMR

Heart Model

- ➢FAST
- ➢EASY
- ➢REPRODUCIBLE