# 3D Models
# Mitral Valve

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# Disclosure

GE Healthcare

SIEMENS

PHILIPS

QLAB cardiac analysis

eSie Valve

TOMTEC

# Objectives

- Road map of 3D
- Describe types
- Recommedations
- Limitations

3D

DICOM FILE

- ECHO
- CT
- MRI

SEGMENTATION

# Road Map 3D modes MV

3 types

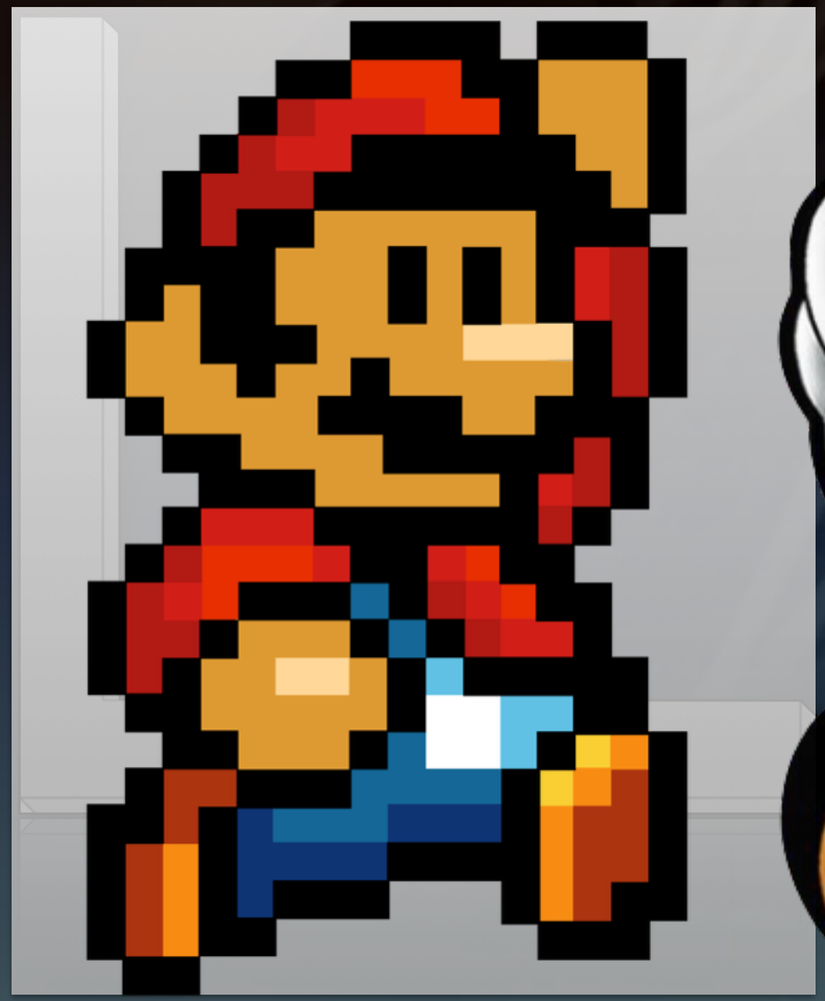
MODELS

QLab

TomTec

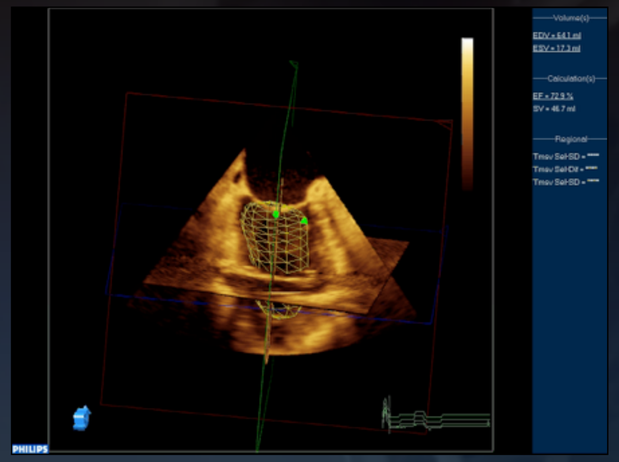
eSie Valve

# Overview: *Innovation*



# 3D acquisition: *RENDERING*

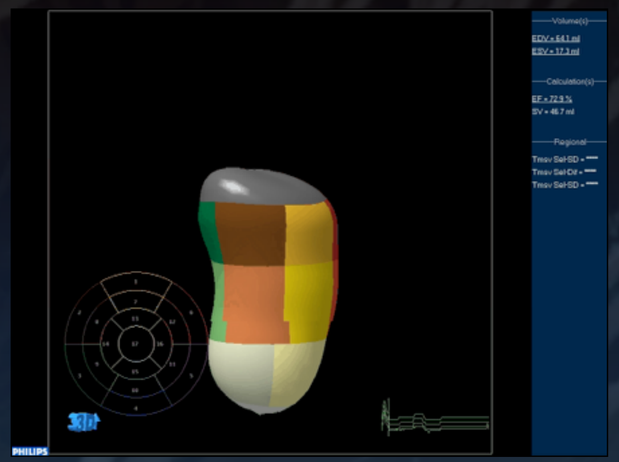
Wire Frame



Equidistant Points Connected

Flat Surface Structures

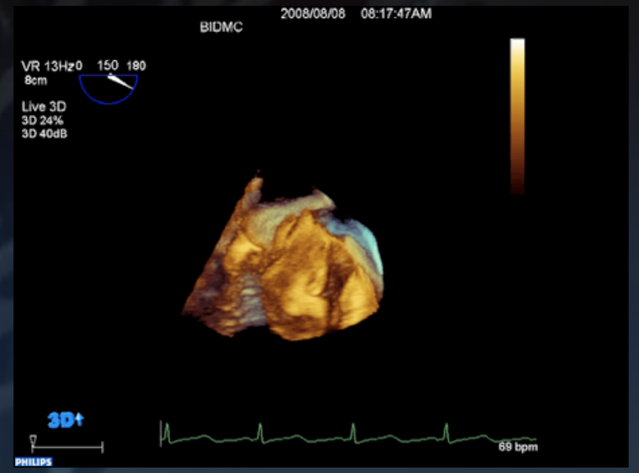
Surface Rendering



More Data Points

Hollow Structures

Volume Rendering




Most Complex

Intra-Cardiac Structure

# Overview: 3D acquisition

REAL BENEFIT?

…COOL IMAGES

# Advantage: 3D IMAGES

- Localization
- Mechanism
- Quantification
- Surgical Approach

Sugimoto, T., Dulgheru et al. What Does 3D Echocardiography Add to 2D Echocardiography in the Assessment of Mitral Regurgitation? Current Cardiology Reports, 19(10), 90.

# Overview: 3D acquisition

Curr Cardiol Rep (2017) 19: 90
DOI 10.1007/s11886-017-0901-7

CrossMark

ECHOCARDIOGRAPHY (JM GARDIN AND AH WALLER, SECTION EDITORS)

## What Does 3D Echocardiography Add to 2D Echocardiography in the Assessment of Mitral Regurgitation?

**Tadafumi Sugimoto[1,2] · Raluca Dulgheru[1,2] · Stella Marchetta[1,2] · Federica Ilardi[1,2] · Laura Contu[1,2] · Yun Yun Go[1,2] · Patrizio Lancellotti[1,2,3]**

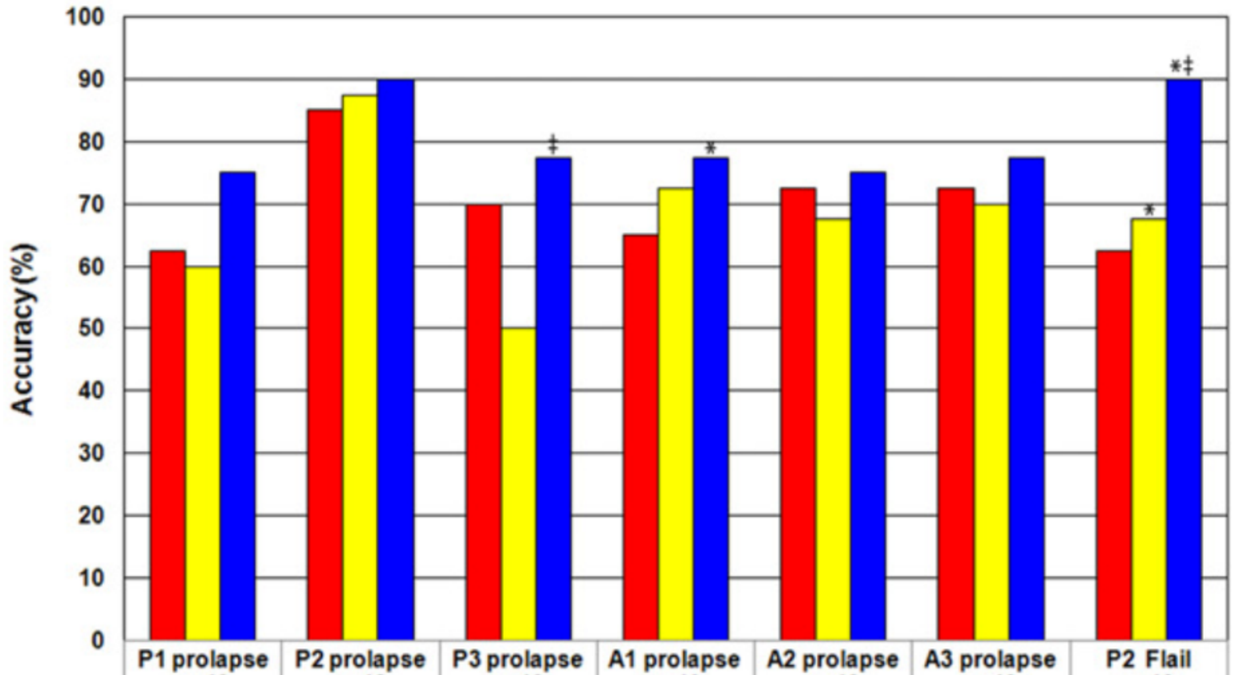
**Table 2** 2D and 3D-derived echocardiographic parameters obtainable in MR

| Mitral parameters | 2D TOE | 3D TOE |
|---|---|---|
| Annulus | | |
| Intercommissural distance | + | ++ |
| Septo-lateral distance | + | ++ |
| Perimeter | + | ++ |
| Annulus height | − | ++ |
| Annulus dynamics | − | ++ |
| Leaflets | | |
| Anterior leaflet area | − | ++ |
| Posterior leaflet area | − | ++ |
| Posterior leaflet angle | + | ++ |
| Anterior leaflet angle | + | ++ |
| Coaptation depth | + | ++ |
| Coaptation indexes | − | ++ |
| Leaflet coaptation area | − | ++ |
| Tenting area | + | ++ |
| Tenting volume | − | ++ |
| Interpapillary distance: | | |
| Papillary muscle tip | + | + |
| Papillary muscle body | + | + |
| Ventricle | | |
| LV end-diastolic volume | + | ++ |
| LV end-systolic volume | + | ++ |
| LV dyssynchrony (global/PMs) | + | ++ |
| Vena contracta shape | + | +++ |
| PISA shape | + | +++ |

*LV* left ventricle, *PISA* proximal isovelocity surface area, *PPM* papillary muscle, *TOE* transoesophageal echocardiography

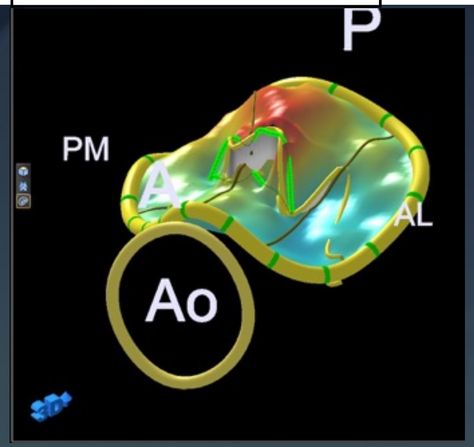
# Comparative Accuracy of Two- and Three-Dimensional Transthoracic and Transesophageal Echocardiography in Identifying Mitral Valve Pathology in Patients Undergoing Mitral Valve Repair: Initial Observations

phen H. Little, MD, Miguel A. Quinones, MD,
lizabeth L. Herrera, MD, Gerald M. Lawrie, MD,
, MD, *Houston, Texas*




| | P1 prolapse n=40 | P2 prolapse n=40 | P3 prolapse n=40 | A1 prolapse n=40 | A2 prolapse n=40 | A3 prolapse n=40 | P2 Flail n=40 |
|---|---|---|---|---|---|---|---|
| 3D TTE | 62.5 | 85 | 70 | 65 | 72.5 | 72.5 | 62.5 |
| 2D TEE | 60 | 87.5 | 50 | 72.5 | 67.5 | 70 | 67.5 |
| 3D TEE | 75 | 90 | 77.5 | 77.5 | 75 | 77.5 | 90 |

Models ?

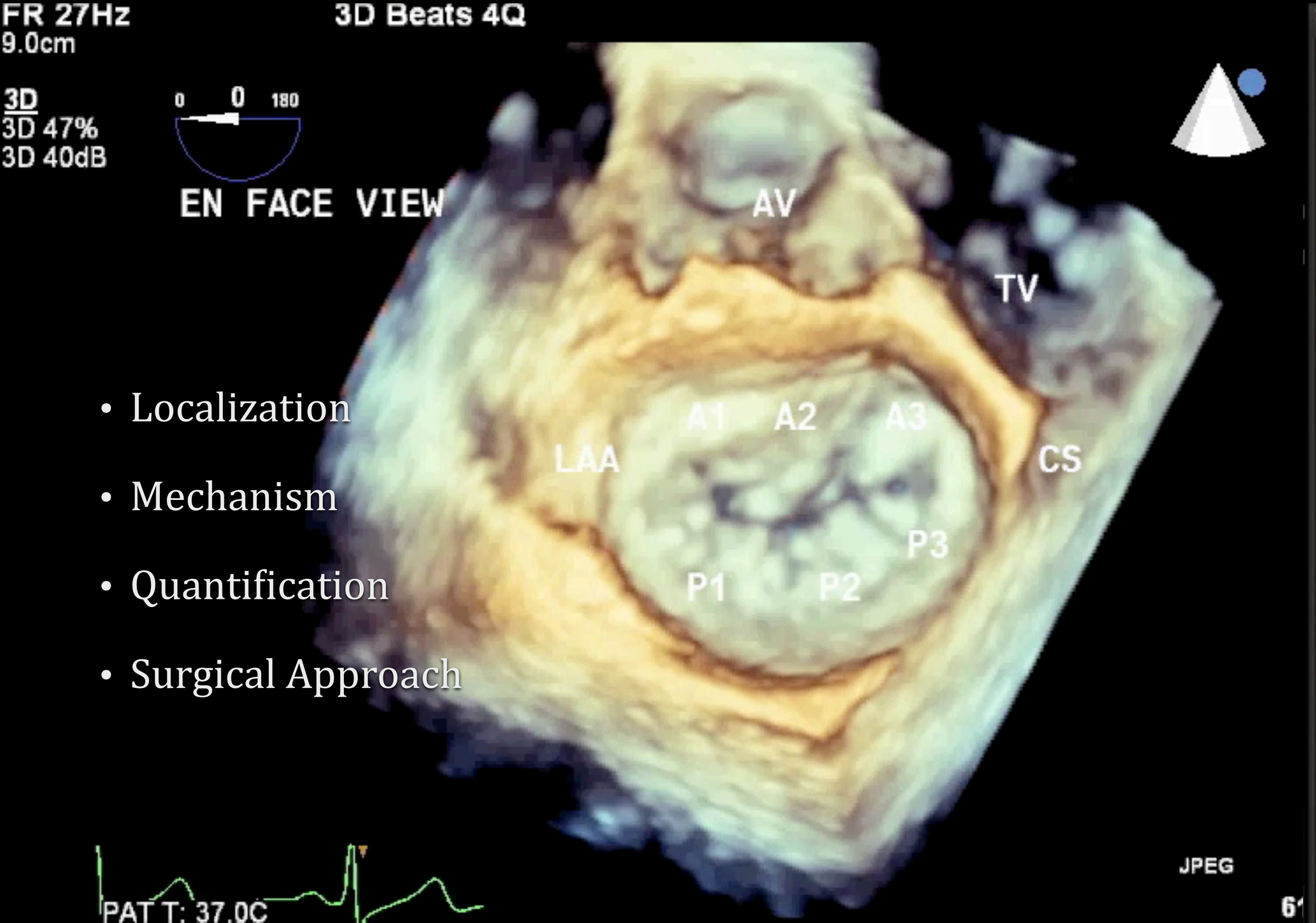


# Real-Time Three-Dimensional Transesophageal Echocardiography: Improvements in Intraoperative Mitral Valve Imaging

Maximilian Dominik Hien, MD,* Helmut Rauch, MD,† Artur Lichtenberg, MD,‡ Raffaele De Simone, MD,§ Marc Weimer, DSc,‖ Oriana Amanda Ponta, MSc,‖ and Christian Rosendal, MD, DESA†

**Table 6. Analysis of Localization per Scallop: Three-Dimensional Transesophageal Echocardiography Versus Two-Dimensional Transesophageal Echocardiography and Surgical Inspection**

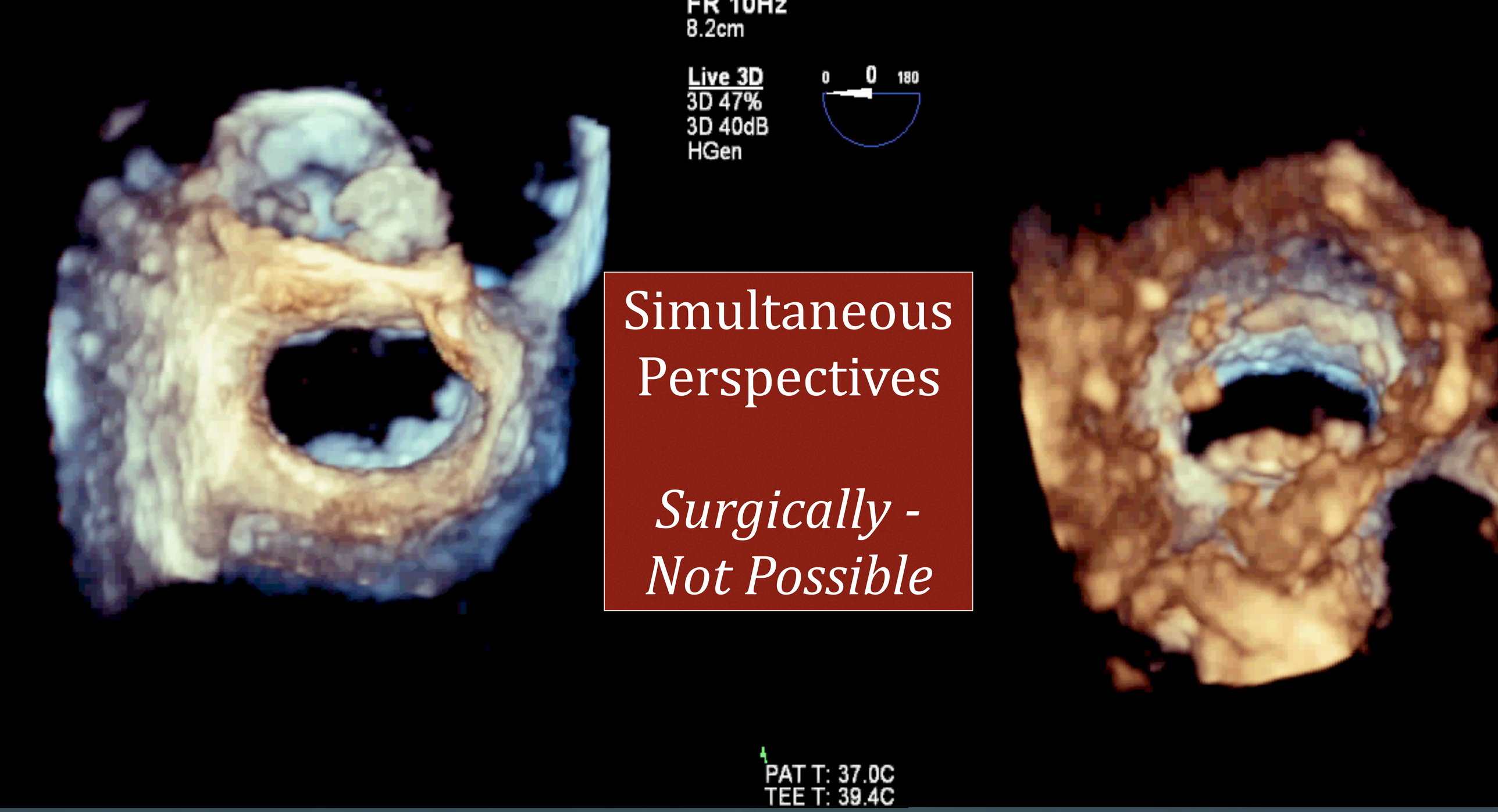
| | | Sensitivity % | | Specificity % | | Accuracy % | | |
|---|---|---|---|---|---|---|---|---|
| | True count | 3D | 2D | 3D | 2D | 3D | 2D | *P* (2-tailed) |
| Prolapse (per scallop) | | | | | | | | |
| A1 | 4 | 100.0 | 50.0 | 98.3 | 98.3 | 98.4 | 95.2 | 0.317 |
| A2 | 7 | 85.7 | 42.9 | 98.2 | 90.9 | 96.8 | 85.5 | 0.020* |
| A3 | 7 | 100.0 | 57.1 | 94.5 | 96.4 | 95.2 | 91.9 | 0.480 |
| P1 | 13 | 84.6 | 69.2 | 91.8 | 71.4 | 90.3 | 71.0 | 0.005* |
| P2 | 45 | 97.8 | 80.0 | 100.0 | 88.2 | 98.4 | 82.3 | 0.002* |
| P3 | 8 | 75.0 | 62.5 | 90.7 | 90.7 | 88.7 | 87.1 | 0.782 |
| Chordae (per scallop) | | | | | | | | |
| A1 | 1 | 0.0 | 0.0 | 100.0 | 100.0 | 98.4 | 98.4 | 1.000 |
| A2 | 2 | 100.0 | 0.0 | 100.0 | 96.7 | 100.0 | 93.5 | 0.046* |
| A3 | 1 | 100.0 | 0.0 | 98.4 | 100.0 | 98.4 | 98.4 | 1.000 |
| P1 | 7 | 100.0 | 28.6 | 96.4 | 96.4 | 96.8 | 88.7 | 0.096 |
| P2 | 28 | 82.1 | 35.7 | 100.0 | 94.1 | 91.9 | 67.7 | <0.001* |
| P3 | 5 | 80.0 | 40.0 | 100.0 | 96.5 | 98.4 | 91.9 | 0.102 |
| Cleft | 22 | 77.3 | | 82.5 | | 80.6 | | |




- Localization
- Mechanism
- Quantification
- Surgical Approach

Results

| | |
|---|---|
| MV Ann2D Circ | 113.5 mm |
| MV Ann2D Area | 986.8 mm² |
| MV Ann3D Min Area | 1077.3 mm² |
| MV Ann 2D/3D Min A | 91.6 % |
| MV Ann 2D/3D Circ | 89.6 % |
| MV Ann Ellipsicity | 101.2 % |
| Leaflet Area | |
| Leaflet Volume | |
| Leaflet Len./Ang. | |
| MV A1 | ***** mm |
| MV A2 | ***** mm |
| MV A3 | ***** mm |
| MV P1 | ***** mm |
| MV P2 | ***** mm |
| MV P3 | ***** mm |
| MV A2 Total | ***** mm |
| MV P2 Total | ***** mm |
| MV Ant Leaf Angle | 20.0 ° |
| MV Post Leaf Angle | 37.2 ° |
| MV Nonplanar Angle | 122.8 ° |
| MV A2 2D Direct | ***** mm |
| MV P2 2D Direct | ***** mm |
| MV Tenting Height | 2.9 mm |
| MV Prolapse Height | 4.2 mm |
| Coaptation | |
| Aortic-Mitral | |


FR 10Hz
8.2cm
Live 3D
3D 47%
3D 40dB
HGen
0 0 180
Simultaneous Perspectives
*Surgically - Not Possible*
PAT T: 37.0C
TEE T: 39.4C

©yannis amador

# 3D MODELS

# 3D Models

Brands

3

Off-line

# 3D Models

PHILIPS → QLAB cardiac analysis

GE Healthcare → TOMTEC

SIEMENS → eSie Valve

Off-line

3D

DICOM FILE

- ECHO
- CT
- MRI

SEGMENTATION

# Road Map 3D models MV

MODELS

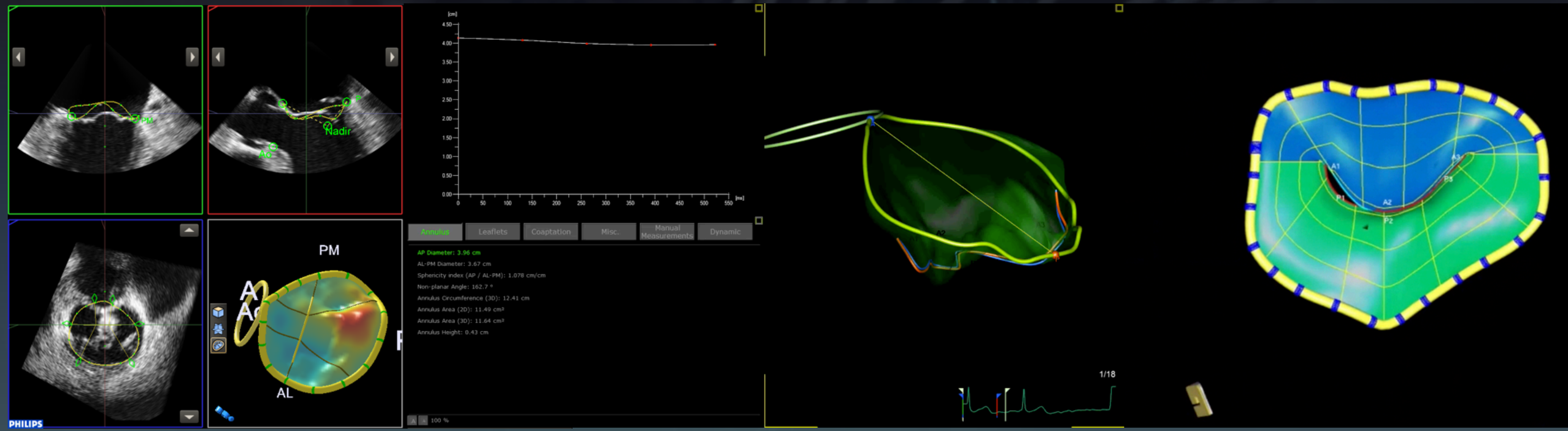
QLab

TomTec

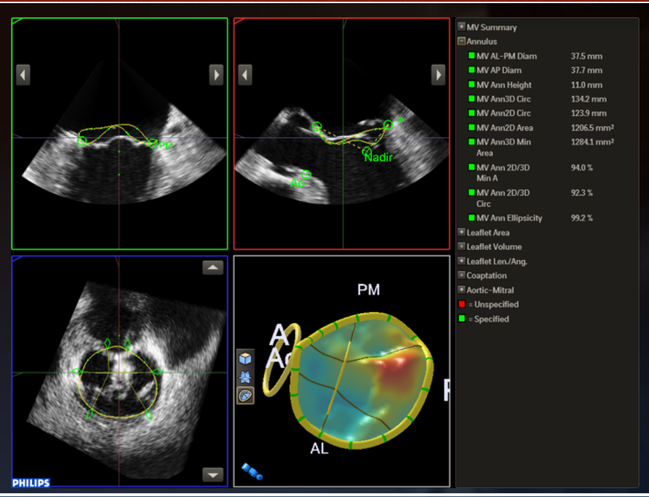
eSie Valve

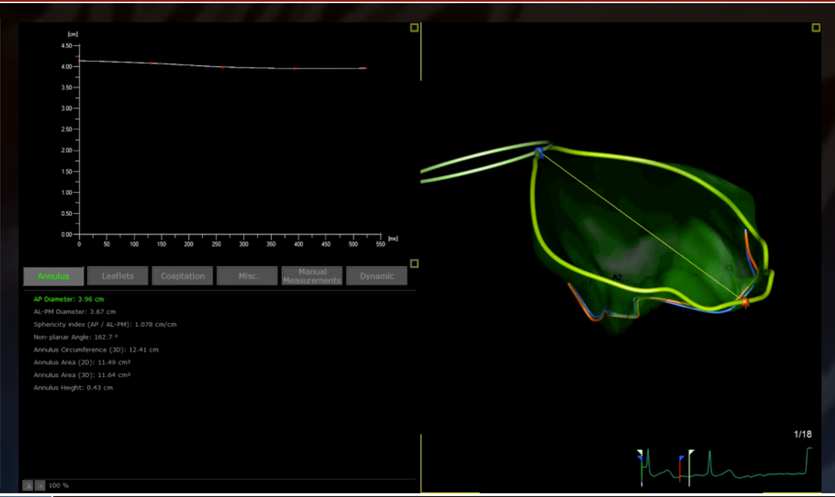
# Overview: 3D MODELS

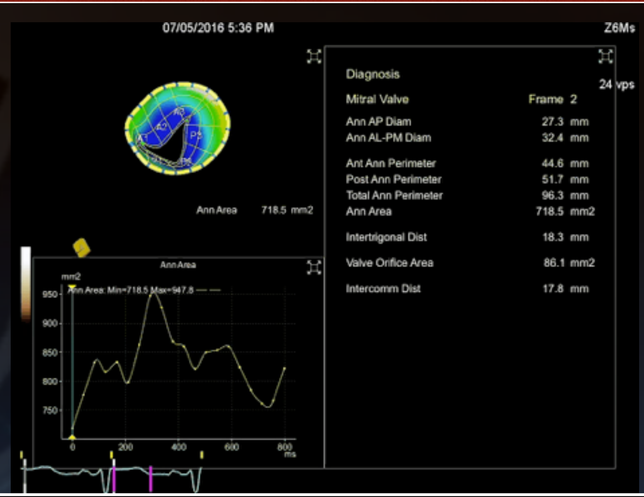
| Philips<br>QLab-MVN | GE<br>Tomtec/MV4D | Siemens<br>e Sie valve |
|---|---|---|



# Overview: 3D MODELS



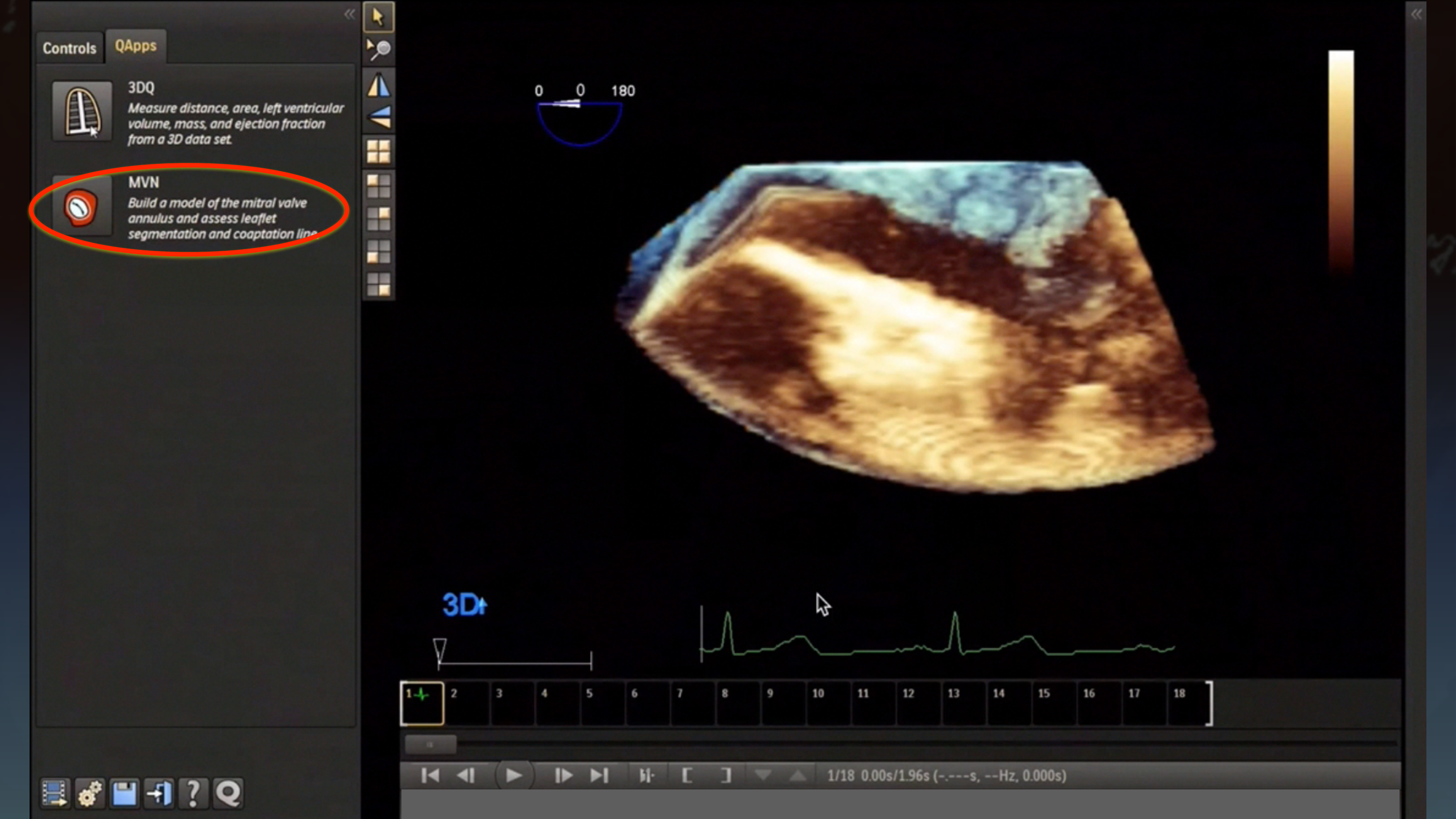




| Philips MVN |
| --- |
| Semi-Automated |
| Static |
| Philips only |

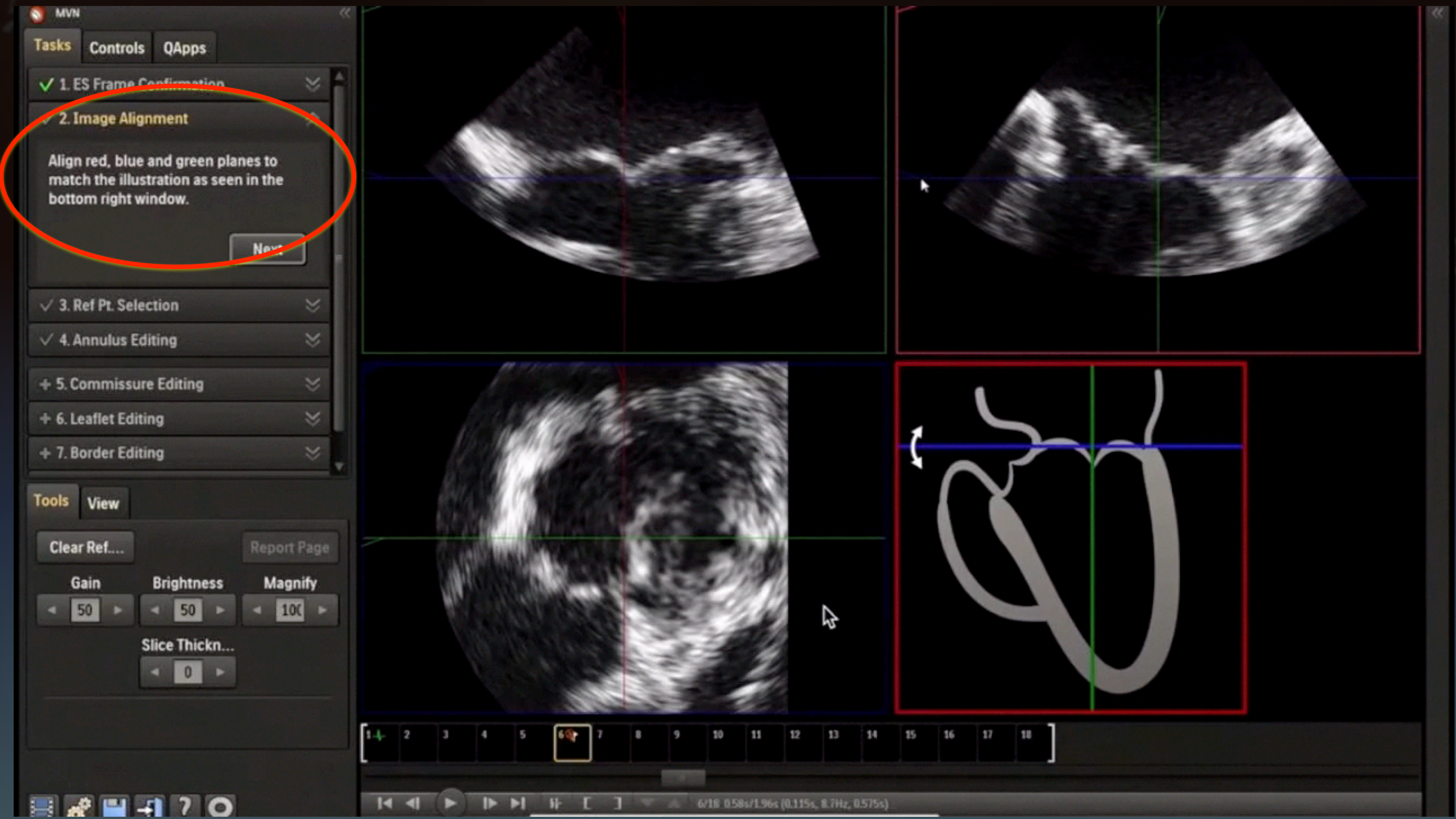
# Overview: 3D MV Model -QLab

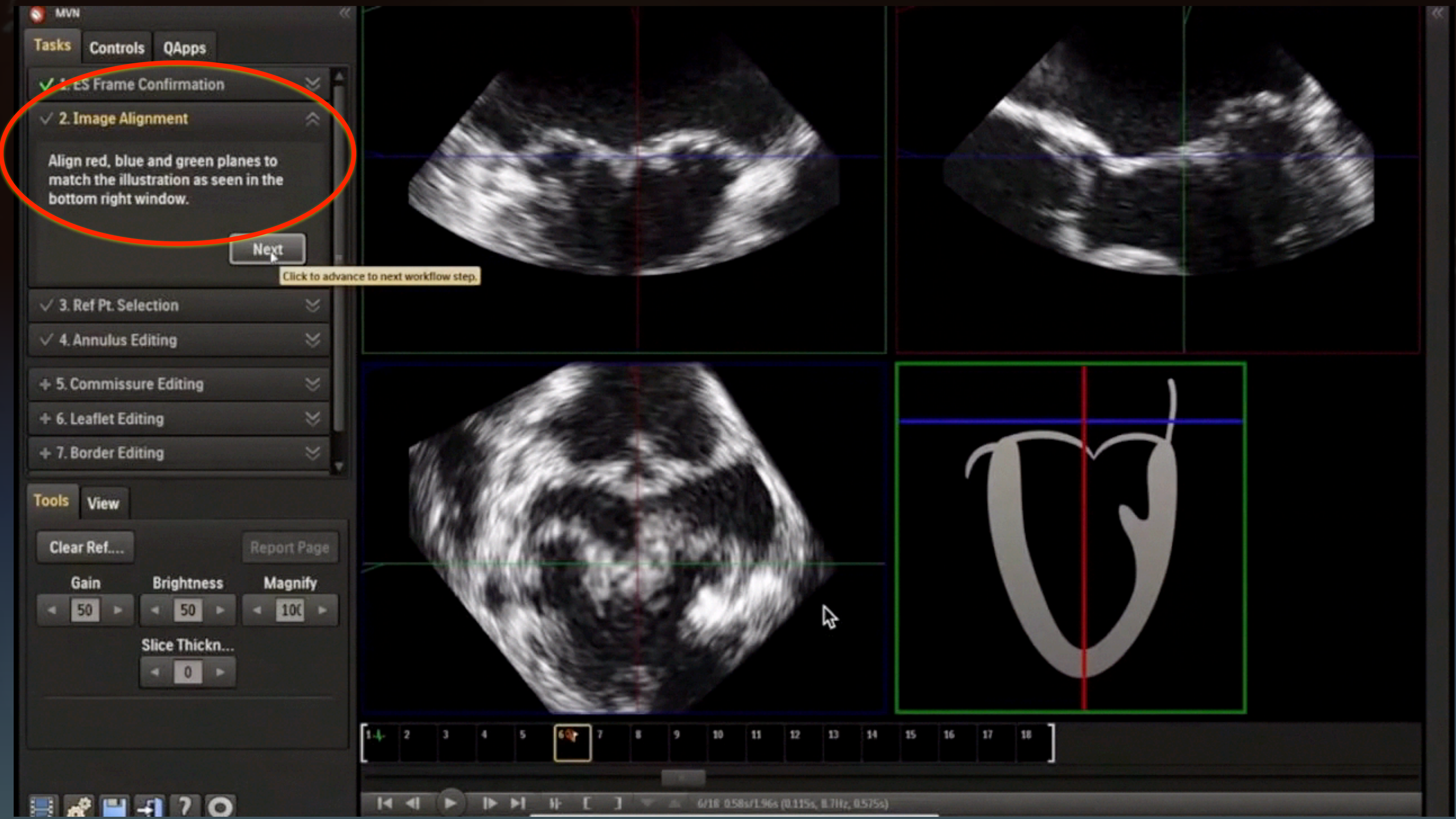
Anatomy of Mitral Valve Navigation

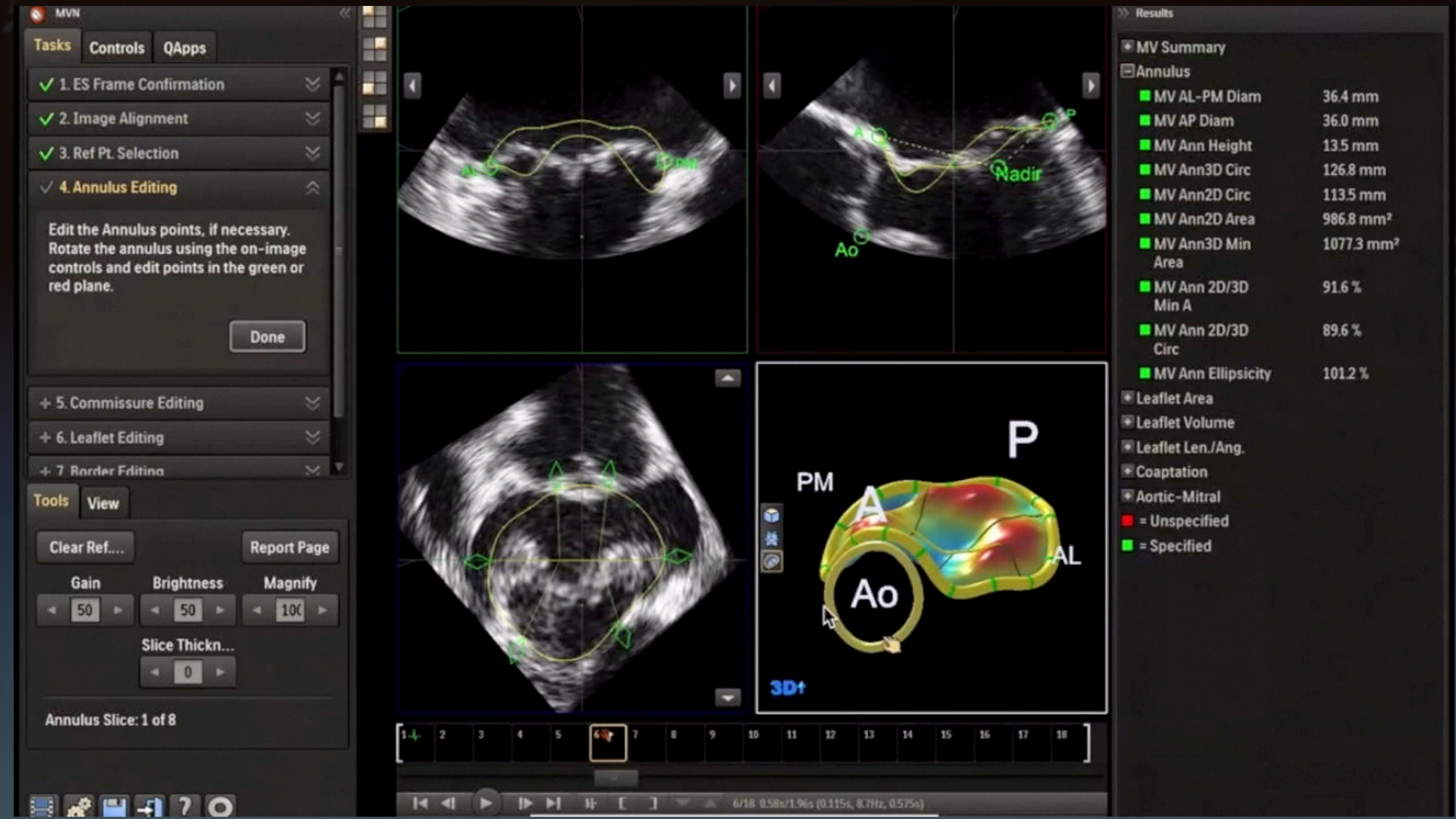
MVN

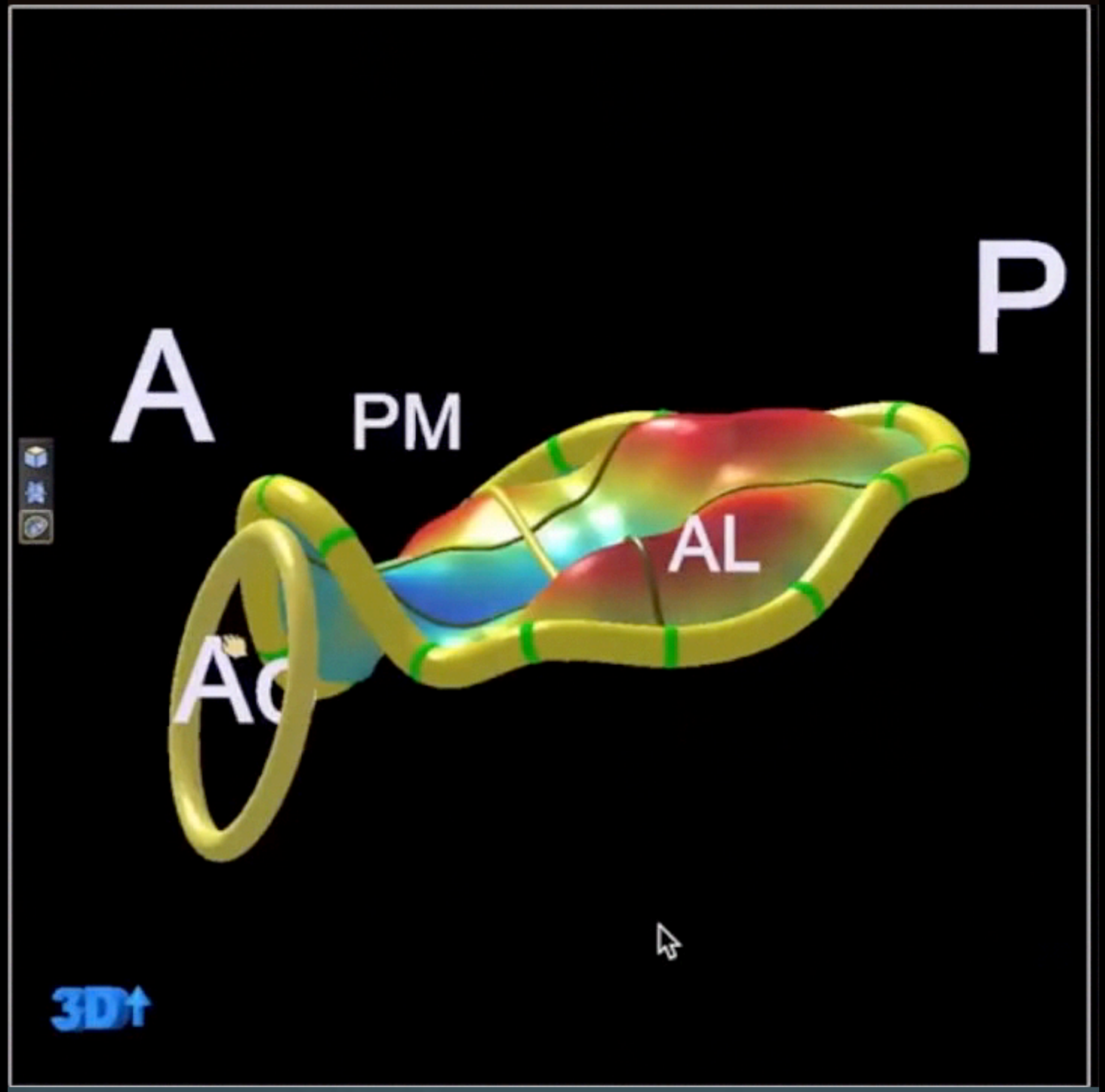

Controls
QApps
3DQ
Measure distance, area, left ventricular volume, mass, and ejection fraction from a 3D data set.
MVN
Build a model of the mitral valve annulus and assess leaflet segmentation and coaptation line
0
0
180
3D
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
1/18 0.00s/1.96s (-.---s, --Hz, 0.000s)

MVN
Tasks
Controls
QApps
1. ES Frame Confirmation
Confirm
2. Image Alignment
3. Ref Pt. Selection
4. Annulus Editing
5. Commissure Editing
6. Leaflet Editing
7. Border Editing
Tools
View
Clear Ref...
Report Page
Gain
Brightness
Magnify
50
50
100
Slice Thickn...
0
End Systole
Last frame before OPENS


MVN
Tasks
Controls
QApps
1. ES Frame Confirmation
2. Image Alignment
Align red, blue and green planes to match the illustration as seen in the bottom right window.
Next
3. Ref Pt. Selection
4. Annulus Editing
5. Commissure Editing
6. Leaflet Editing
7. Border Editing
Tools
View
Clear Ref....
Report Page
Gain
Brightness
Magnify
50
50
100
Slice Thickn...
0


MVN
Tasks
Controls
QApps
1. ES Frame Confirmation
2. Image Alignment
Align red, blue and green planes to match the illustration as seen in the bottom right window.
Next
Click to advance to next workflow step.
3. Ref Pt. Selection
4. Annulus Editing
5. Commissure Editing
6. Leaflet Editing
7. Border Editing
Tools
View
Clear Ref....
Report Page
Gain
Brightness
Magnify
50
50
100
Slice Thickn...
0

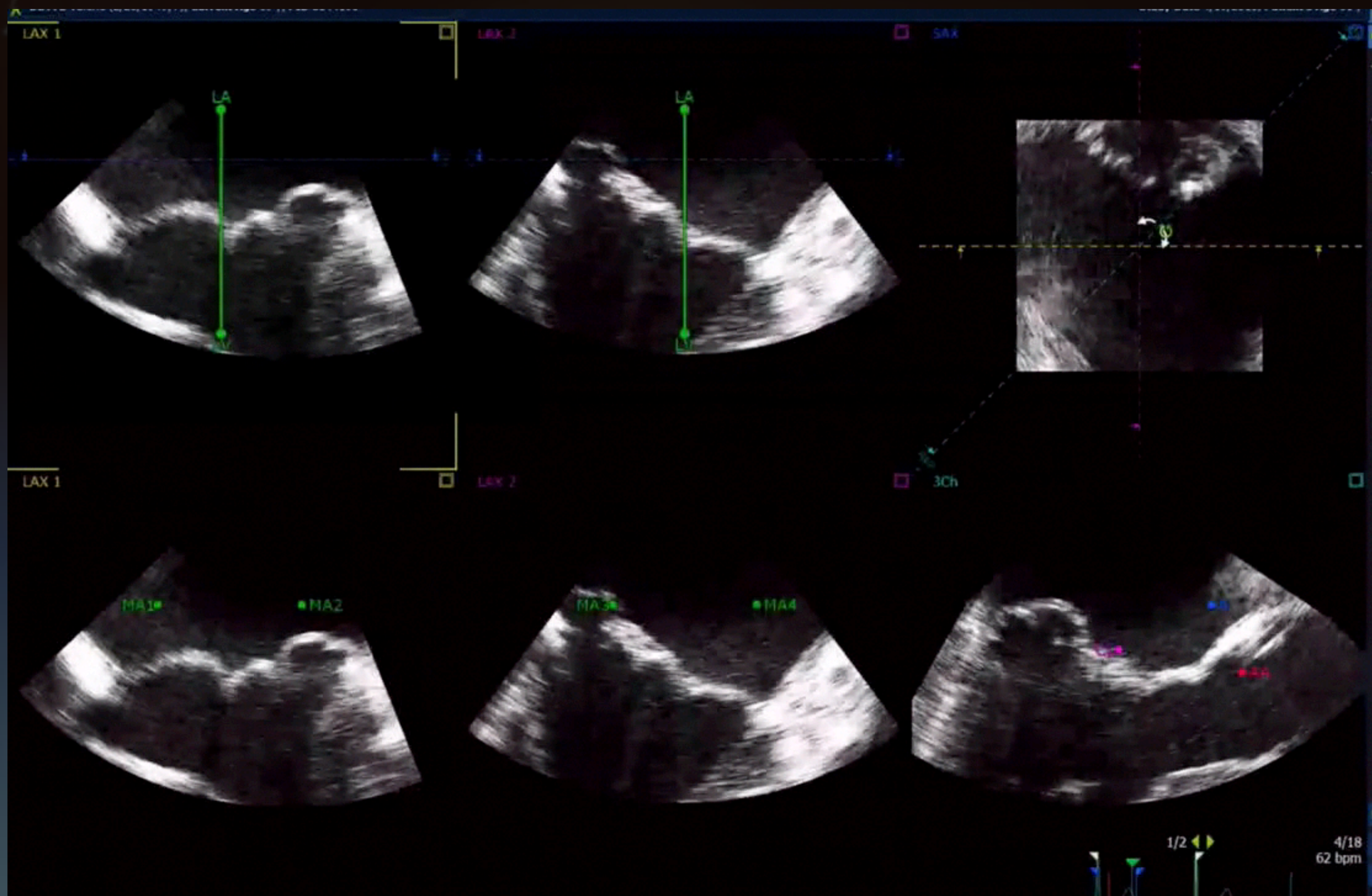

MVN
Tasks
Controls
QApps
1. ES Frame Confirmation
2. Image Alignment
3. Ref Pt. Selection
4. Annulus Editing
Edit the Annulus points, if necessary. Rotate the annulus using the on-image controls and edit points in the green or red plane.
Done
5. Commissure Editing
6. Leaflet Editing
7. Border Editing
Tools
View
Clear Ref....
Report Page
Gain
Brightness
Magnify
50
50
100
Slice Thickn...
0
Annulus Slice: 1 of 8
AL
PM
A
P
Nadir
Ao
P
PM
A
AL
Ao
3D
Results
MV Summary
Annulus
MV AL-PM Diam 36.4 mm
MV AP Diam 36.0 mm
MV Ann Height 13.5 mm
MV Ann3D Circ 126.8 mm
MV Ann2D Circ 113.5 mm
MV Ann2D Area 986.8 mm²
MV Ann3D Min Area 1077.3 mm²
MV Ann 2D/3D Min A 91.6 %
MV Ann 2D/3D Circ 89.6 %
MV Ann Ellipsicity 101.2 %
Leaflet Area
Leaflet Volume
Leaflet Len./Ang.
Coaptation
Aortic-Mitral
= Unspecified
= Specified

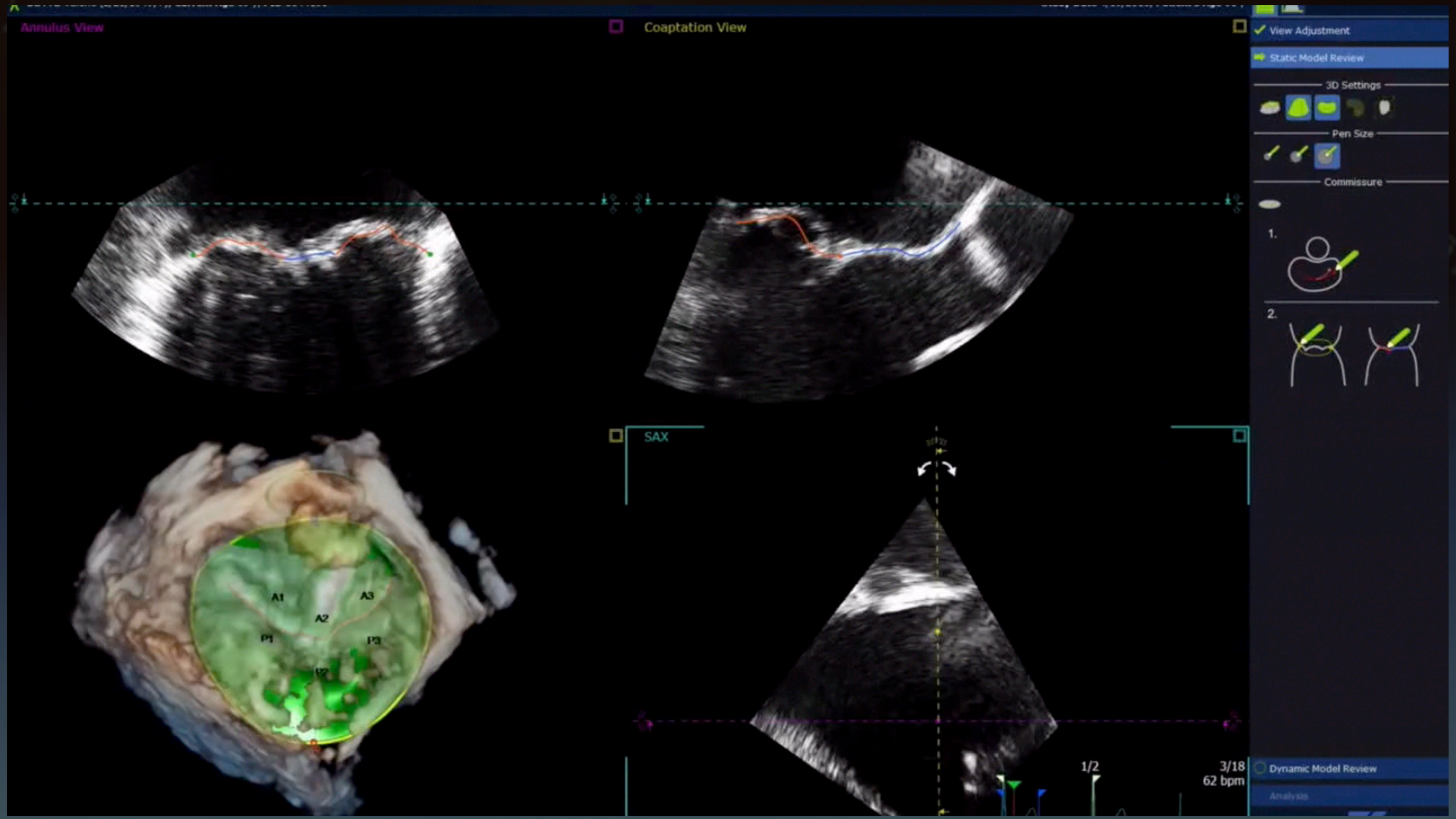

A
PM
P
AL
3D

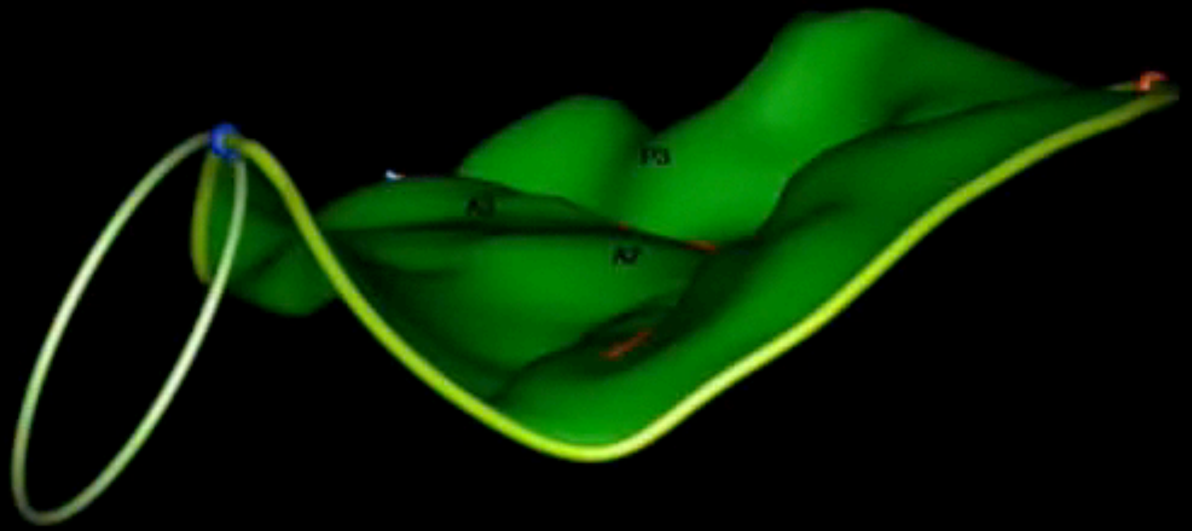
# Overview: TomTec

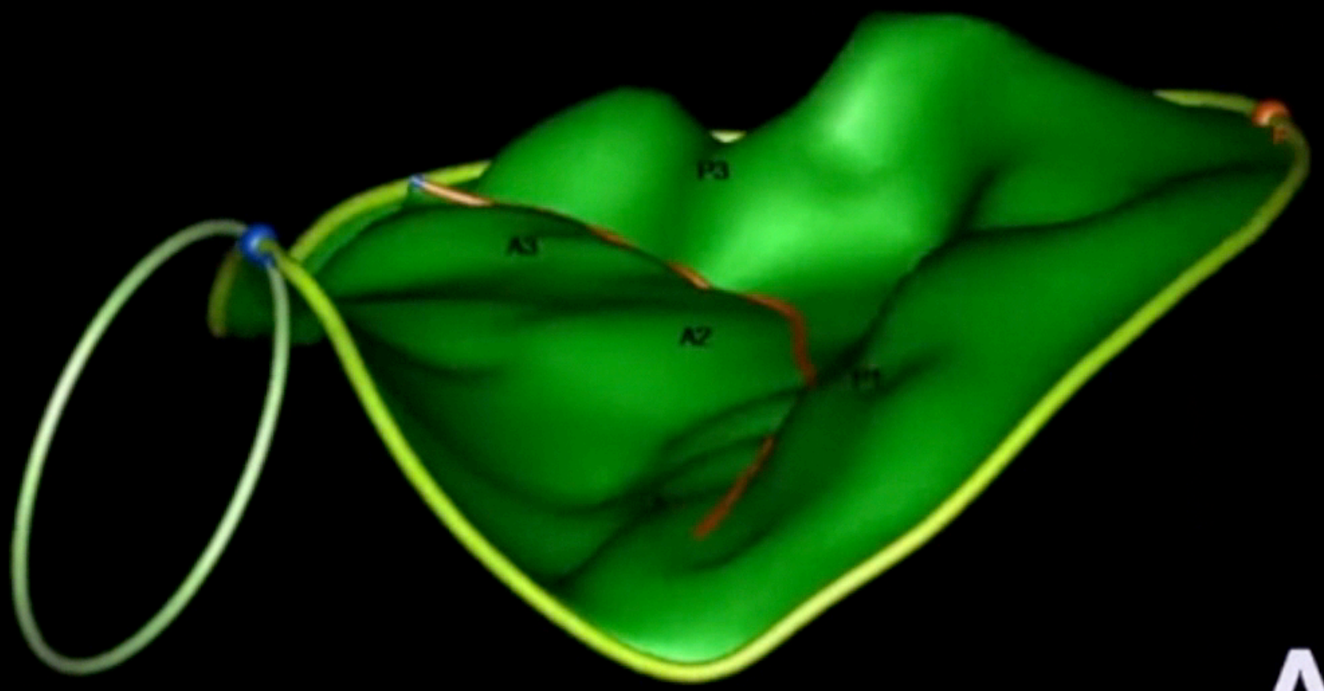
## Anatomy of TomTec

TOMTEC
TOMTEC
IMAGING SYSTEMS GMBH
Edisonstrasse 6
85716 Unterschleissheim
Germany/Allemagne/Almanya
http://www.tomtec.de
Copyright © TOMTEC IMAGING SYSTEMS GMBH
All rights reserved
TOMTEC-ARENA™ TTA2
Image-Com©


LAX 1
LAX 2
SAX
LA
LA
3Ch
LAX 1
MA1
MA2
MA3
MA4
AA
1/2
4/18
62 bpm
View Adjustment
Cardiac Cycle
Aortic Annulus
1.
2.
3.
4.
5.
6.
Static Model Review
Dynamic Model Review
Analysis

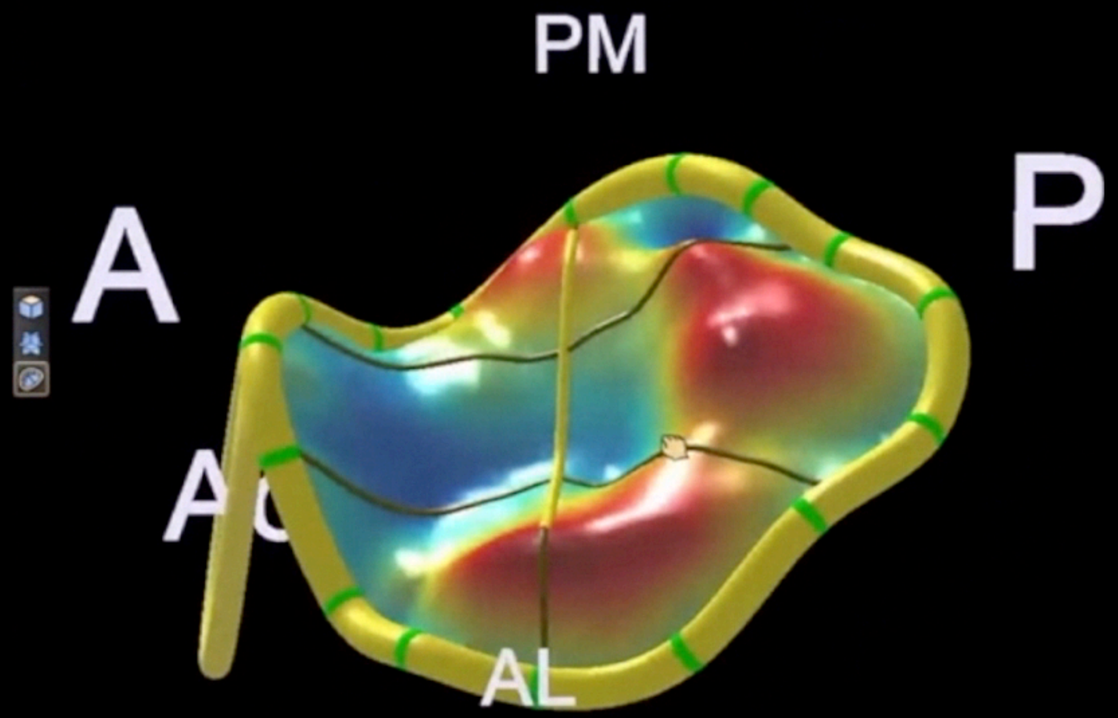

Annulus View
Coaptation View
SAX
A1
A2
A3
P1
P2
P3
View Adjustment
Static Model Review
3D Settings
Pen Size
Commissure
1.
2.
Dynamic Model Review
Analysis
1/2
3/18
62 bpm






TomTec

QLab



# Overview: eSie Valves

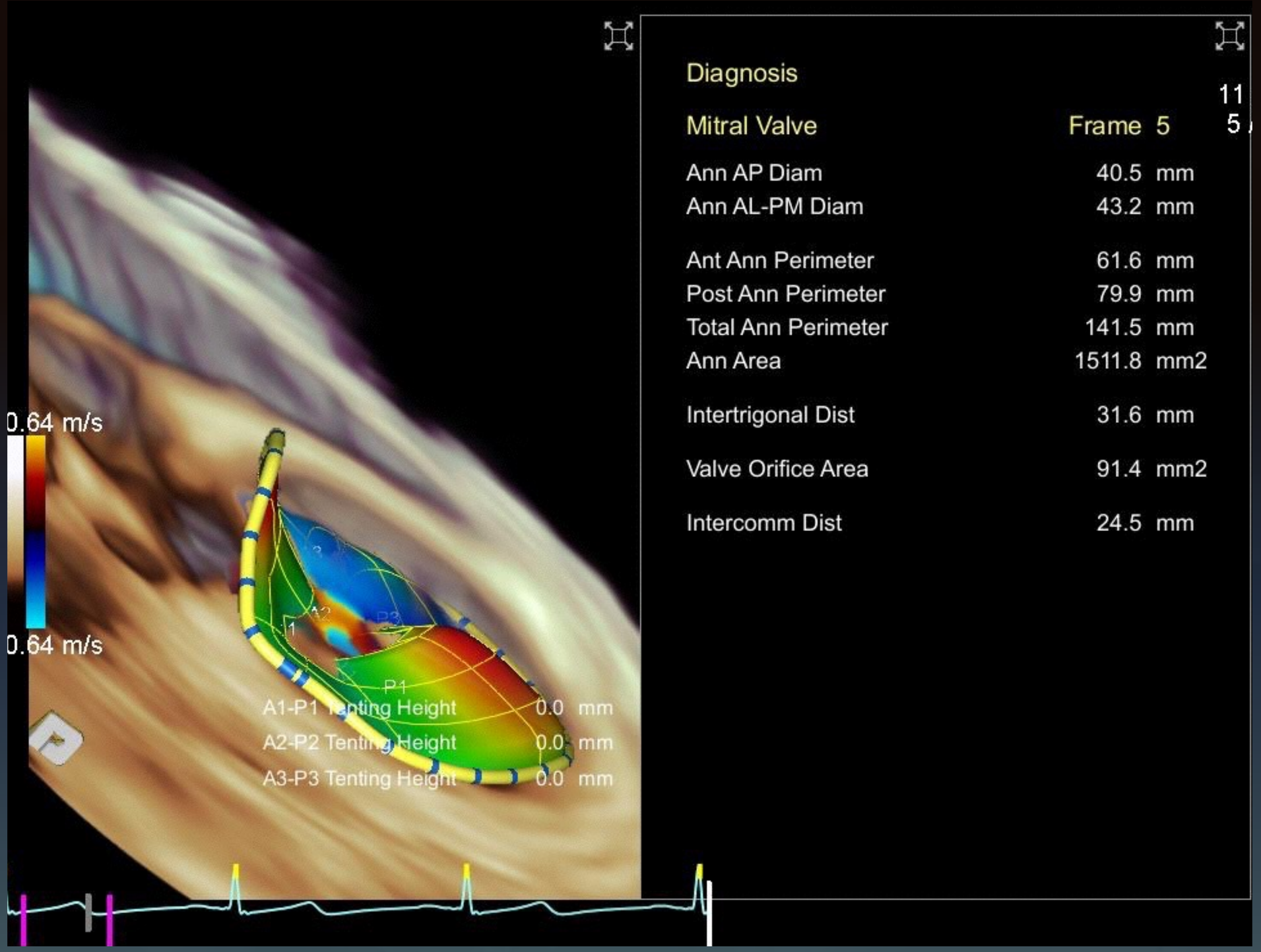
## Anatomy of eSie Valves

## SC 2000

Browse Refresh Select Dicom tags Export Close Selection Criteria: auto C:/Users/API1_Admin/Desktop/EZ

DICOM list

Load Image Copy Convert 0 Play/Stop Prev Next Gen. full 2D Copy both 2D-3D Fit Dicom Tags Adjust IM

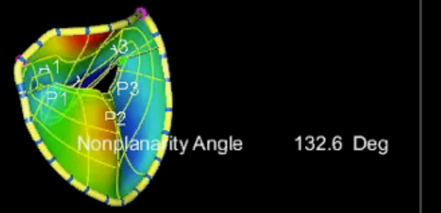



Diagnosis

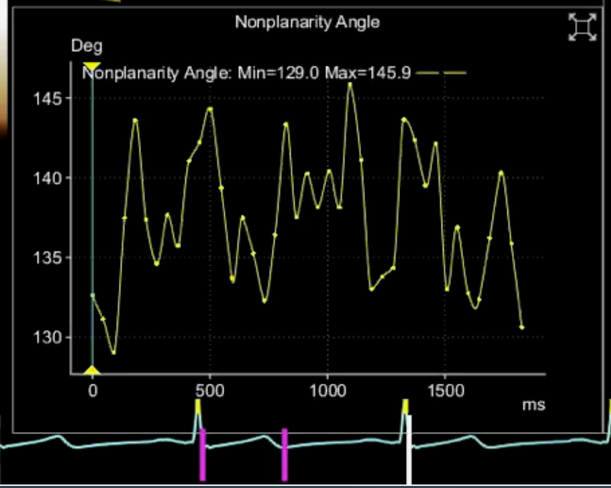
11
5

| Mitral Valve | Frame 5 | |
|---|---|---|
| Ann AP Diam | 40.5 | mm |
| Ann AL-PM Diam | 43.2 | mm |
| Ant Ann Perimeter | 61.6 | mm |
| Post Ann Perimeter | 79.9 | mm |
| Total Ann Perimeter | 141.5 | mm |
| Ann Area | 1511.8 | mm2 |
| Intertrigonal Dist | 31.6 | mm |
| Valve Orifice Area | 91.4 | mm2 |
| Intercomm Dist | 24.5 | mm |

05/12/2016 7:45 AM Z6Ms




Nonplanarity Angle 132.6 Deg

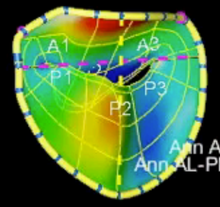



Diagnosis

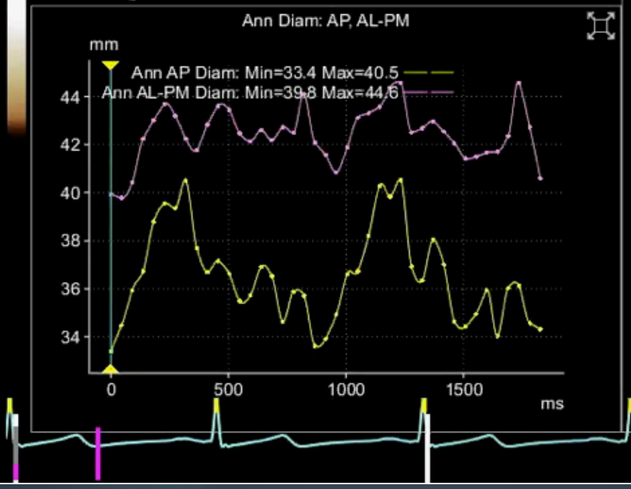
22 vps

| Mitral Valve | Frame 2 | |
|---|---|---|
| Ann AP Diam | 33.4 | mm |
| Ann AL-PM Diam | 39.9 | mm |
| Ant Ann Perimeter | 54.7 | mm |
| Post Ann Perimeter | 70.2 | mm |
| Total Ann Perimeter | 124.9 | mm |
| Ann Area | 1132.5 | mm2 |
| Intertrigonal Dist | 33.8 | mm |
| Valve Orifice Area | 200.0 | mm2 |
| Intercomm Dist | 22.7 | mm |

05/12/2016 7:45 AM Z6Ms



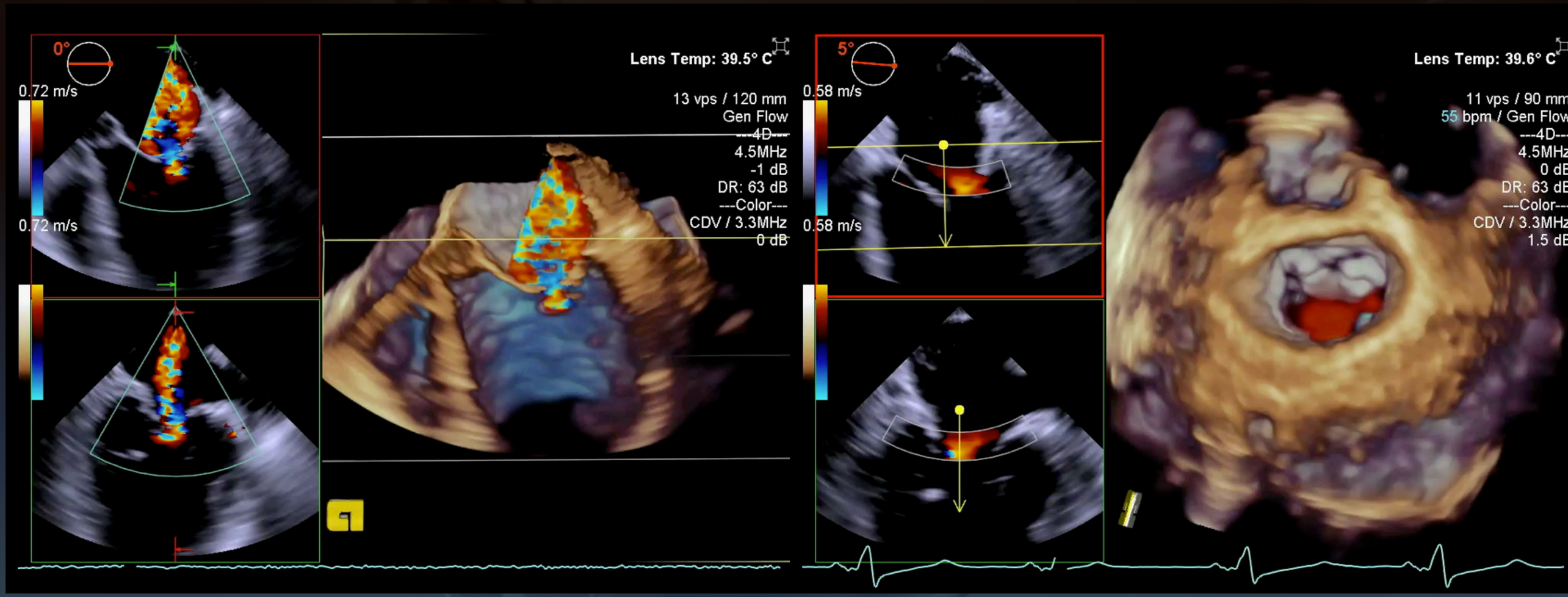

Ann AP Diam 33.4 mm
Ann AL-PM Diam 39.9 mm

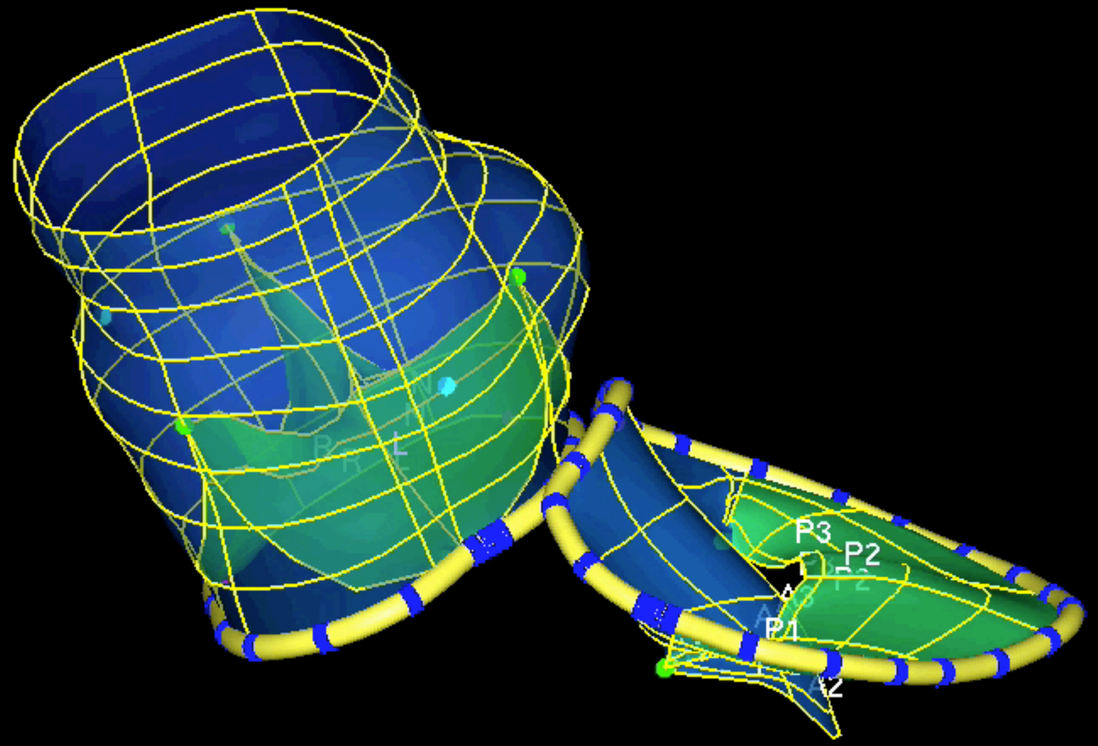


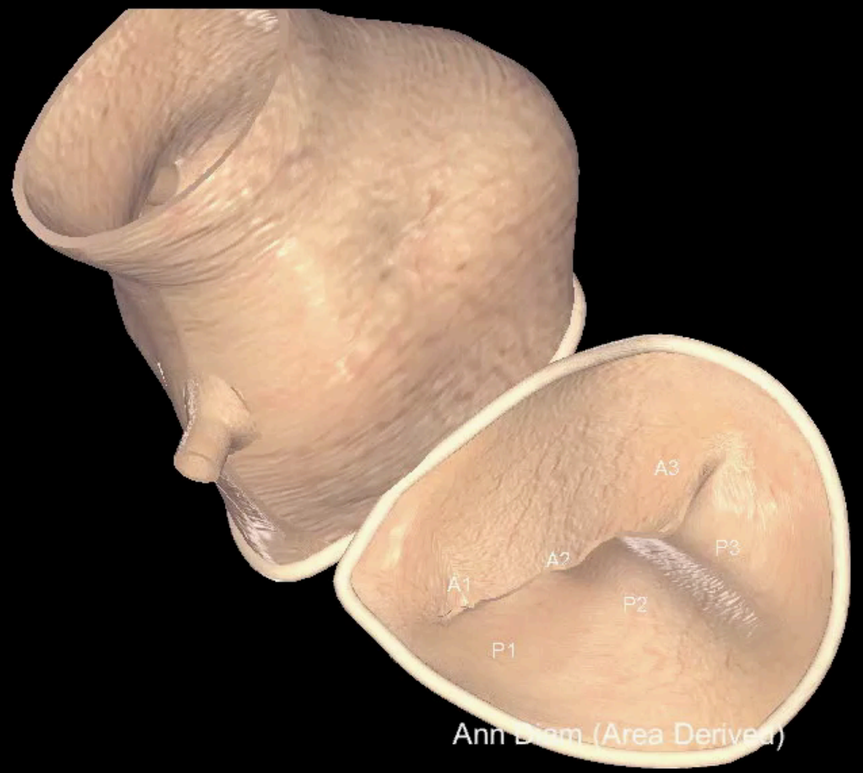

Diagnosis

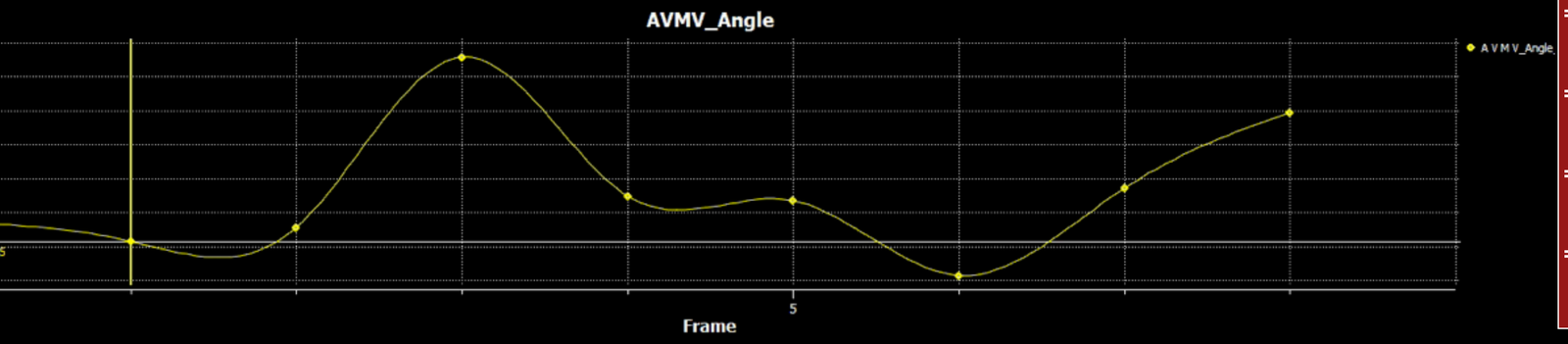
22 vps

| Mitral Valve | Frame 2 | |
|---|---|---|
| Ann AP Diam | 33.4 | mm |
| Ann AL-PM Diam | 39.9 | mm |
| Ant Ann Perimeter | 54.7 | mm |
| Post Ann Perimeter | 70.2 | mm |
| Total Ann Perimeter | 124.9 | mm |
| Ann Area | 1132.5 | mm2 |
| Intertrigonal Dist | 33.8 | mm |
| Valve Orifice Area | 200.0 | mm2 |
| Intercomm Dist | 22.7 | mm |


0°
0.72 m/s
0.72 m/s
Lens Temp: 39.5° C
13 vps / 120 mm
Gen Flow
---4D---
4.5MHz
-1 dB
DR: 63 dB
---Color---
CDV / 3.3MHz
0 dB
5°
0.58 m/s
0.58 m/s
Lens Temp: 39.6° C
11 vps / 90 mm
55 bpm / Gen Flow
---4D---
4.5MHz
0 dB
DR: 63 dB
---Color---
CDV / 3.3MHz
1.5 dB






All frames analyzed (systolic & diastolic)

Automated analysis

Based on anatomical landmark recognition

# Limitations

PHILIPS

GE Healthcare

SIEMENS

- NO global MV apparatus
- NO stl.file

# Limitations

- Gap between scallops

# Limitations

PHILIPS

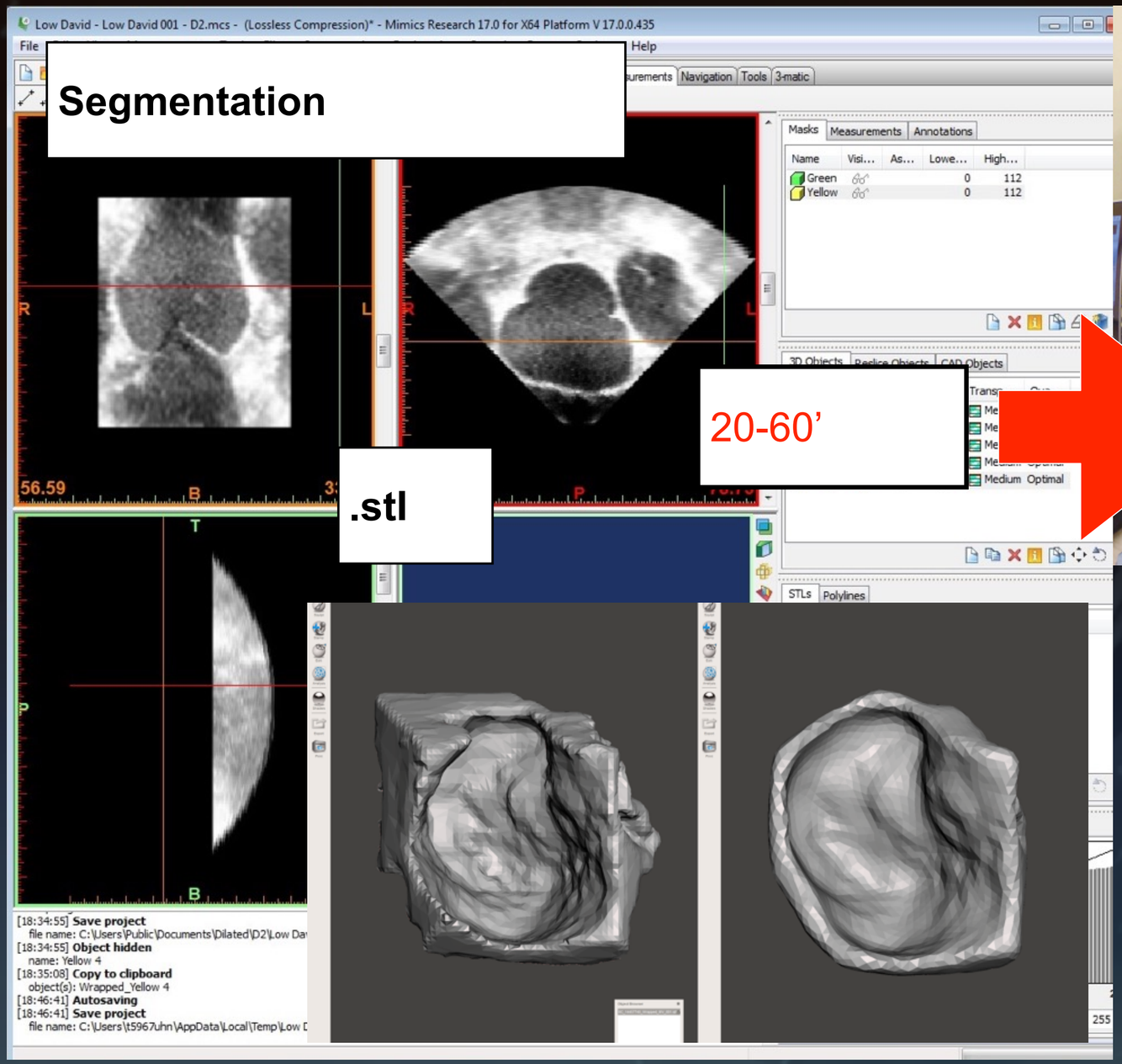
GE Healthcare

SIEMENS

- Leaflet contour

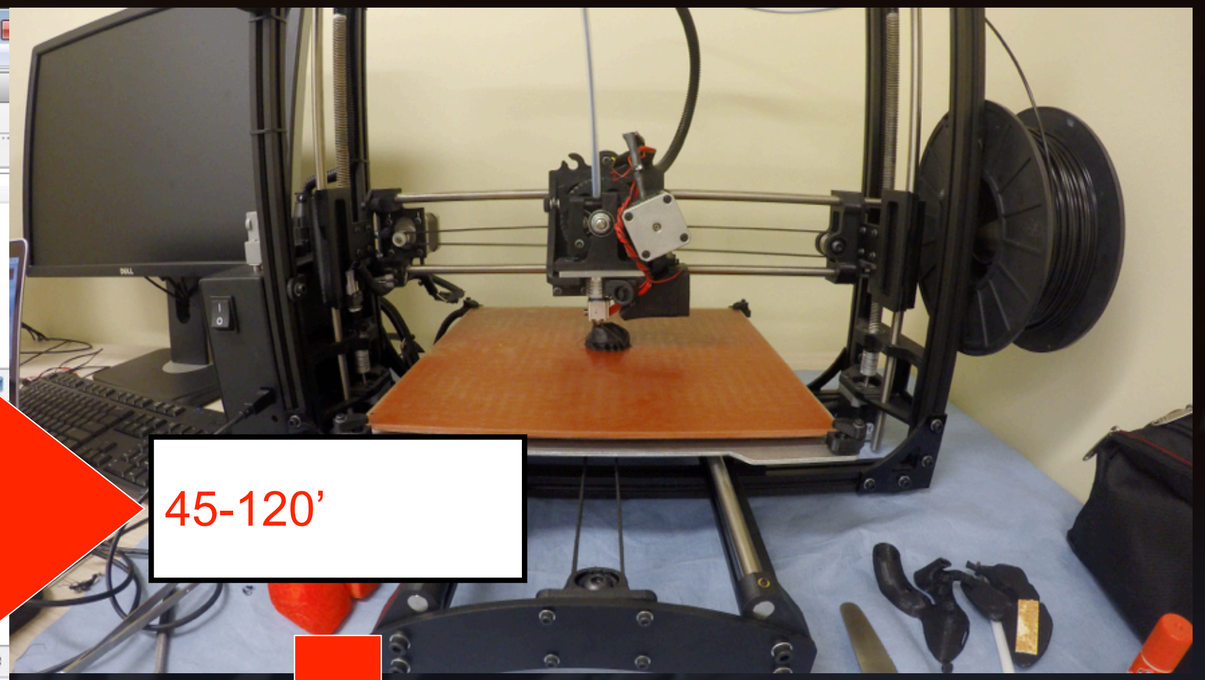
# Three-Dimensional Printing

# Segmentation

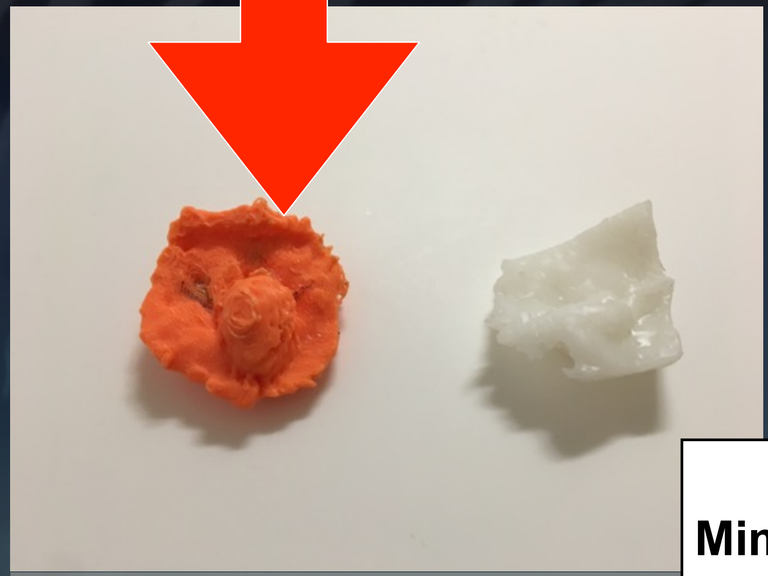



.stl

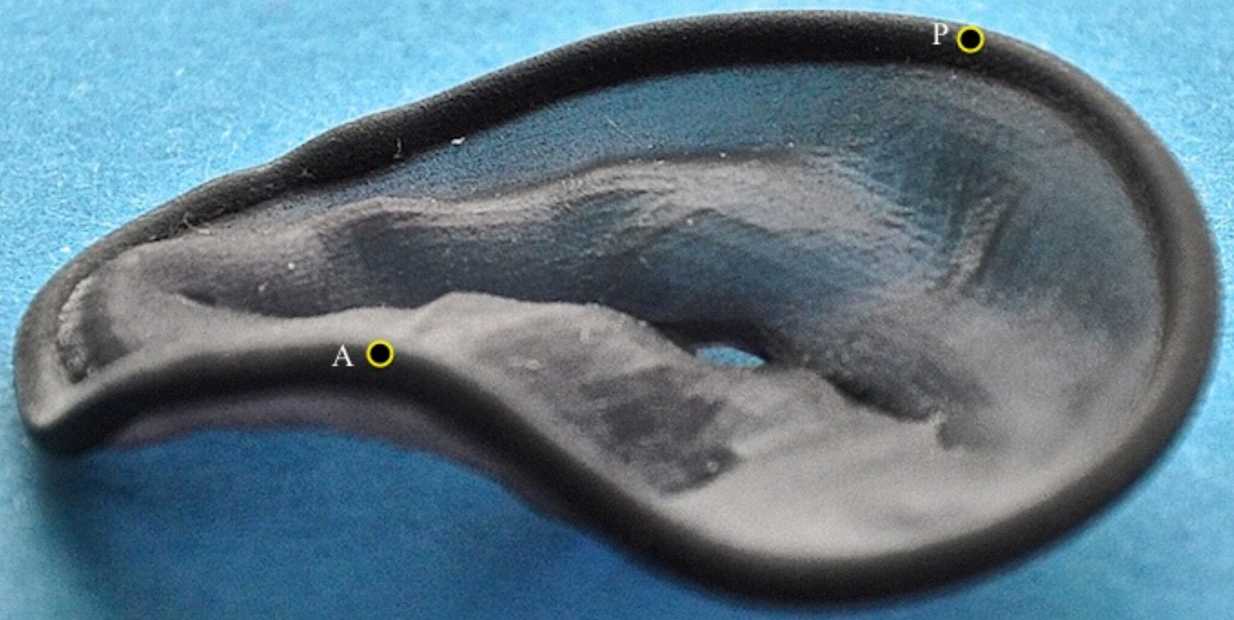
20-60’



45-120’



Mimics
ATK snap




BIDMC, EchoLab, P. F. Mahmood

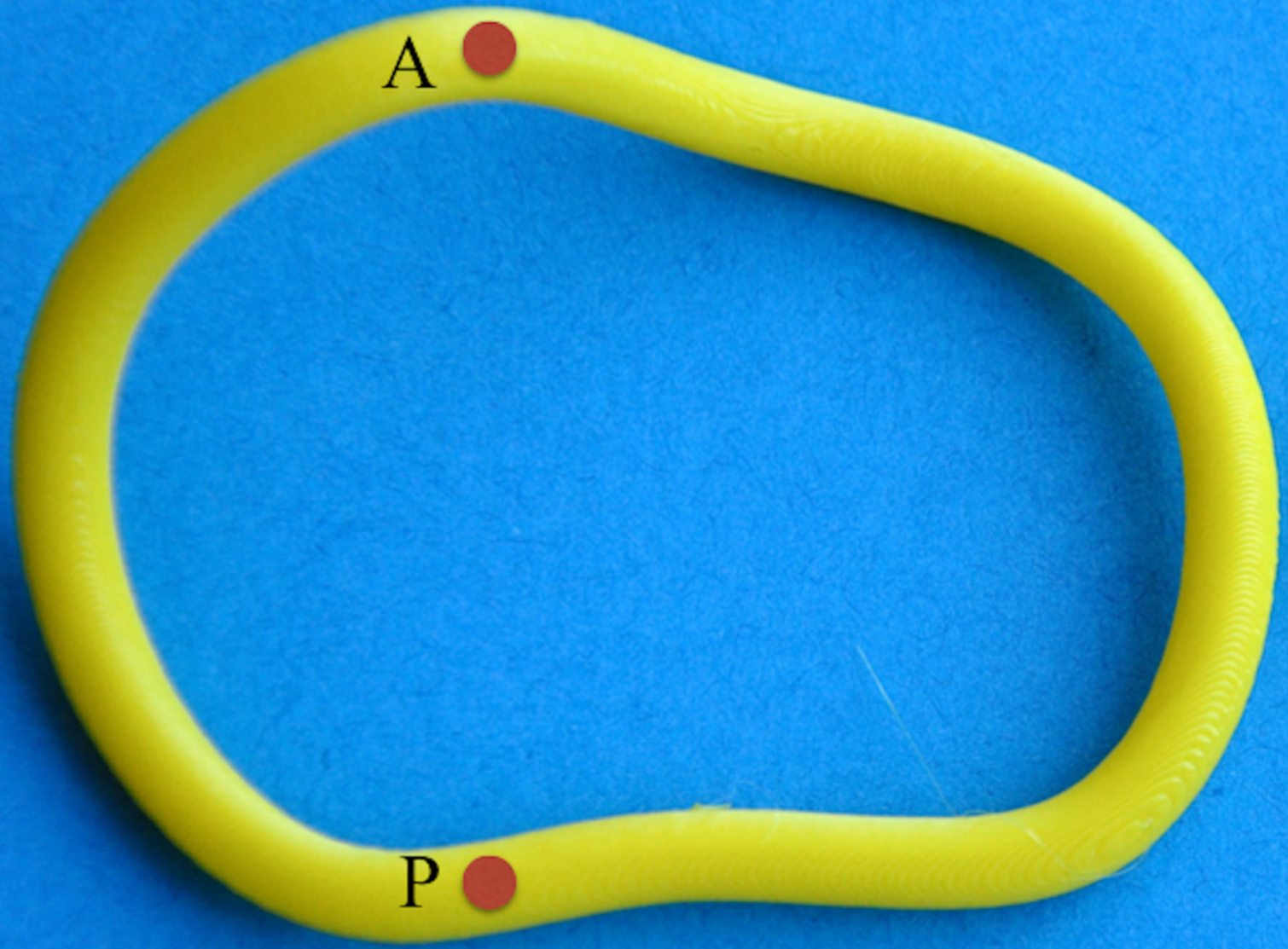
# NORMAL

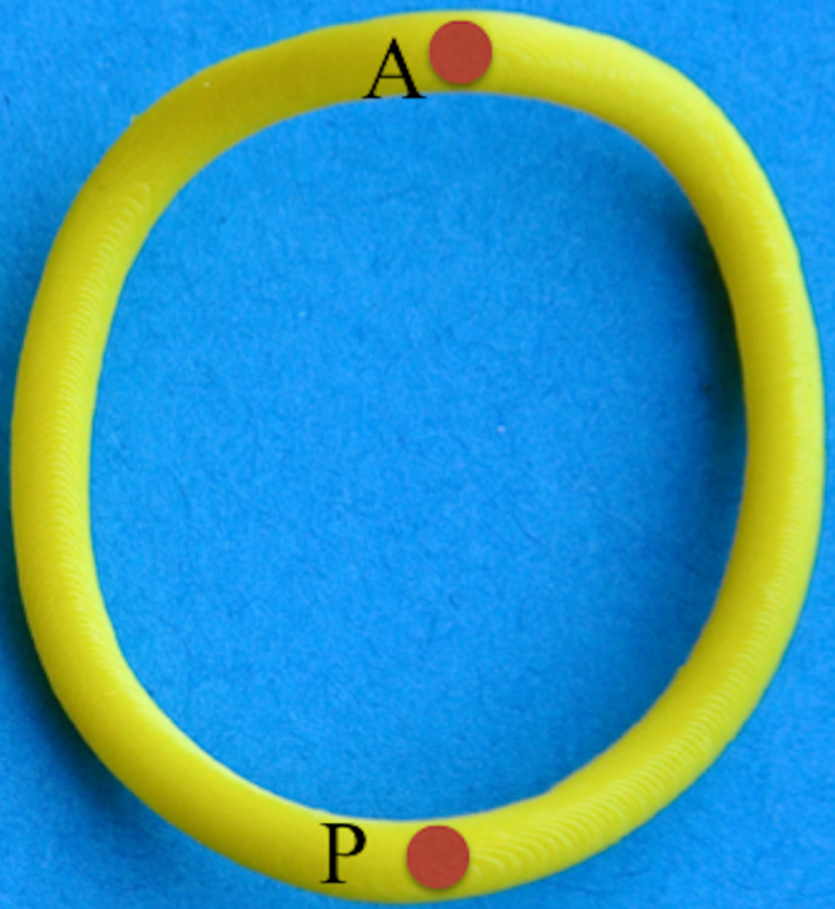
# Ischemic

BIDMC, EchoLab, P. F. Mahmood

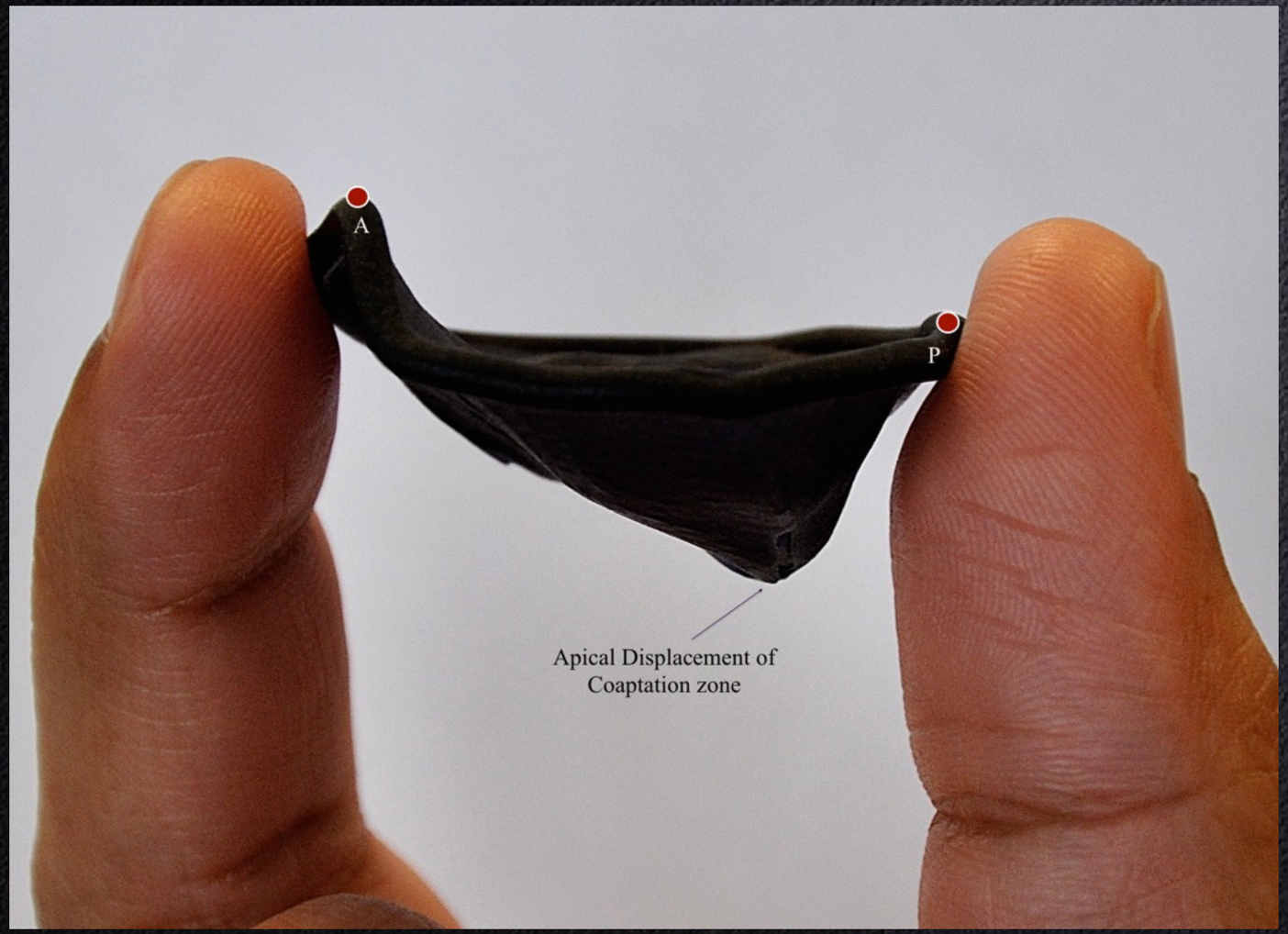
# Barlow's Valve

# After a Ring



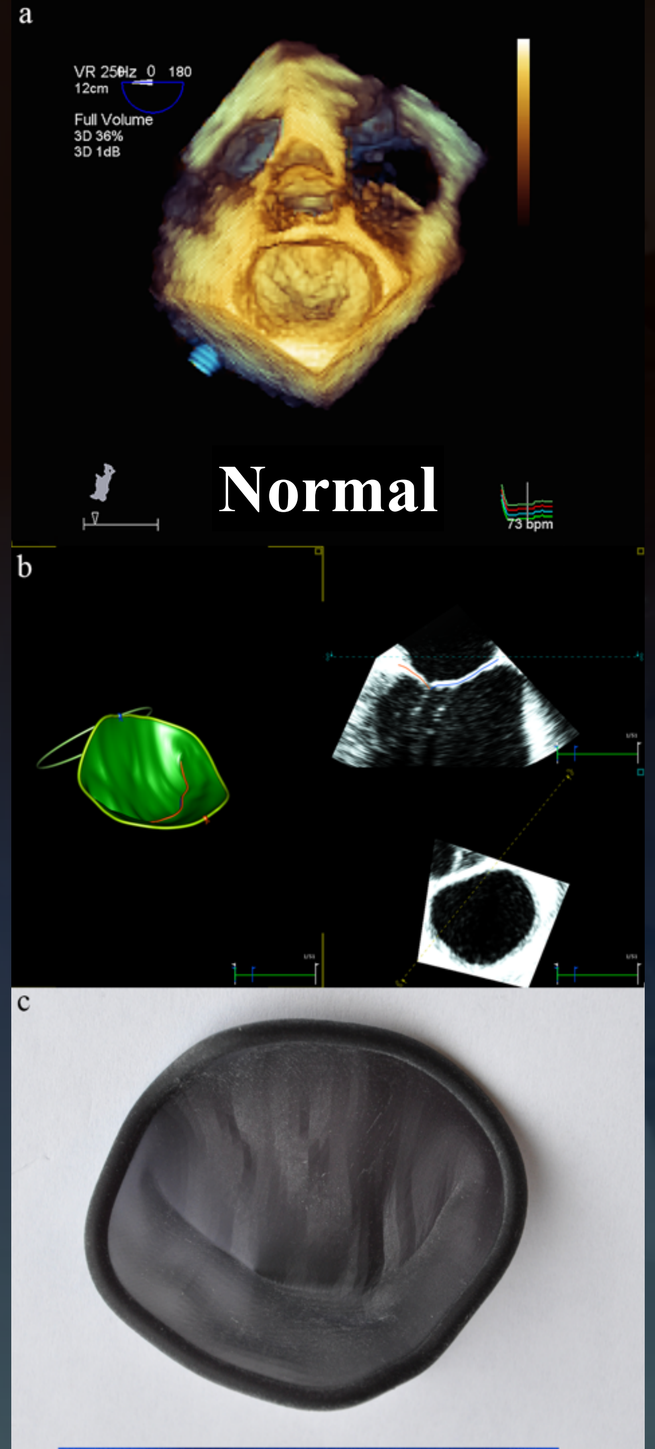



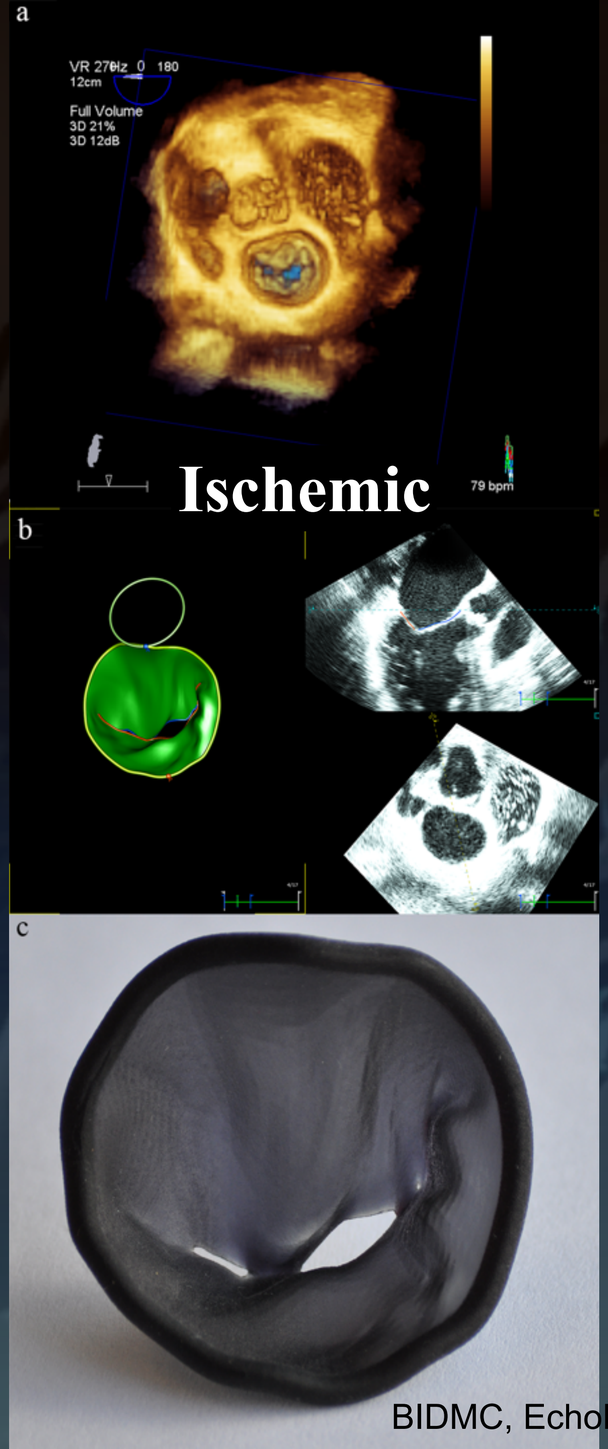

BIDMC, EchoLab, P. F. Mahmood

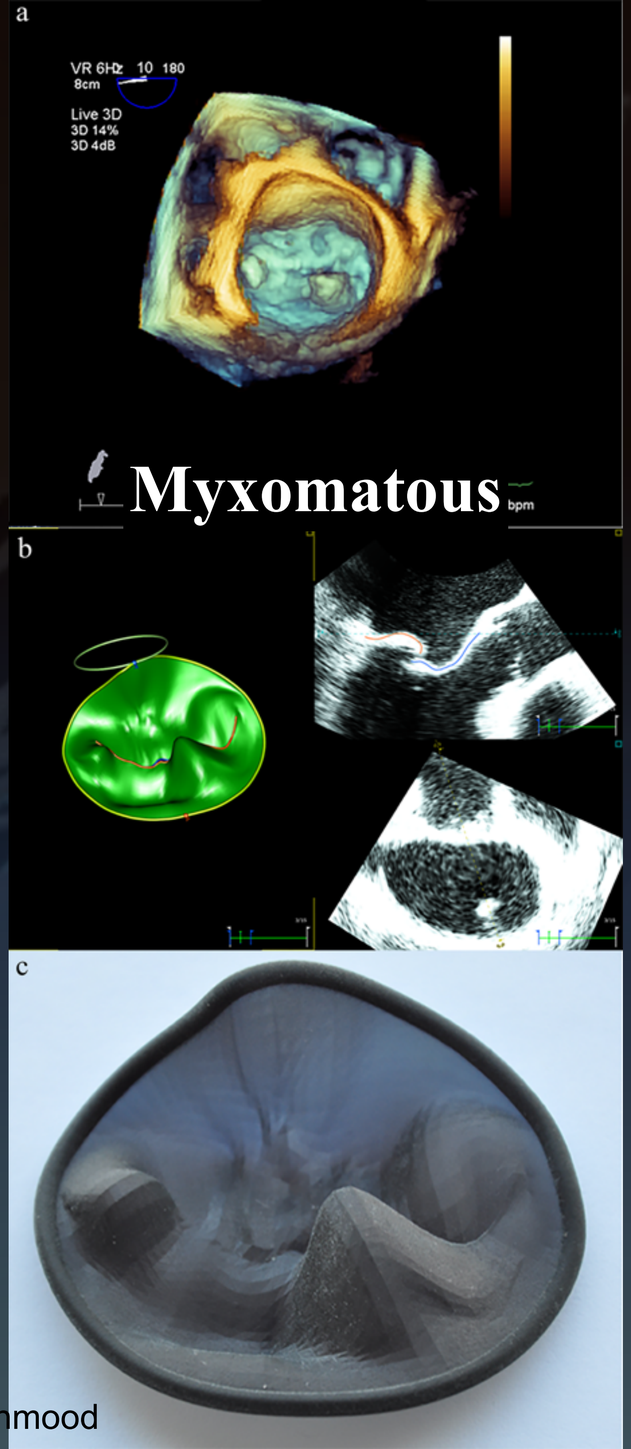


BIDMC, EchoLab, P. F. Mahmood

BIDMC, EchoLab, P. F. Mahmood



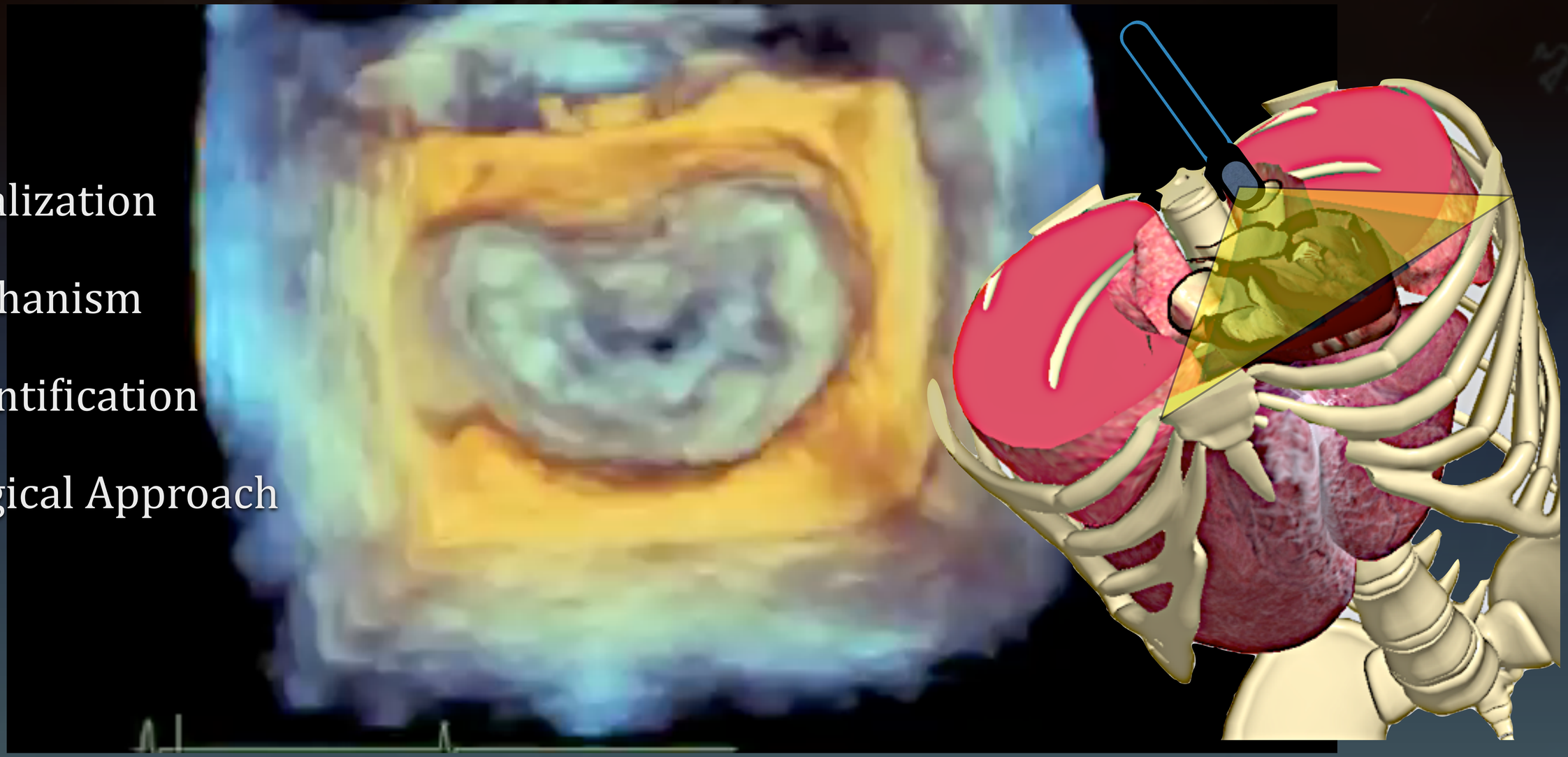



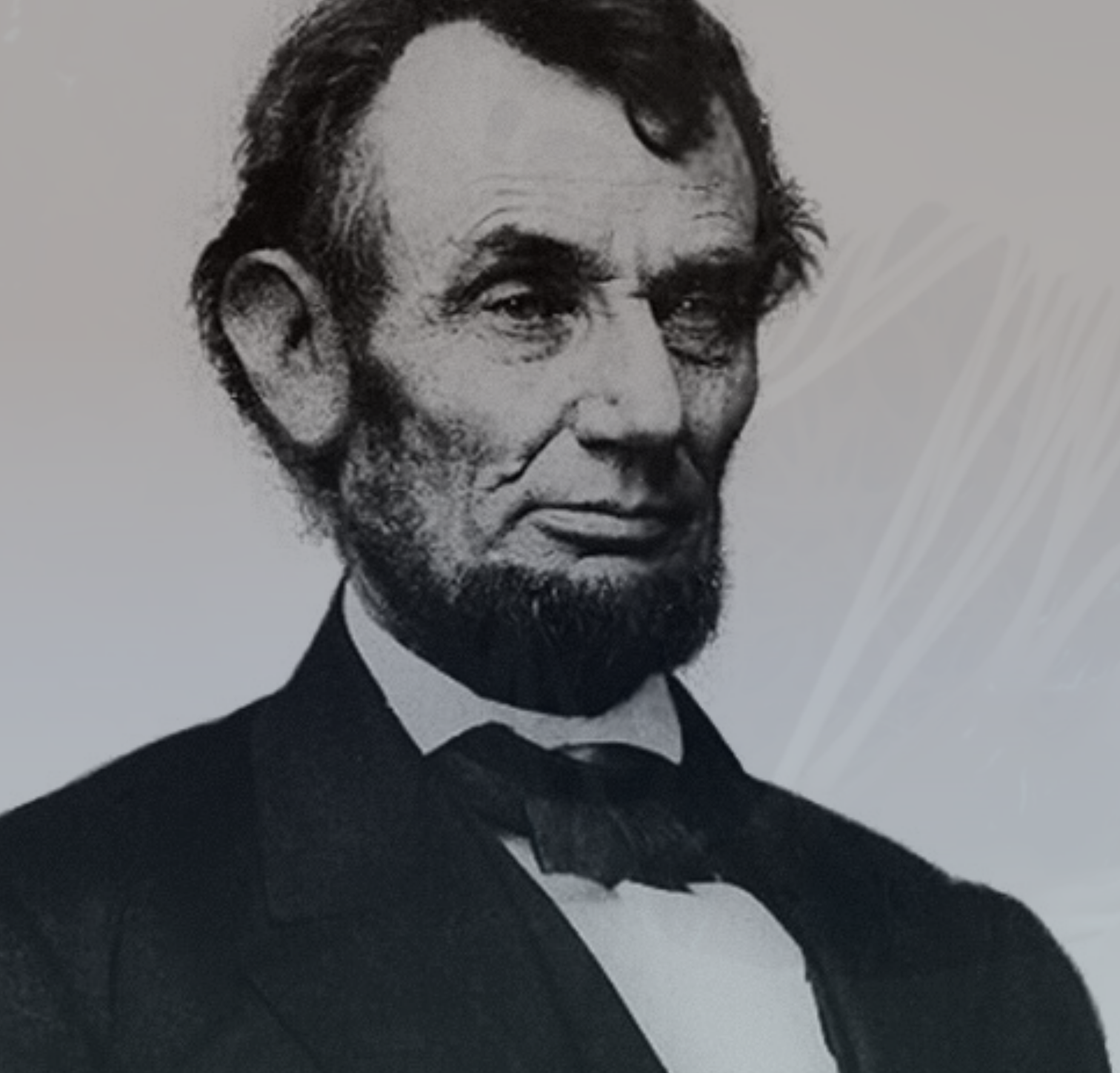




BIDMC, EchoLab, P. F. Mahmood

# Conclusions: 3D acquisition

- Localization
- Mechanism
- Quantification
- Surgical Approach





***Beauty lies in the hands of the probe-holder***

- *Abraham Lincoln*
*1863 A.D.*

Thanks