Sunday, November 11th, 2018

J. Moreno
Department of Anesthesia &
Interdepartmental Division of Critical Care Medicine
Toronto General Hospital. University Health Network.
Jacobo.Moreno@uhn.ca

Presented by the Department of Anesthesiology
and Division of Cardiac Surgery
Peter Munk Cardiac Centre
Toronto General Hospital
University Health Network

Sixteenth Annual Toronto Perioperative TEE Symposium

Toronto - November 10-11, 2018

MaRS Auditorium
101 College St.
Toronto, M5G 1L7

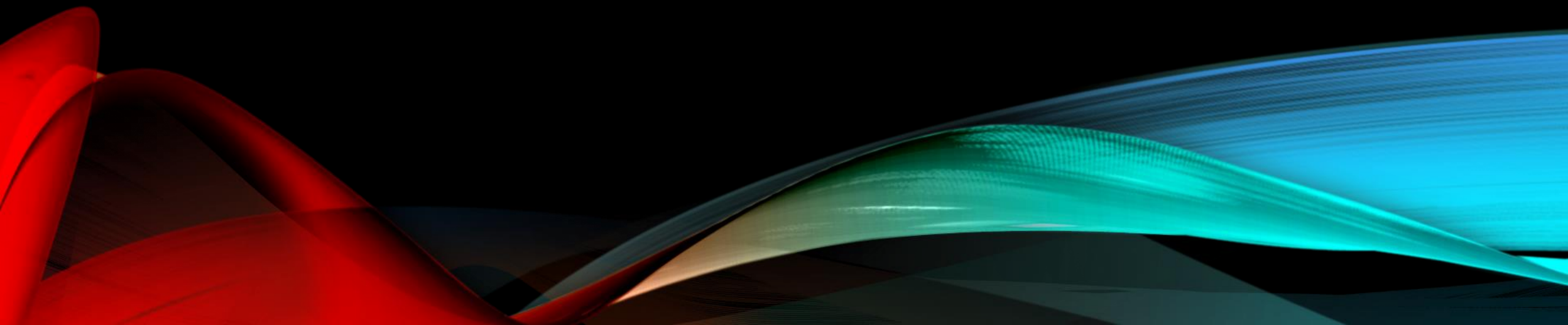
3D TEE MULTIPLANAR RECONSTRUCTION

Problem Based Learning Discussions:
Workshops • Multi-vendor • Hands-on 3D TEE • Basic TEE

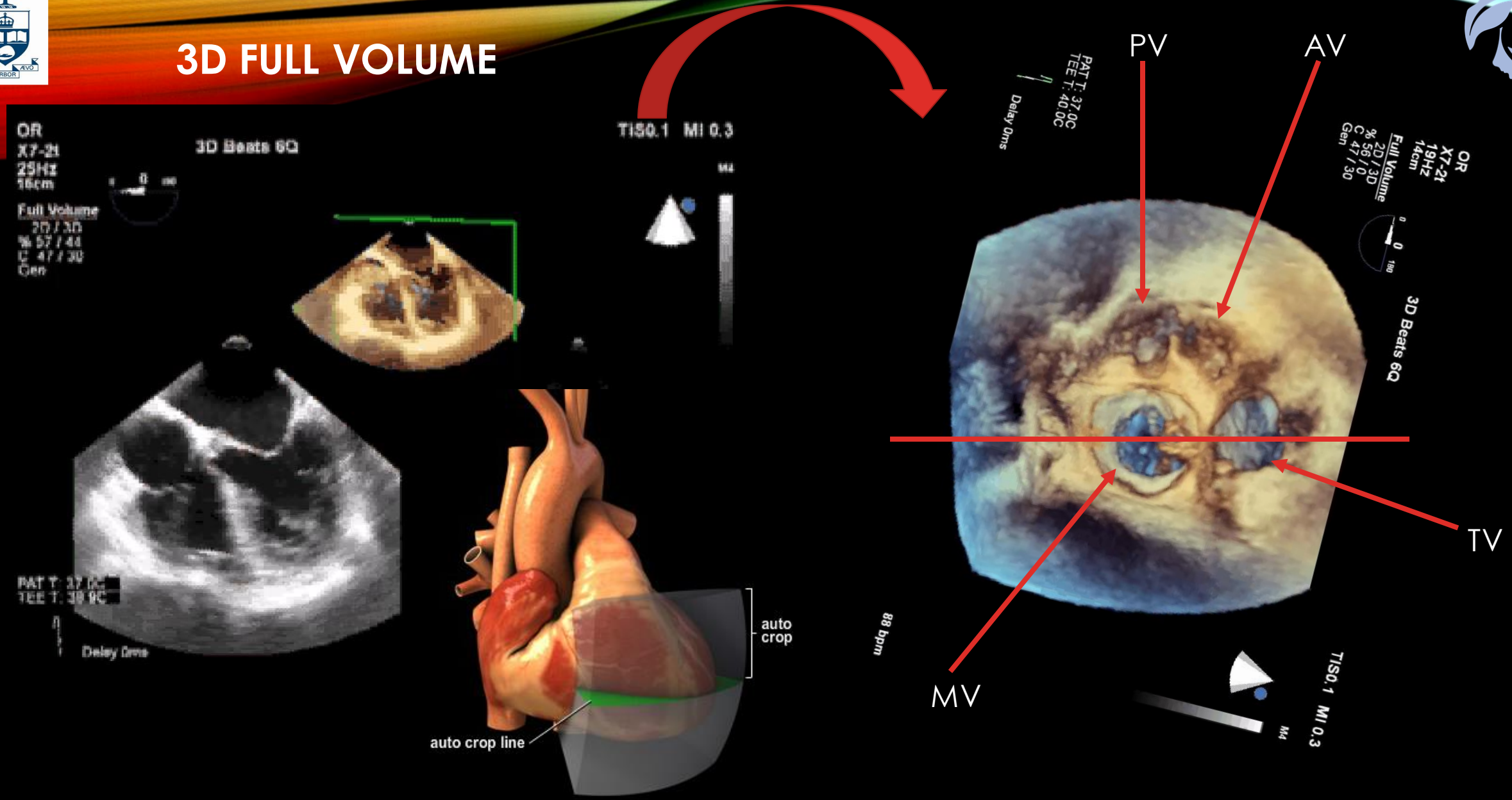
DISCLOSURE

- No academic conflict of interest
- No financial conflict of interest
- No compensation received for pharmaceuticals and/or devices discussed

HOW CAN WE USE 3D MPR?

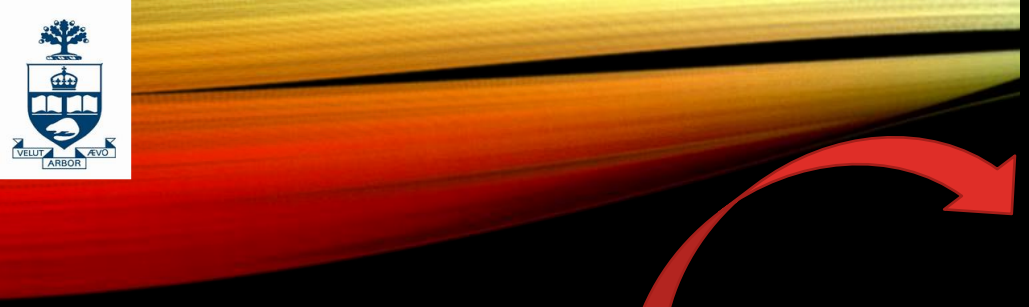


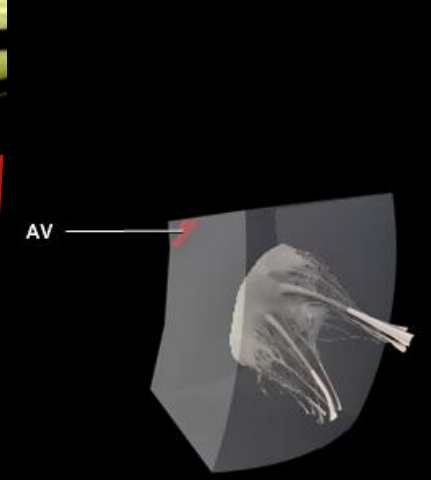
3D FULL VOLUME



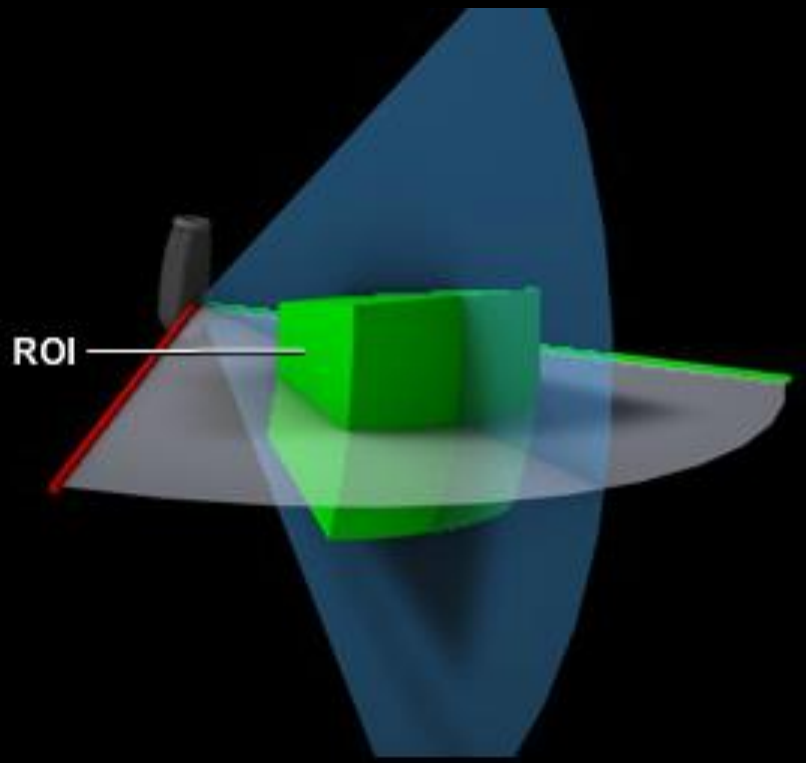
Other 3D vendors: GE, Siemens.

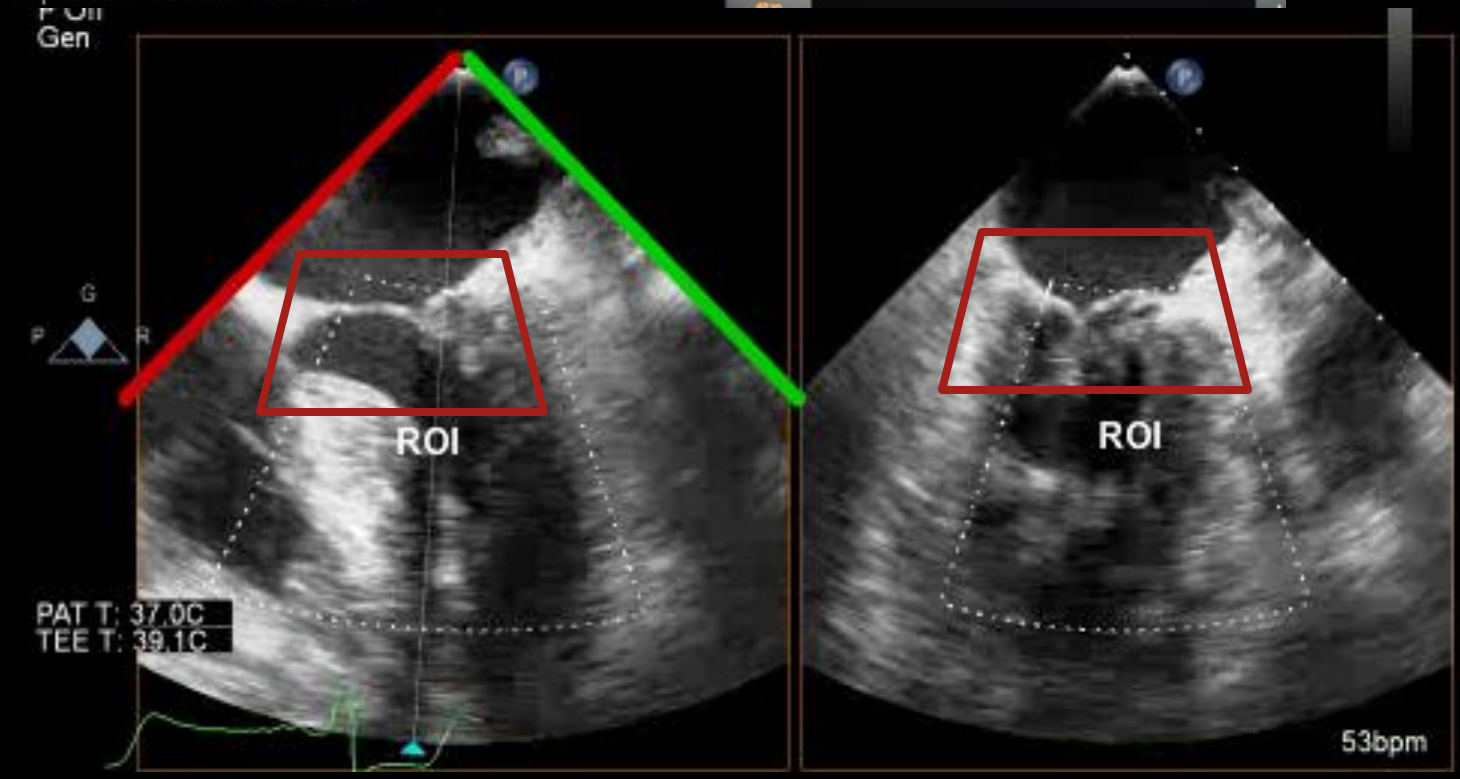
3D ZOOM



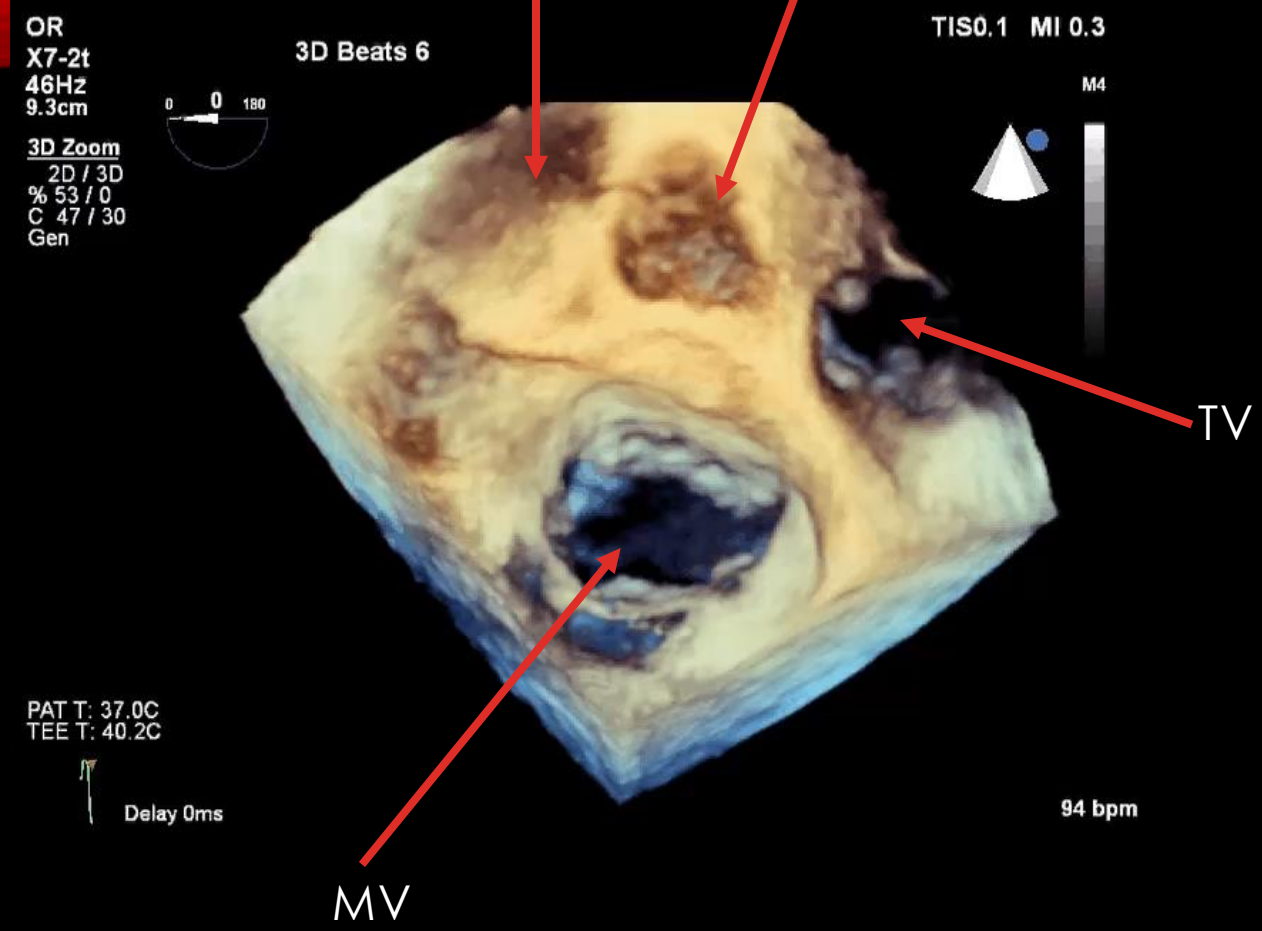

AV

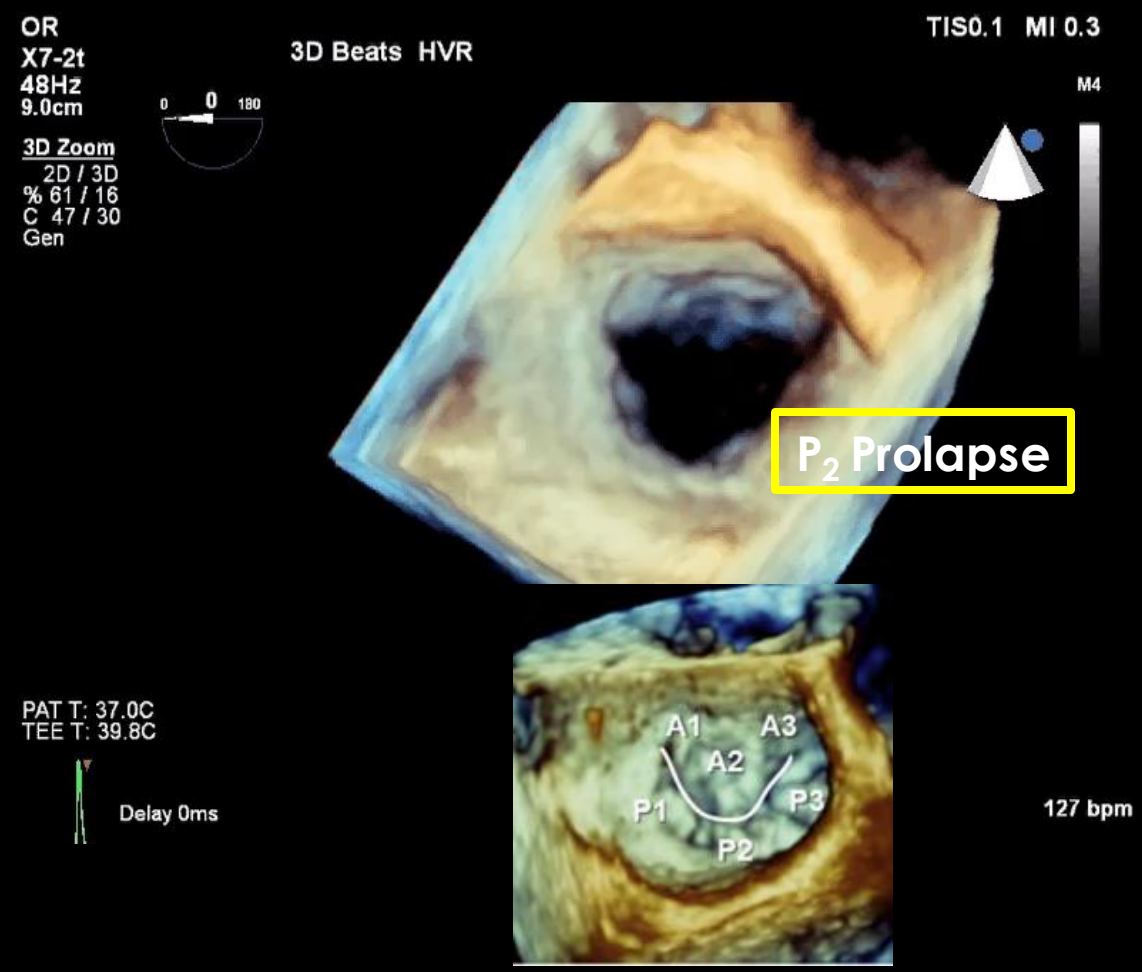

X7-2t
6Hz
7.1cm
3D Zoom
2D / 3D
% 51 / 44
C 50 / 30
Gen
3D Beats 1
M4
AV
PAT T: 37.0C
TEE T: 38.8C
46bpm


ROI

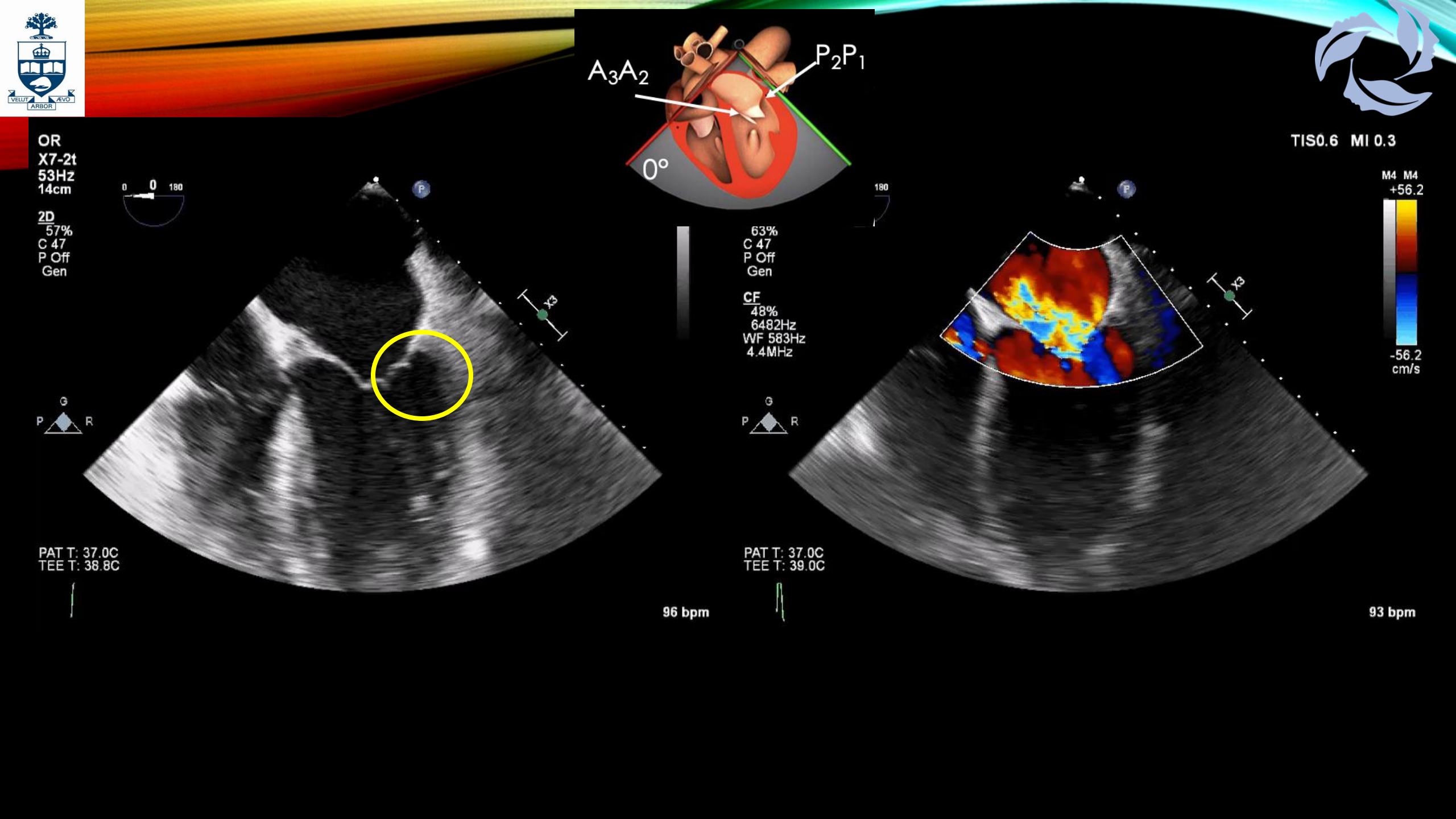

Acquisition Modes - 3D Zoom
Gen
ROI
PAT T: 37.0C
TEE T: 39.1C
ROI
53bpm

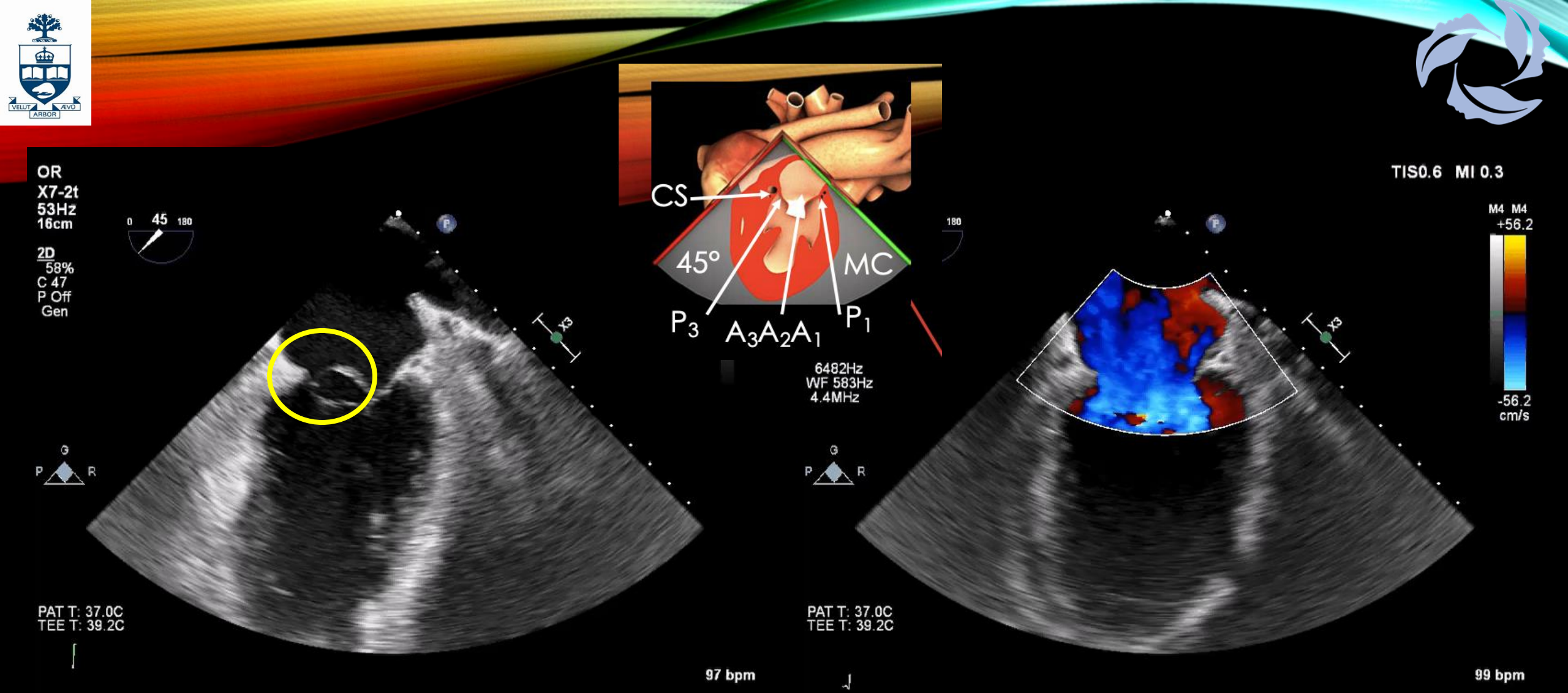
3D ZOOM

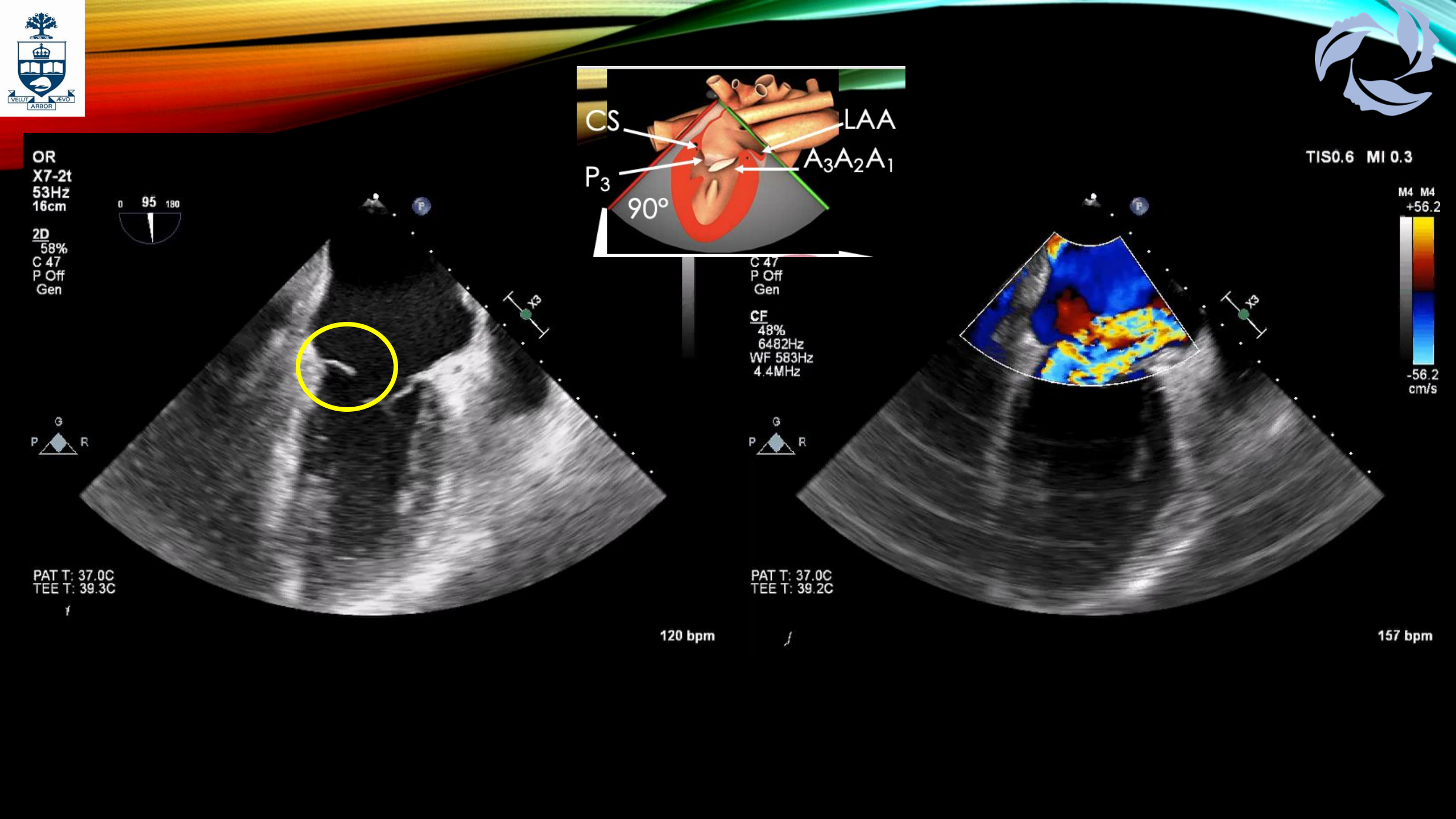


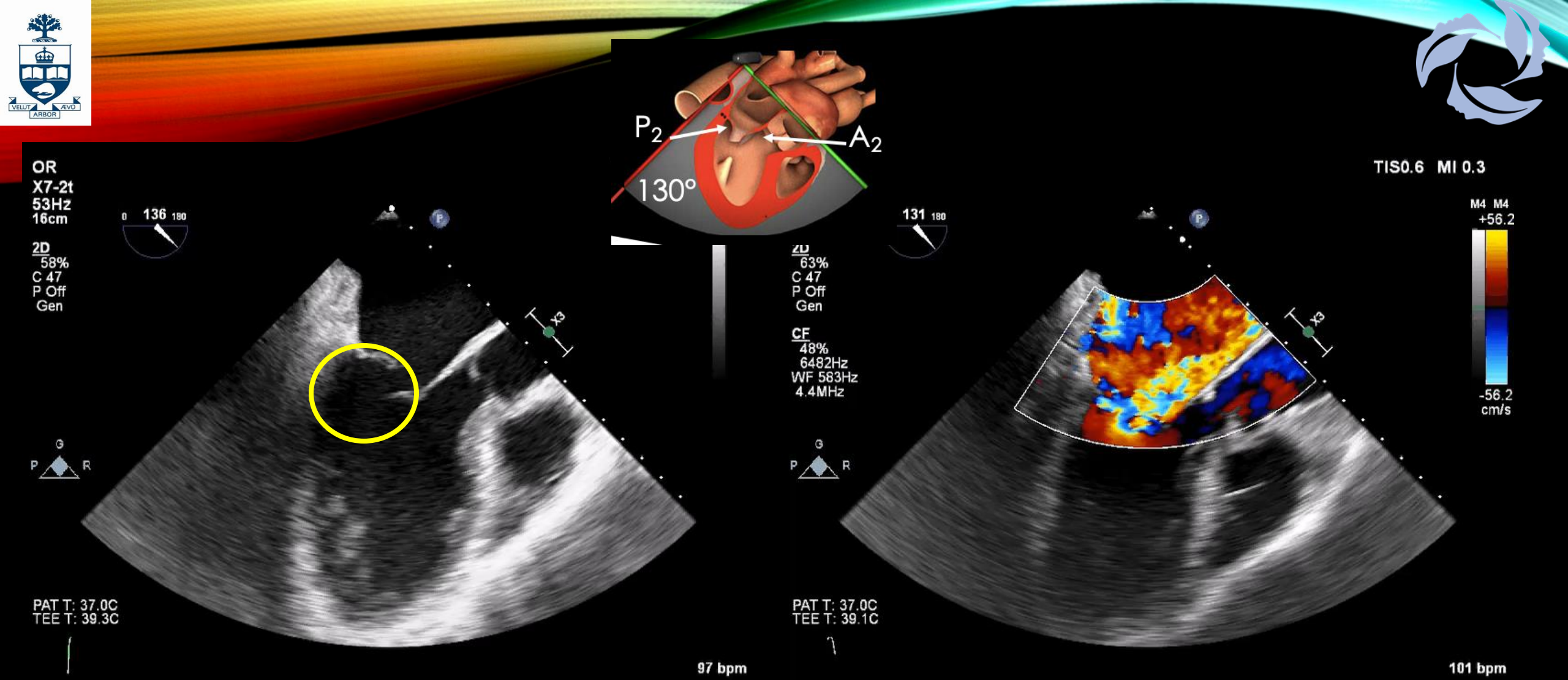


J Am Soc Echocardiogr. 2017 Apr;30(4):303-371


A3A2
P2P1
0°
OR
X7-2t
53Hz
14cm
2D
57%
C 47
P Off
Gen
63%
C 47
P Off
Gen
CF
48%
6482Hz
WF 583Hz
4.4MHz
TIS0.6 MI 0.3
M4 M4
+56.2
-56.2
cm/s
PAT T: 37.0C
TEE T: 38.8C
96 bpm
PAT T: 37.0C
TEE T: 39.0C
93 bpm

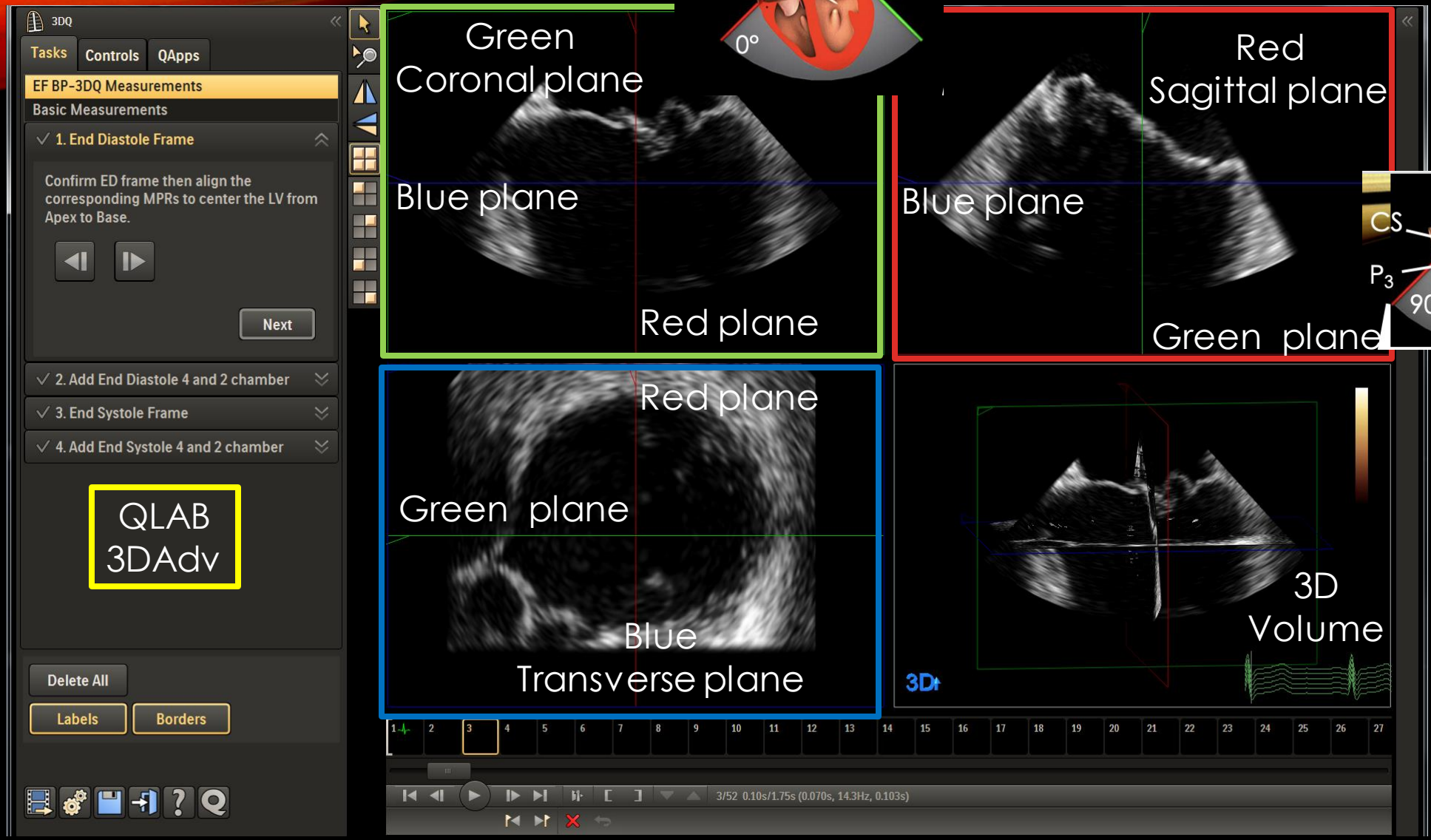

OR
X7-2t
53Hz
16cm
2D
58%
C 47
P Off
Gen
0
45
180
PAT T: 37.0C
TEE T: 39.2C
97 bpm
CS
45°
MC
P3
A3A2A1
P1
6482Hz
WF 583Hz
4.4MHz
TIS0.6 MI 0.3
M4 M4
+56.2
-56.2
cm/s
PAT T: 37.0C
TEE T: 39.2C
99 bpm


CS
LAA
P_3
$A_3A_2A_1$
90°
OR
X7-2t
53Hz
16cm
2D
58%
C 47
P Off
Gen
0 95 180
X3
G
P R
PAT T: 37.0C
TEE T: 39.3C
120 bpm
C 47
P Off
Gen
CF
48%
6482Hz
WF 583Hz
4.4MHz
TIS0.6 MI 0.3
M4 M4
+56.2
-56.2
cm/s
PAT T: 37.0C
TEE T: 39.2C
157 bpm


P2
A2
130°
OR
X7-2t
53Hz
16cm
2D
58%
C 47
P Off
Gen
136
PAT T: 37.0C
TEE T: 39.3C
97 bpm
2D
63%
C 47
P Off
Gen
CF
48%
6482Hz
WF 583Hz
4.4MHz
131
PAT T: 37.0C
TEE T: 39.1C
TIS0.6 MI 0.3
M4 M4
+56.2
-56.2
cm/s
101 bpm

UNDERSTANDING MPR

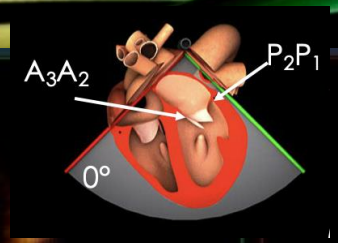
3D MPR



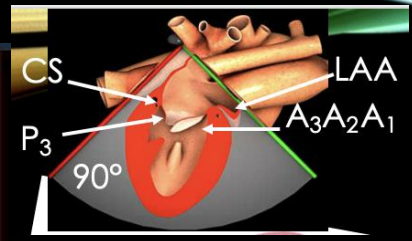
Other MPR software: Flexi-Slide (GE), Image-COM MPR (Tom-Tec), eSieValves (Siemens).

Coronal and Sagittal planes are real acquired 2D tomographic images

Green
Coronal plane



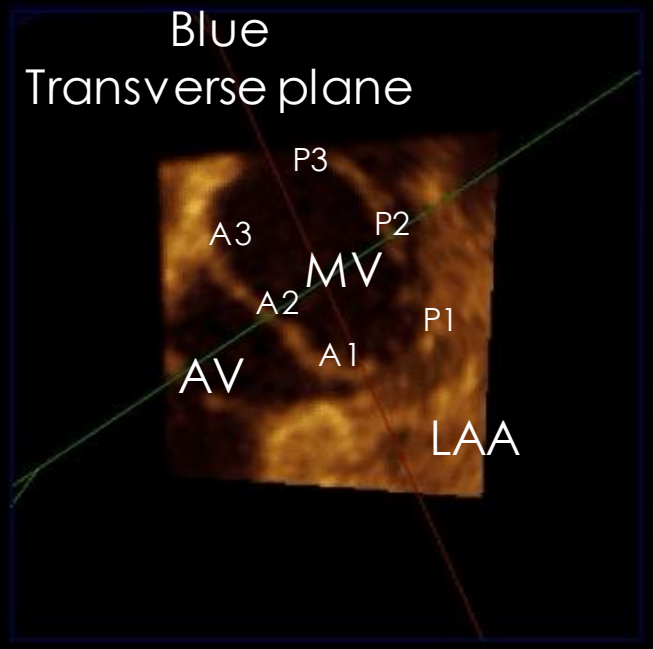
Red
Sagittal plane



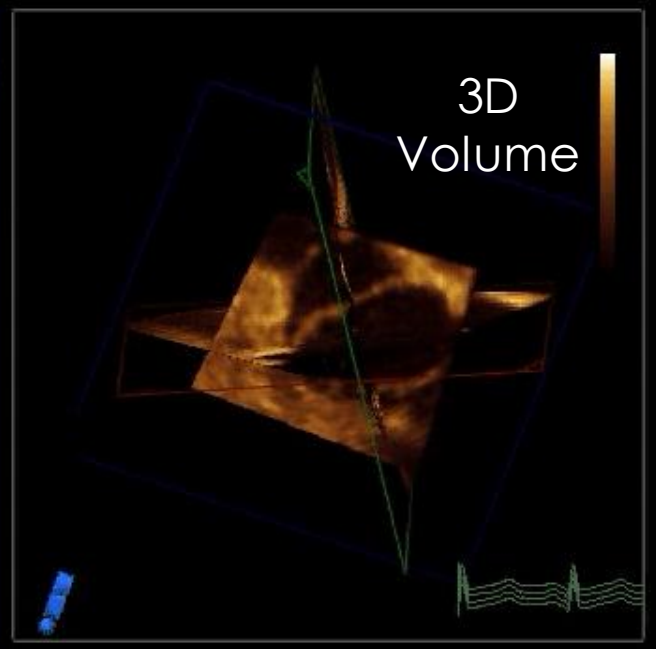
Coronal and Sagittal planes are where the measures should be taken.

Transverse plane is reconstructed by 3D software

Blue
Transverse plane



3D
Volume



WHAT CAN 3D MPR DO?

European Heart Journal – Cardiovascular Imaging (2012) **13**, 1–46
doi:10.1093/ehjci/jer316

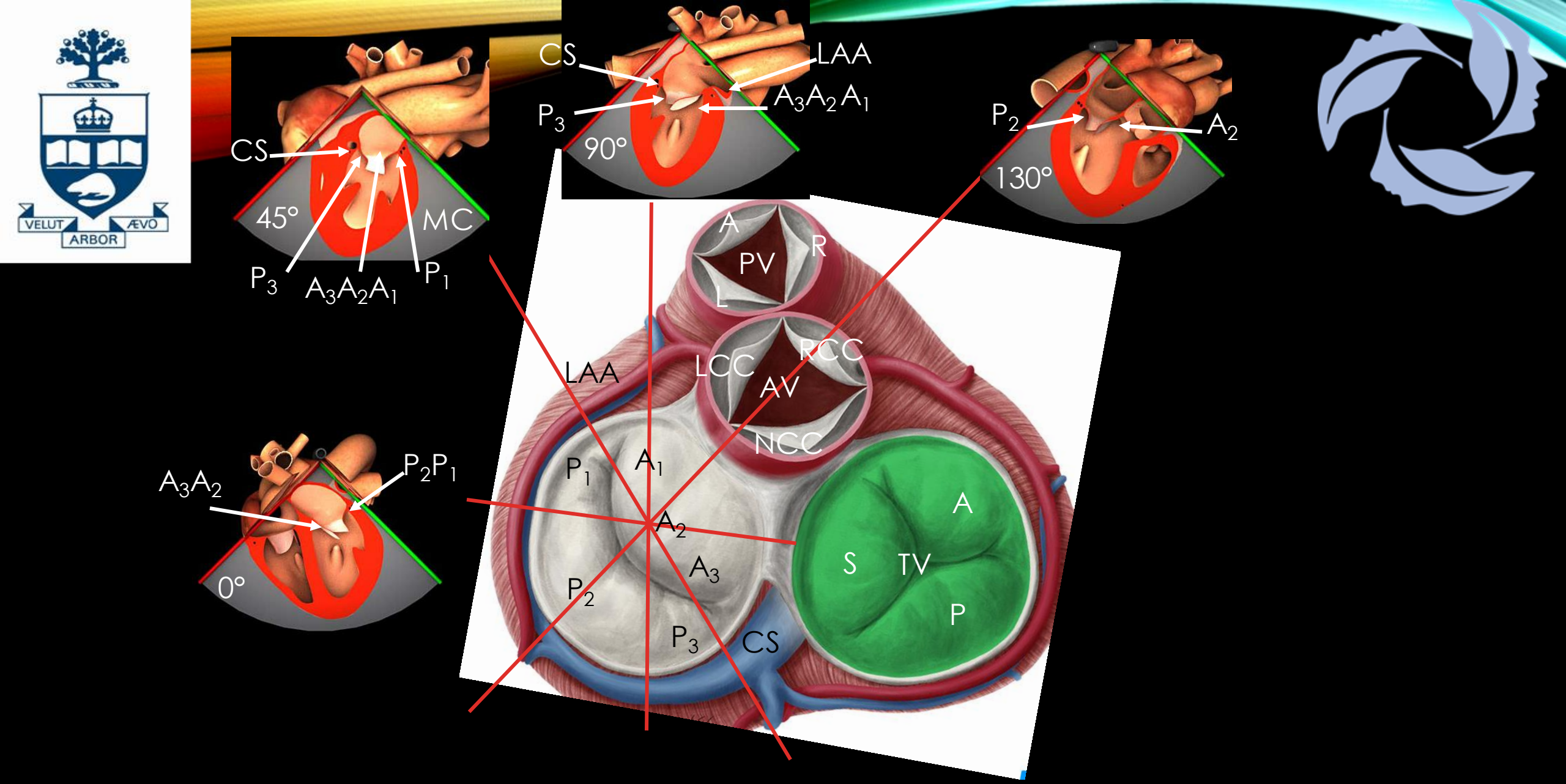
EAE/ASE RECOMMENDATIONS

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

b. Cropping Methods

Color flow analysis includes (1) distal jets, (2) the proximal flow field of valvular flow regurgitation, and (3) flow through heart defects such as ventricular or atrial septal defects. Cropping of 3D color Doppler data sets follows the same principles as non–color Doppler data set cropping and is determined mainly by the analysis intended. For regurgitant jets, it is recommended to crop the 3D color Doppler data set to show two long-axis views of the jet: one with the narrowest and one with the broadest width of the jet. This display should also include a short-axis view of the jet at the level of the vena contracta (Figures 5[13] and 6).

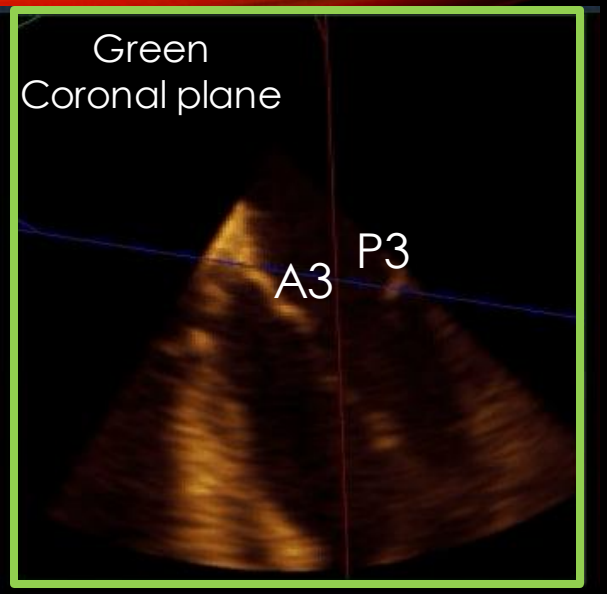
Alternatively, color Doppler flow can be displayed using a multiple slice representation extracted from the 3D color Doppler data set, as shown in Figure 7.

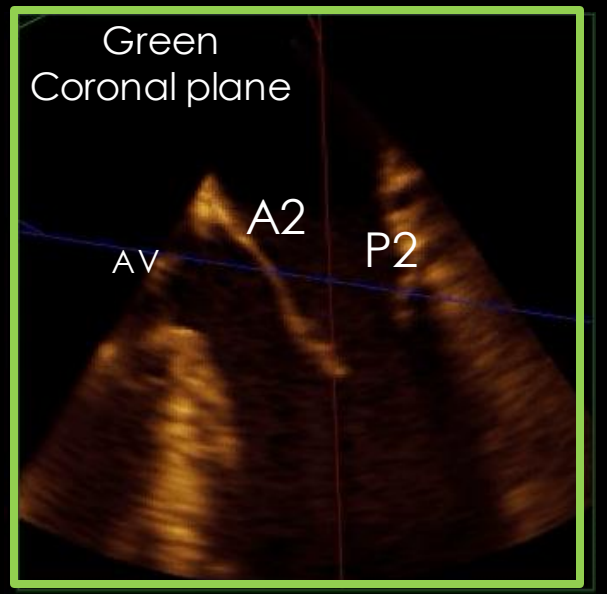


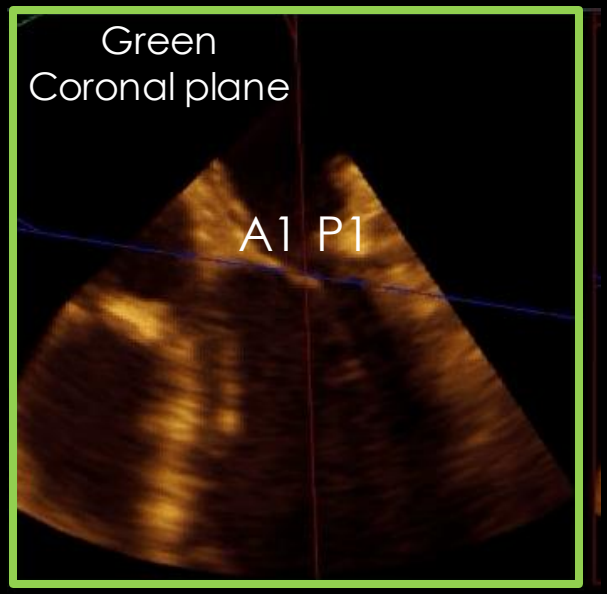
https://www.kenhub.com/en/library/anatomy/heart-valves

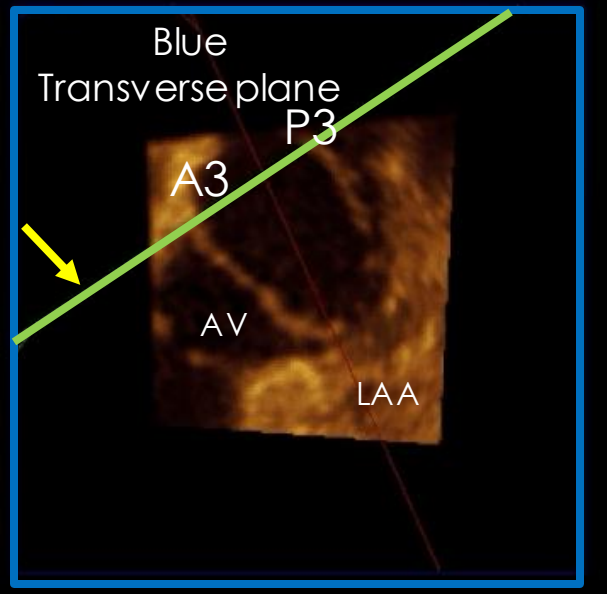
Hahn et al. J Am Soc Echocardiogr 2013;26:921-64

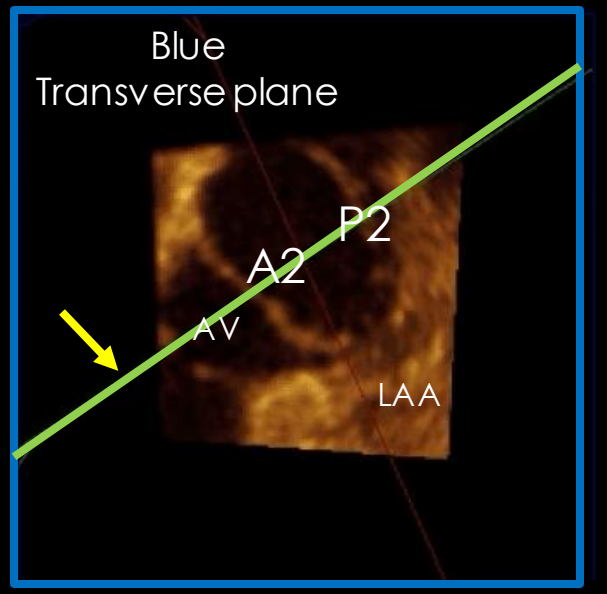
SCROLL THROUGH ANY VALVE

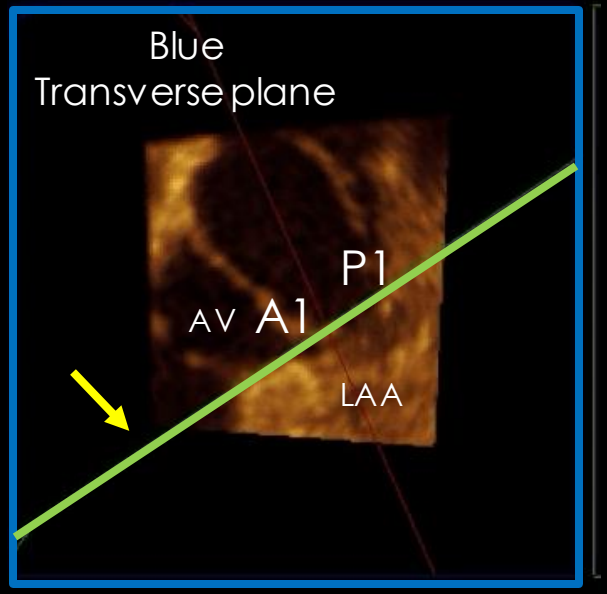




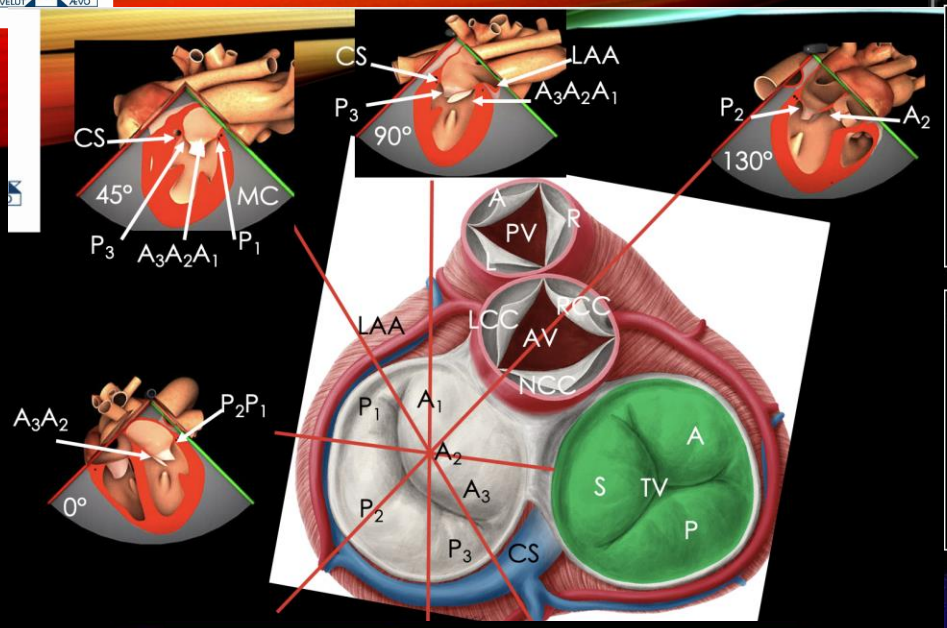


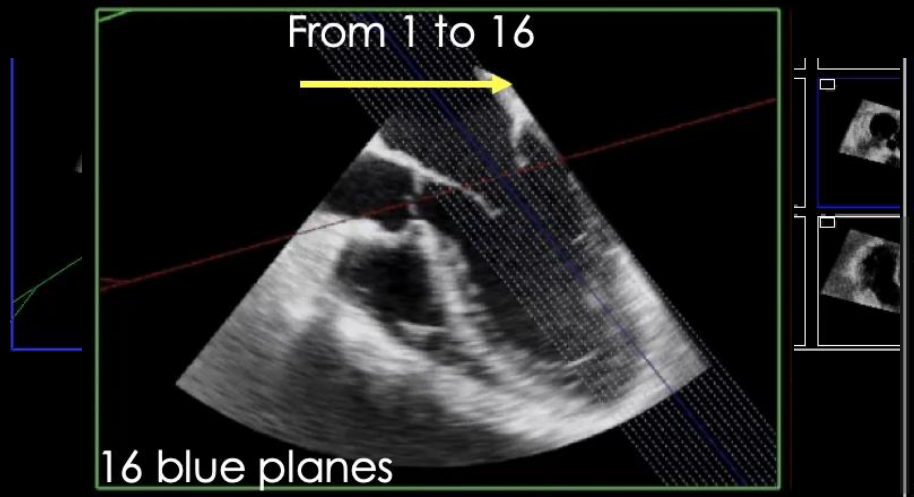


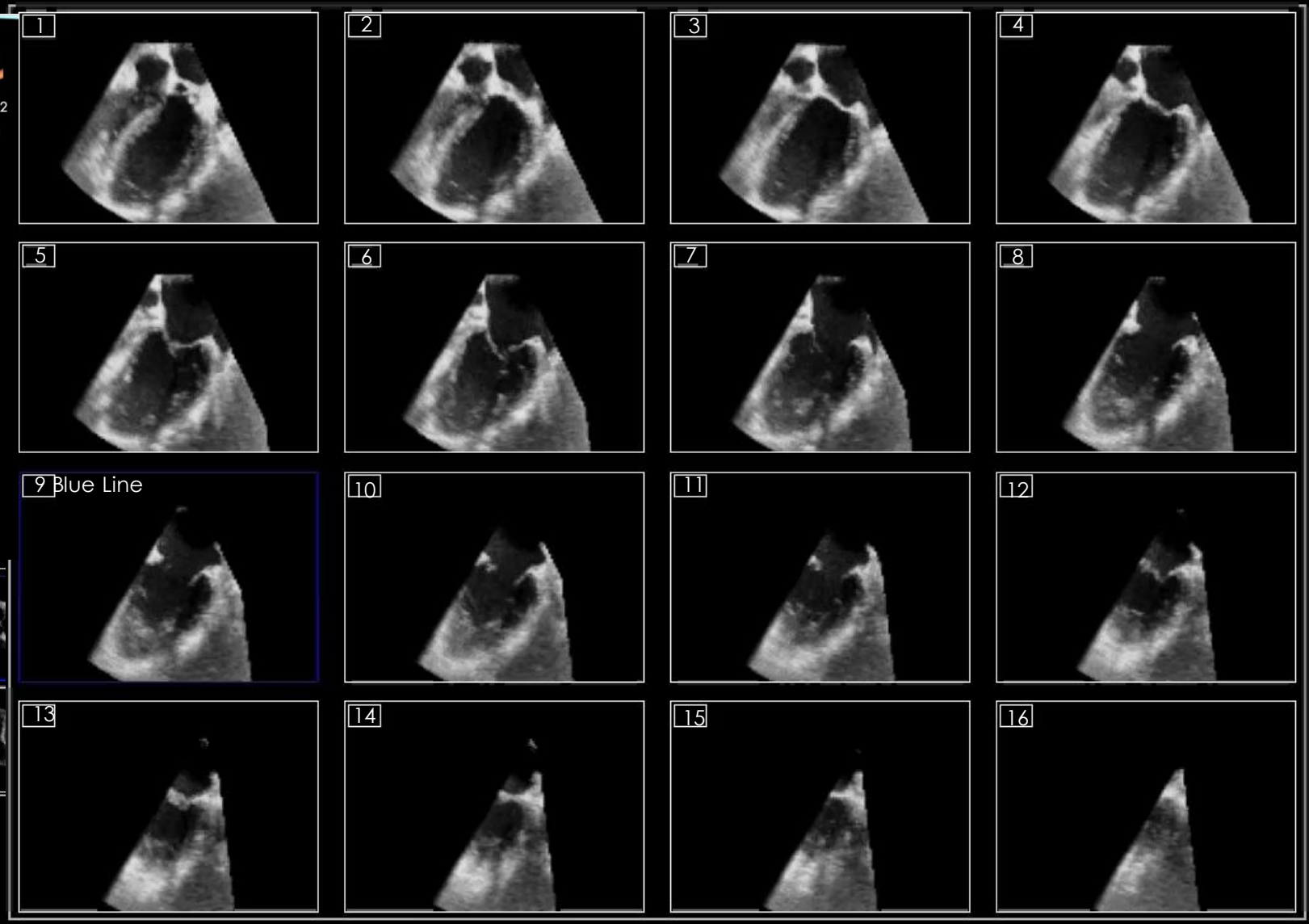




QLAB MPR i-Slice (Philips)



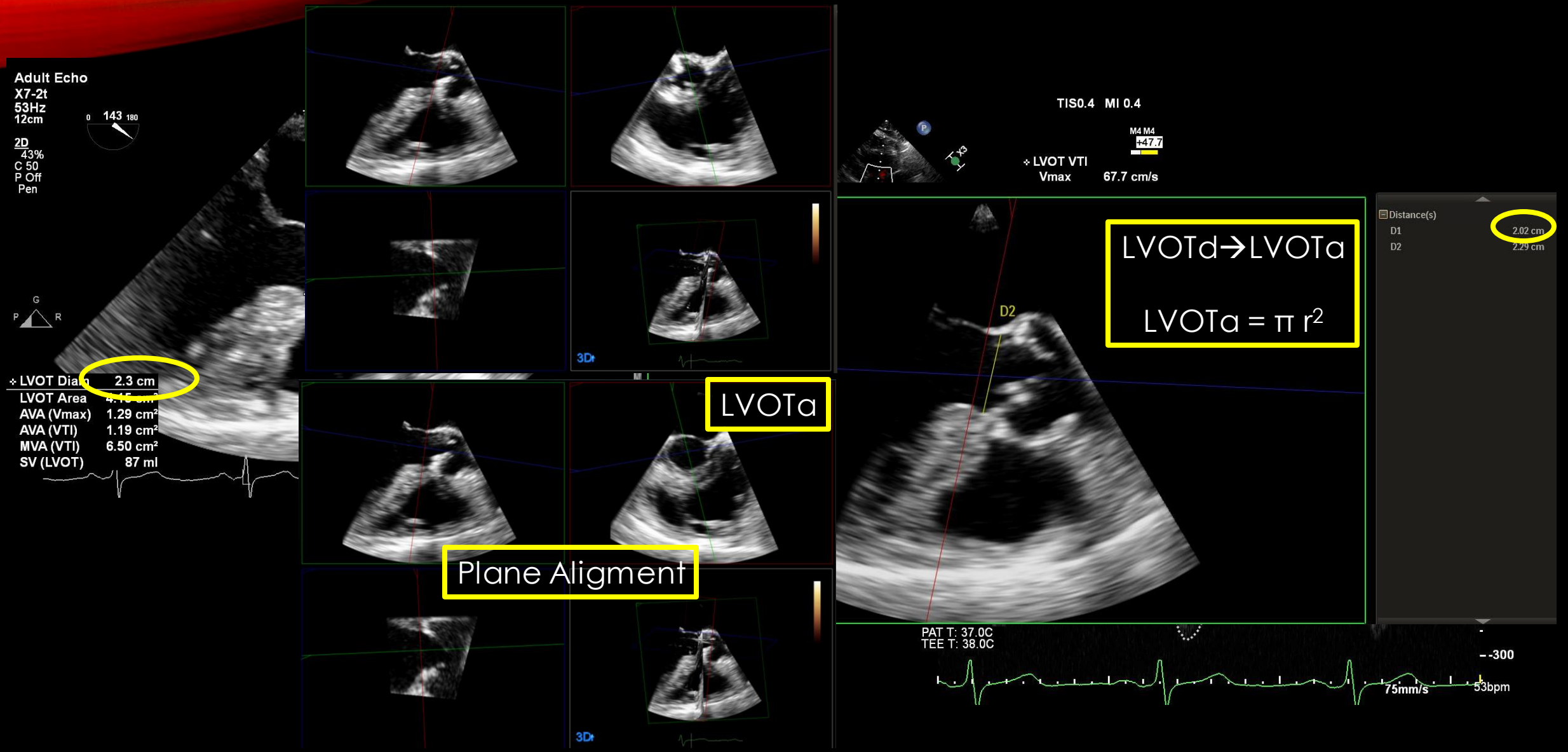




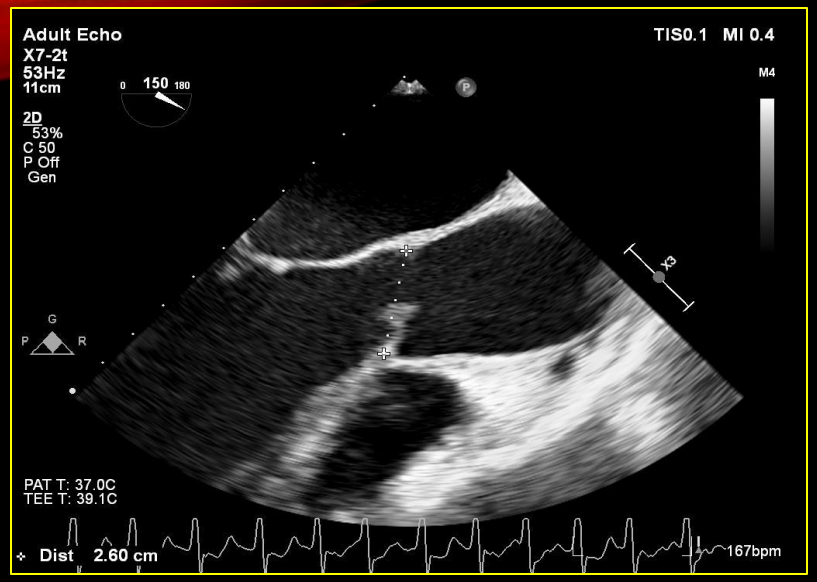
Other MPR software: Flexi-Slide (GE), Image-COM MPR (Tom-Tec), eSieValves (Siemens).

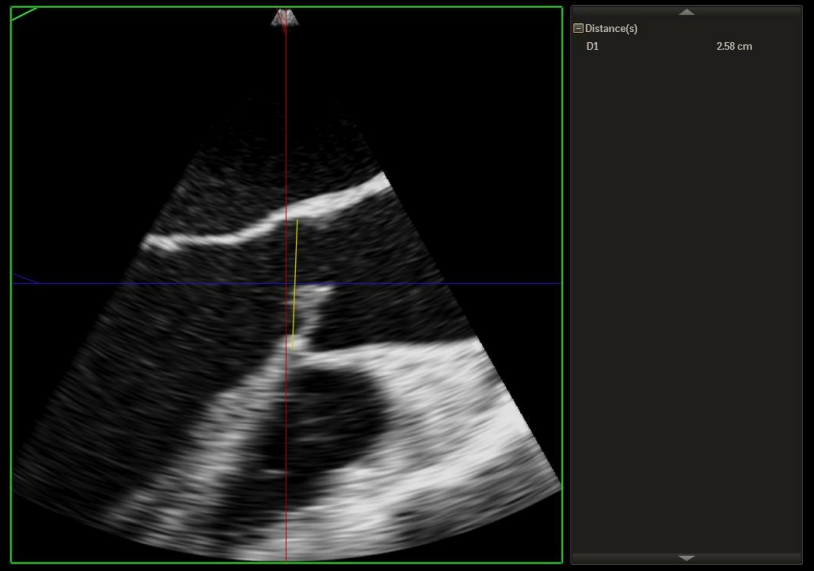
MPR FOR STENOSIS

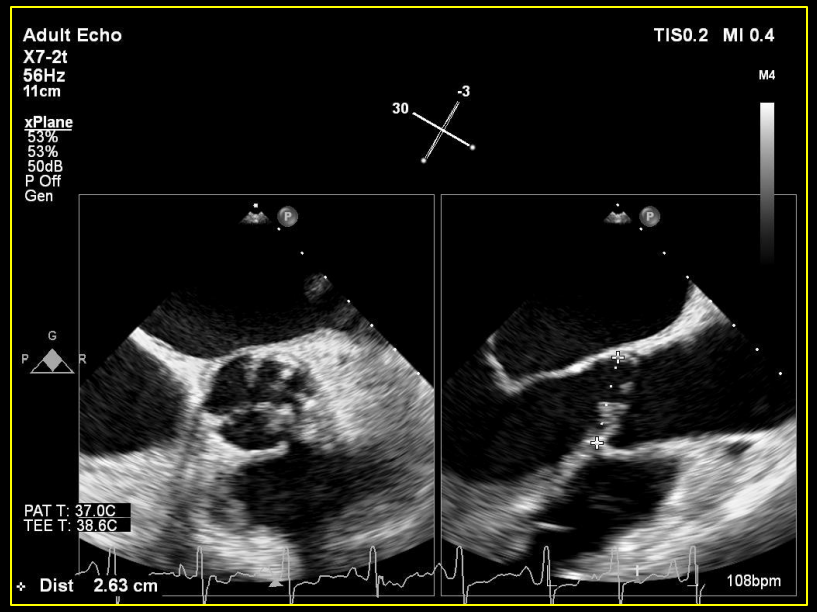
AORTIC STENOSIS: LVOTd

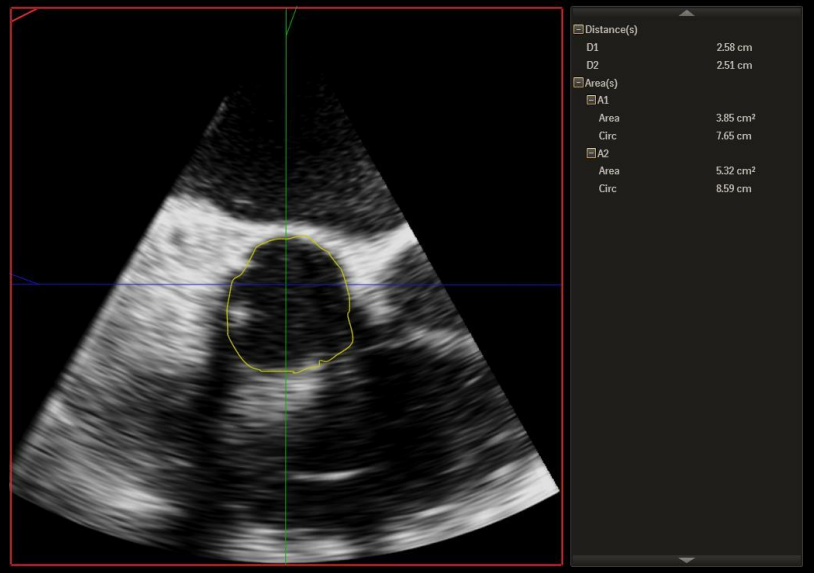


TAVI: AORTIC VALVE ANNULUS

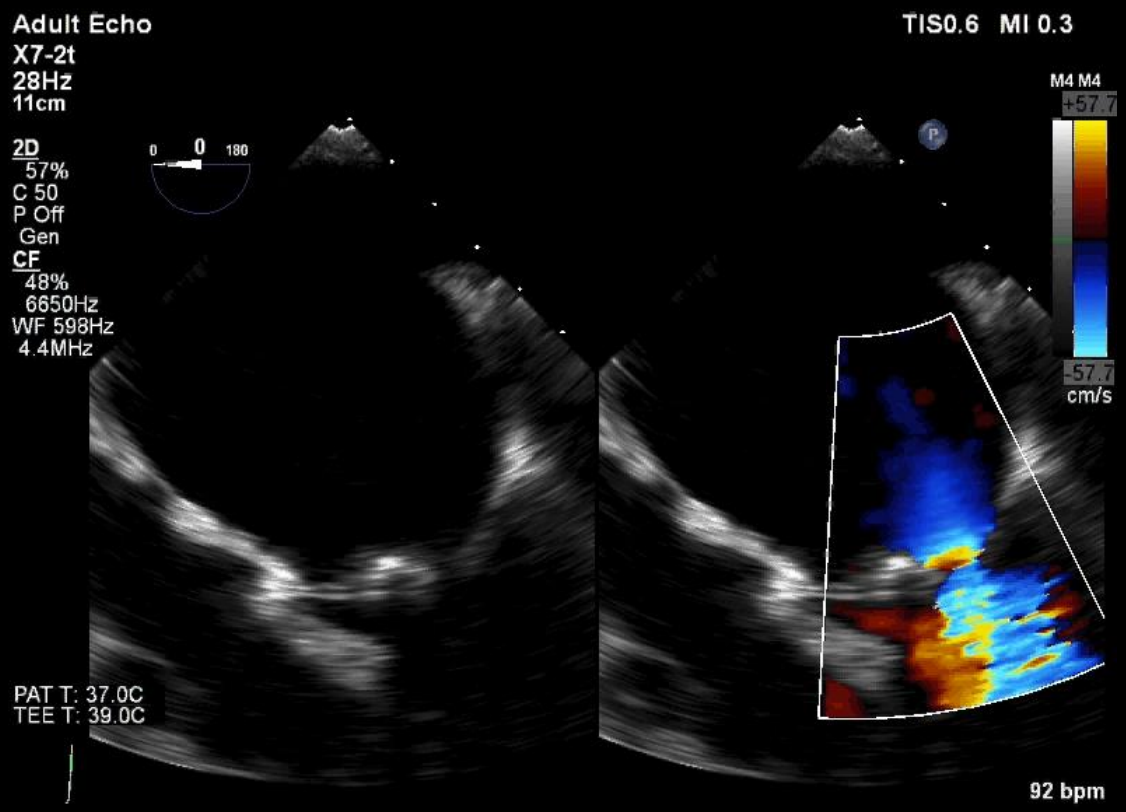


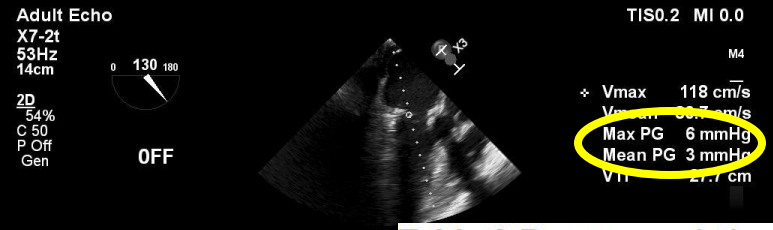






MITRAL STENOSIS





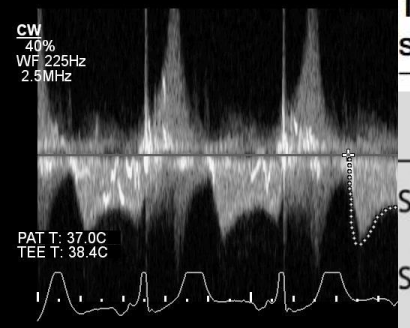
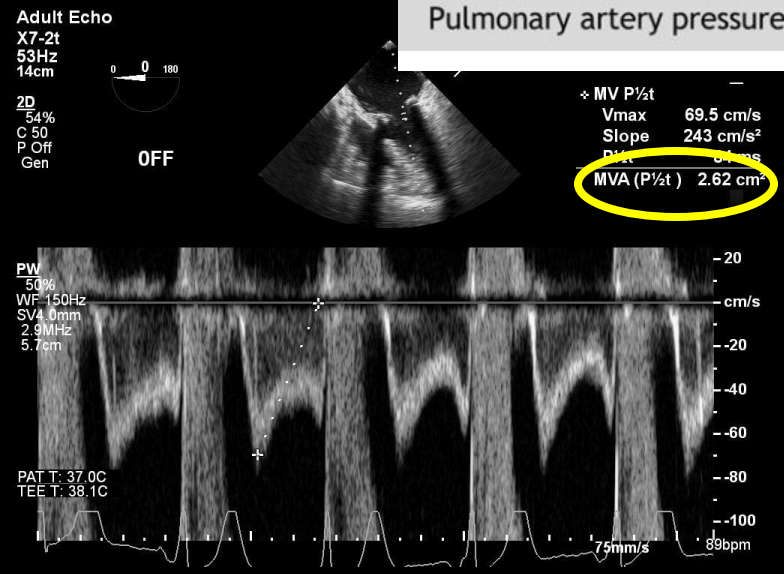


Table 9 Recommendations for classification of mitral stenosis severity

	Mild	Moderate	Severe
Specific findings			
Valve area (cm^2)	>1.5	1.0–1.5	<1.0
Supportive findings			
Mean gradient (mmHg)[a]	<5	5–10	>10
Pulmonary artery pressure (mmHg)	<30	30–50	>50

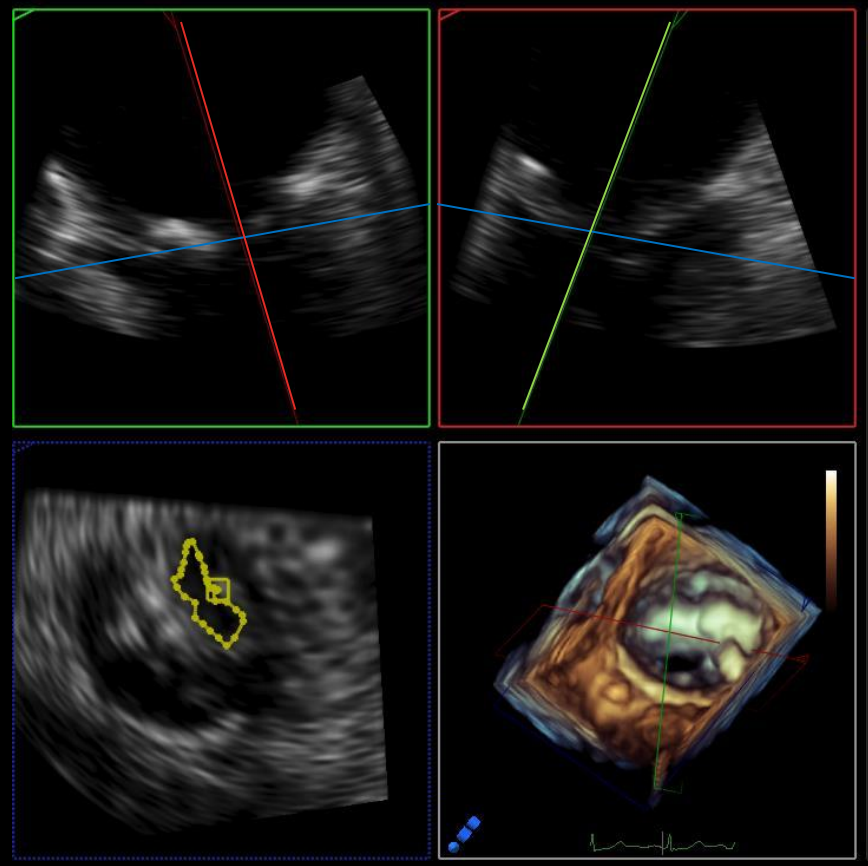


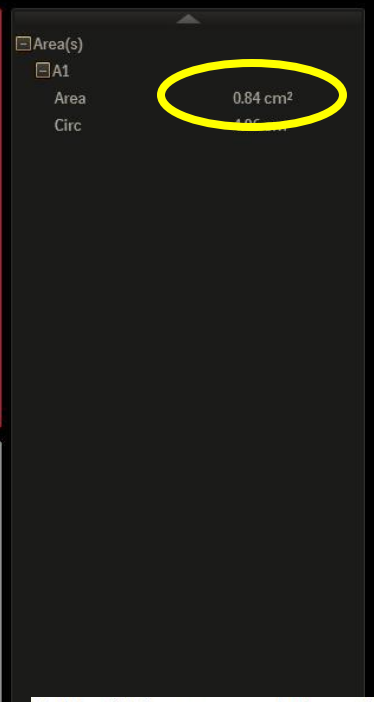
Concomitant AR
Unable to get good TG pictures

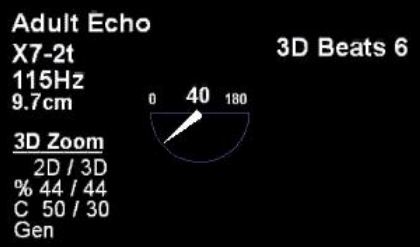
Level 1 for MVA: 2D Planimetry or PHT.

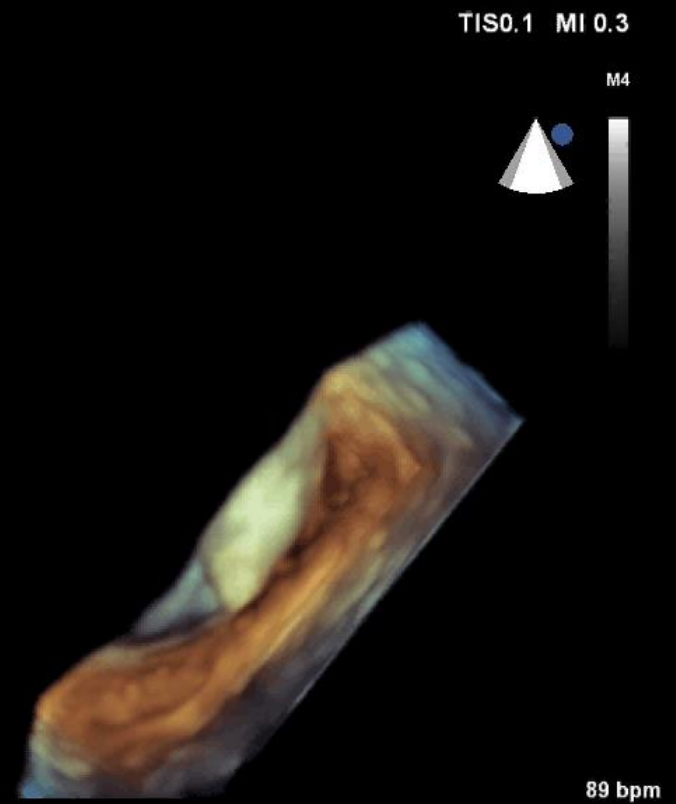
Baumgartner H, et al. J Am Soc Echocardiogr. 2009 Jan;22(1):1-23

3D MITRAL VALVE PLANIMETRY









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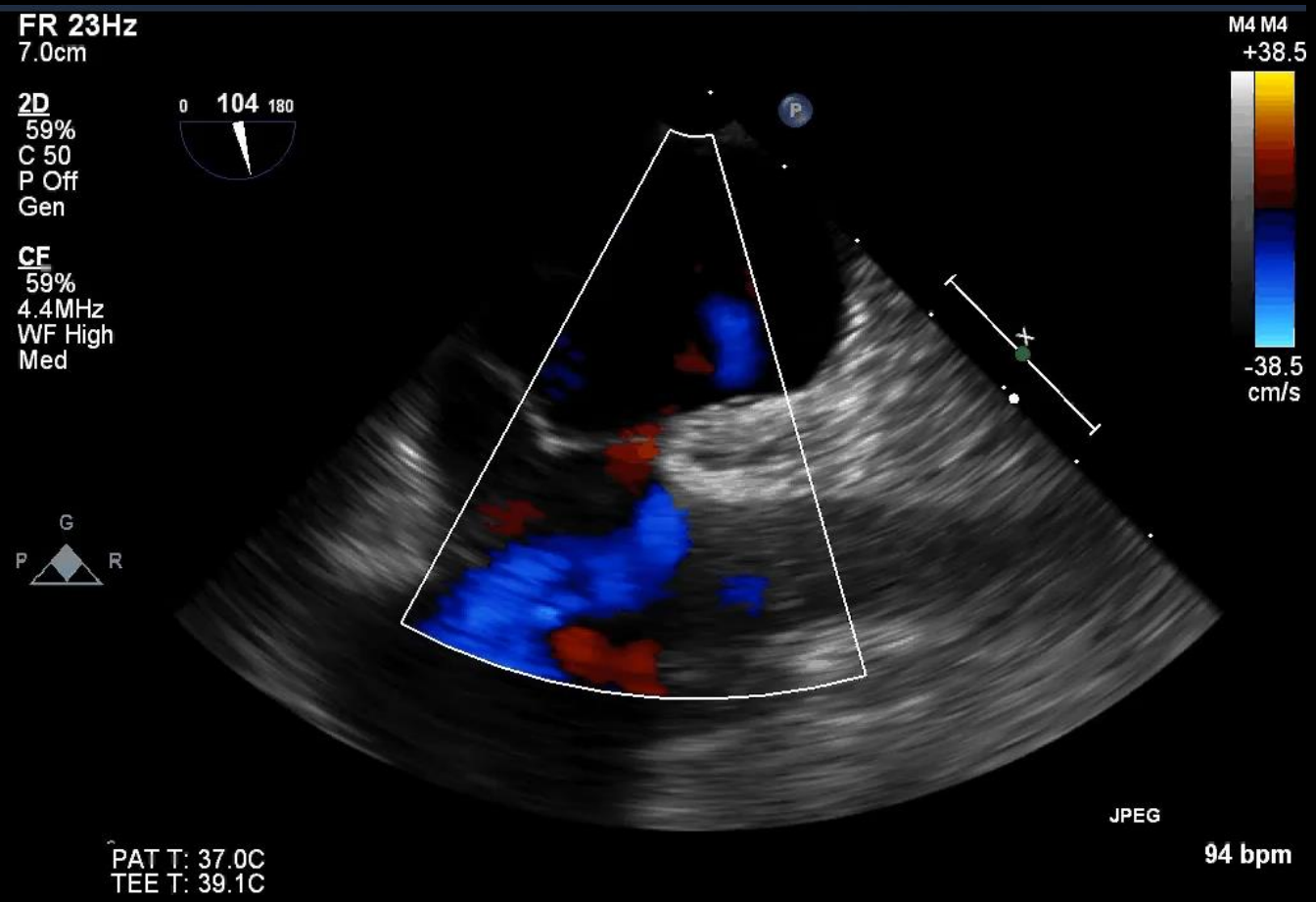
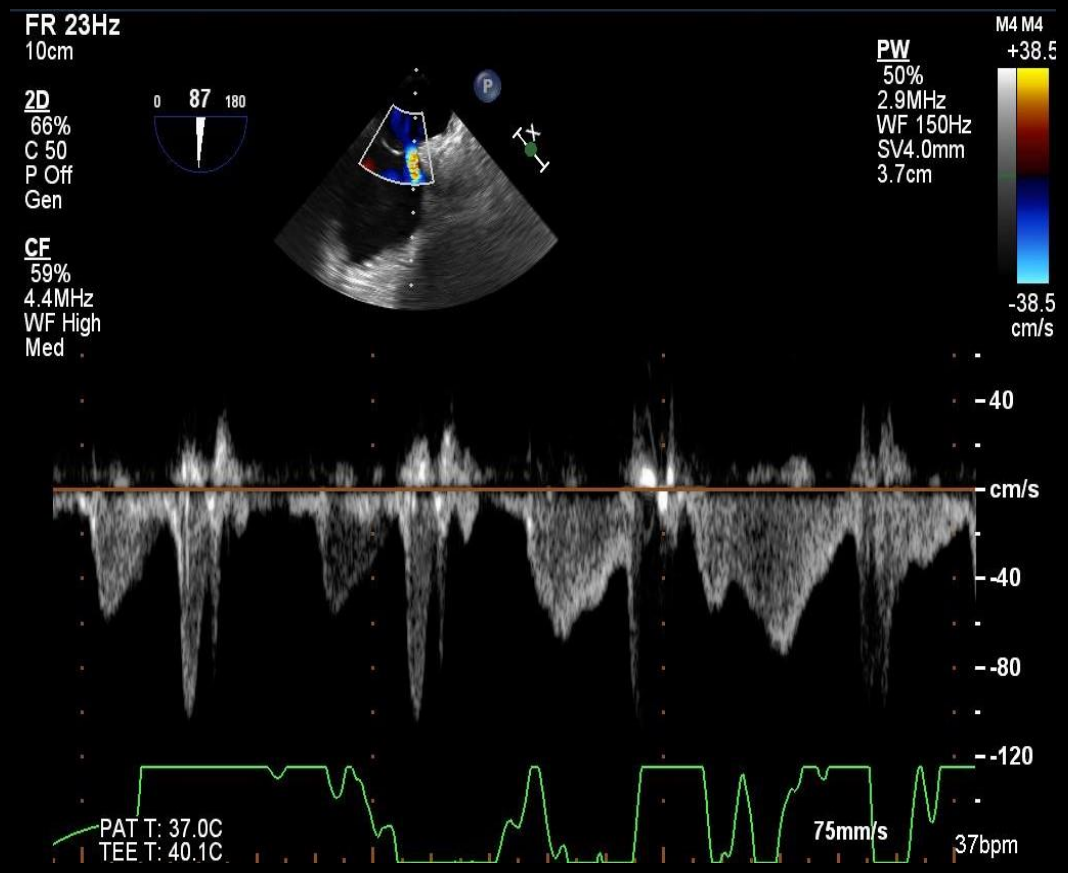
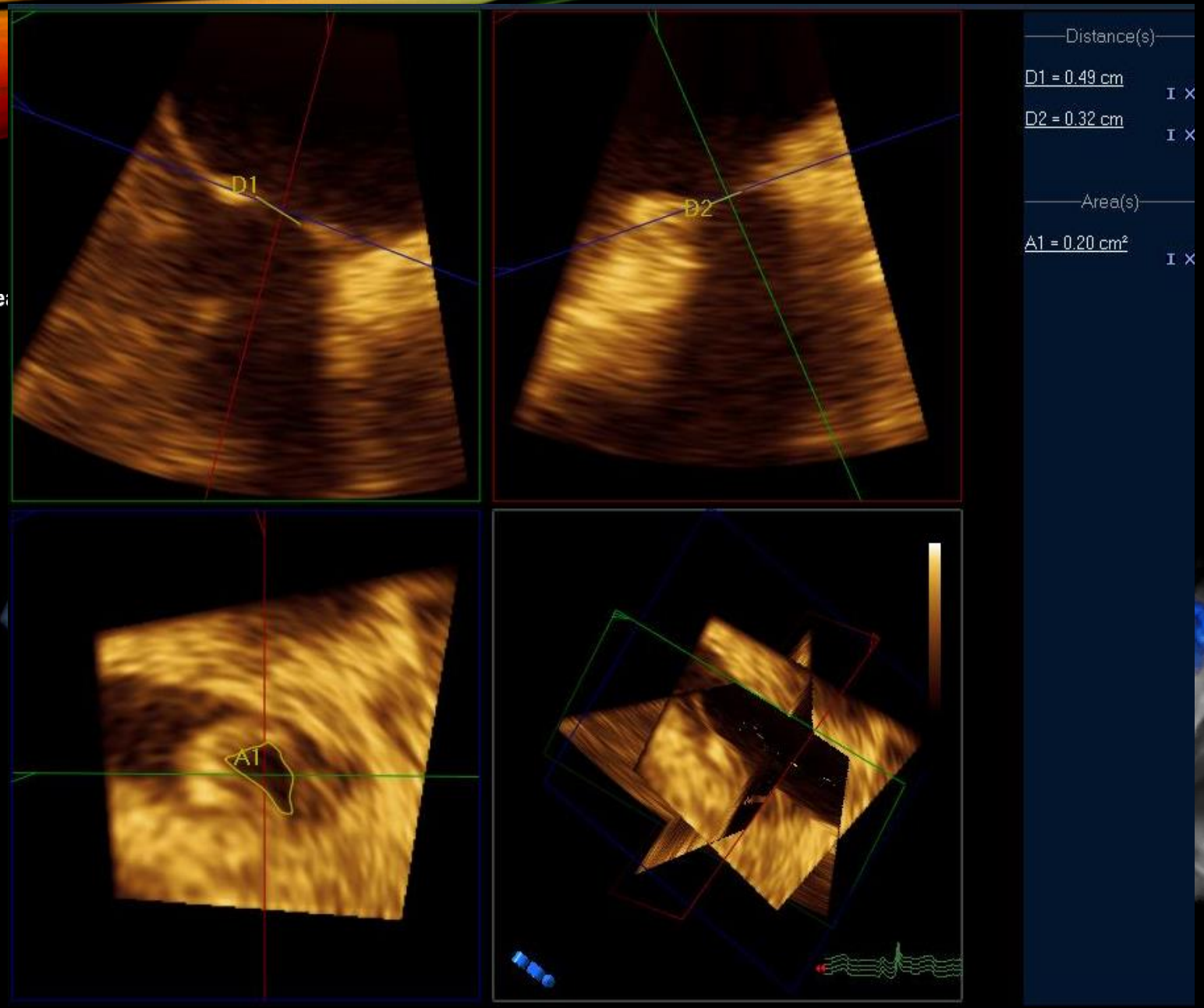
OTHER MPR APPLICATIONS

ASD

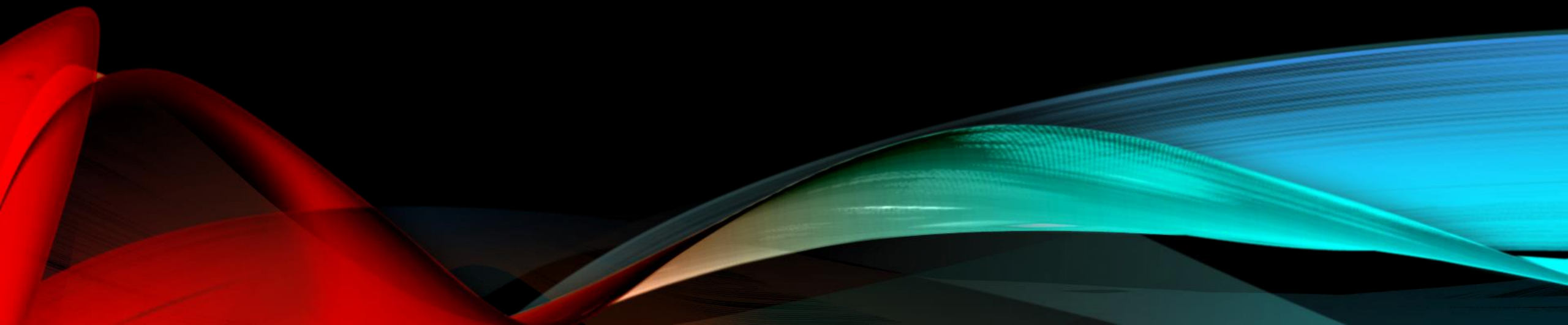

FR 23Hz
7.0cm
2D
59%
C 50
P Off
Gen
CF
59%
4.4MHz
WF High
Med
0 104 180
M4 M4
+38.5
-38.5
cm/s
G
P
R
JPEG
94 bpm
PAT T: 37.0C
TEE T: 39.1C


FR 23Hz
10cm
2D
66%
C 50
P Off
Gen
CF
59%
4.4MHz
WF High
Med
0 87 180
PW
50%
2.9MHz
WF 150Hz
SV4.0mm
3.7cm
M4 M4
+38.5
-38.5
cm/s
-40
cm/s
-40
-80
-120
PAT T: 37.0C
TEE T: 40.1C
75mm/s
37bpm

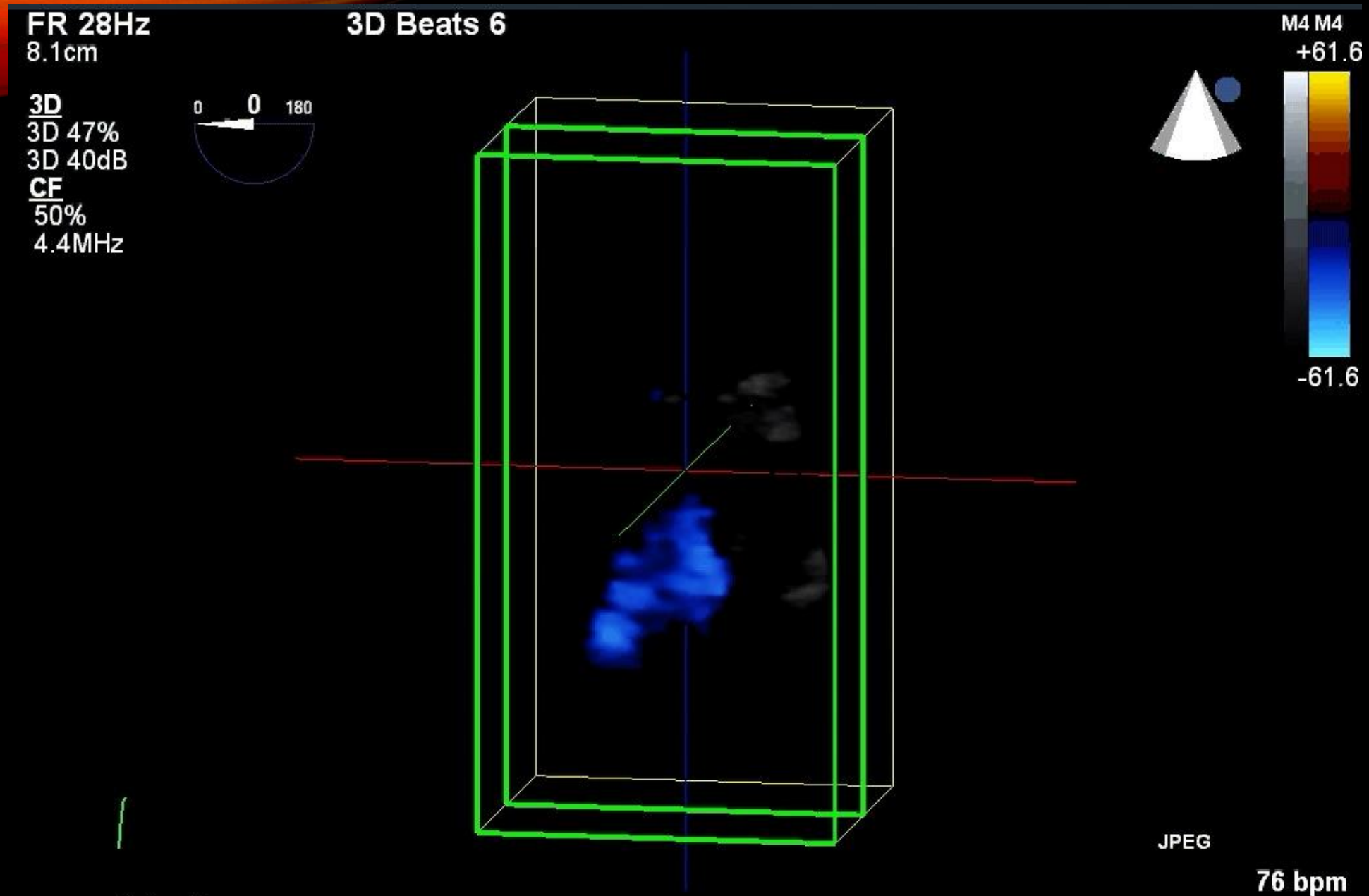
ASD

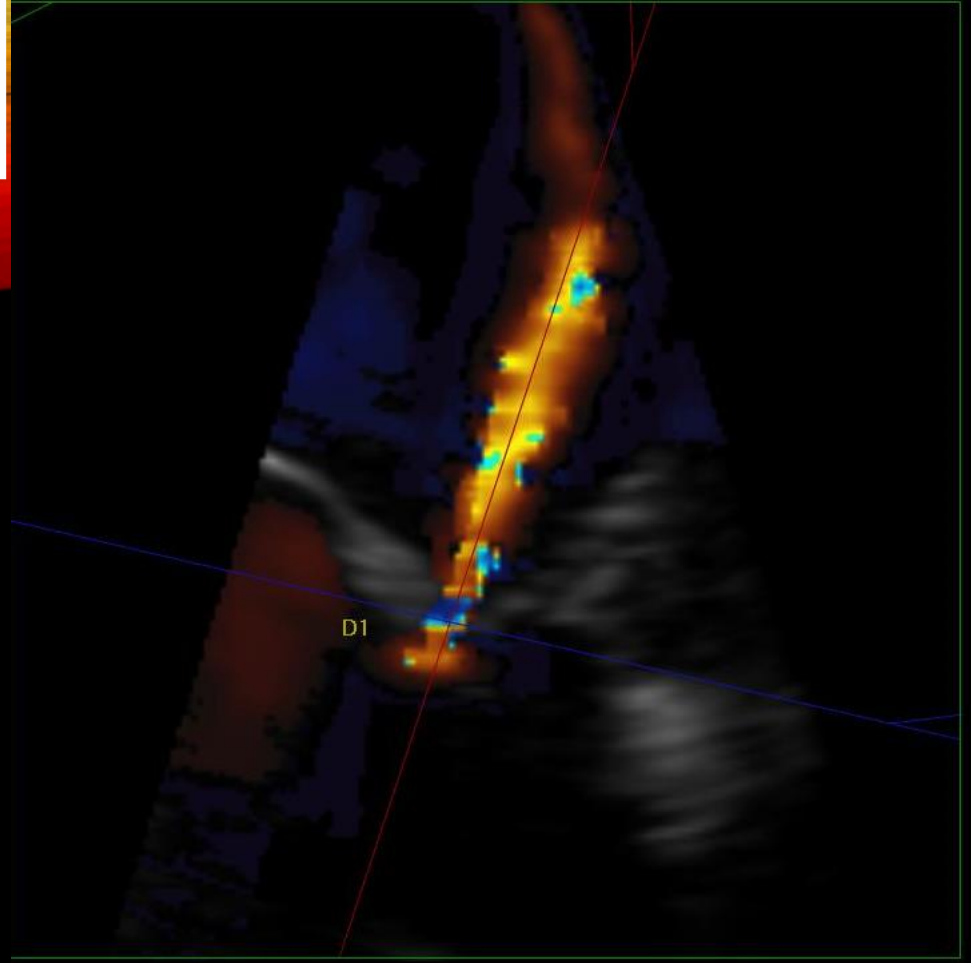

D1
D2
A1
Distance(s)
D1 = 0.49 cm
D2 = 0.32 cm
Area(s)
A1 = 0.20 cm²
6.2cm
3D
3D 52%
3D 40dB
0
70
180
M4 M4
+53.9
-53.9

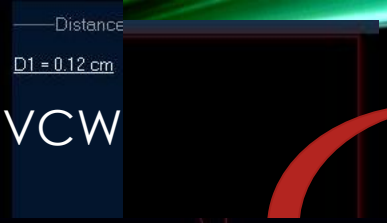
3D MPR FOR REGURGITATION



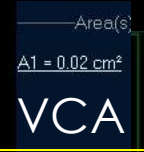
3D COLOR REGURGITATION







Regurgitant Jet Plane Alignment



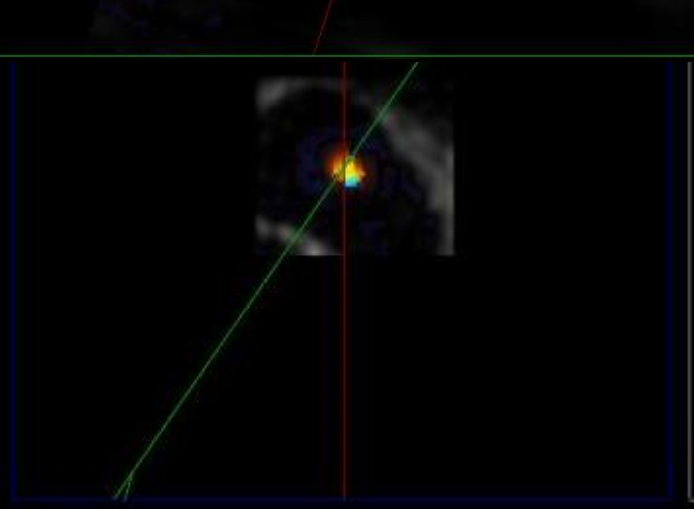
Red Sagittal plane

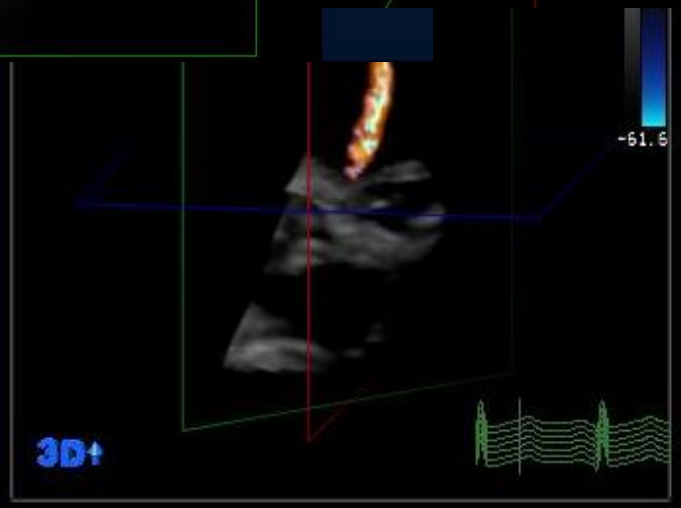
At valve coaptation level or just within the left atrium.

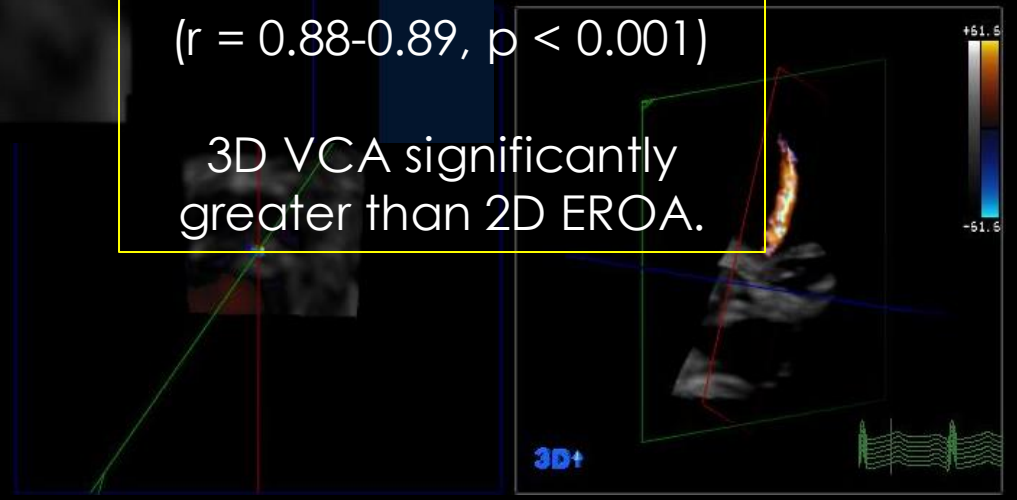
Correlation 2D vs 3D VCA
$r = 0.97$; $p < 0.001$
Chin et al. Echocardiography. 2010;27(2):161-6

3D VCA vs 2DE EROA
($r = 0.88$-0.89, $p < 0.001$)

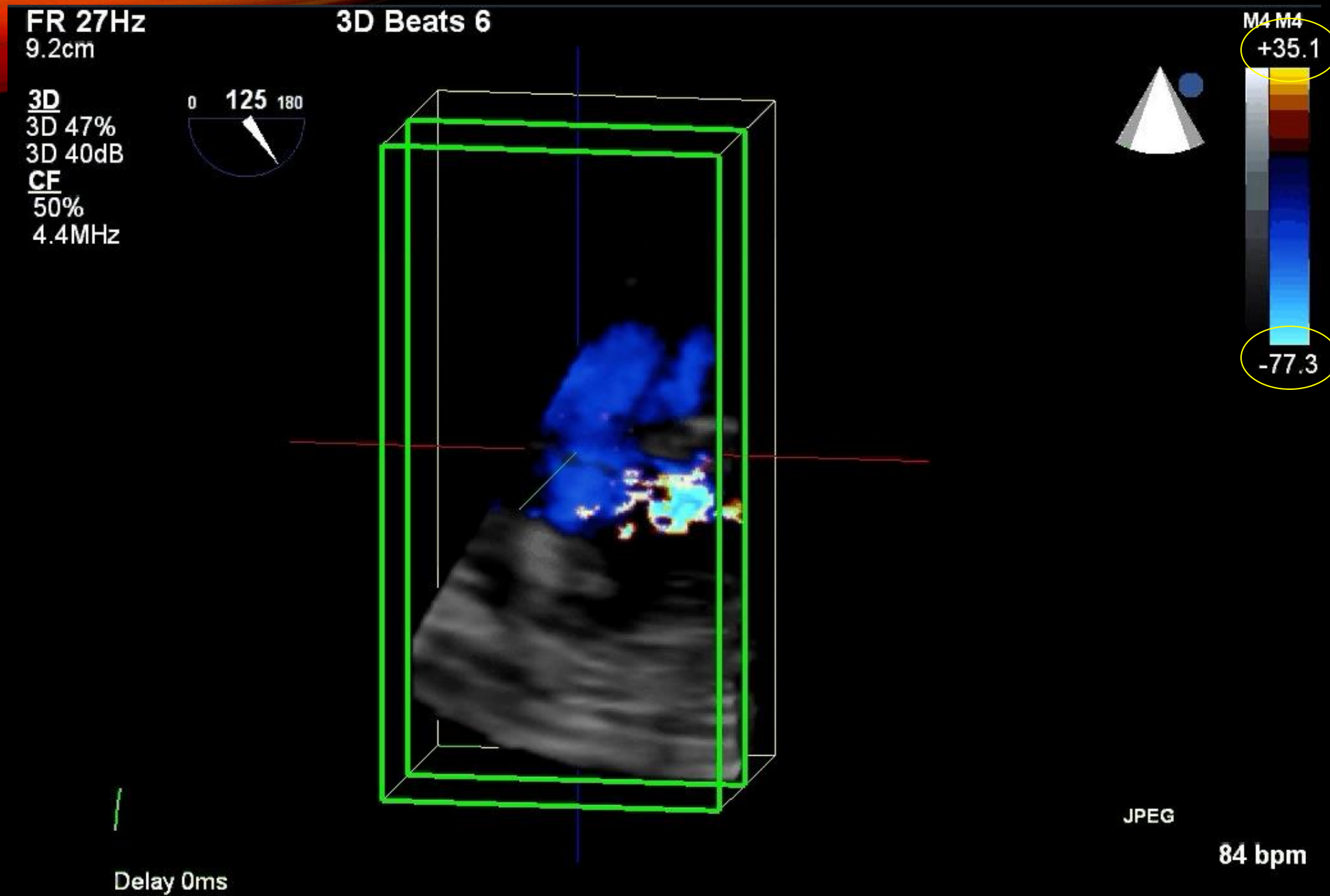
3D VCA significantly greater than 2D EROA.

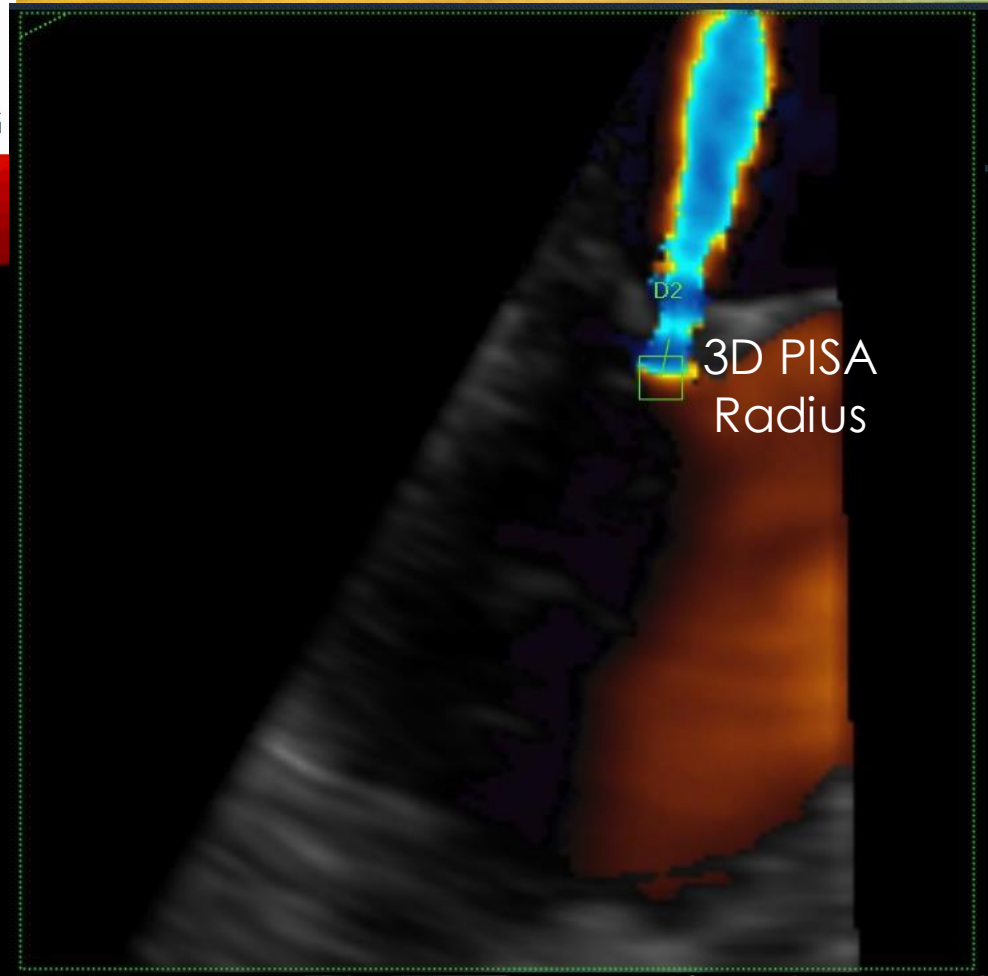






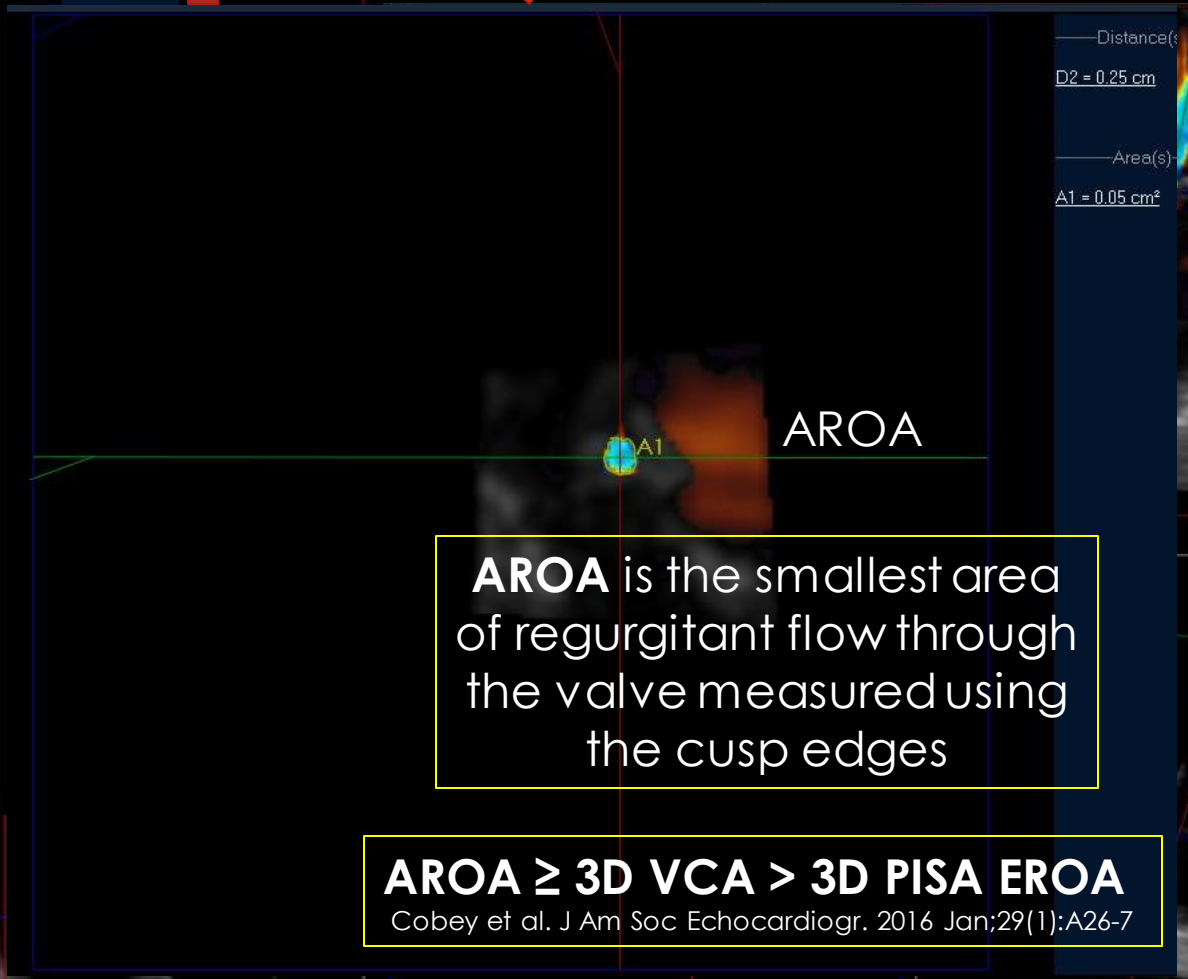
PISA 3D COLOR REGURGITATION





3D PISA Radius

Regurgitant Jet Plane Alignment



AROA

AROA is the smallest area of regurgitant flow through the valve measured using the cusp edges

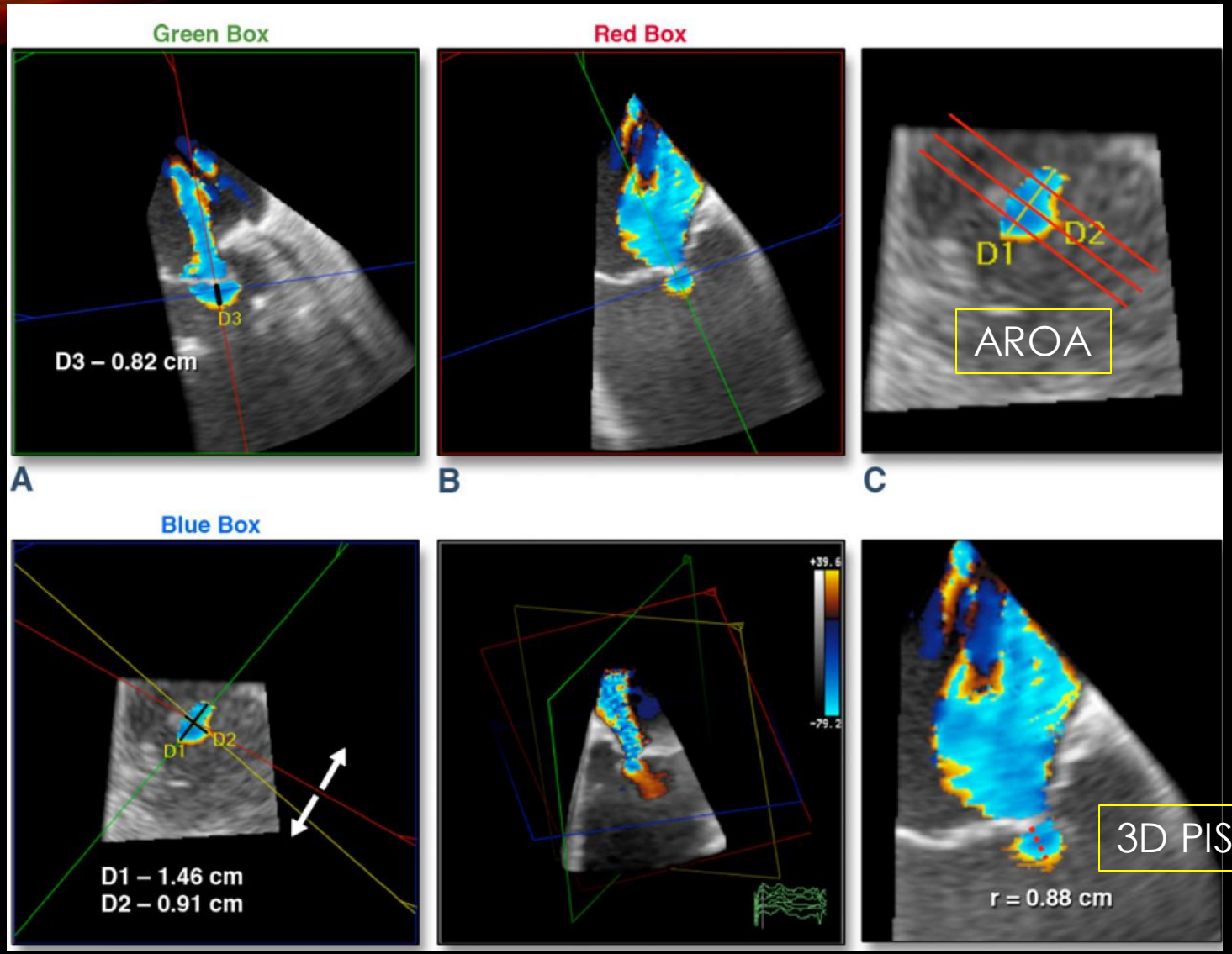
AROA ≥ 3D VCA > 3D PISA EROA

Cobey et al. J Am Soc Echocardiogr. 2016 Jan;29(1):A26-7

3D COLOR MPR QLAB (Phillips): 3D PISA EROA, AROA

RV calculated from EROA by 3D PISA or 3D VCA, have a favorably comparison with MRI calculated volumes

RV = 3D VCA x MR VTI
RV = 3D EROA x MR VTI

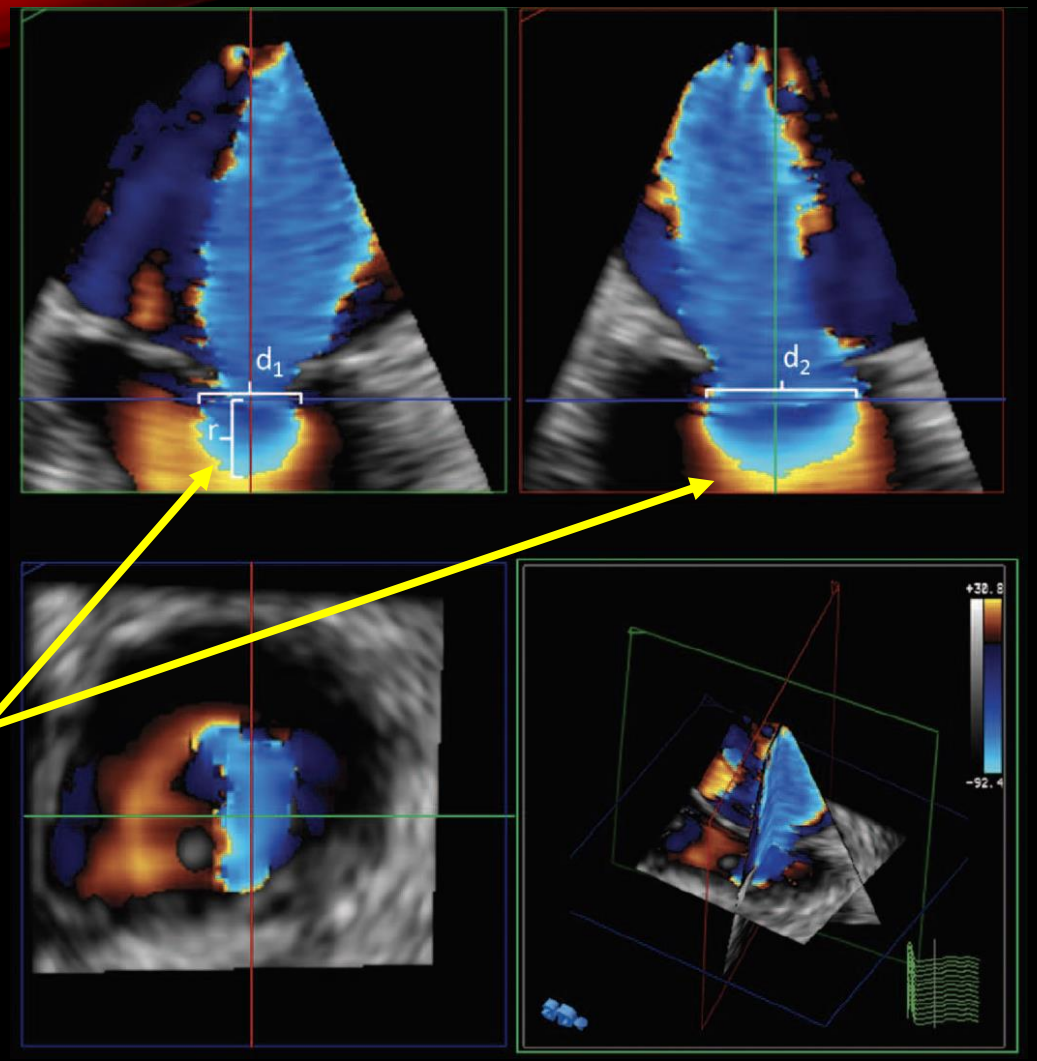


AROA is the smallest area of regurgitant flow through the valve measured using the cusp edges (slightly bigger than the VCA)

$$EROA = \frac{2\pi r^2 \times Aliasing\ Velocity\left(\frac{cm}{s}\right)}{MR\ Vmax\left(\frac{cm}{s}\right)}$$

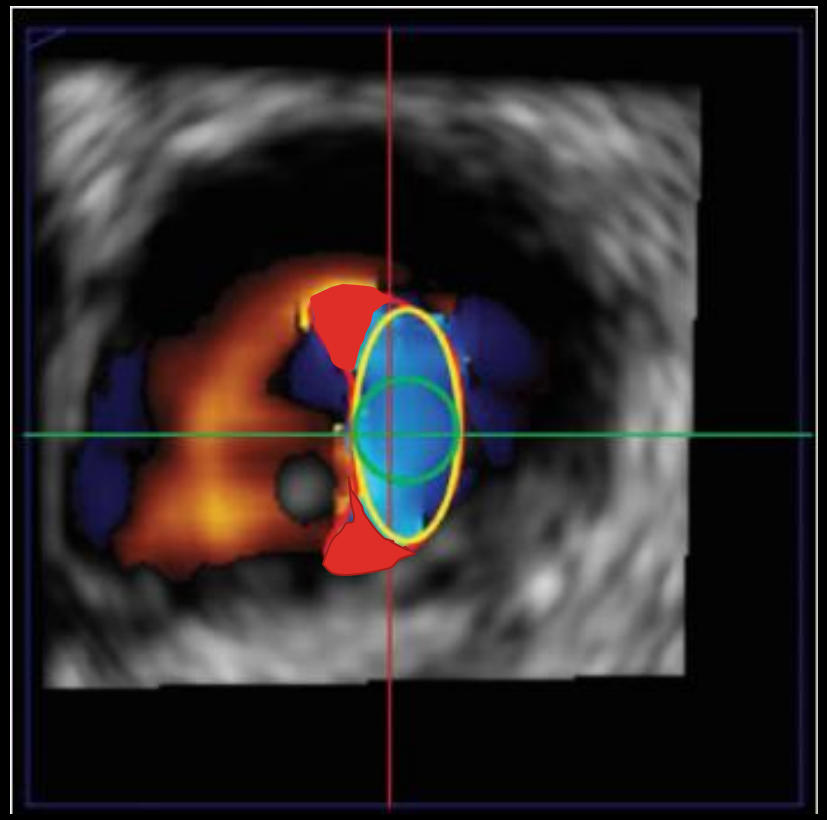
Thavendiranathan P, et al. JACC Cardiovasc Imaging. 2012;5(11):1161-75.

3D COLOR MPR QLAB (Phillips): 3D PISA EROA



Hemisphere or Hemielliptical?

Other 3D PISA software: eSie PISA™ (Siemens)



Ashikhmina et al. Anesth Analg. 2015;120(3):534-42.

VCA, EROA, AROA

- We cannot assume that 3D planimetered VCA is equivalent to EROA.
- Real 3D **EROA** should be calculated by 3D PISA.
- Despite significant correlation between 2D-3D VCA and 2D EROA ($r=0.88\text{-}0.89$, $p<0.001$), 3D VCA is significantly greater than 2D EROA.
- **AROA** is slightly bigger than the VCA.
- **AROA ≥ 3D VCA > 3D PISA EROA**.

Chin et al. Echocardiography. 2010;27(2):161-6
Sato et al.. Cardiovasc Ultrasound. 2015;13:24
Zoghbi et al. J Am Soc Echocardiogr. 2003;16(7):777-802
Lancellotti et al. Eur J Echocardiogr. 2010;11(3):223-44.
Mascherbauer et al. J Am Soc Echocardiogr. 2005;18(10):999-1006.
Thavendiranathan P, et al. JACC Cardiovasc Imaging. 2012;5(11):1161-75
Cobey et al. J Am Soc Echocardiogr. 2016 Jan;29(1):A26-7

3D MPR LIMITATIONS

- Limited **temporal** and **spatial** resolution.
- Translation artifacts.
- Angle dependence.
- Complex dynamic changes of VCA size and shape.
- VCA is characterized by high-velocity flow acquired using CFD, being more representative of a functional or hemodynamic EROA rather than a true EROA.

Ashikhmina E, et al. Anesth Analg. 2015;120(3):534-42.
Buck T,et al. Curr Cardiovasc Imaging Rep. 2015;8(10):38.

The Lynn & Arnold Irwin

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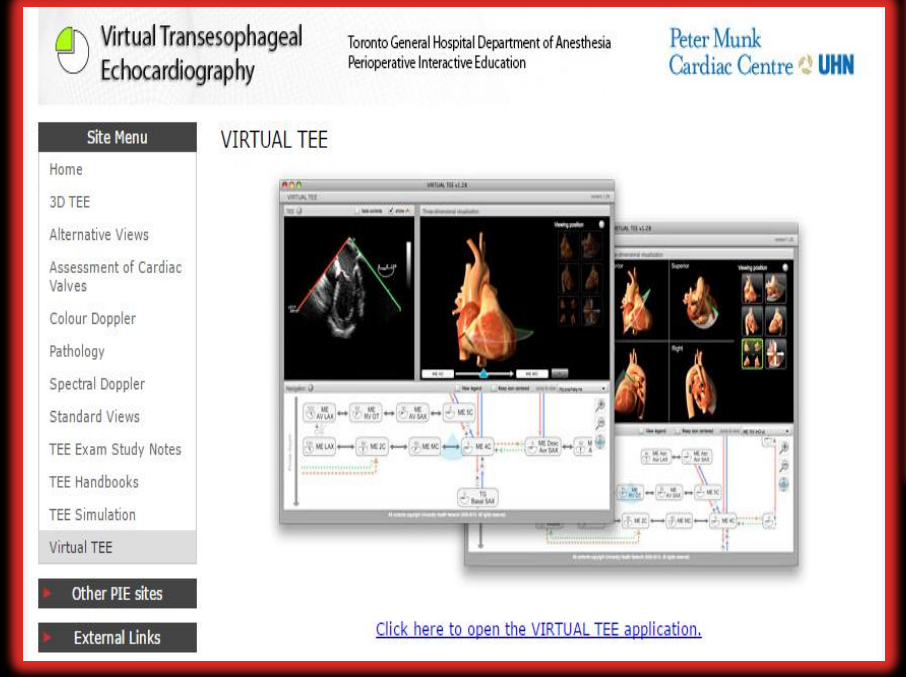
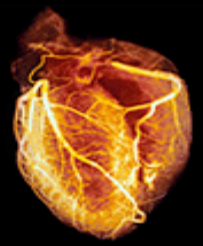


Toronto General Hospital

Jacobo.Moreno@uhn.ca

UNIVERSITY OF TORONTO



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