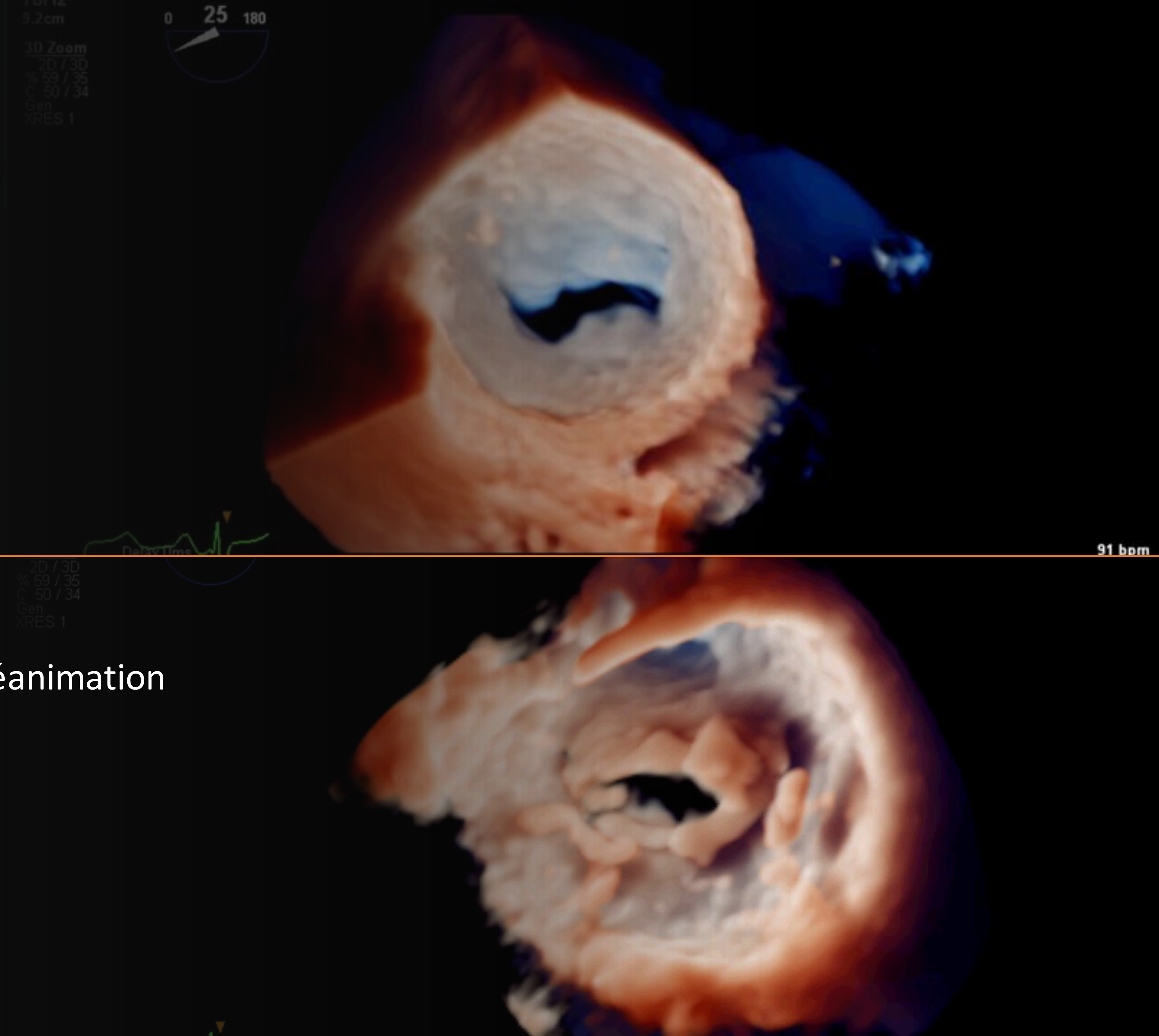
Introduction à l'Echo 3D



DIU TUSAR Février 2025

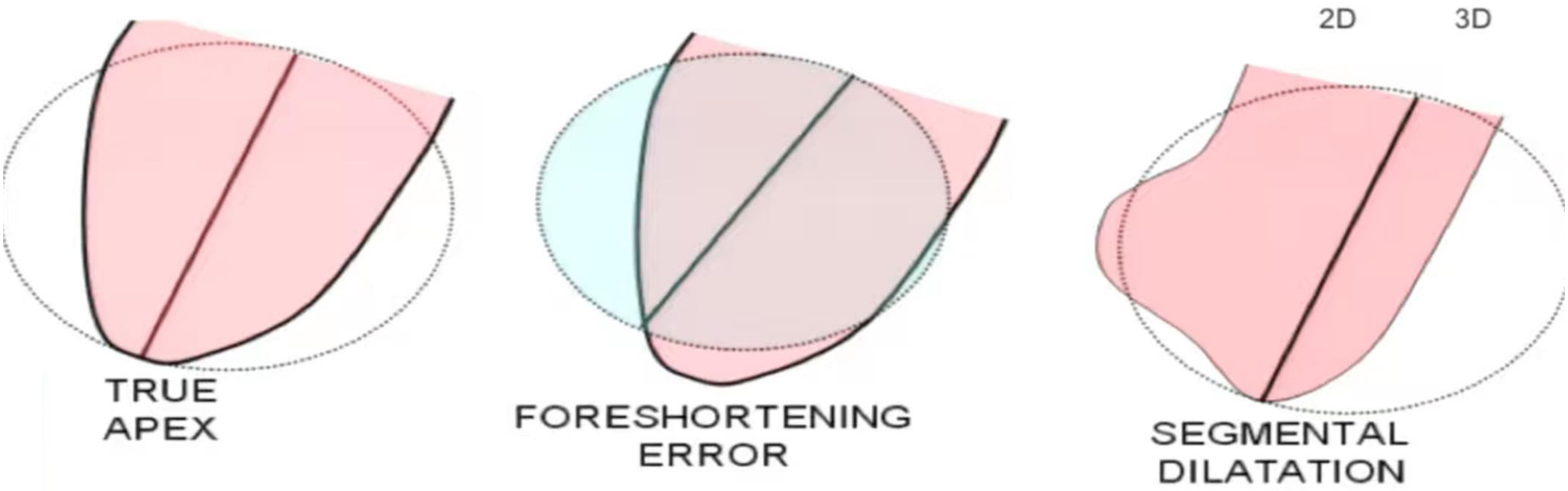
Dr Manon Canevet – Anesthésie Réanimation
CTCV CHU Nantes

CENTRE HOSPITALIER
UNIVERSITAIRE DE NANTES

Pourquoi faire de l’écho 3D?

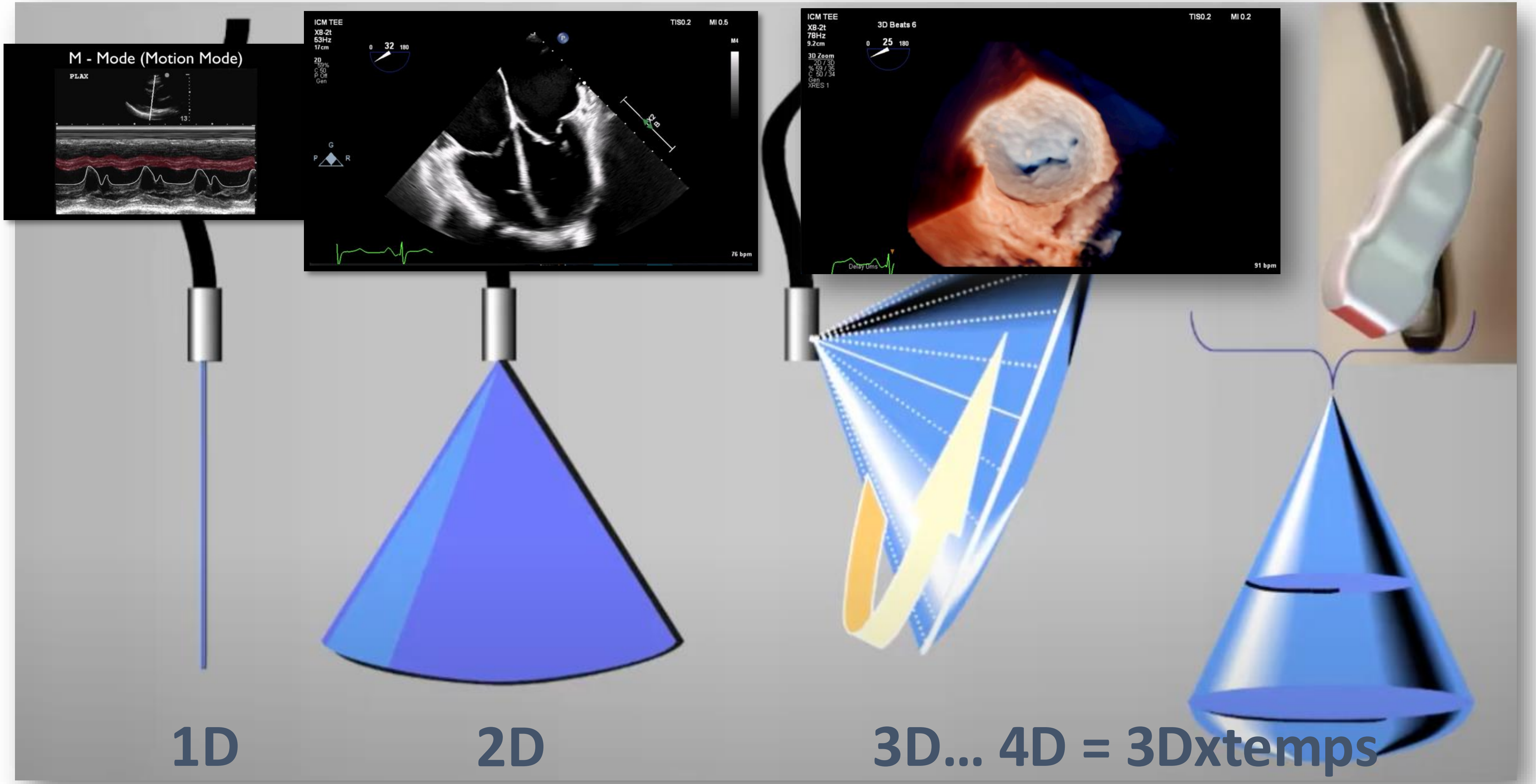
- Evaluation des volumes et de la masse des cavités cardiaques
- Evaluation du mouvement régional de la paroi du ventricule gauche (VG) et la quantification de la dyssynchronie systolique
- Présentation de vues réalistes des valves cardiaques
- Evaluation volumétrique des lésions régurgitantes et des shunts avec l'imagerie Doppler couleur 3DE
- Evaluation de l'imagerie de stress 3DE
- Échoguidage des procédures percutanées

Pourquoi faire de l'écho 3D?



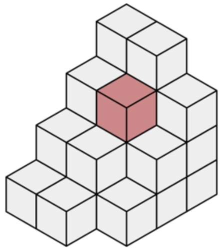
Mor-Avi V, Lang RM et al., *Circulation* 2004. 110: 1814-1818.

1D …. À 4D



M - Mode (Motion Mode)
PLAX
ICM TEE
X8-2t
53Hz
17cm
TIS0.2
MI 0.5
75 bpm
ICM TEE
X8-2t
78Hz
9.2cm
3D Beats 6
3D Zoom
TIS0.2
MI 0.2
91 bpm
1D
2D
3D… 4D = 3Dxtemps

Principe de la 3D



- Acquisition automatisée et sérielle d’images biplan
  - Bras motorisé en ETT ou robotisation de la rotation du plan en ETO avec intégration du positionnement de chaque plan dans l’espace analysé

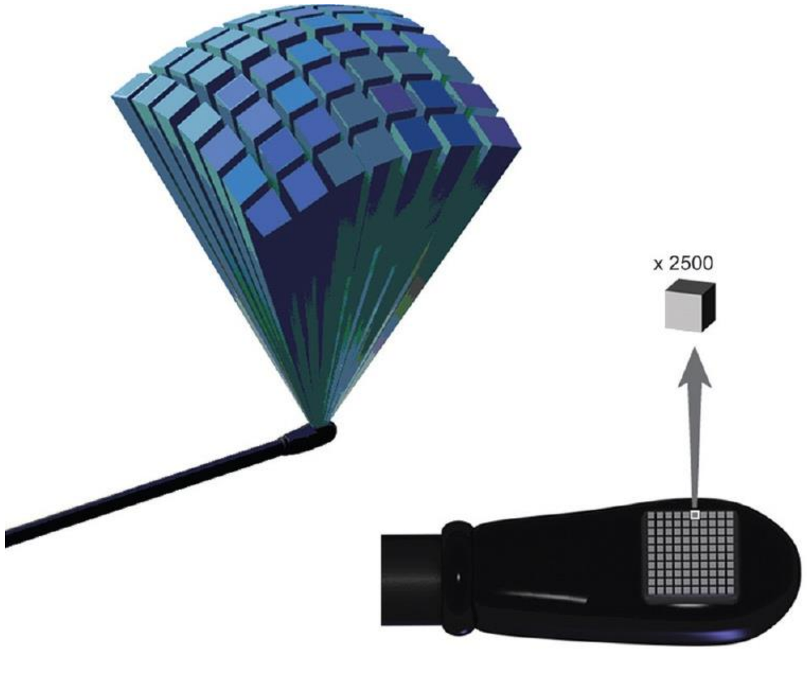
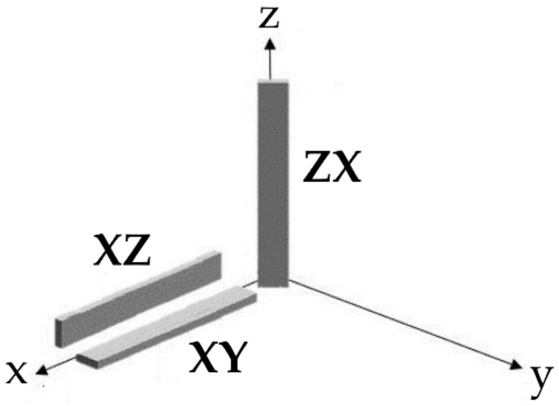


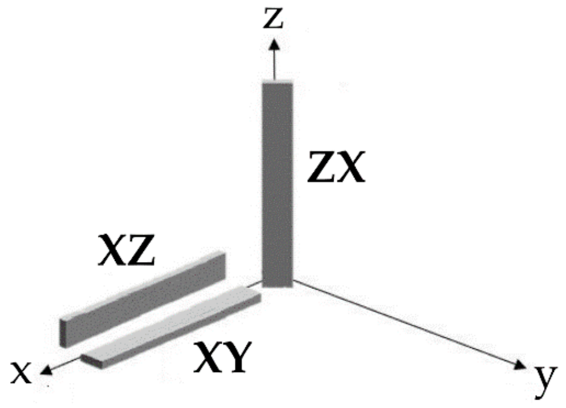
Image courtesy of Michael Corrin

VOXEL



Résolution

- Axiale = 0.5 mm >> latérale = 2,5 mm > élévation = 3 mm



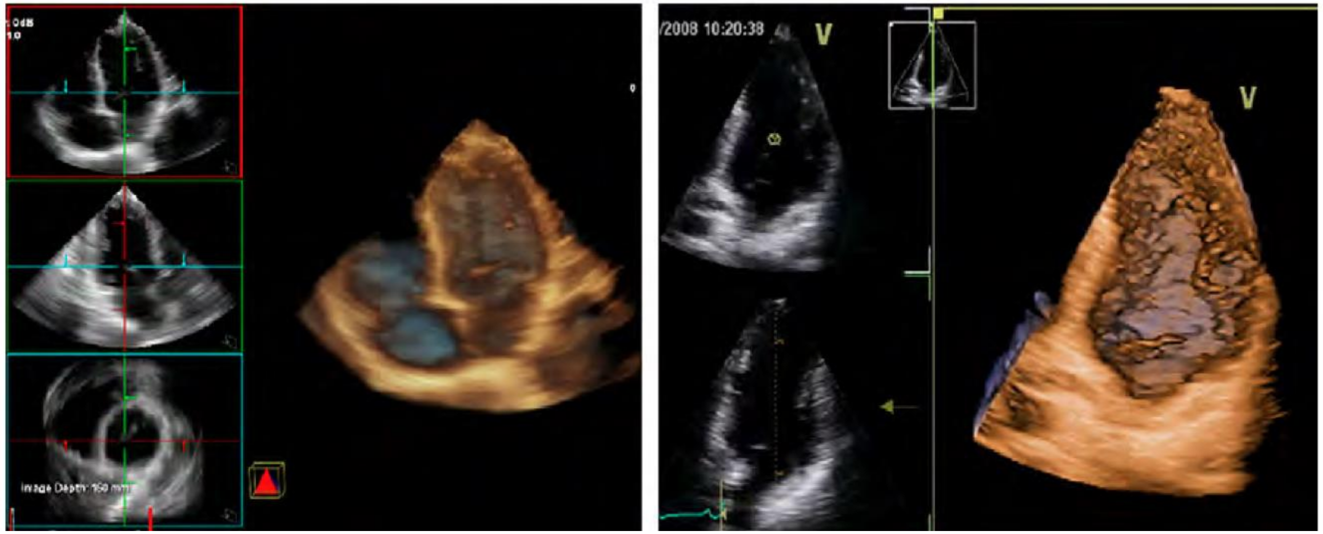
= peut générer des voxels anisotropiques

! Un changement de plan d'étude peut résulter en une différence d'aspect 3D sur une même structure

3D en temps réel ou à battements multiples

3D en temps réel

3DE en temps réel ou en direct fait référence à l'acquisition de plusieurs ensembles de données pyramidales par seconde au cours d'un seul battement de cœur.



Avantages = en cas de mouvements respiratoires ou de trouble du rythme

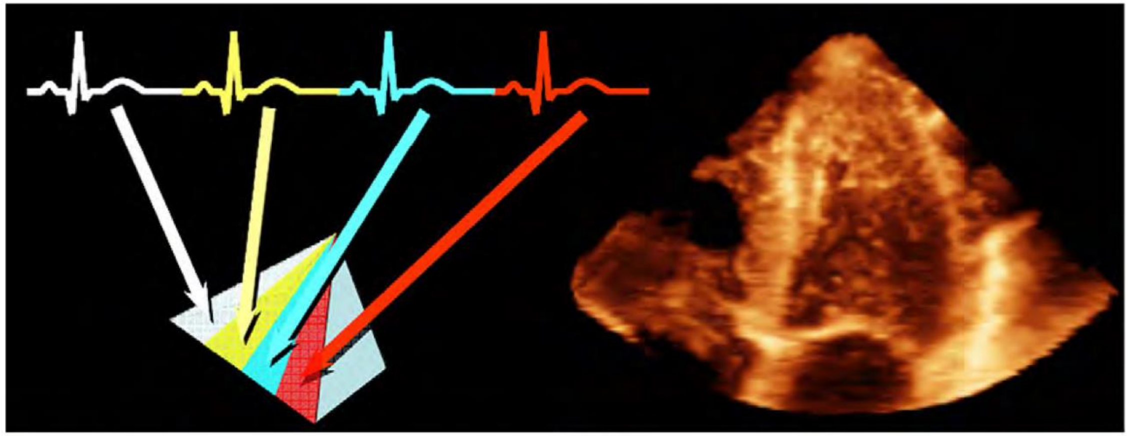
Inconvénient = mauvaise résolution spatiale et temporelle

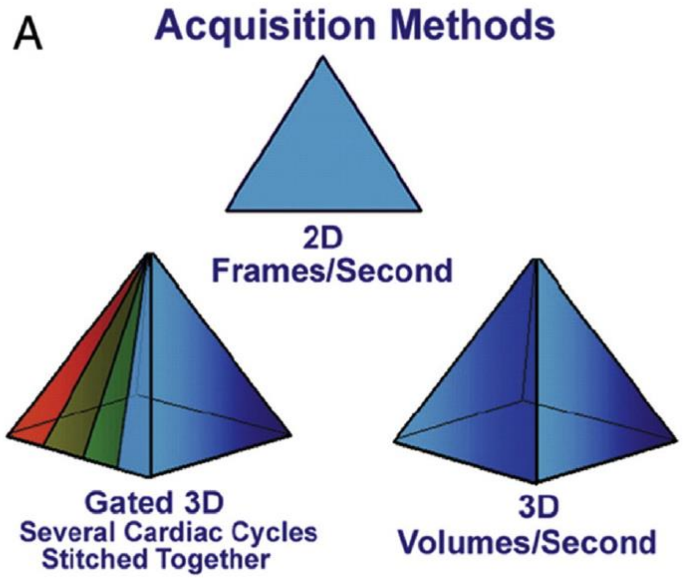
3D en temps réel ou à battements multiples

3D à battements multiples

volumes étroits d'informations sur plusieurs battements cardiaques

Avantages = augmente résolution spatiale et temporelle



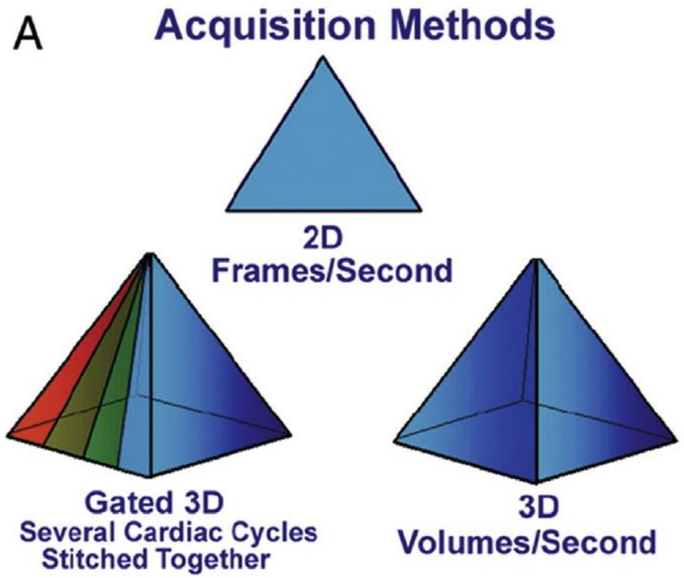


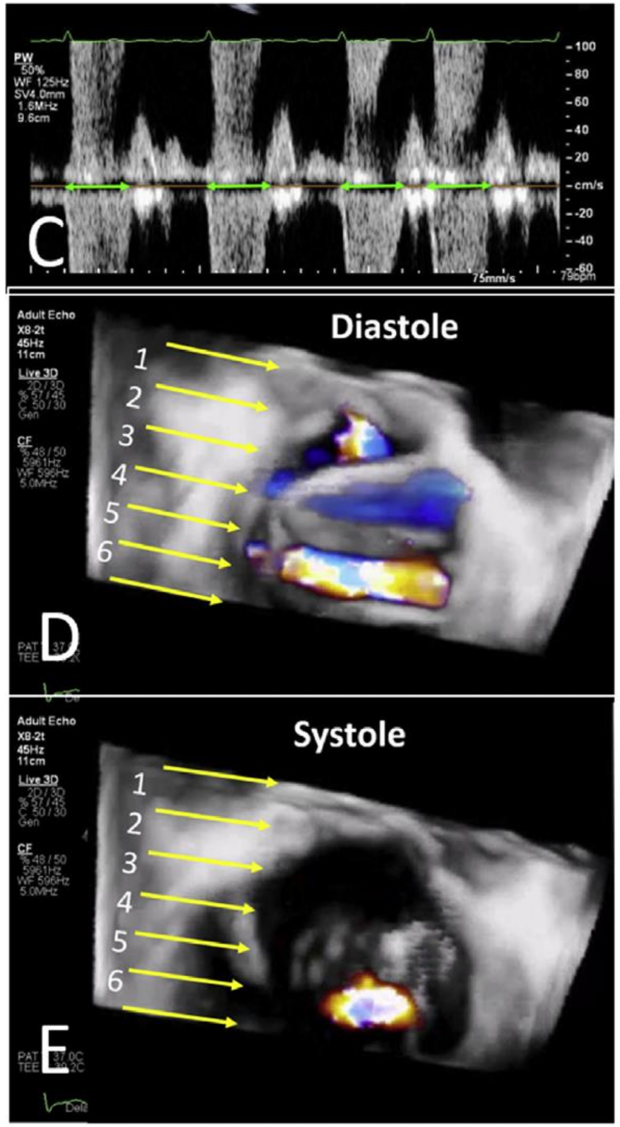
3D en temps réel ou à battements multiples

3D à battements multiples

volumes étroits d'informations sur plusieurs battements cardiaques

Avantages = augmente résolution spatiale et temporelle

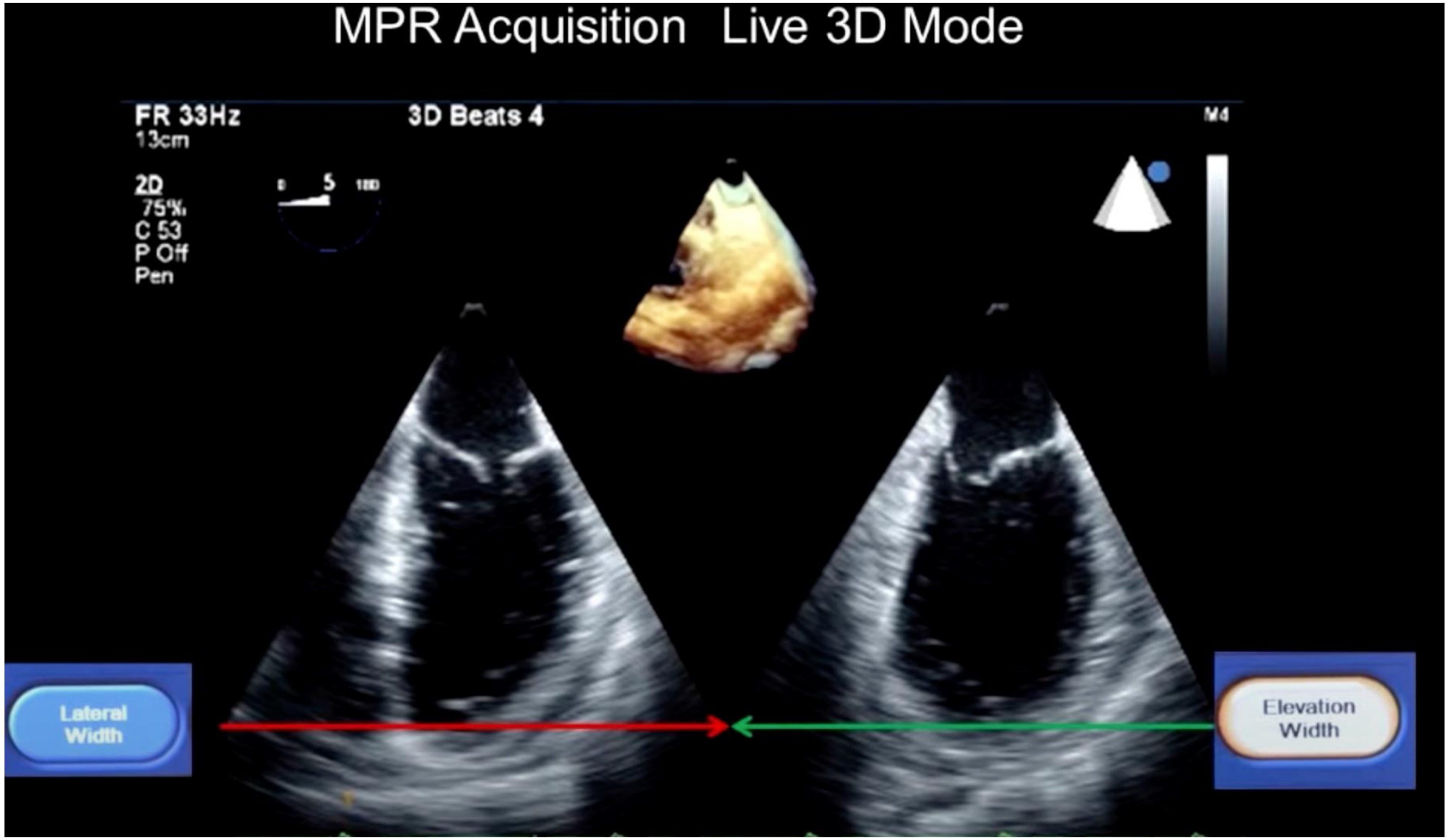


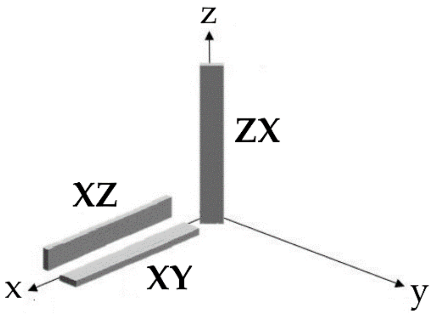


Patient en FA

Plusieurs étapes

- Etape 1 = définir la zone d'intérêt





Mauvaise qualité d’image 2D

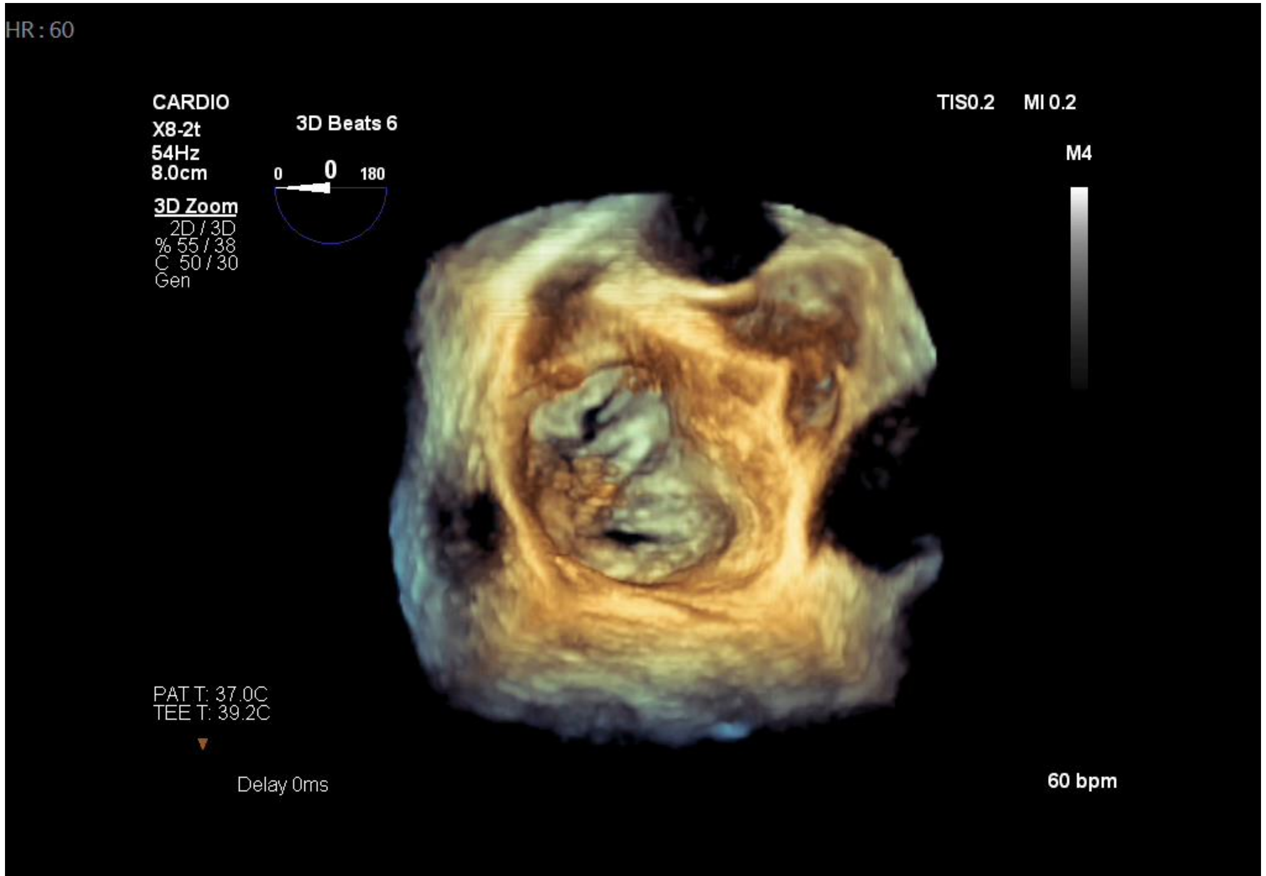
=

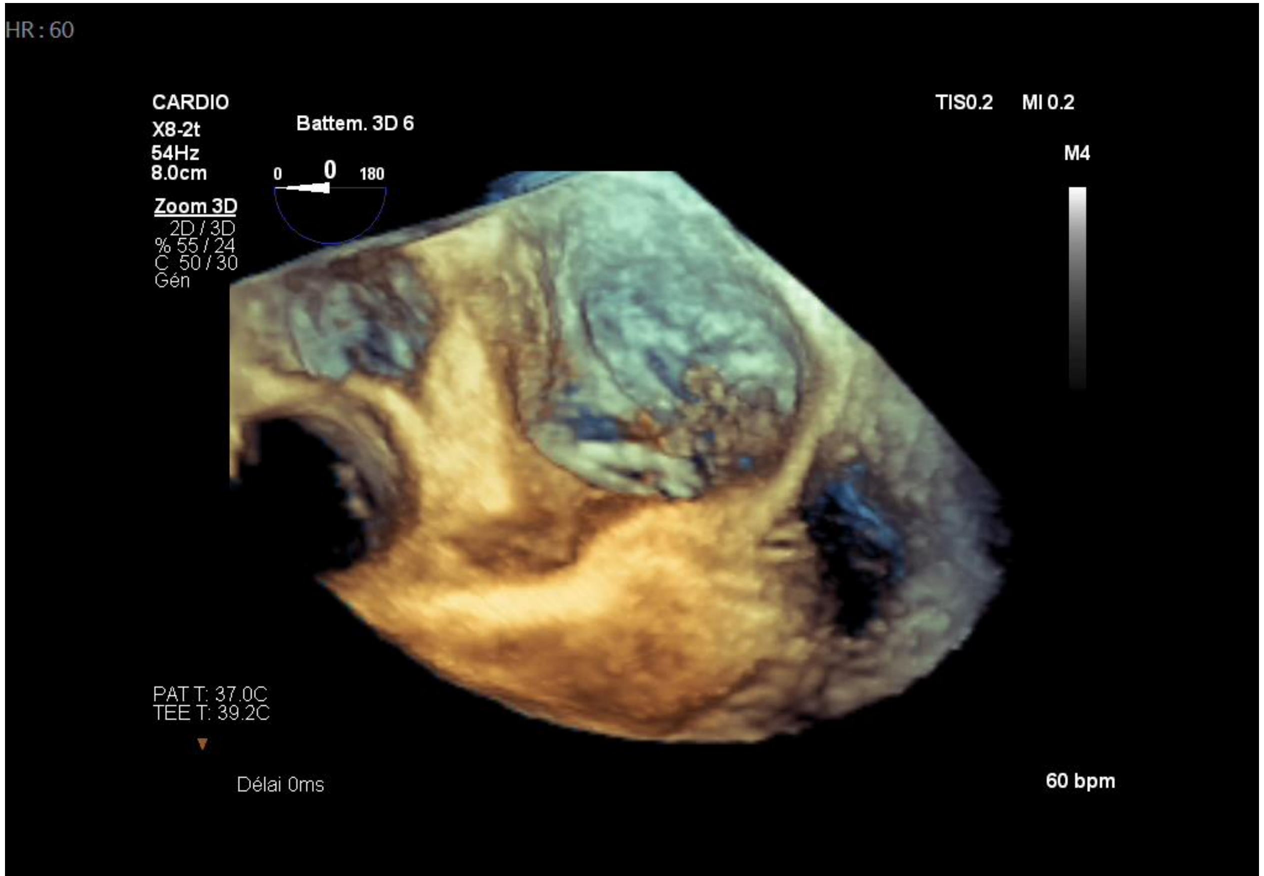
Mauvaise qualité d’image 3D +++

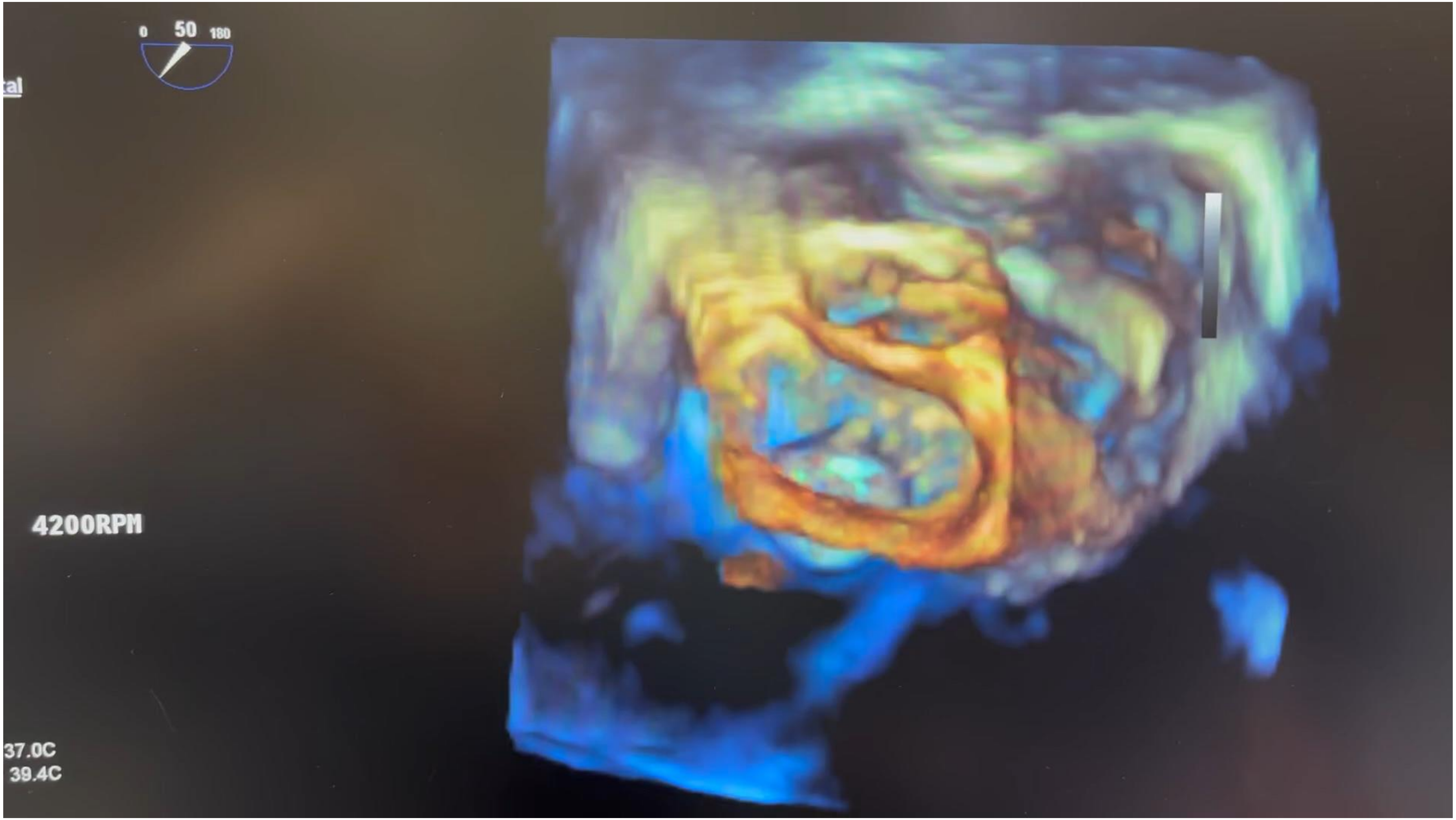
Plusieurs étapes

- Etape 2 = Acquisition du volume dynamique
  - Visualisation du volume cardiaque en temps réel

ZOOM 3D



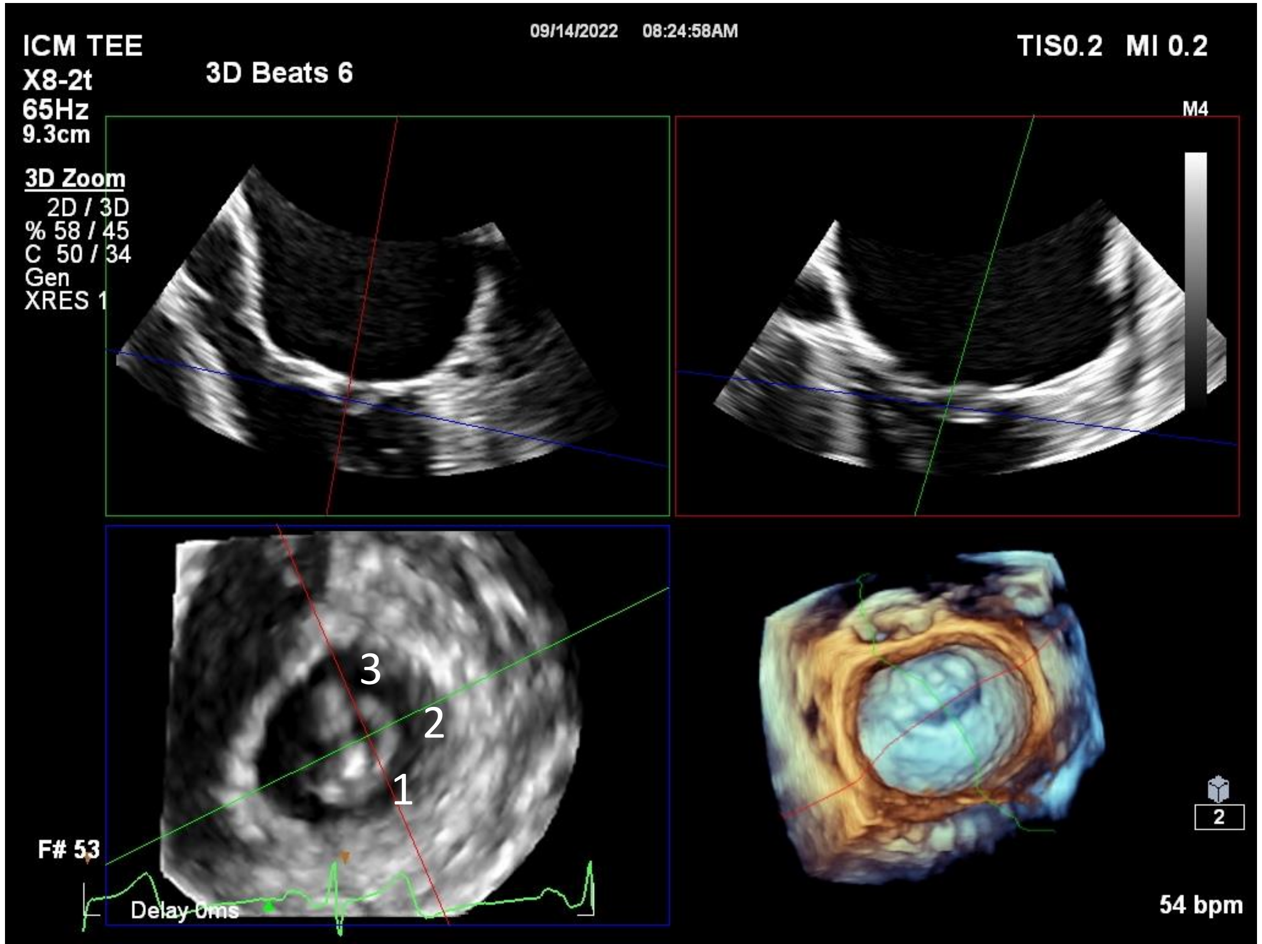


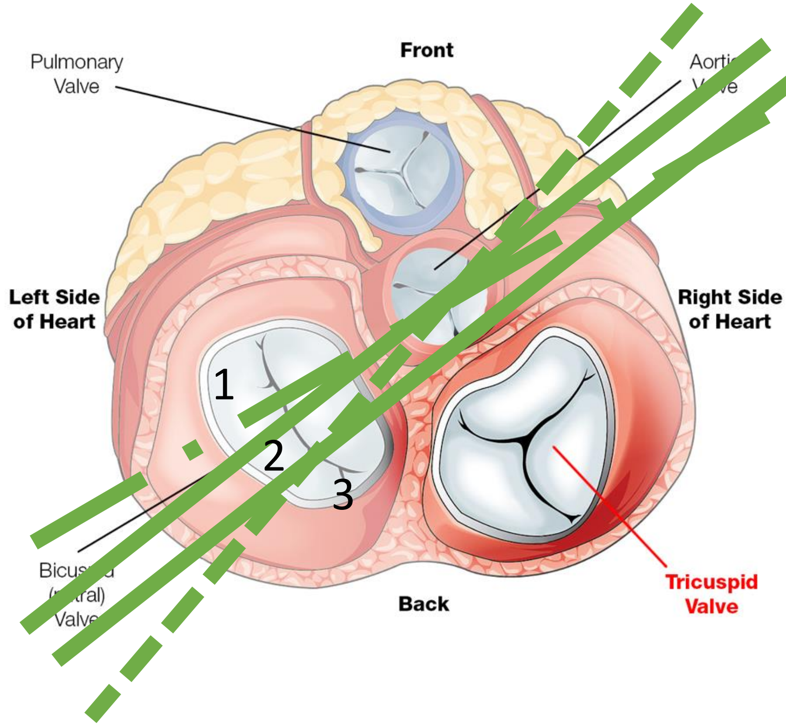

0
50
180
4200RPM
37.0C
39.4C

Plusieurs étapes

- Etape 3 = navigation dans le volume cardiaque

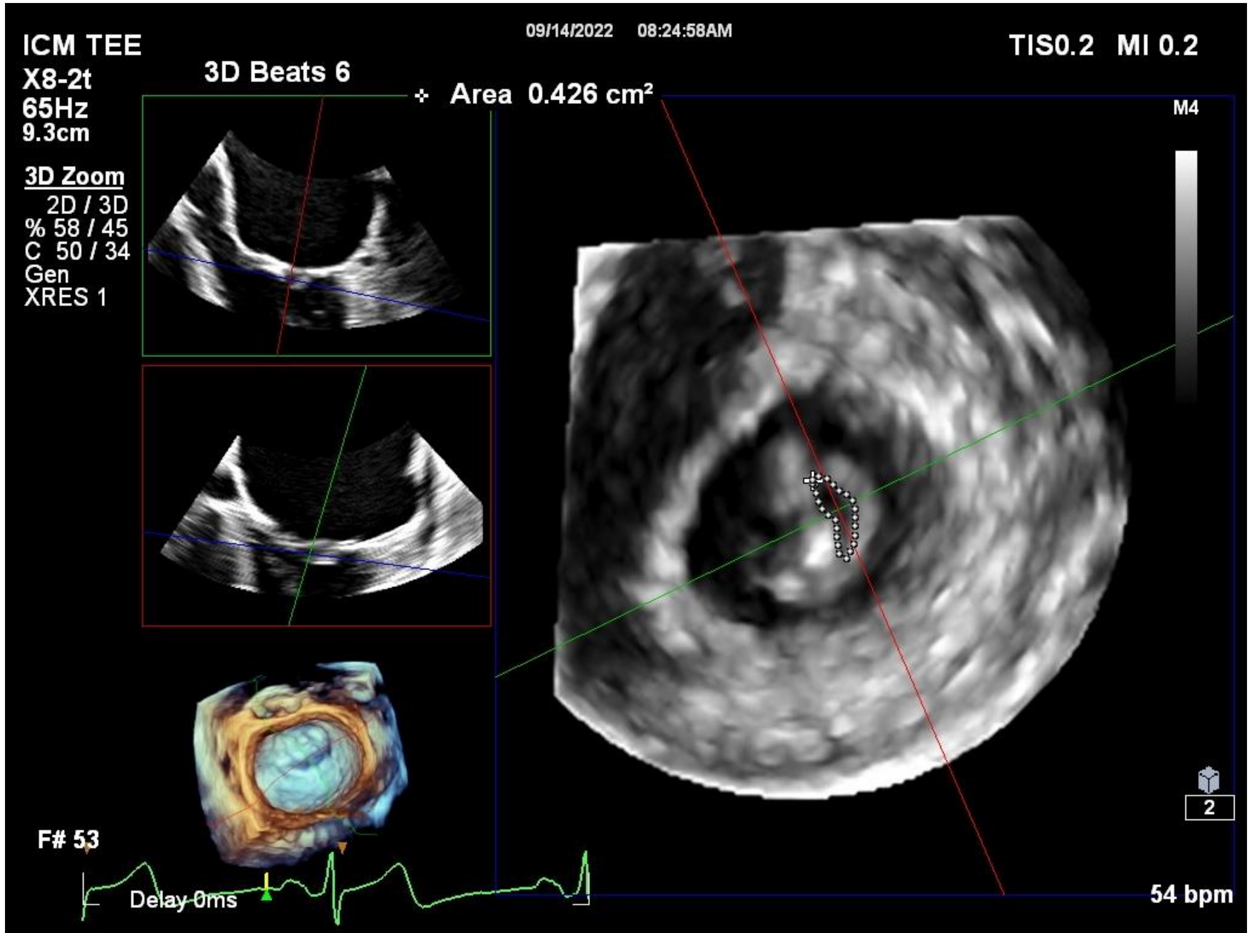
120-140° ETO





Plusieurs étapes

- Etape 3 = navigation dans le volume cardiaque



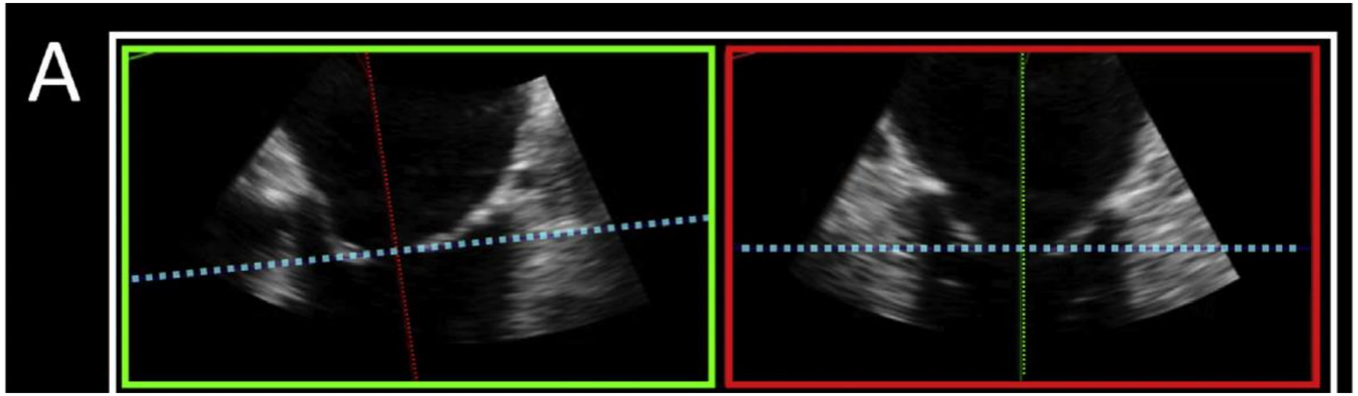
Mesures = Ne pas mesurer directement sur la 3D!

- peut être hors axe comparativement à une mesure dans le plan 2D
- l'épaisseur augmentée de l'image 3D peut accentuer artificiellement la taille de la structure et empêche une délimitation nette et précise de celle-ci, altérant la précision de la mesure
- une approche en 3 étapes doit être réalisée pour mesurer une structure +++

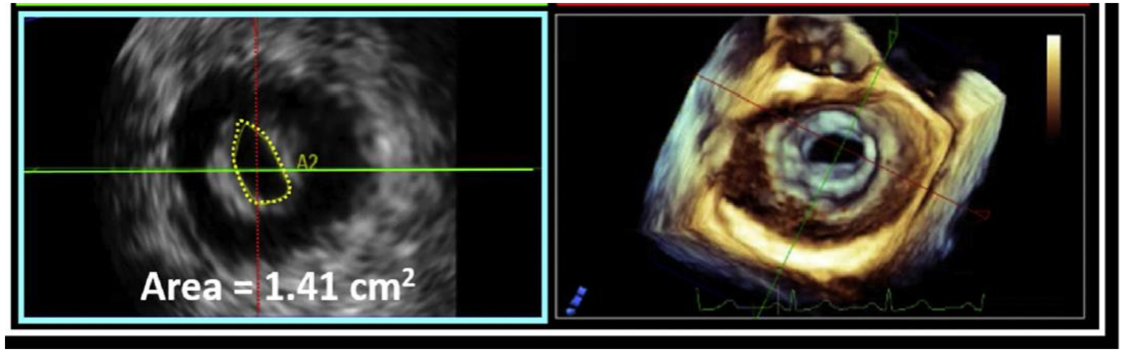
Mesure : ex d'approche en 3 étapes

MVA 3D

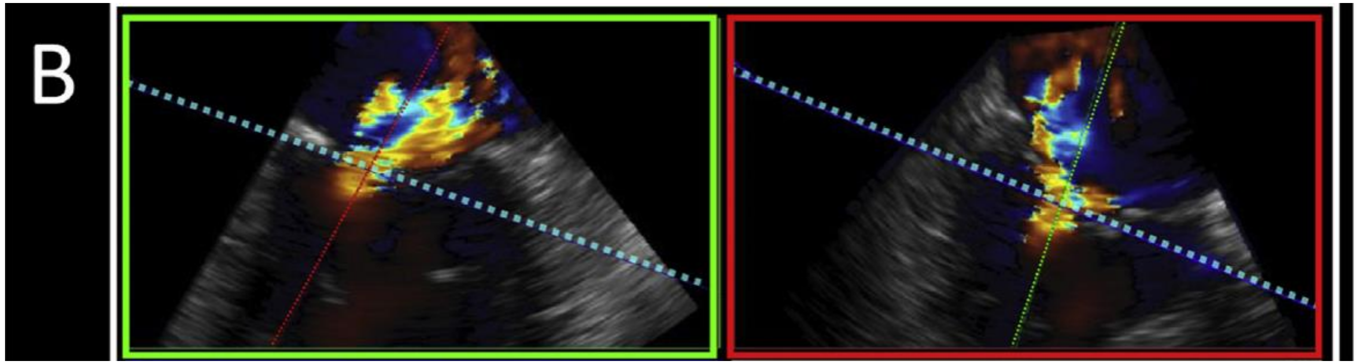
Etape 1 et 2

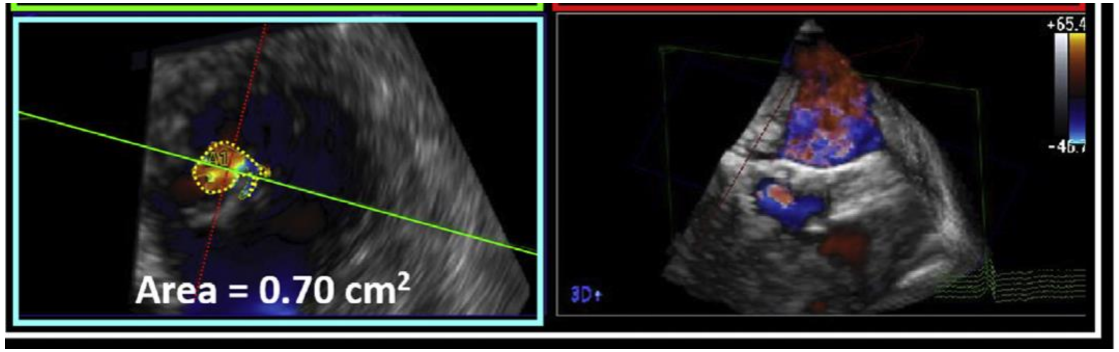


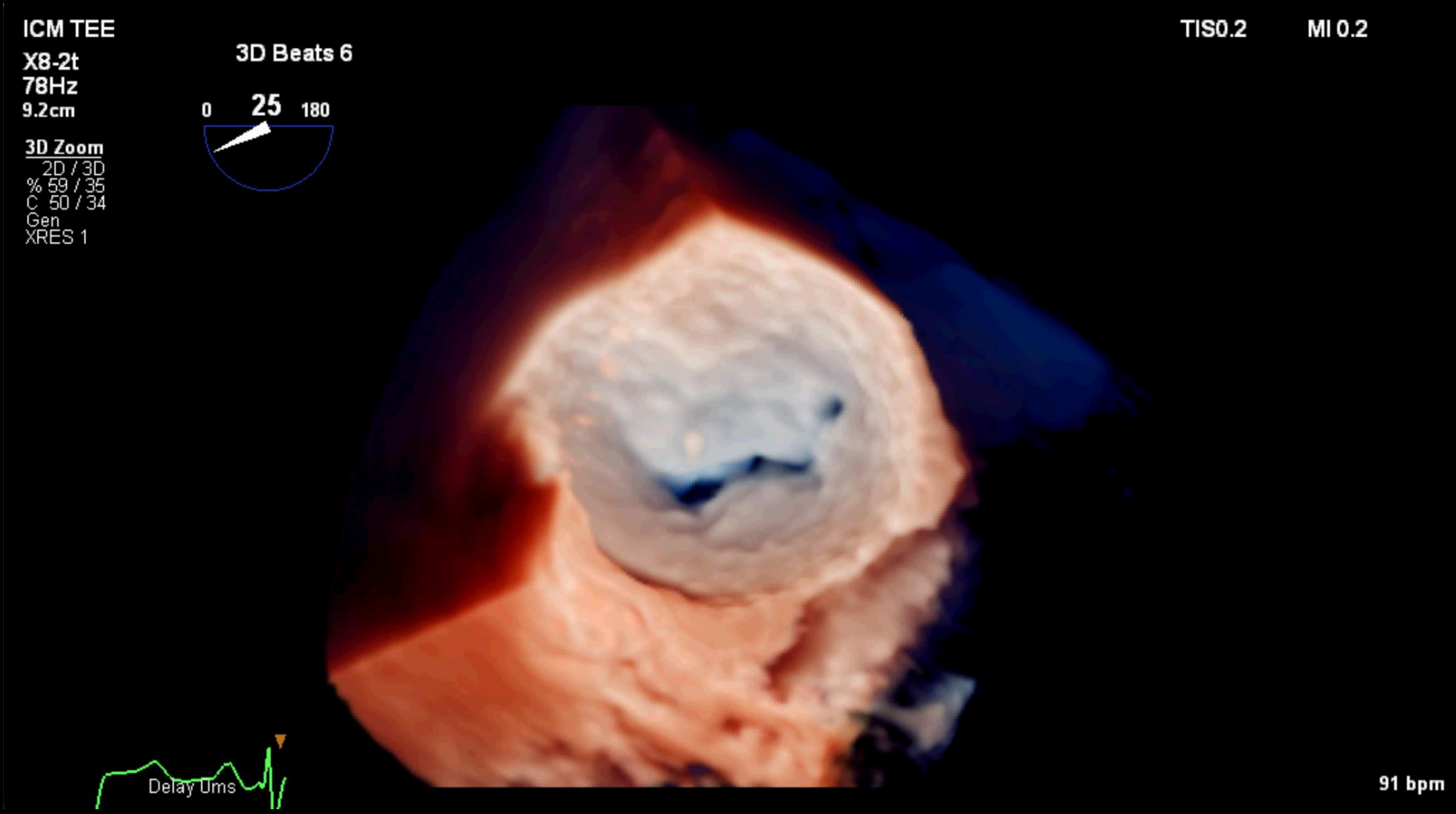
Etape 3



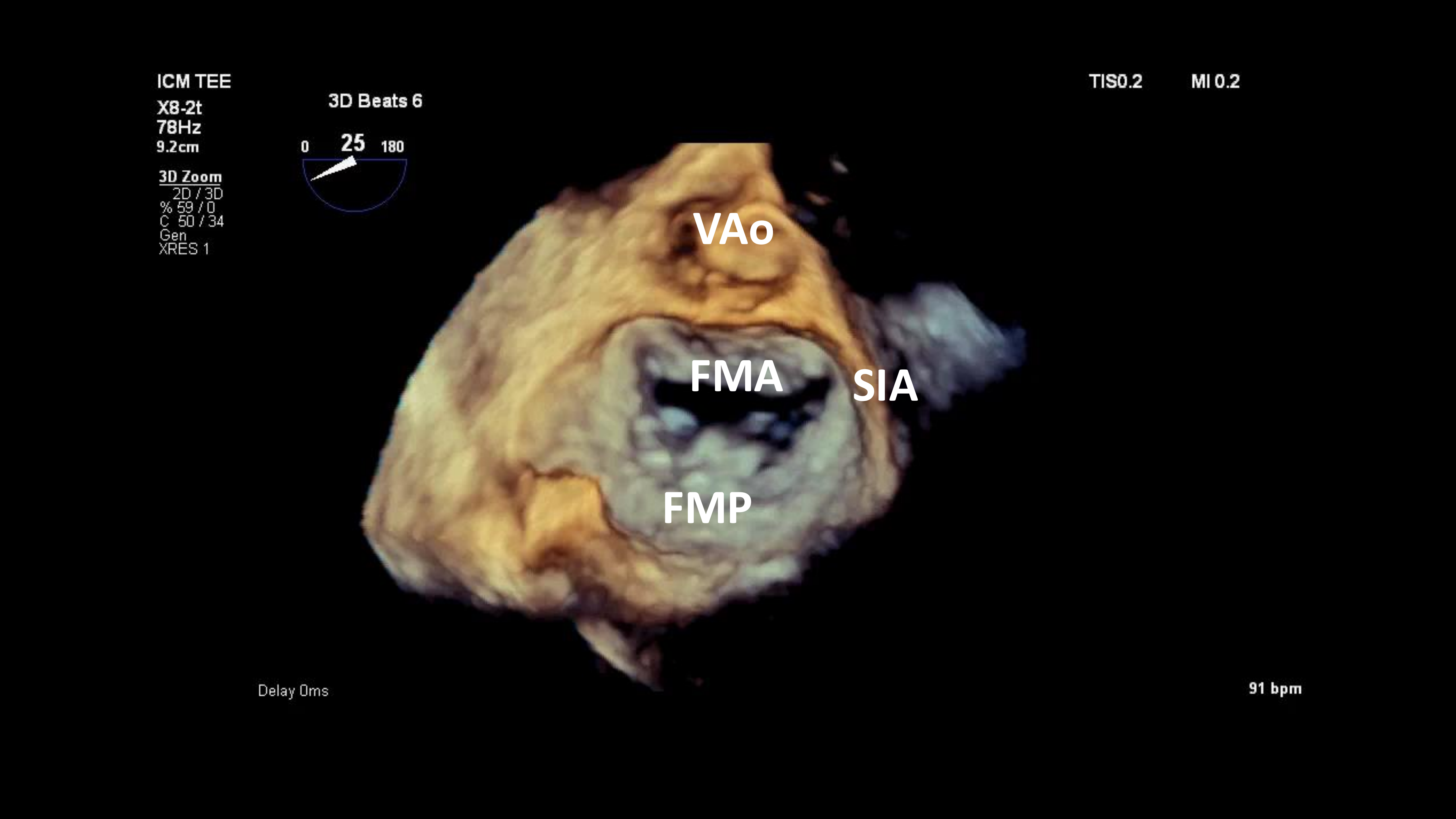
VCA 3D



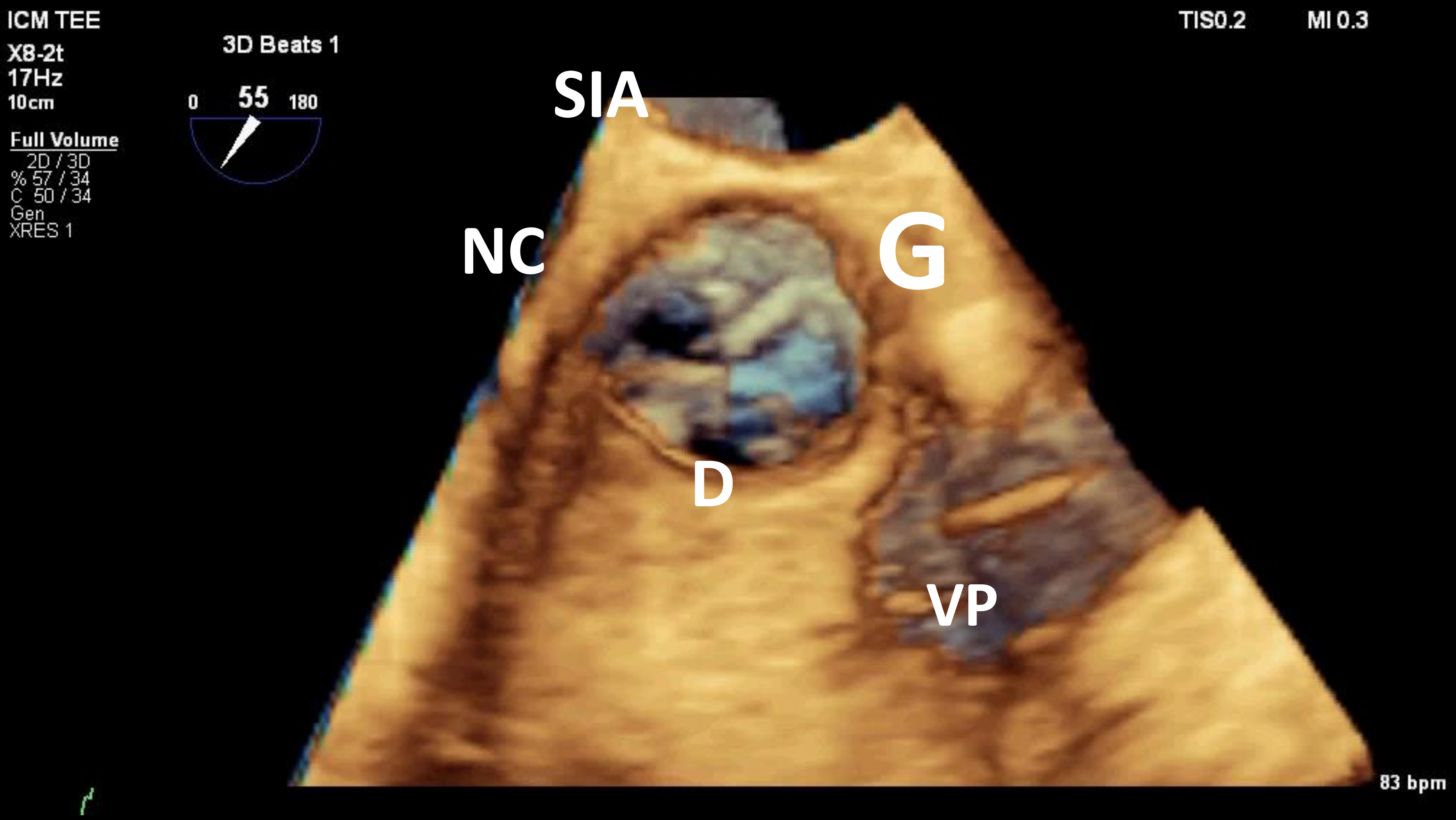




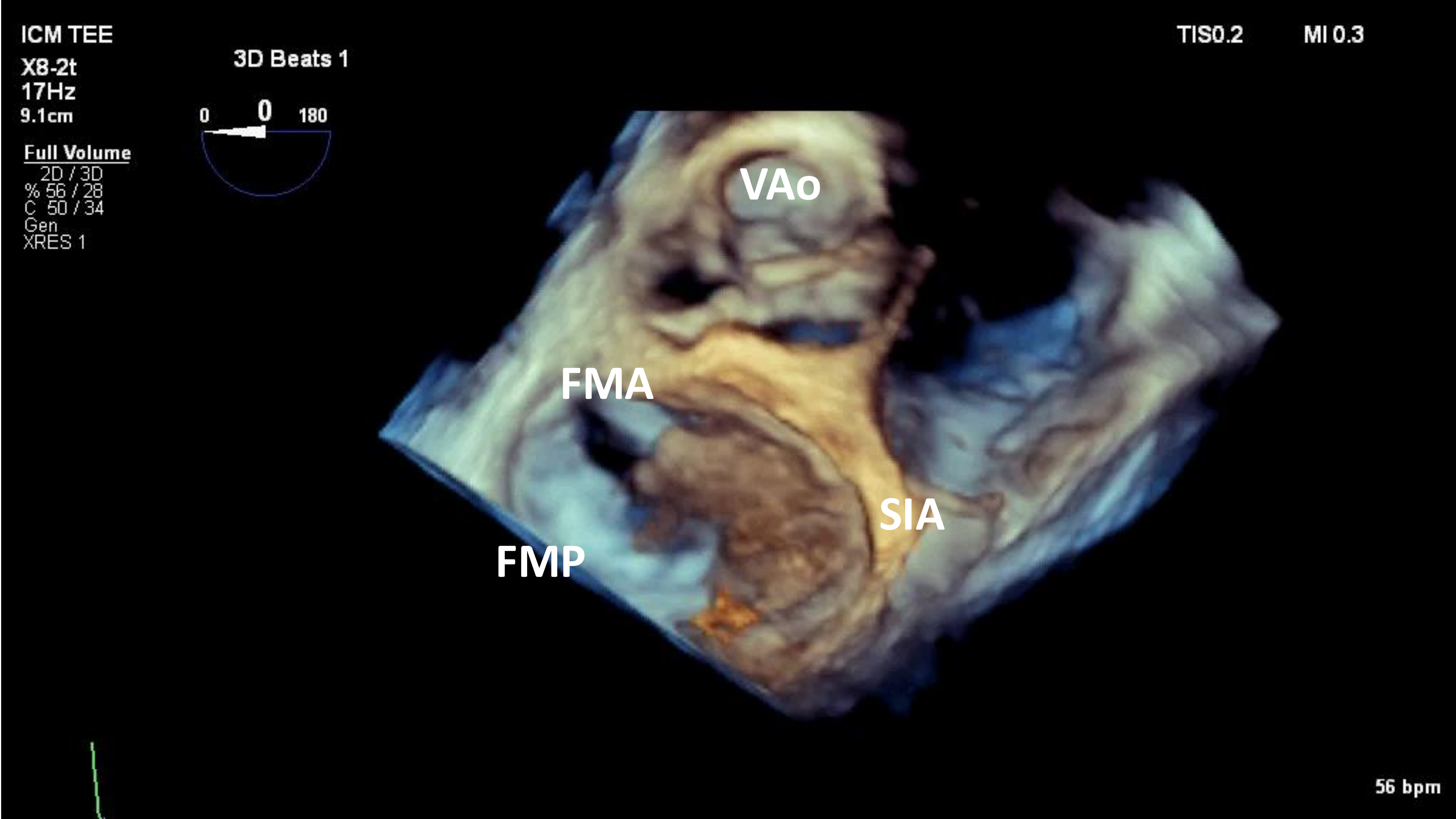
ICM TEE
X8-2t
78Hz
9.2cm
3D Zoom
2D / 3D
% 59 / 35
C 50 / 34
Gen
XRES 1
3D Beats 6
0
25
180
TIS0.2
MI 0.2
Delay 0ms
91 bpm

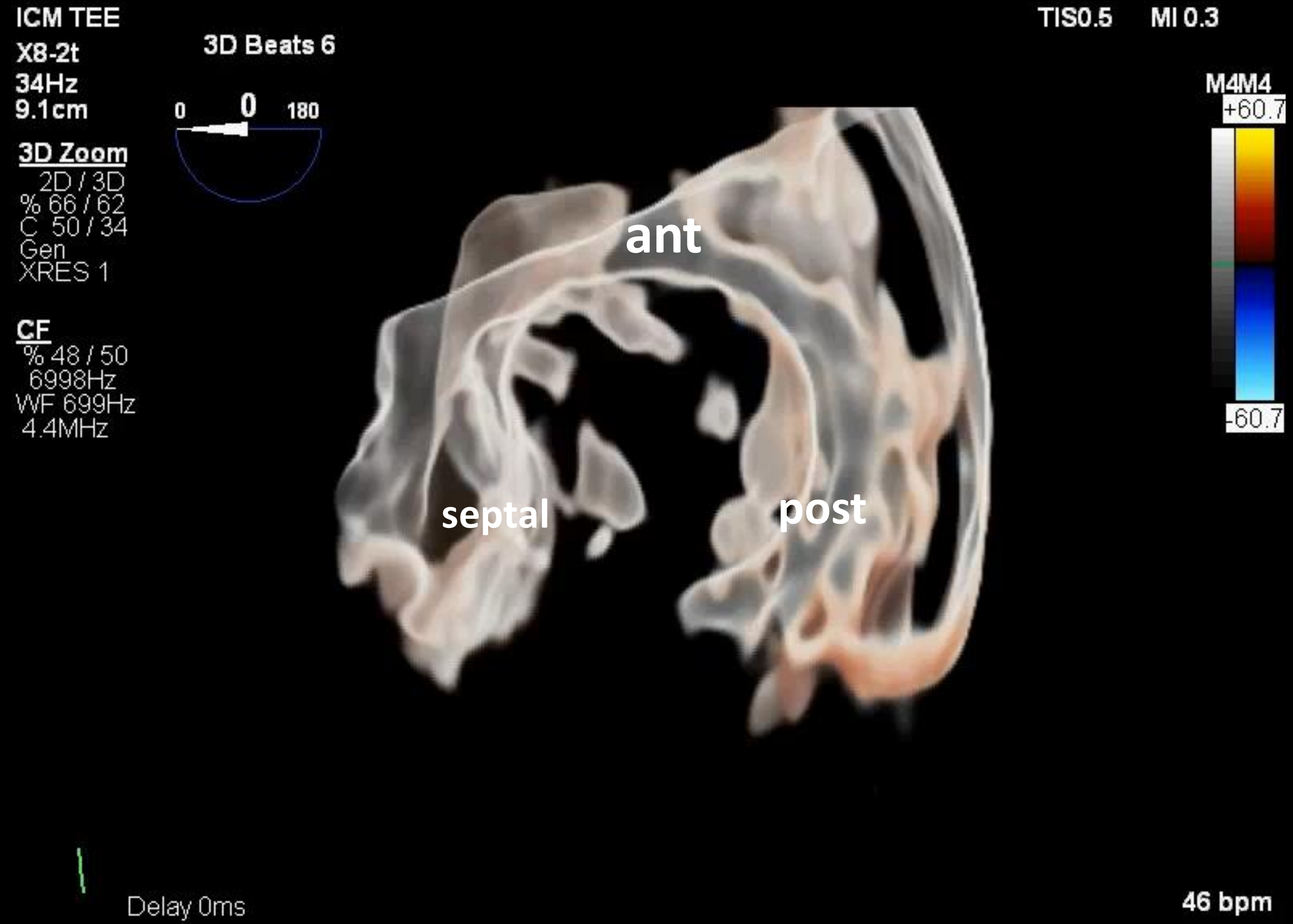


ICM TEE
X8-2t
78Hz
9.2cm
3D Zoom
2D / 3D
% 59 / 0
C 50 / 34
Gen
XRES 1
3D Beats 6
0
25
180
TIS0.2
MI 0.2
VAo
FMA
SIA
FMP
Delay 0ms
91 bpm

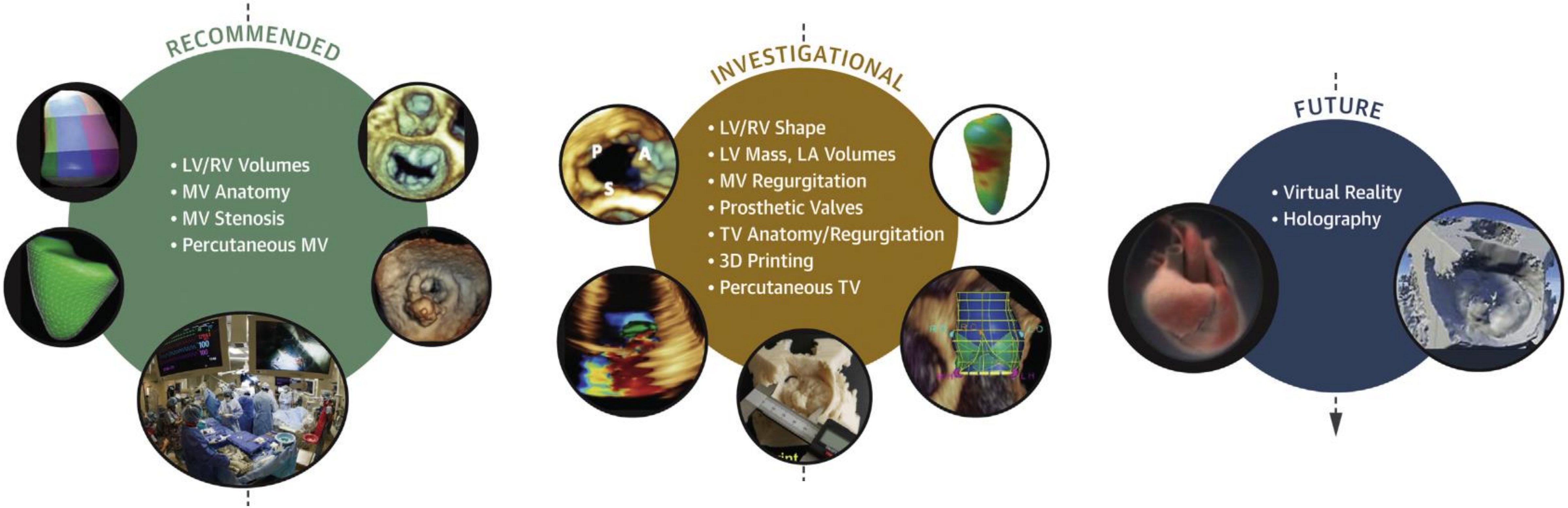


ICM TEE
X8-2t
17Hz
10cm
3D Beats 1
0
55
180
Full Volume
2D / 3D
% 57 / 34
C 50 / 34
Gen
XRES 1
TIS0.2
MI 0.3
SIA
NC
G
D
VP
83 bpm


ICM TEE
X8-2t
17Hz
9.1cm
3D Beats 1
0
0
180
Full Volume
2D / 3D
% 56 / 28
C 50 / 34
Gen
XRES 1
TIS0.2
MI 0.3
VAo
FMA
SIA
FMP
56 bpm


ICM TEE
X8-2t
34Hz
9.1cm
3D Beats 6
0
0
180
3D Zoom
2D / 3D
% 66 / 62
C 50 / 34
Gen
XRES 1
CF
% 48 / 50
6998Hz
WF 699Hz
4.4MHz
TIS0.5
MI 0.3
M4M4
+60.7
-60.7
ant
septal
post
Delay 0ms
46 bpm

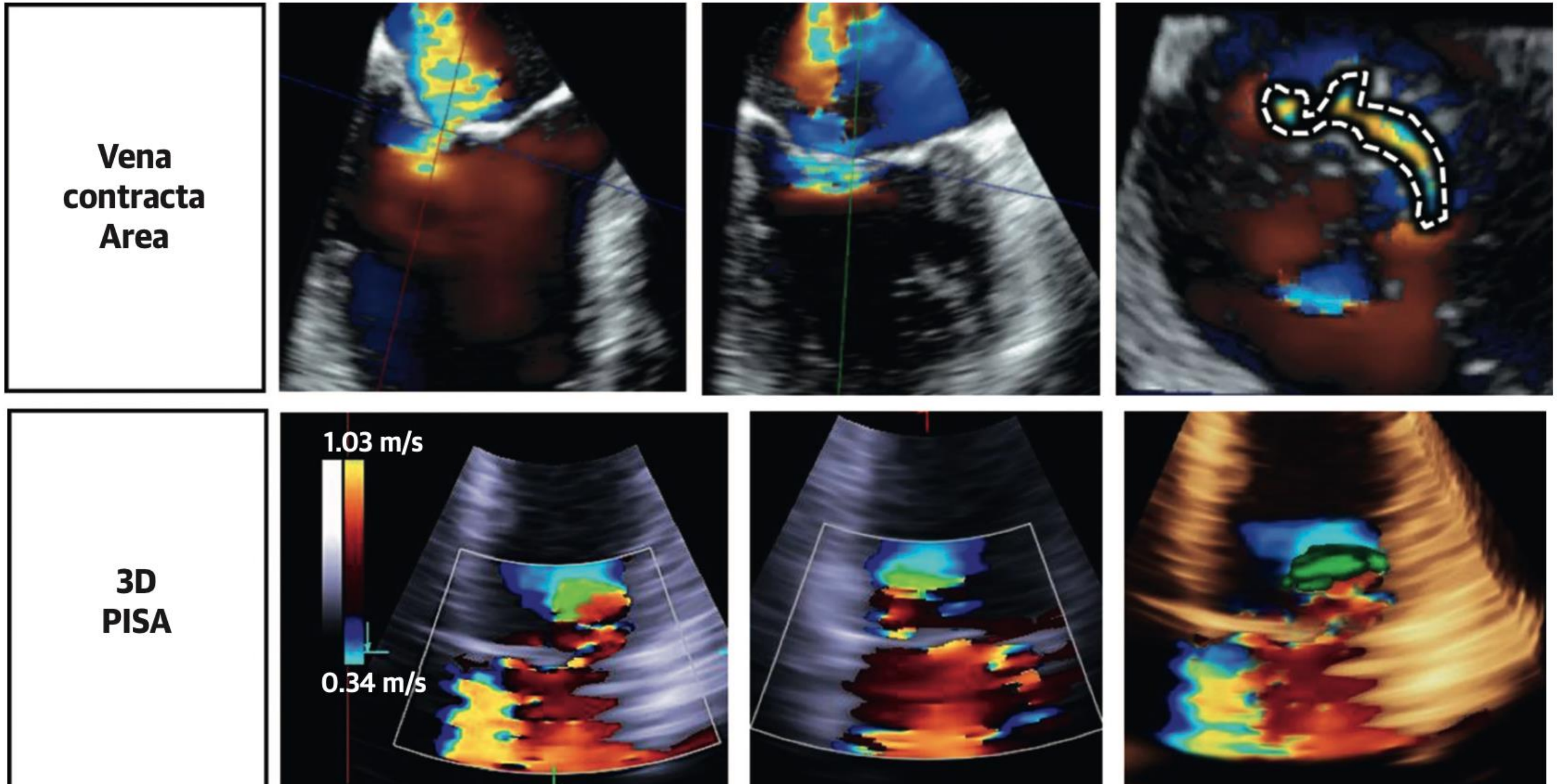
Quelles applications ?



Roberto M. Lang & al, 3-Dimensional echocardiography latest developments and future directions, JACC 2018

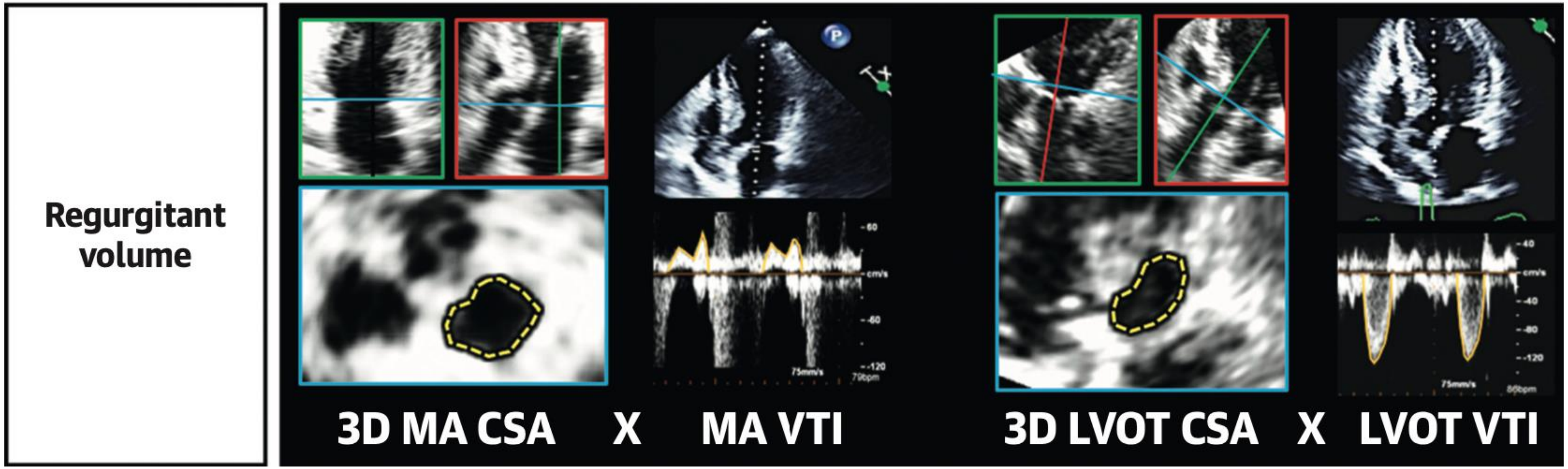
Quelles applications ?

- Quantification 3D de la régurgitation mitrale



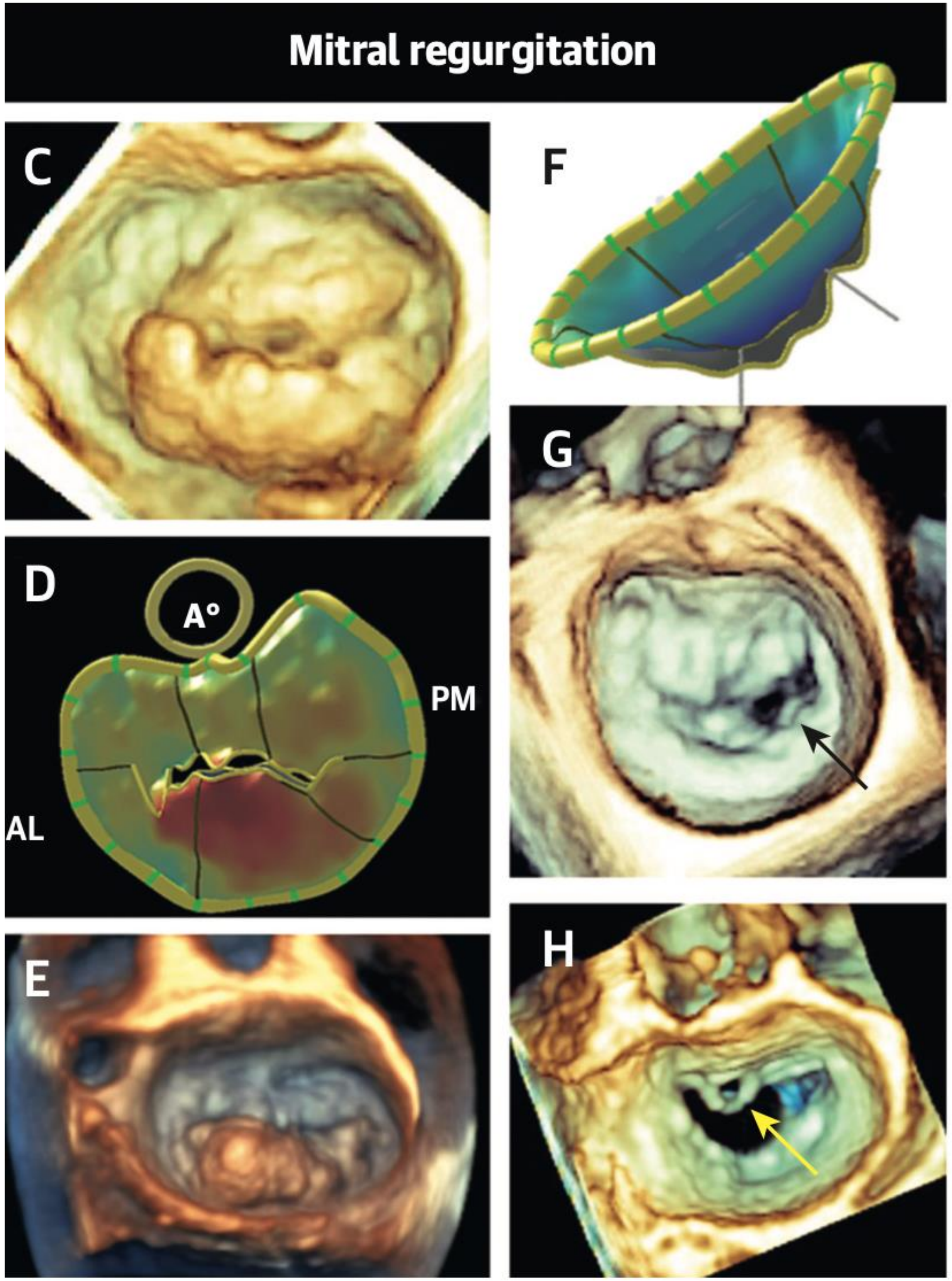
Quelles applications ?

- Quantification 3D de la régurgitation mitrale



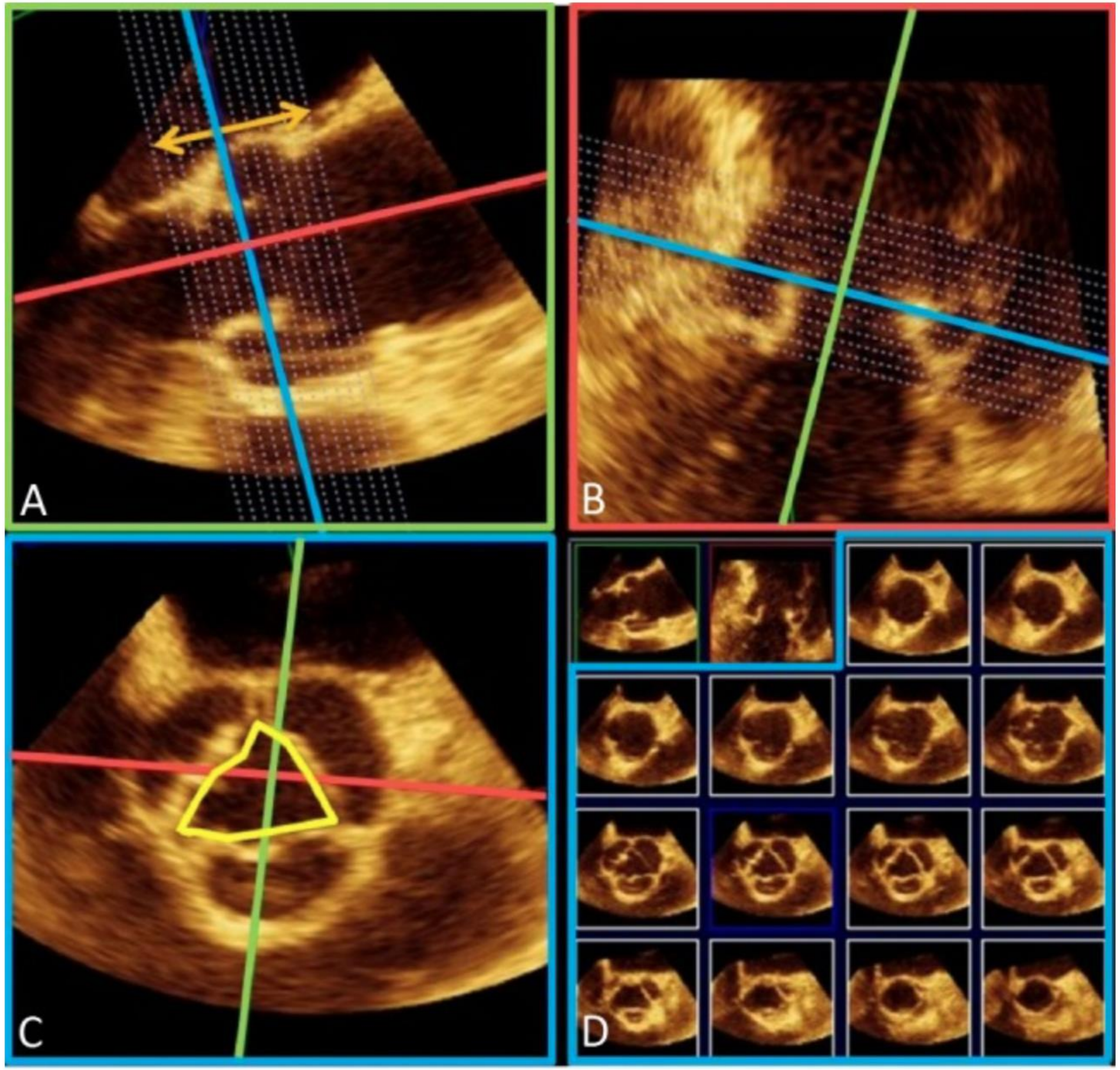
Quelles applications ?

- Préciser la pathologie mitrale
- Modélisation anneau et dimension



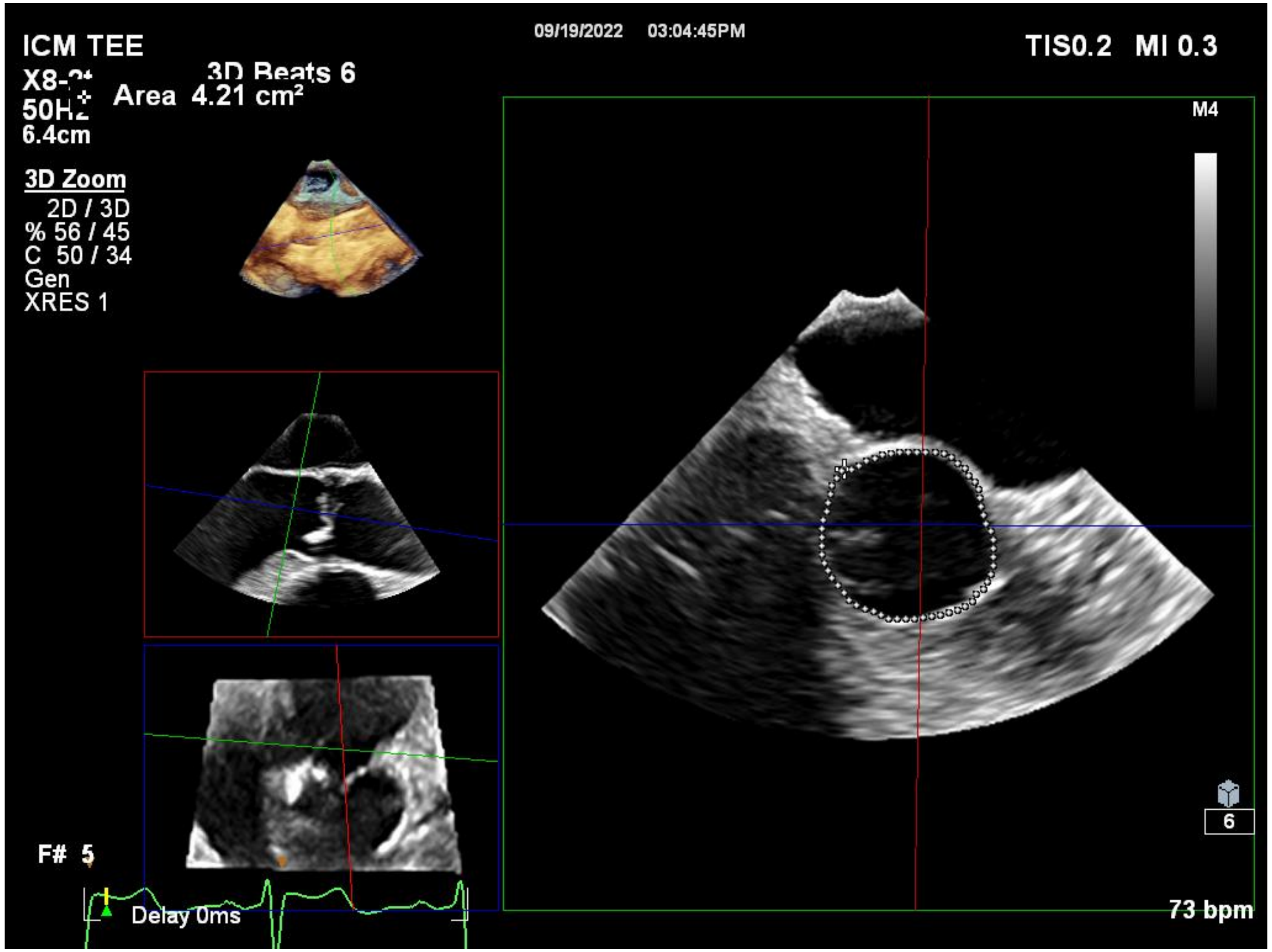
Quelles applications ?

- Surface valvulaire aortique 3D



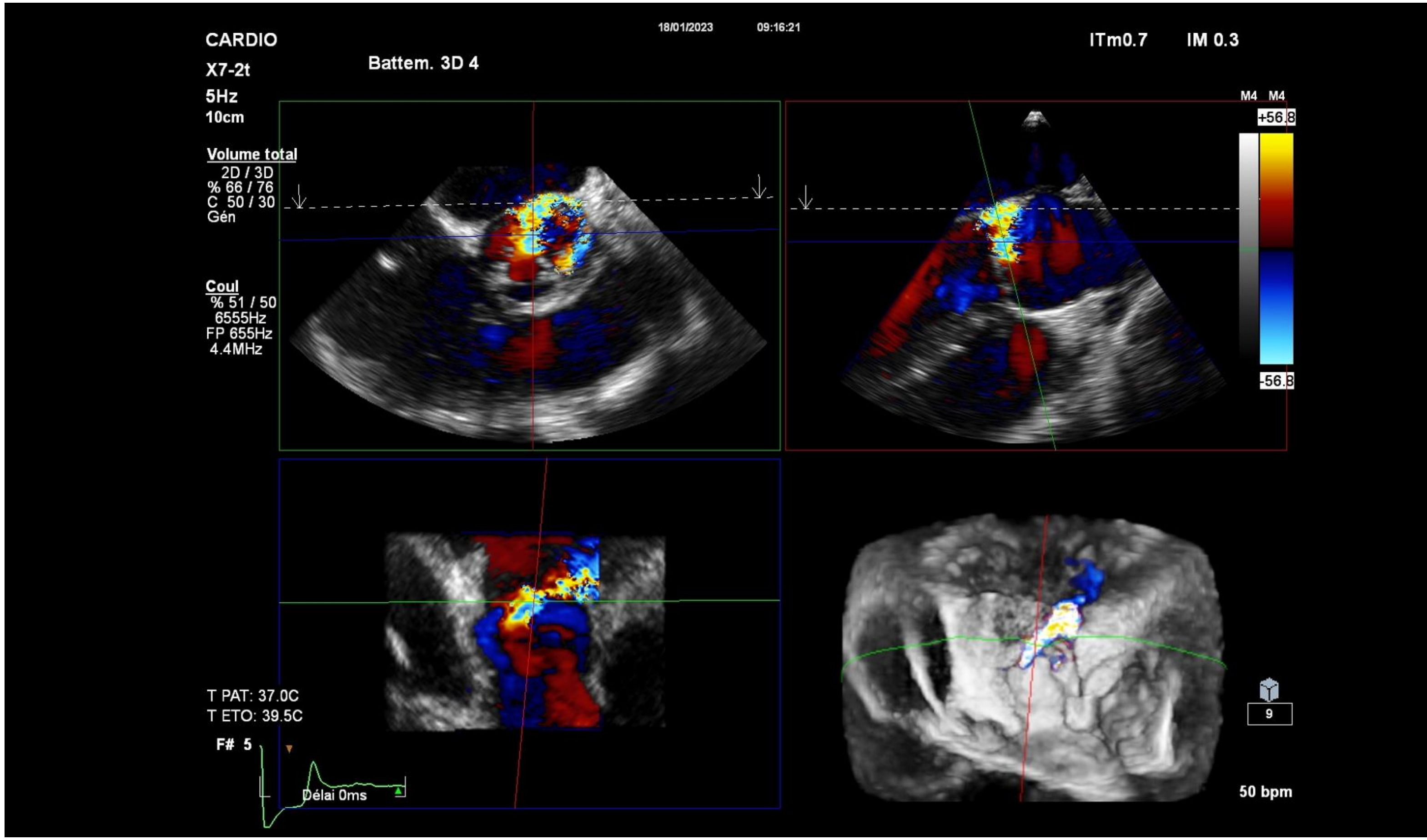
Quelles applications ?

- Surface valvulaire aortique 3D
- Mesure de l’anneau



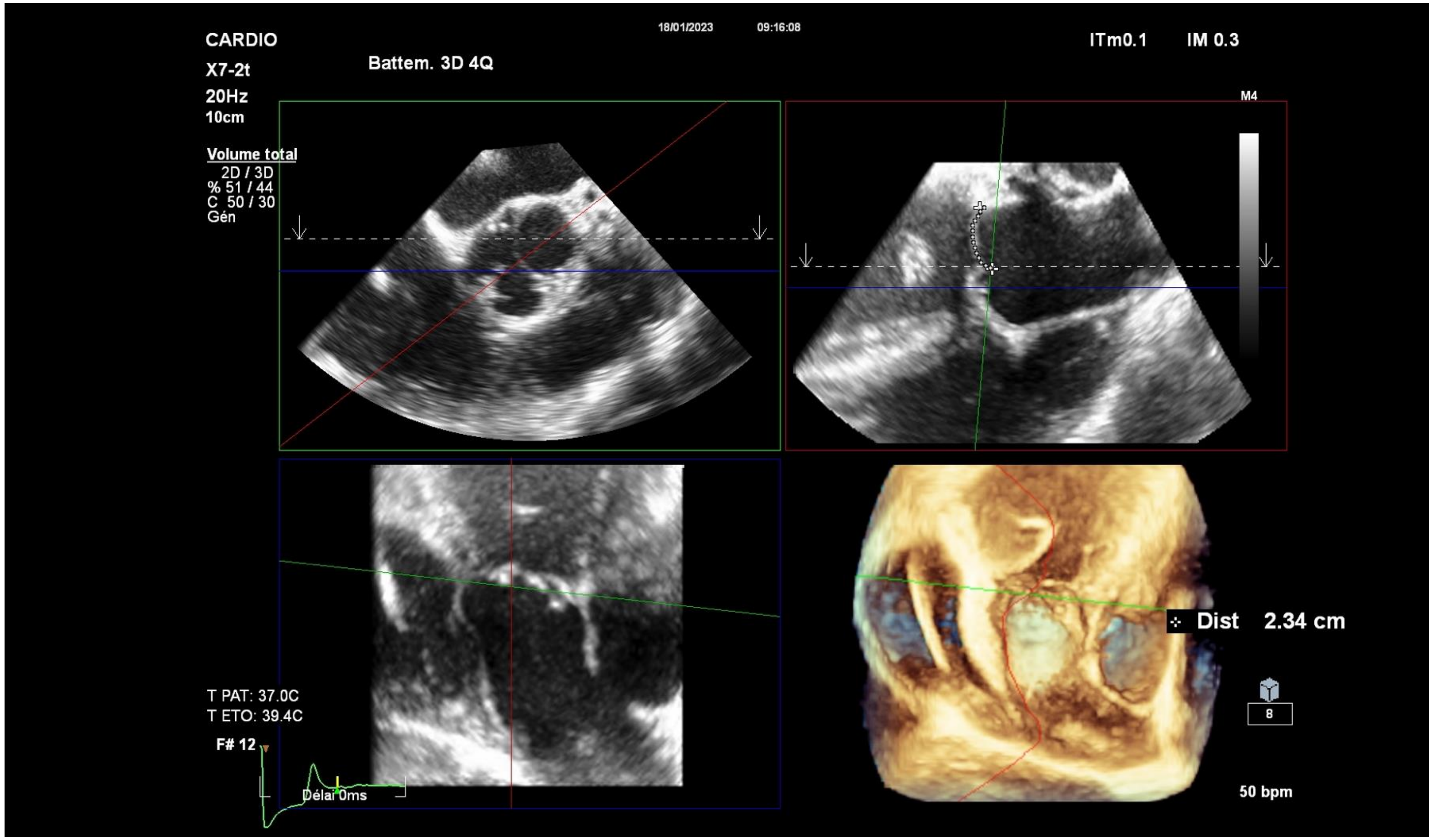
Quelles applications ?

- Surface valvulaire aortique 3D
- Mesure de l’anneau
- Orienter le geste chirurgical

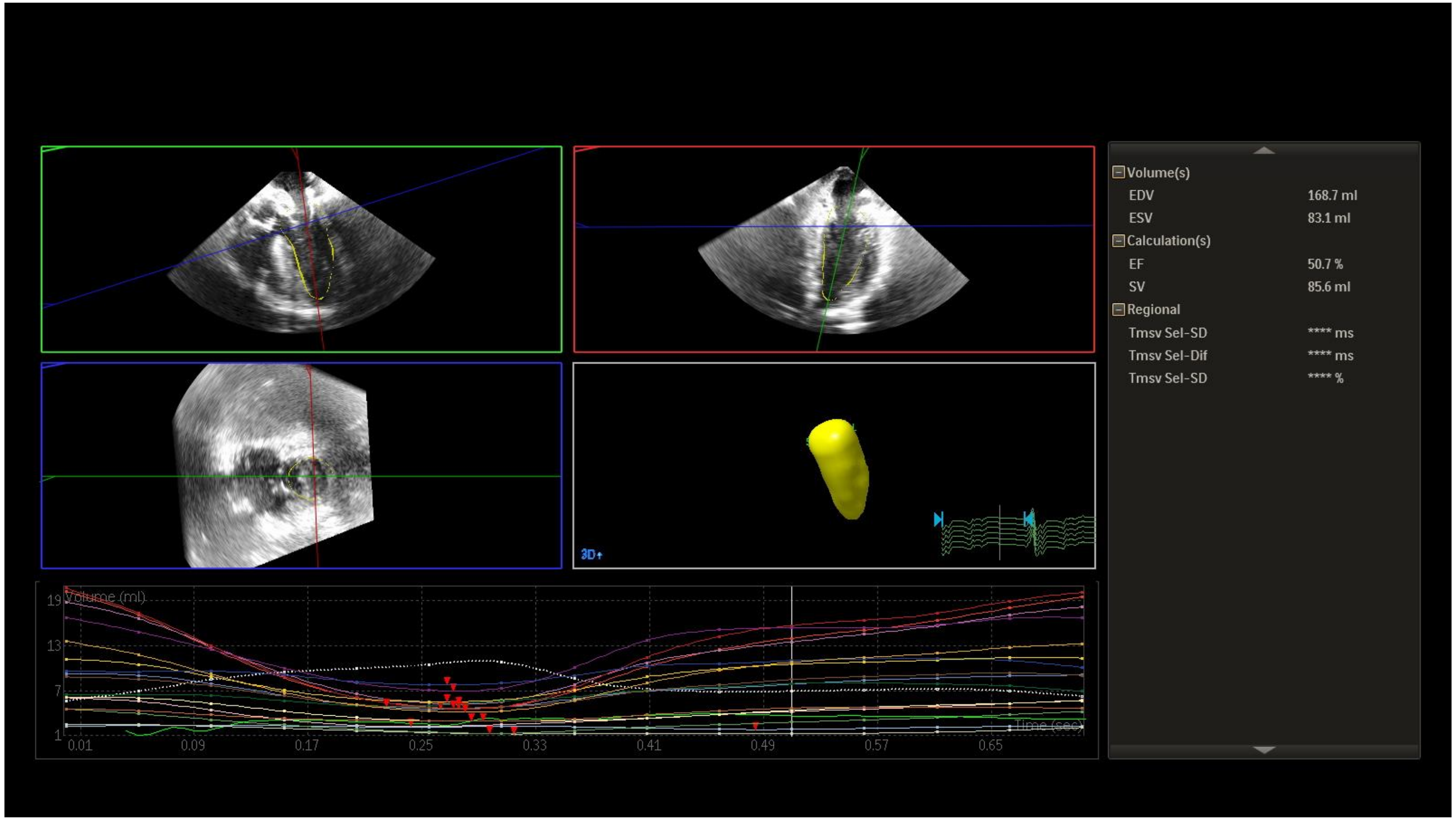


Quelles applications ?

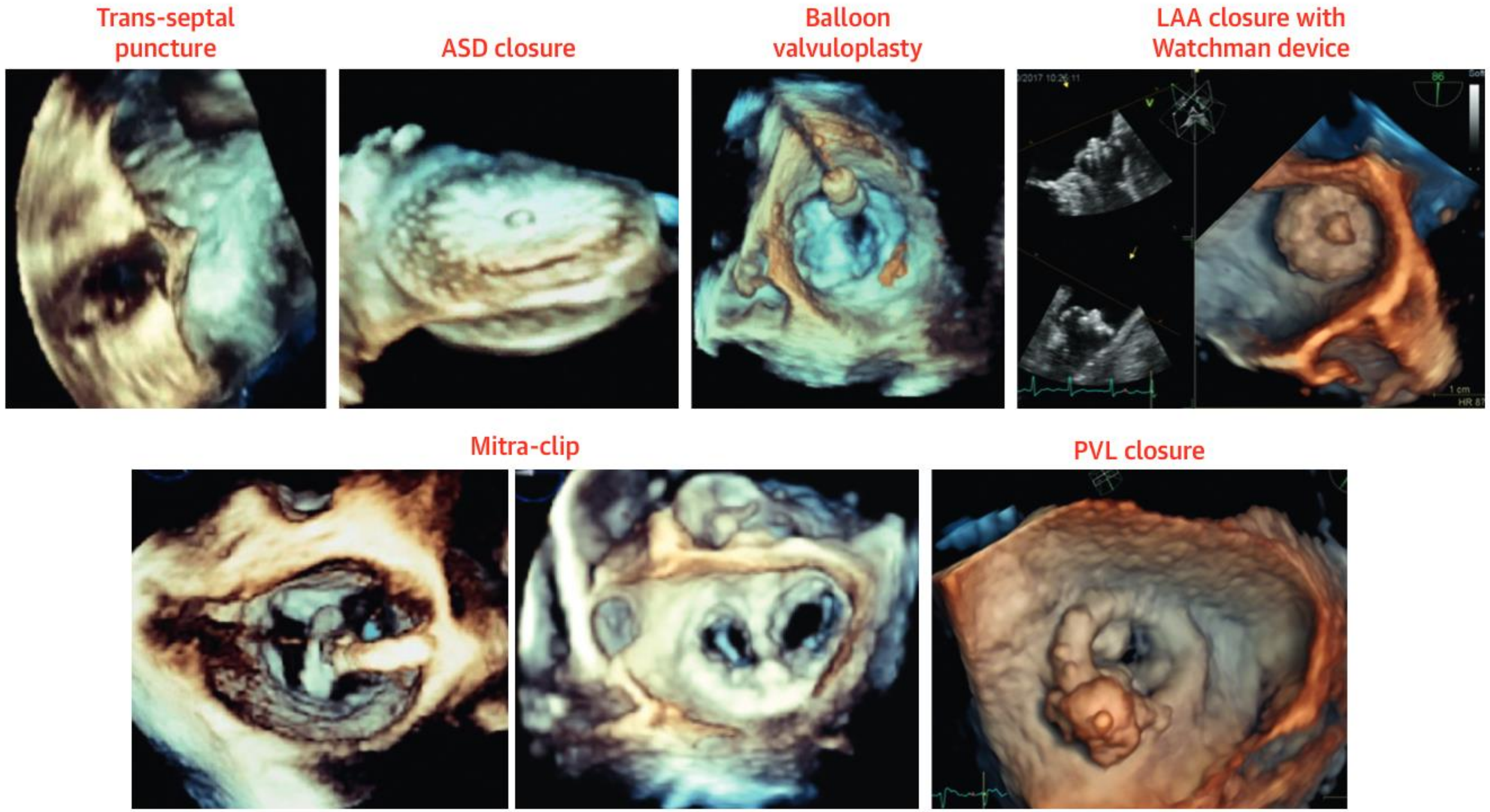
- Surface valvulaire aortique 3D
- Mesure de l'anneau
- Orienter le geste chirurgical



Quelles applications ?

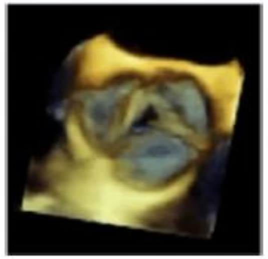


Quelles applications ?

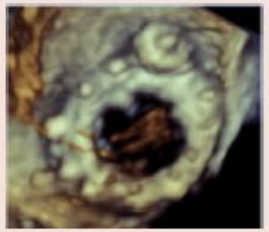
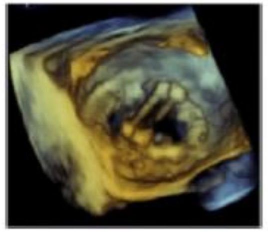
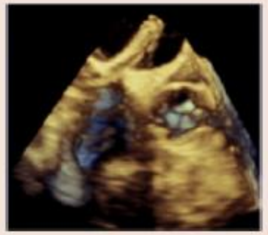


Artéfacts

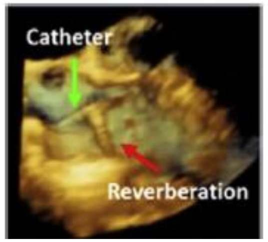
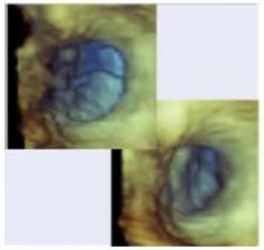
Table 2 Artifacts of 3D imaging

Type of artifact	Mechanism	Impact on images	3D example
Stitching	Incorrect juxtaposition at the interface of sequential subvolumes (because of arrhythmias, breathing, probe/patient motion)	Strong demarcation between subvolumes leading to a "broken" image	
Dropout	Poor echocardiographic signal strength due to weak echoes	These artifacts can be misdiagnosed as true holes/ perforations	

Artéfacts

Blurring	Indistinct edges of structures due to the assembly of nonisotropic voxels (2° to differences in axial > lateral > elevational resolution)	Thin structures (i.e., sutures) appear thicker than they are	
Blooming	Metallic structures when intersected by ultrasound produce fringes extending beyond the borders of the metallic devices/catheters	Metallic structures appear with irregular, thick edges	
Railroad-shaped	In large catheters with wide lumens, two surfaces are perpendicular to the ultrasound beam, producing strong echoes, while the other two are tangential, producing very weak echoes	Single catheter appears as two linear structures	

Artéfacts

Reverberations	Multiple reflection of metallic component of catheters	Depending on the perspective and the position of catheter, reverberations may appear to lengthen the catheter	
Shadowing	Inability of ultrasound to pass through strong reflecting catheters/devices	Lack of tissue posterior to catheters/devices that may appear as a "tear" of cardiac structures	
Gain	Variation of gain may produce significant variation in the size of structures	Orifices may appear larger or smaller according to gain variation	

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

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En bref

- Technologie d'avenir
- Deviendra le gold standard pour l'évaluation des valves ?
- Hologramme et réalité virtuelle