Echocardiographic assessment of AR and its mechanisms.

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The Reconstruction of the Aortic valve and Root. A practical Approach.

Echo & AR

- Aortic valve morphology.
- Mechanisms of AR.
- Quantification of AR.
- Define aortic morphology (root & AA).
- Suitability for valve repair or a valve-sparing surgery of the aortic root.

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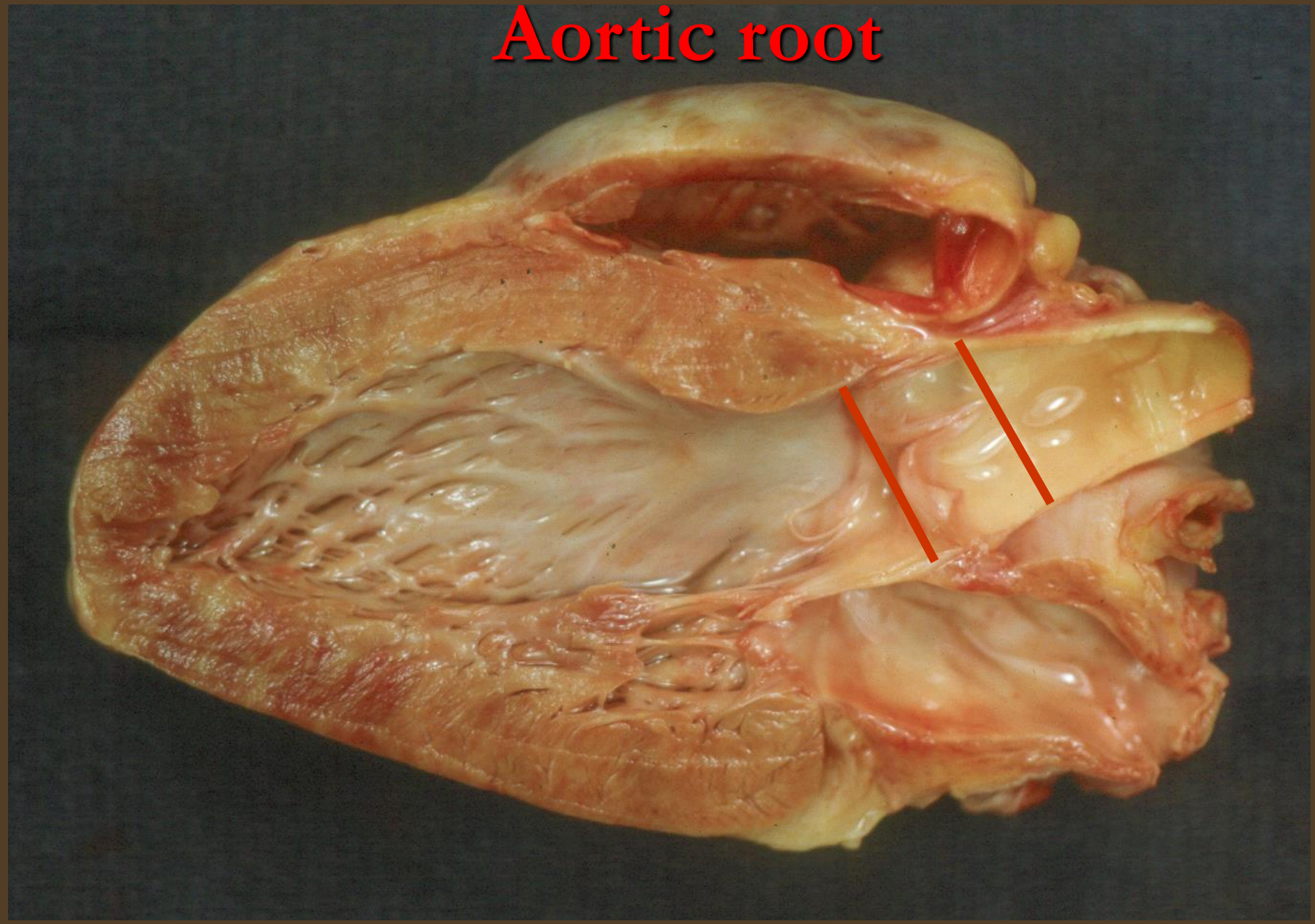
Aortic root & ascending aorta

Aortic root



AORTIC LEAFLETS

Coaptation zone

Aortomitral curtain

Etiology of AR

CONGENITAL (LEAFLET)

- Bicuspid, unicuspid, or quadricuspid Ao valve; VSD.

ACQUIRED (LEAFLET)

- Degenerative (thickened, calcified).
- Endocarditis
- Rheumatic
- Radiation-induced valvulopathy
- Toxin-induced valvulopathy (anorectic drugs, carcinoid)

GENETIC (AORTIC ROOT)

- Anuloaortic ectasia
- Connective tissue d. (Marfan, Loeys-Dietz, Ehlers-Danlos, O. imperfecta)

ACQUIRED (AORTIC ROOT)

- Hypertension - Aneurysm
- Aortic dissection
- Aortitis / Autoimmune disease (Lupus, A. spondylitis, Reiter´s syndrome)
- Trauma

AR Mechanisms

DYSFUNCTION	LESION TYPE
TYPE I: Normal cusps, normal movility.	• Dilatation of the aortic root components, central jet. • Leaflet perforation, eccentric jet.
TYPE II: Increased movility.	• Cusp prolapse with eccentric jet.
TYPE III: Restricted movility.	• Poor cusp tissue quality: retraction, calcification, endocarditis. Large central or eccentric jets.

El Khoury G, et al. Curr Op Cardiol 2005; Le Polain de Waroux JB, et al. Circulation 2007.

AR Mechanisms

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JET DIRECTION AND ORIGIN

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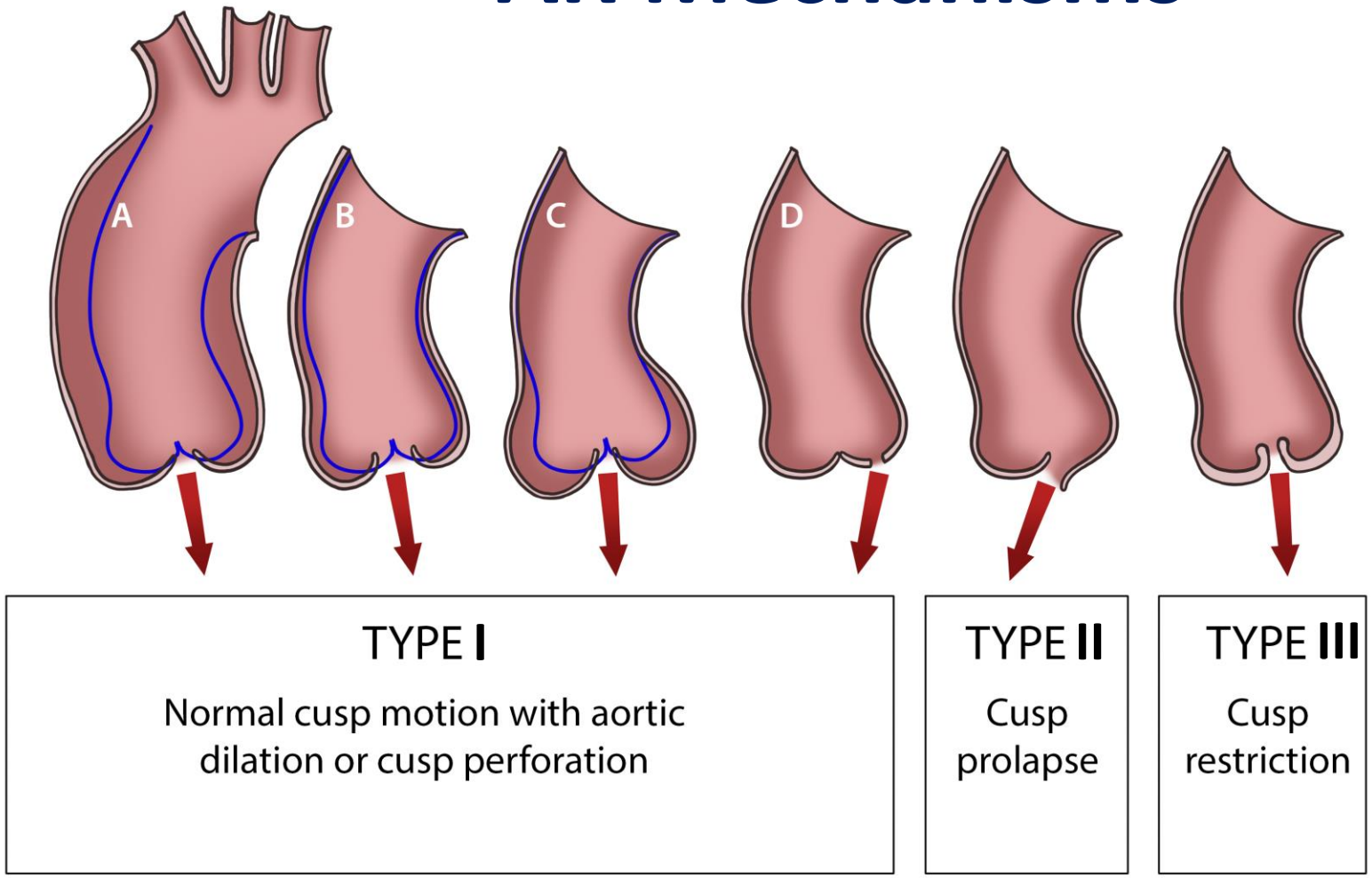
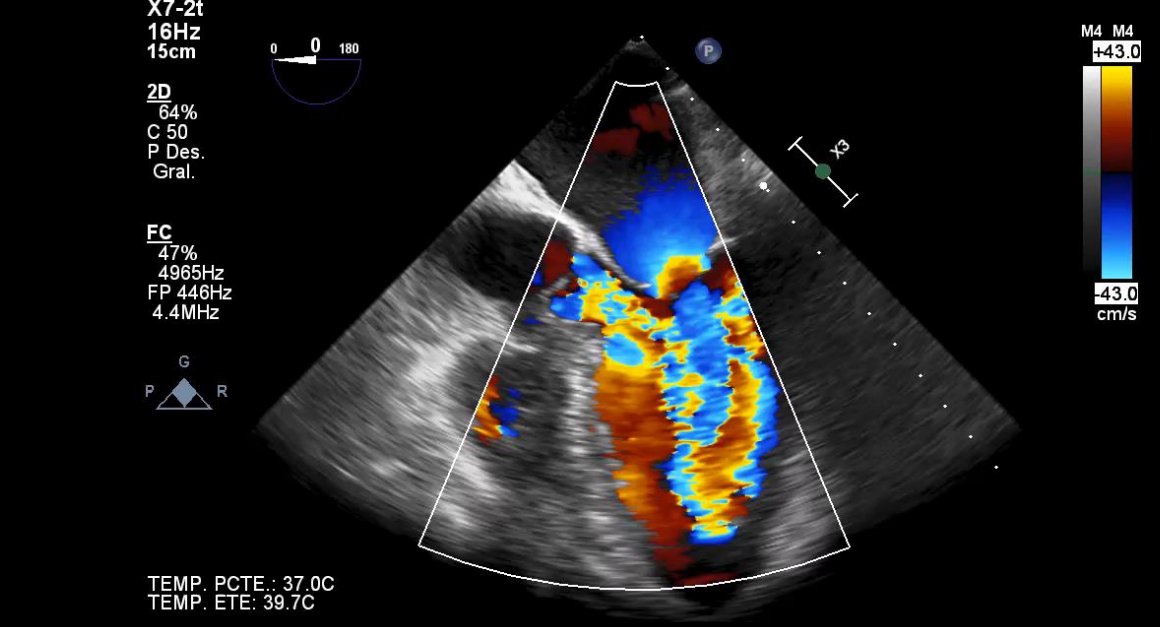
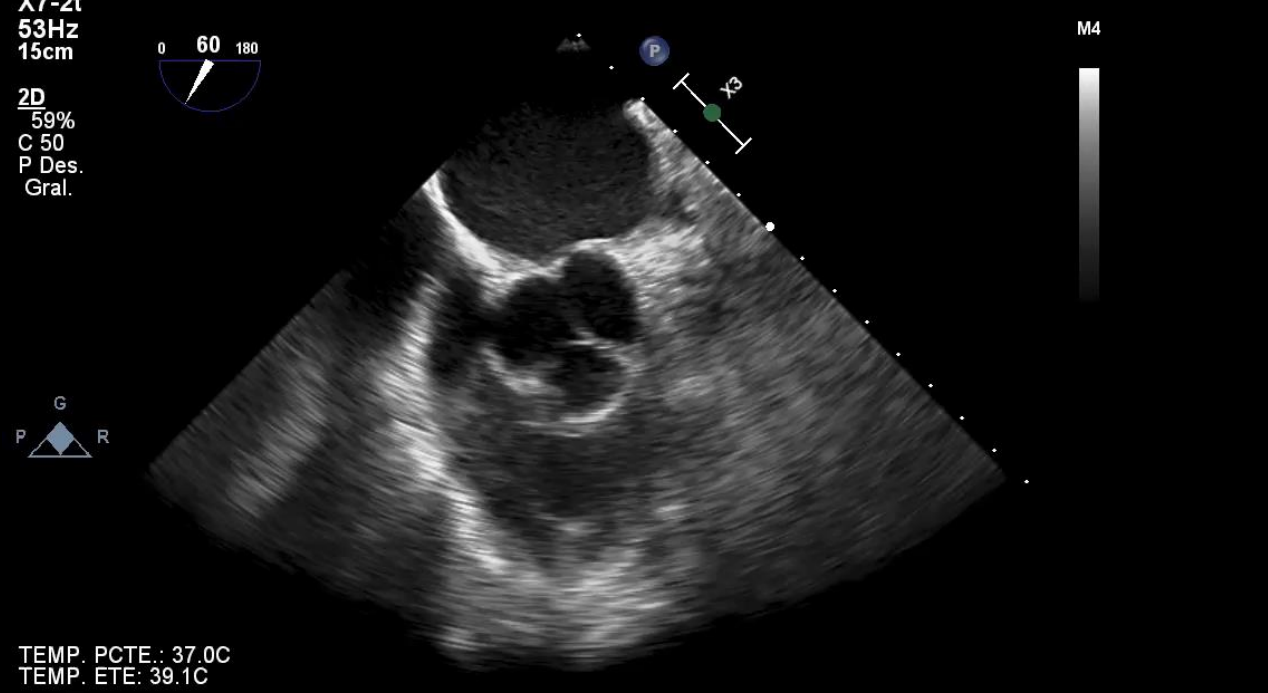
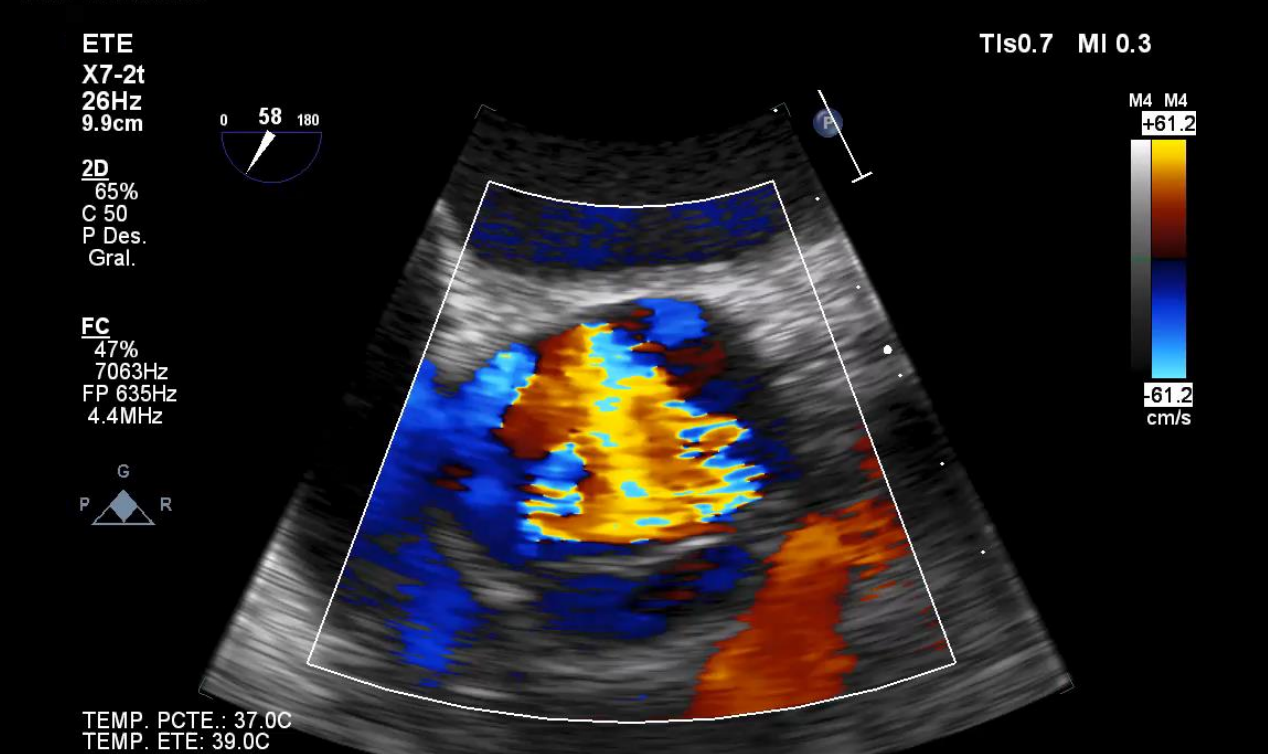
AR Mechanisms

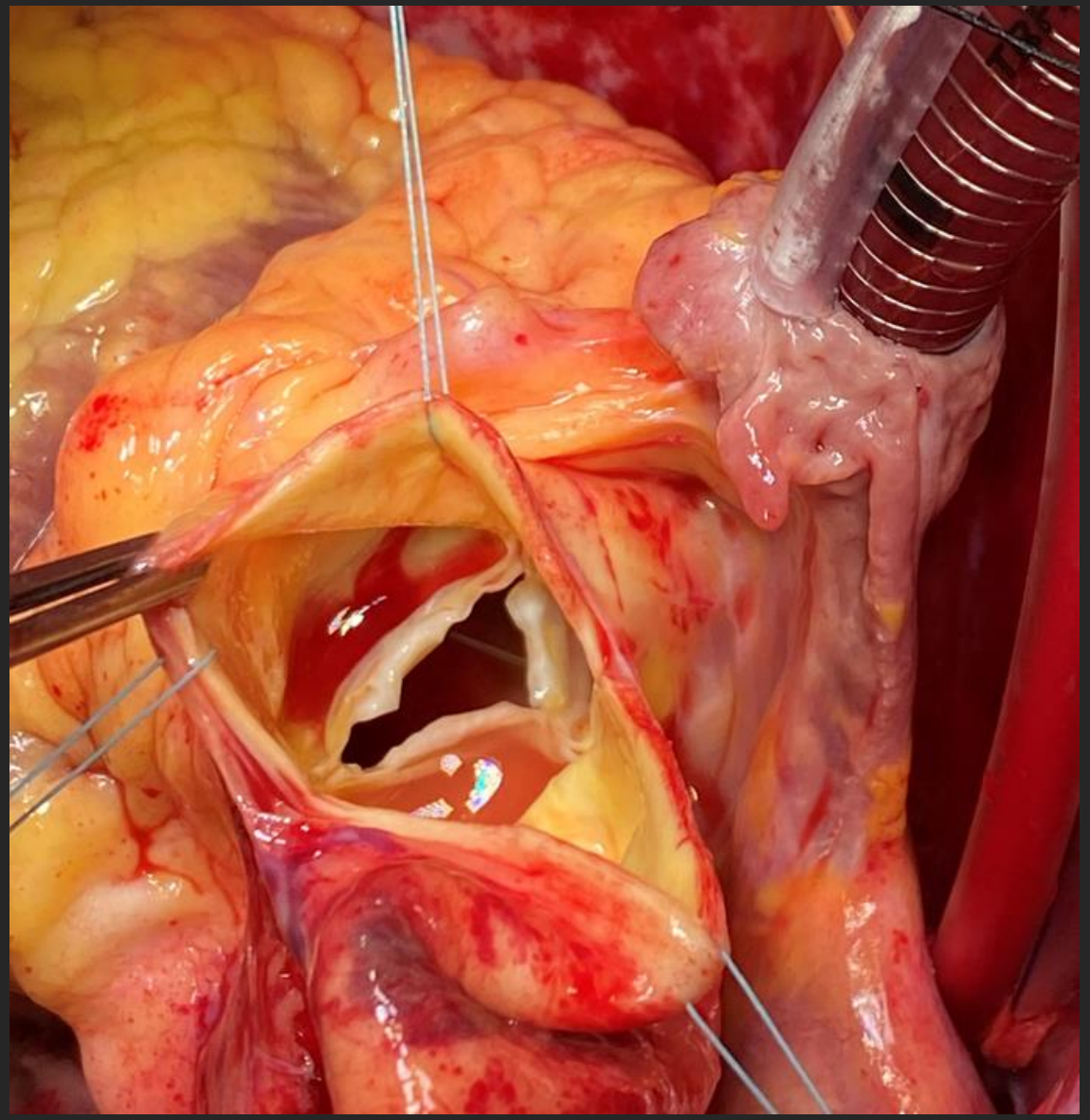


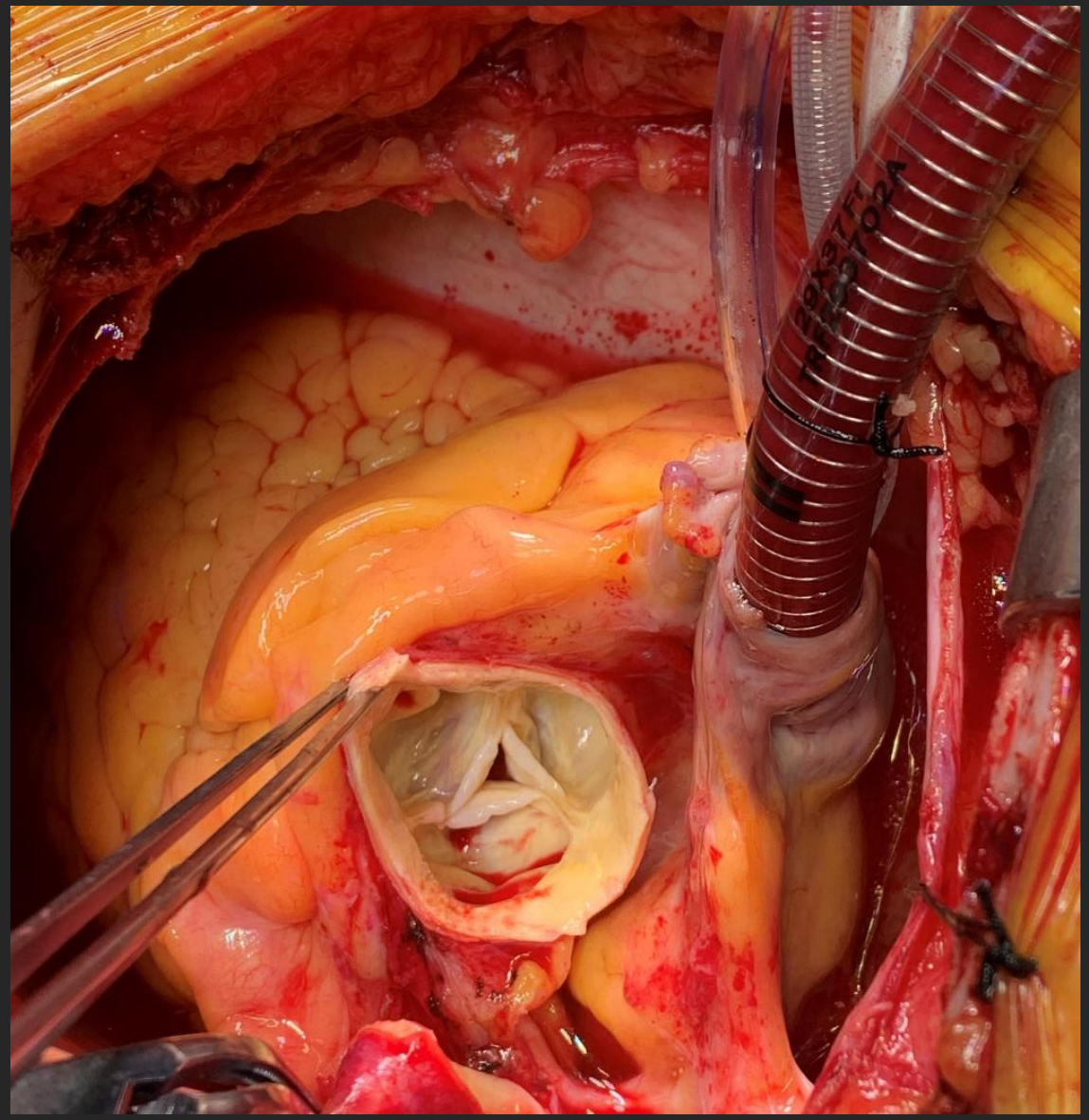
El Khoury G, et al. Curr Opin Cardiol 2005.
Boodhwani M, et al. J Thorac Cardiovasc Surg 2009.

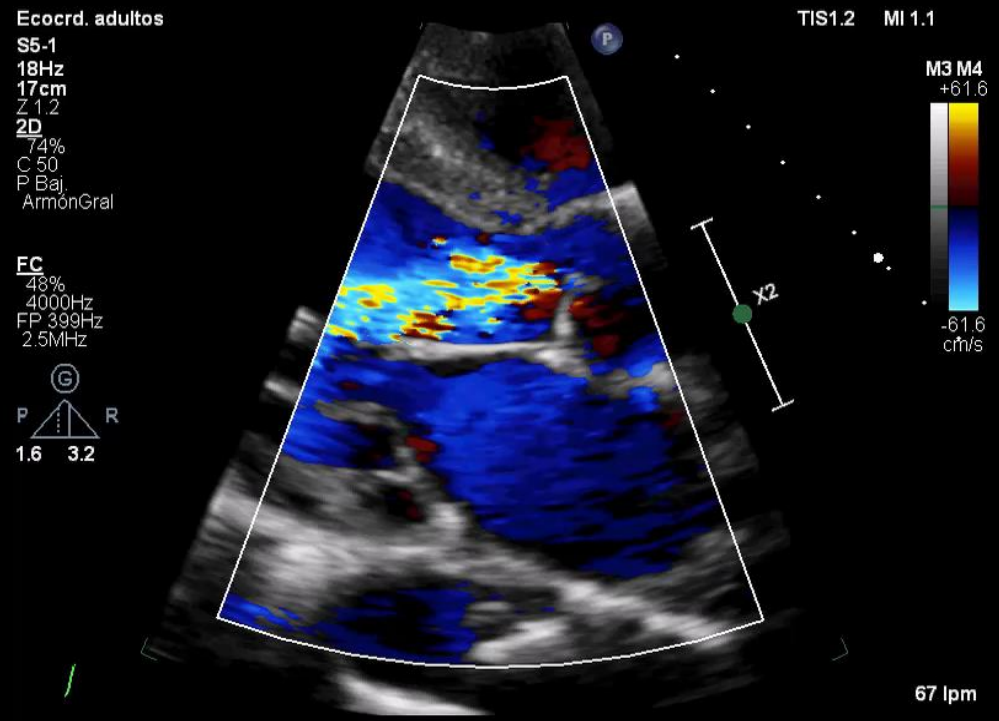

X7-2t
16Hz
15cm
2D
64%
C 50
P Des.
Gral.
FC
47%
4965Hz
FP 446Hz
4.4MHz
0 0 180
M4 M4
+43.0
-43.0
cm/s
X3
G
P R
TEMP. PCTE.: 37.0C
TEMP. ETE: 39.7C

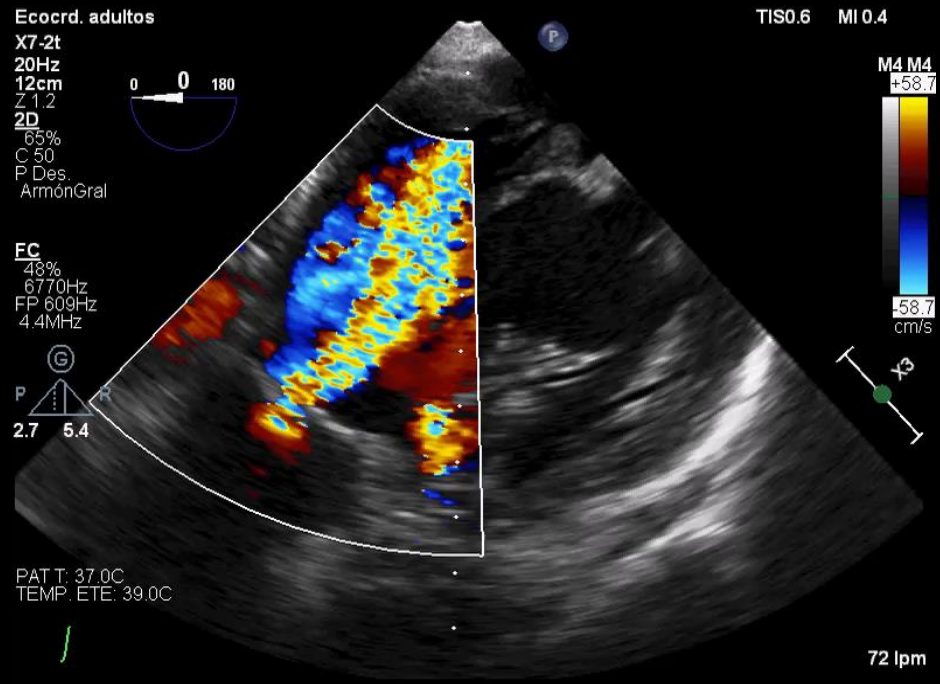

X7-2t
53Hz
15cm
2D
59%
C 50
P Des.
Gral.
0 60 180
M4
X3
G
P R
TEMP. PCTE.: 37.0C
TEMP. ETE: 39.1C

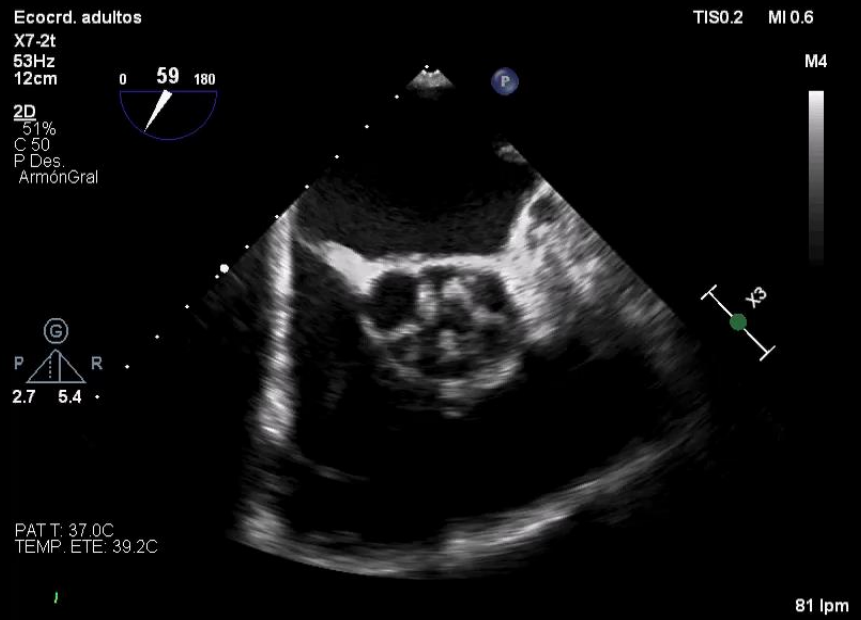

ETE
X7-2t
26Hz
9.9cm
2D
65%
C 50
P Des.
Gral.
FC
47%
7063Hz
FP 635Hz
4.4MHz
0 58 180
TIs0.7 MI 0.3
M4 M4
+61.2
-61.2
cm/s
G
P R
TEMP. PCTE.: 37.0C
TEMP. ETE: 39.0C

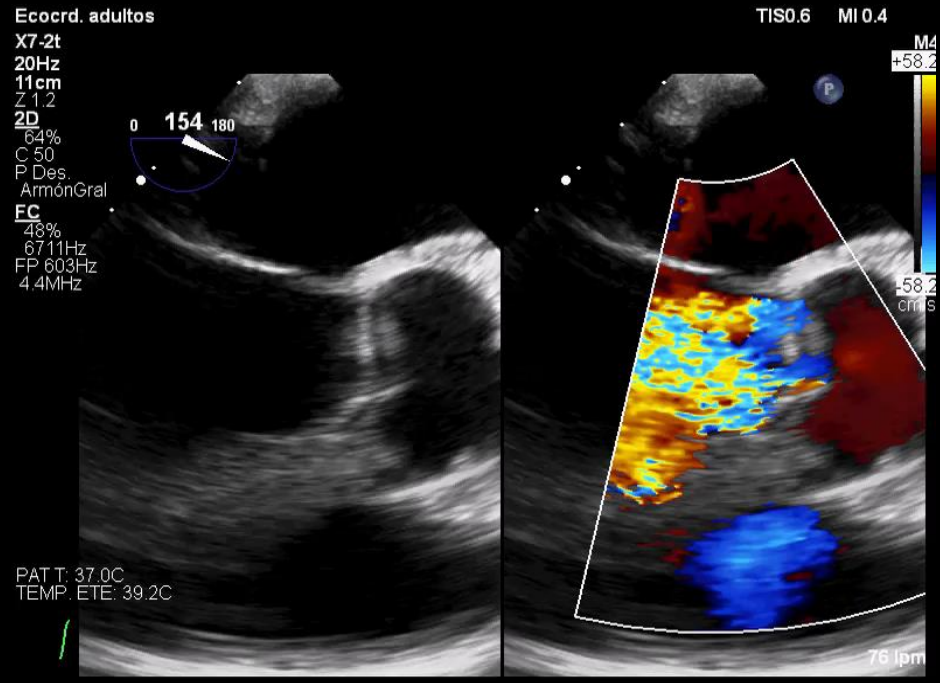


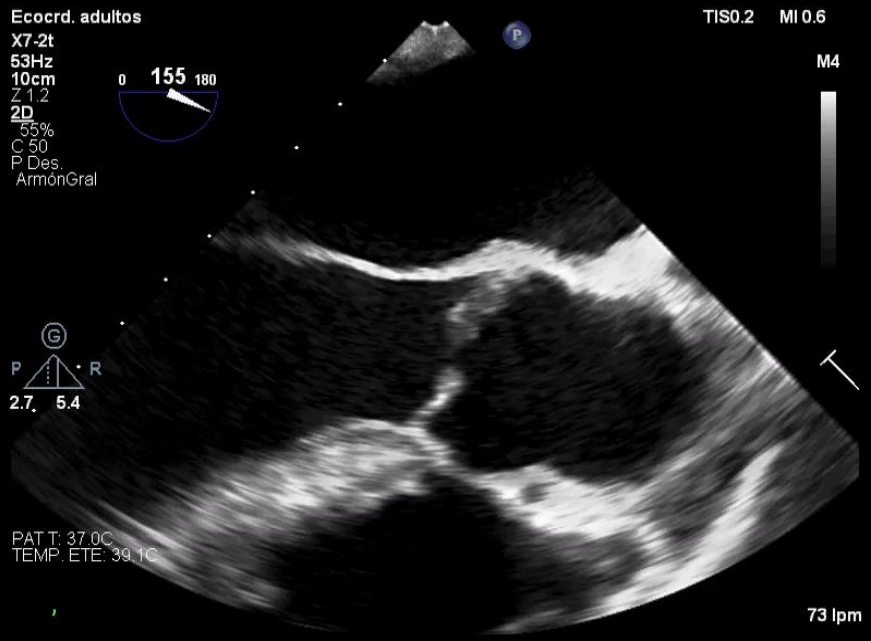


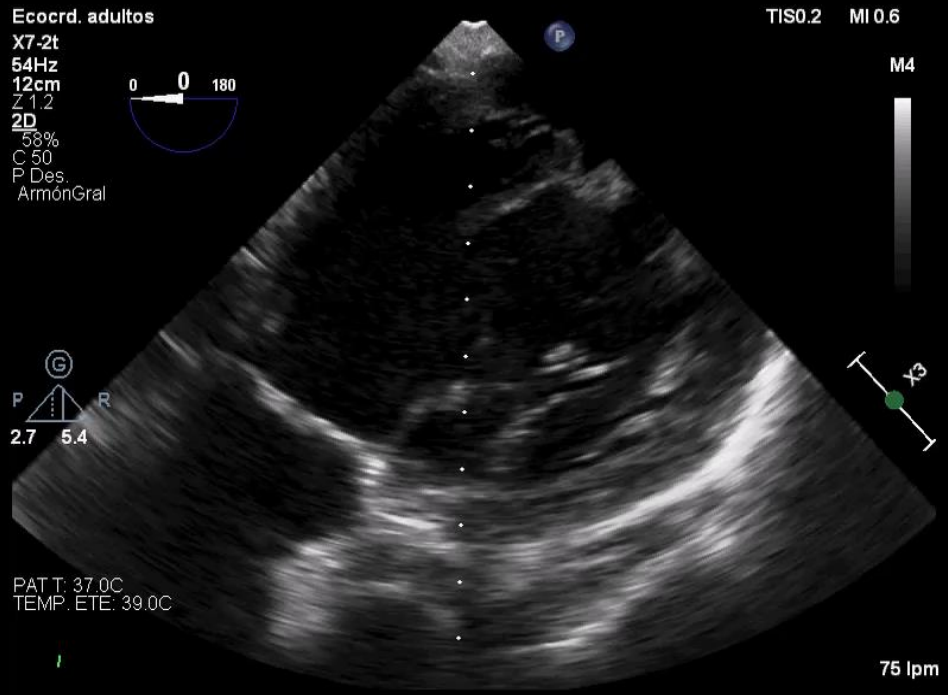

Ecocrd. adultos
S5-1
18Hz
17cm
Z 1.2
2D
74%
C 50
P Baj.
ArmónGral
FC
48%
4000Hz
FP 399Hz
2.5MHz
P
R
1.6
3.2
TIS1.2
MI 1.1
M3 M4
+61.6
-61.6
cm/s
X2
67 lpm

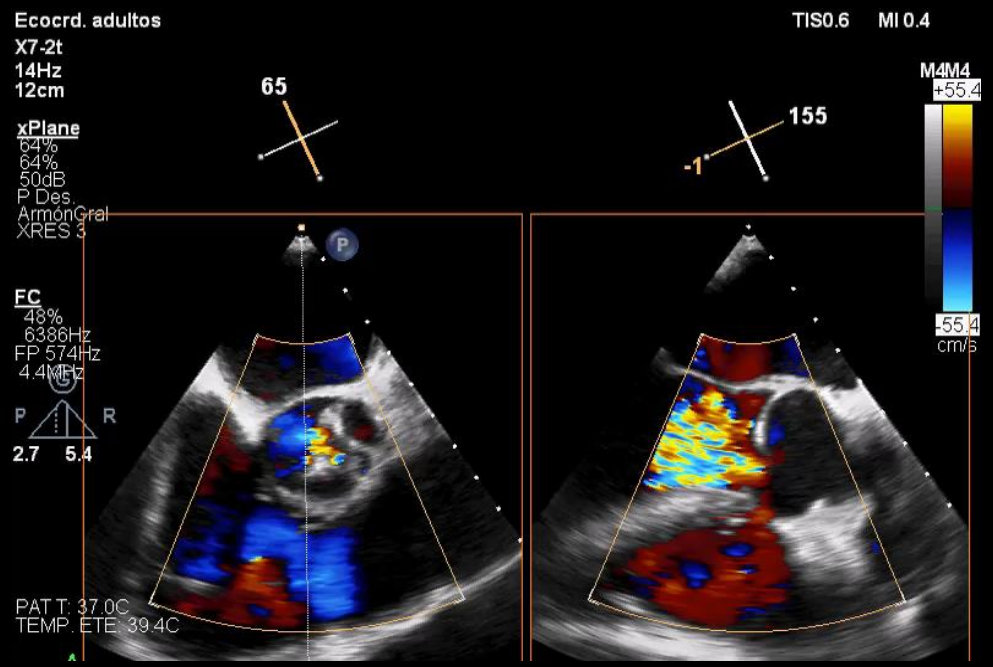

Ecocrd. adultos
X7-2t
20Hz
12cm
Z 1.2
2D
65%
C 50
P Des.
ArmónGral
FC
48%
6770Hz
FP 609Hz
4.4MHz
P
R
2.7
5.4
0
180
TIS0.6
MI 0.4
M4 M4
+58.7
-58.7
cm/s
X3
PAT T: 37.0C
TEMP. ETE: 39.0C
72 lpm


Ecocrd. adultos
X7-2t
53Hz
12cm
2D
51%
C 50
P Des.
ArmónGral
0
59
180
P
R
2.7
5.4
TIS0.2
MI 0.6
M4
X3
PAT T: 37.0C
TEMP. ETE: 39.2C
81 lpm

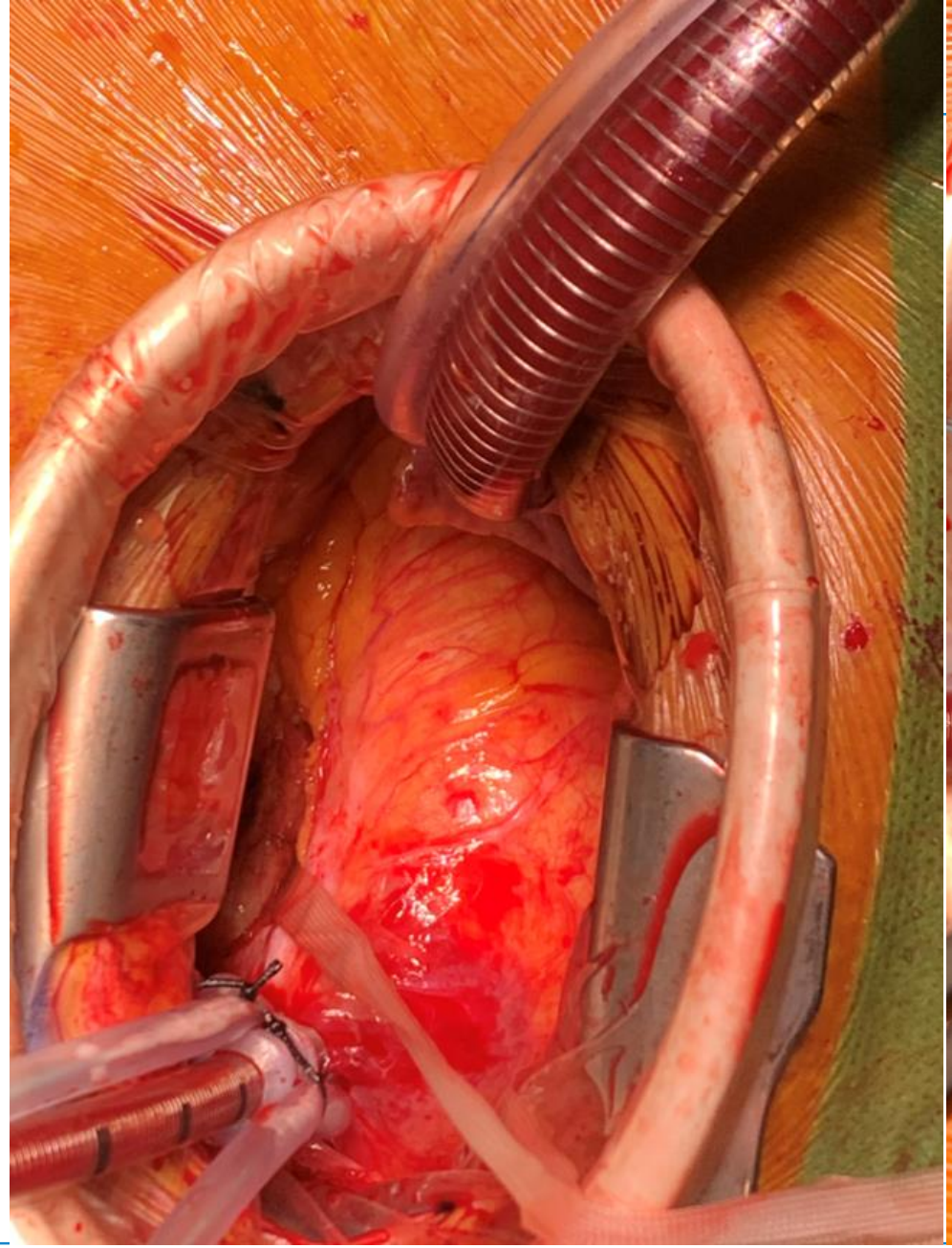

Ecocrd. adultos
X7-2t
20Hz
11cm
Z 1.2
2D
64%
C 50
P Des.
ArmónGral
FC
48%
6711Hz
FP 603Hz
4.4MHz
0
154
180
TIS0.6
MI 0.4
M4
+58.2
-58.2
cm/s
PAT T: 37.0C
TEMP. ETE: 39.2C
76 lpm

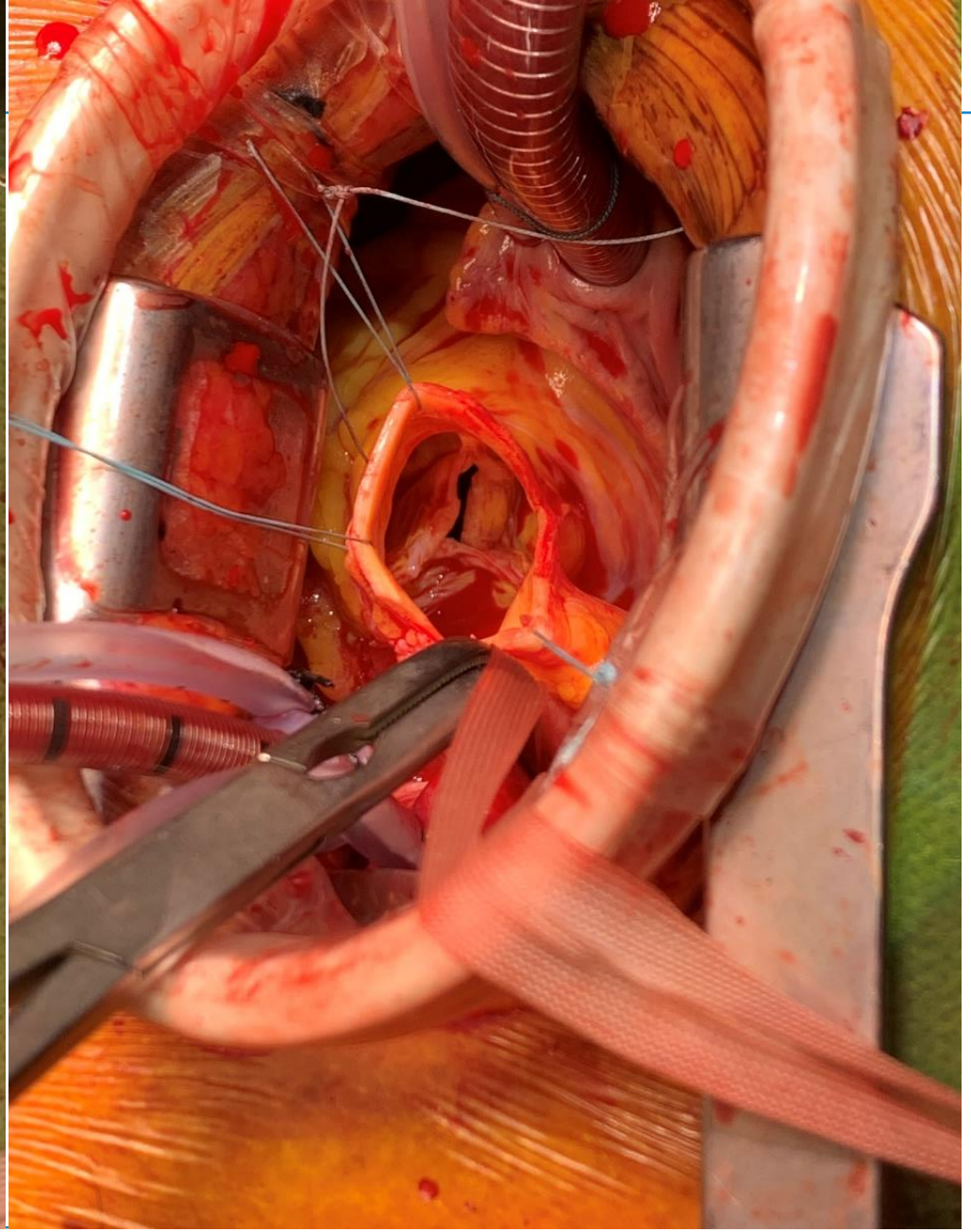

Ecocrd. adultos
X7-2t
53Hz
10cm
Z 1.2
2D
55%
C 50
P Des.
ArmónGral
TIS0.2 MI 0.6
M4
155
PAT T: 37.0C
TEMP. ETE: 39.1C
73 lpm

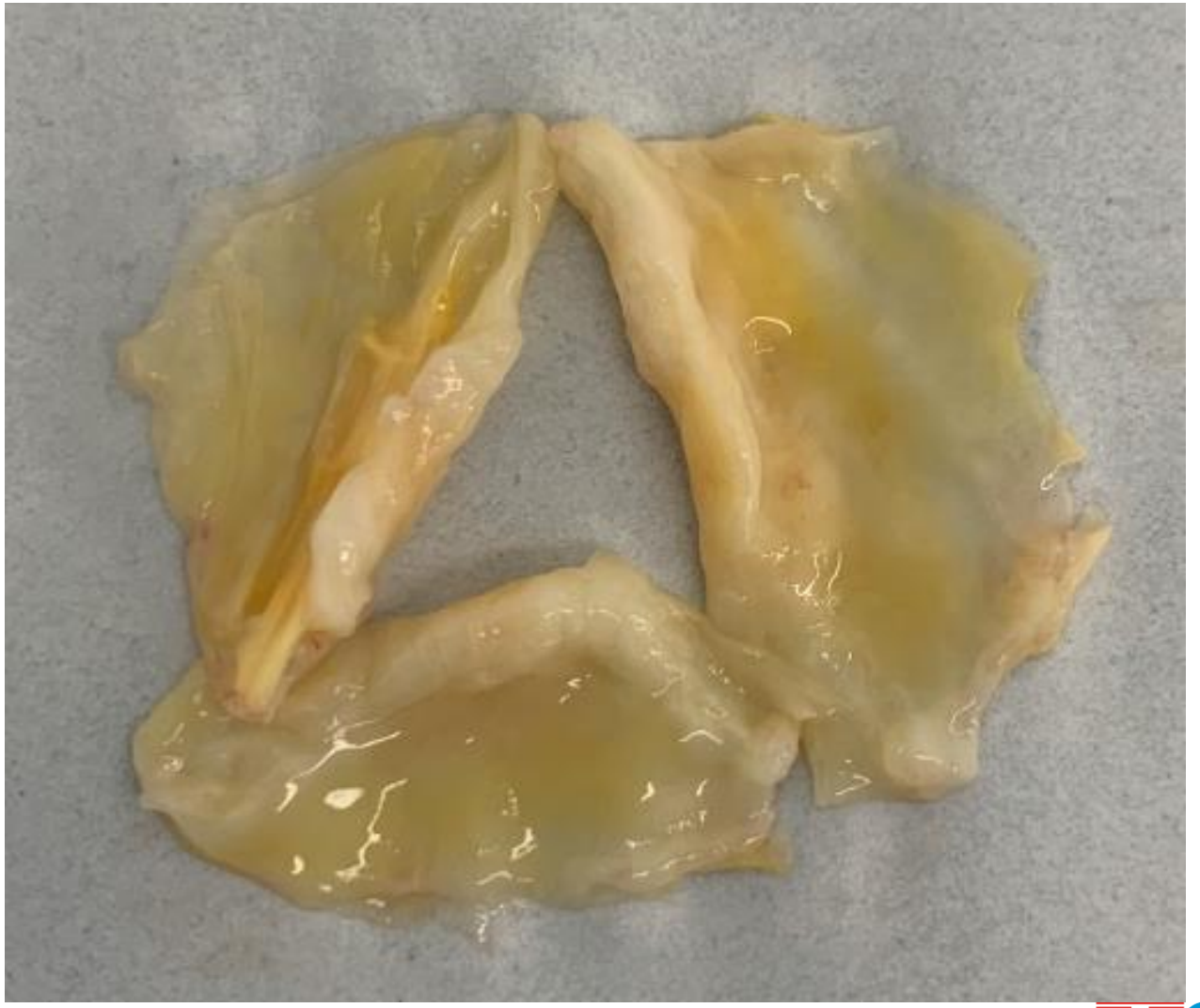

Ecocrd. adultos
X7-2t
54Hz
12cm
Z 1.2
2D
58%
C 50
P Des.
ArmónGral
TIS0.2 MI 0.6
M4
0
PAT T: 37.0C
TEMP. ETE: 39.0C
75 lpm


Ecocrd. adultos
X7-2t
14Hz
12cm
xPlane
64%
64%
50dB
P Des.
ArmónGral
XRES 3
FC
48%
6386Hz
FP 574Hz
4.4MHz
TIS0.6 MI 0.4
M4M4
+55.4
-55.4
cm/s
65
155
-1
PAT T: 37.0C
TEMP. ETE: 39.4C

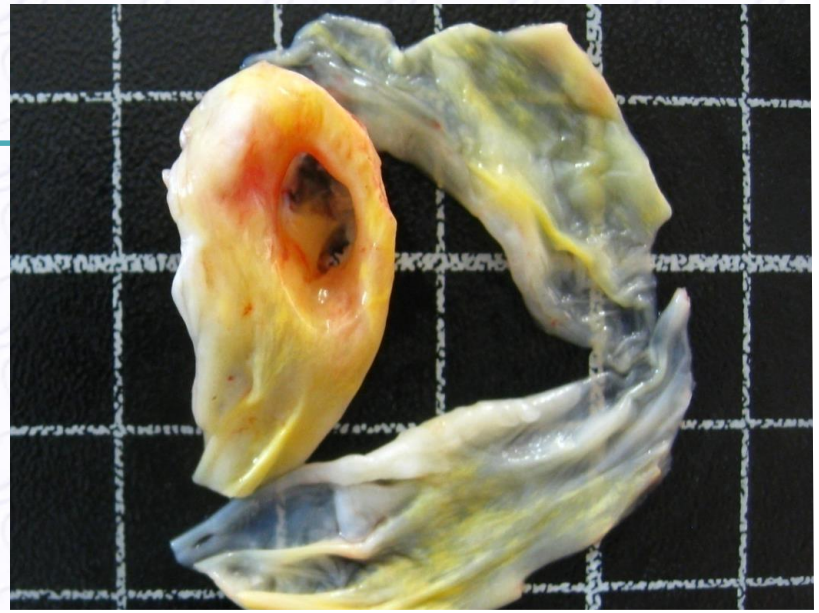

Ecocrd. adultos
X7-2t
17Hz
12cm
Live 3D
2D / 3D
% 59 / 44
C 50 / 30
ArmónGral
XRES ON
Latidos 3D 1
TIs0.2 MI 0.5
65
TEMP. PCTE.: 37.0C
TEMP. ETE: 39.0C
81bpm

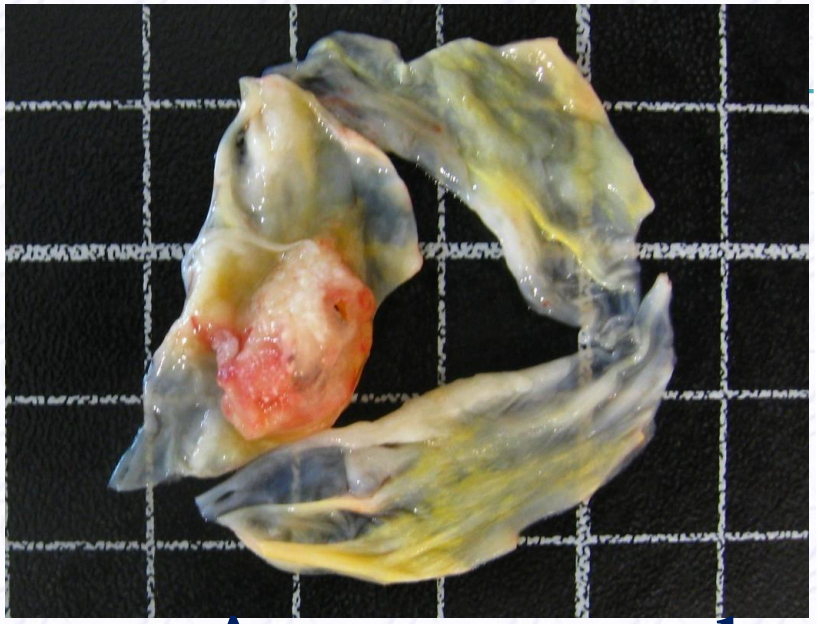




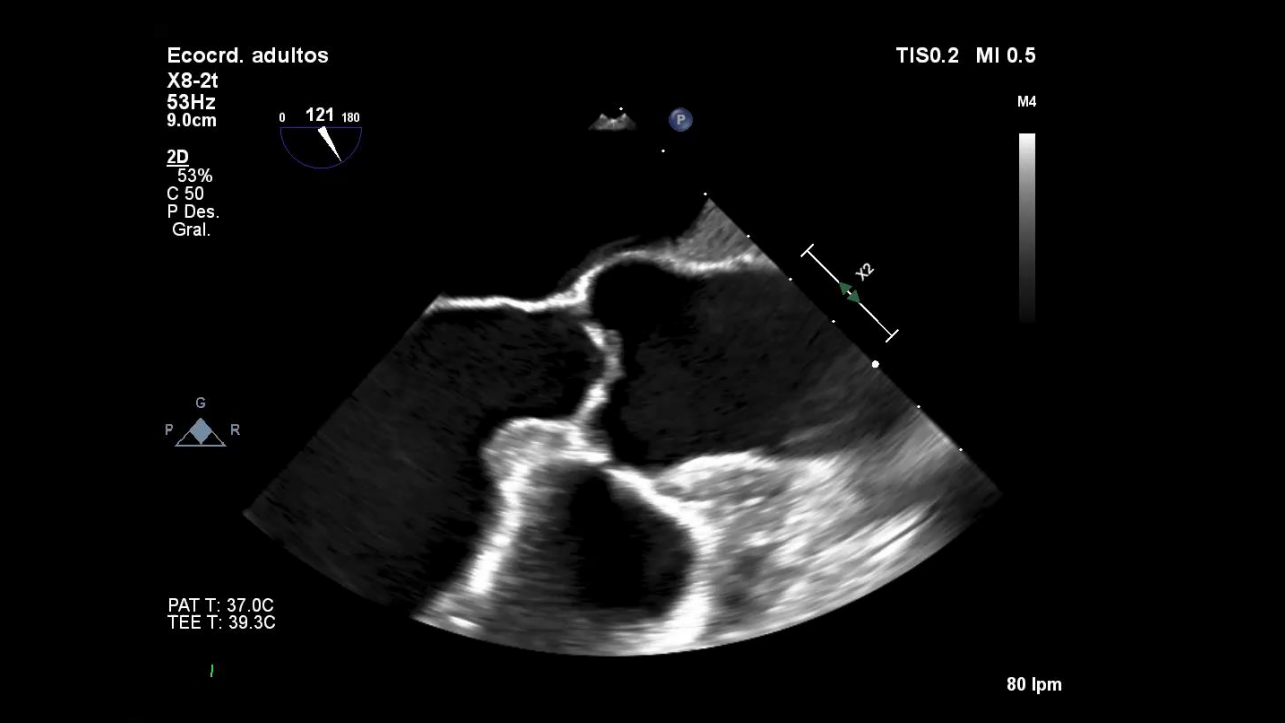


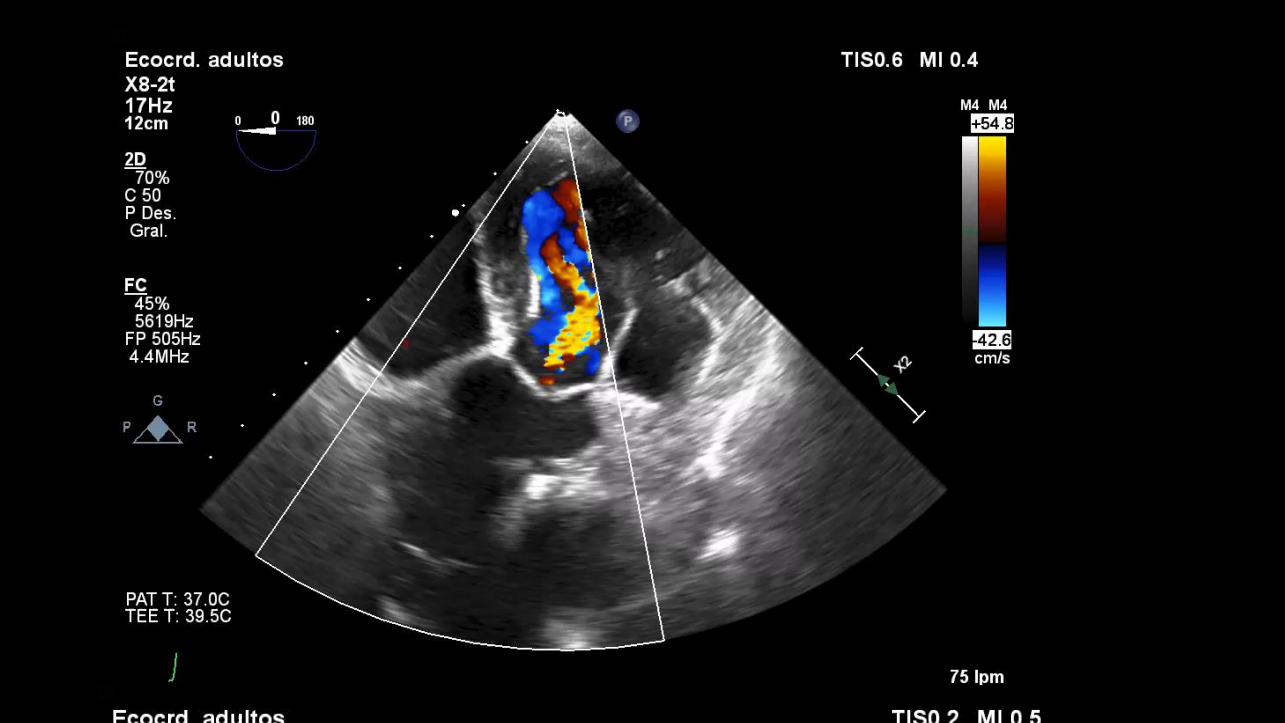
Ao. valve perforation - Type ID

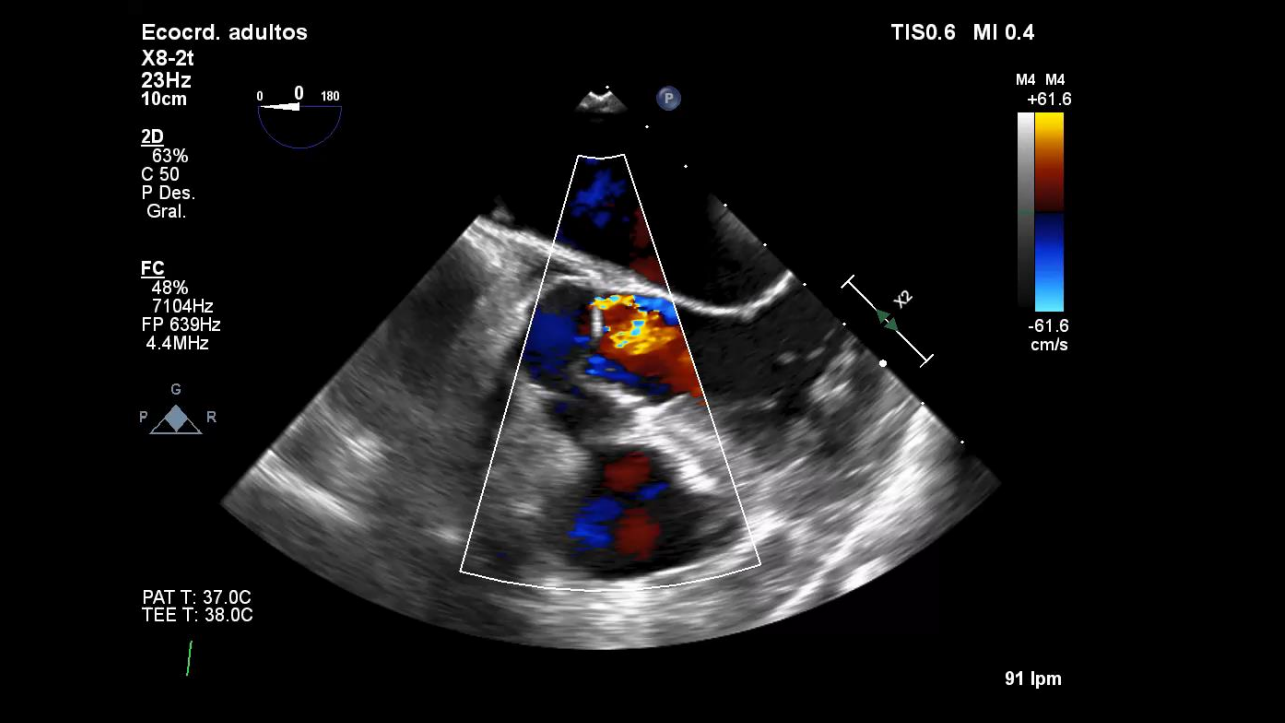


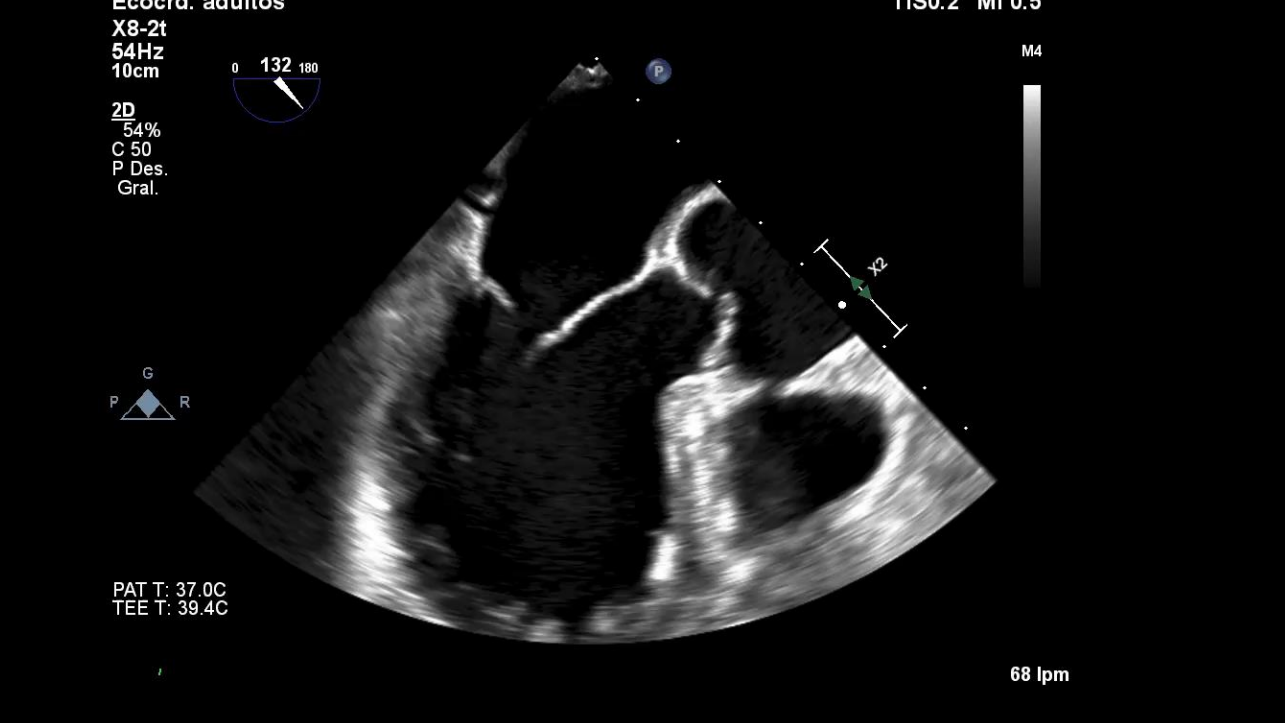


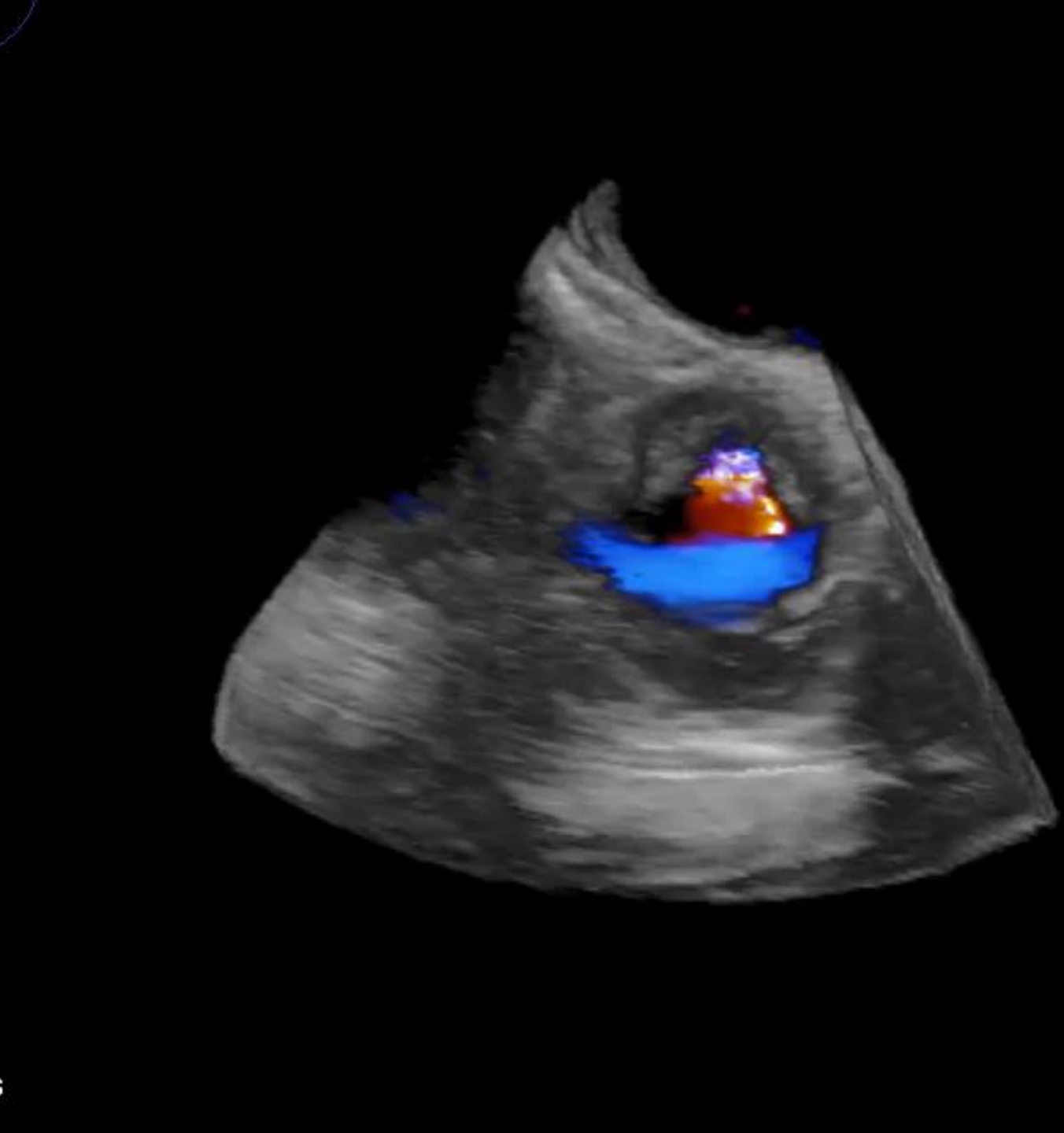
Ao. cusp prolapse - Type II

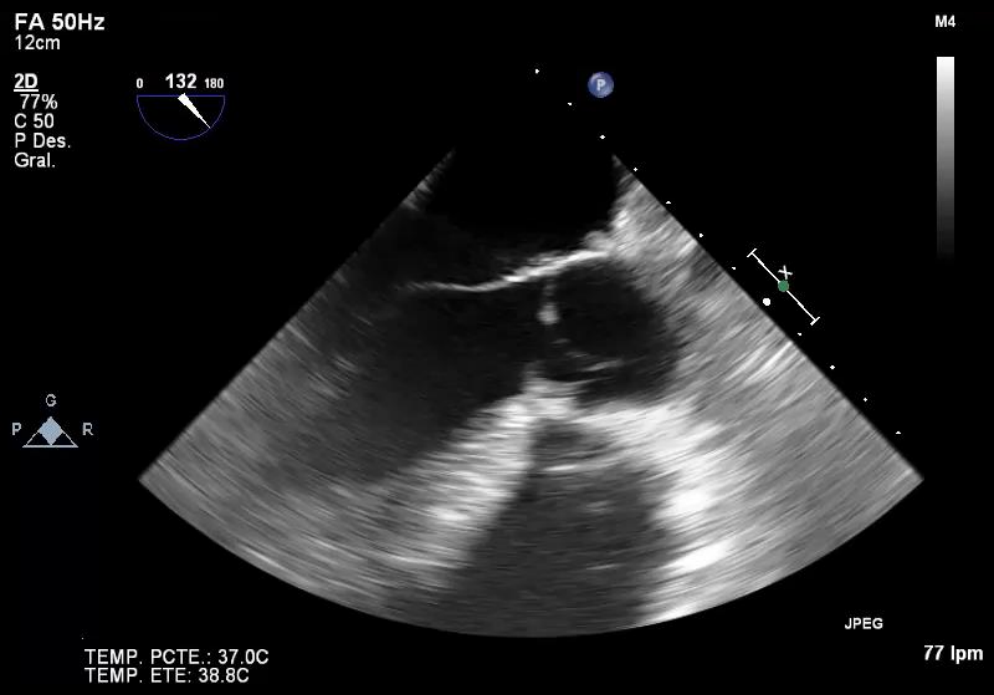

Ecocrd. adultos
X8-2t
53Hz
9.0cm
2D
53%
C 50
P Des.
Gral.
TIS0.2 MI 0.5
M4
PAT T: 37.0C
TEE T: 39.3C
80 lpm

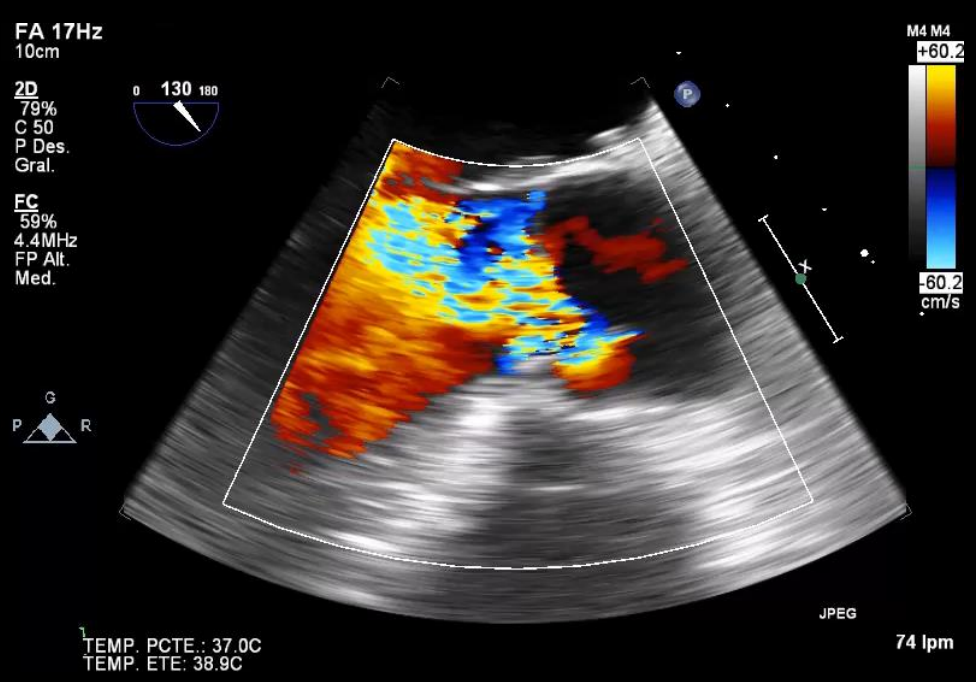

Ecocrd. adultos
X8-2t
17Hz
12cm
2D
70%
C 50
P Des.
Gral.
FC
45%
5619Hz
FP 505Hz
4.4MHz
TIS0.6 MI 0.4
M4 M4
+54.8
-42.6
cm/s
PAT T: 37.0C
TEE T: 39.5C
75 lpm

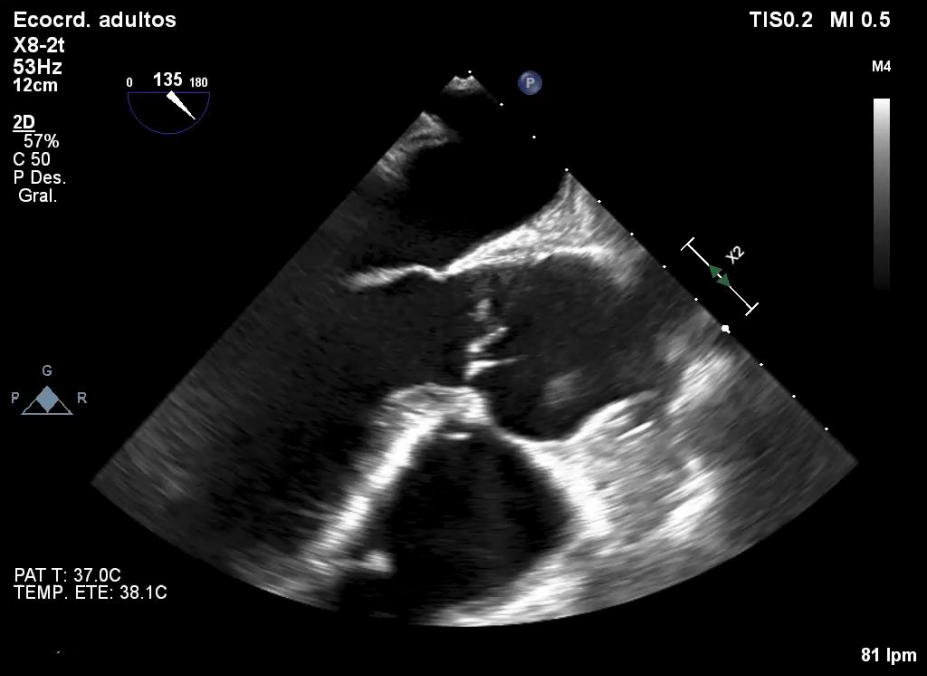

Ecocrd. adultos
X8-2t
23Hz
10cm
2D
63%
C 50
P Des.
Gral.
FC
48%
7104Hz
FP 639Hz
4.4MHz
TIS0.6 MI 0.4
M4 M4
+61.6
-61.6
cm/s
PAT T: 37.0C
TEE T: 38.0C
91 lpm

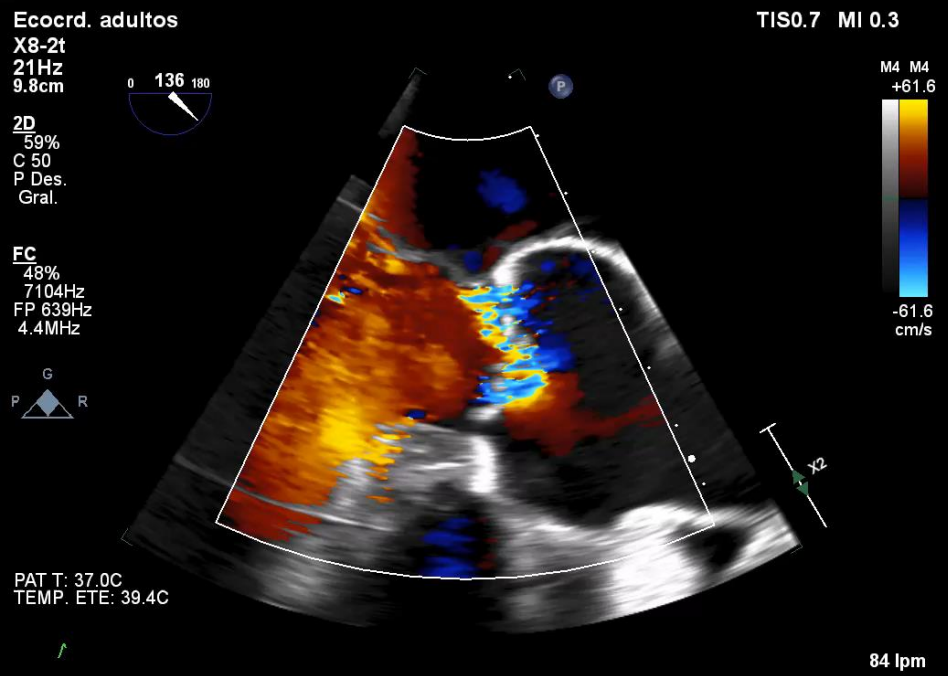

Ecocrd. adultos
X8-2t
54Hz
10cm
2D
54%
C 50
P Des.
Gral.
TIS0.2 MI 0.5
M4
PAT T: 37.0C
TEE T: 39.4C
68 lpm

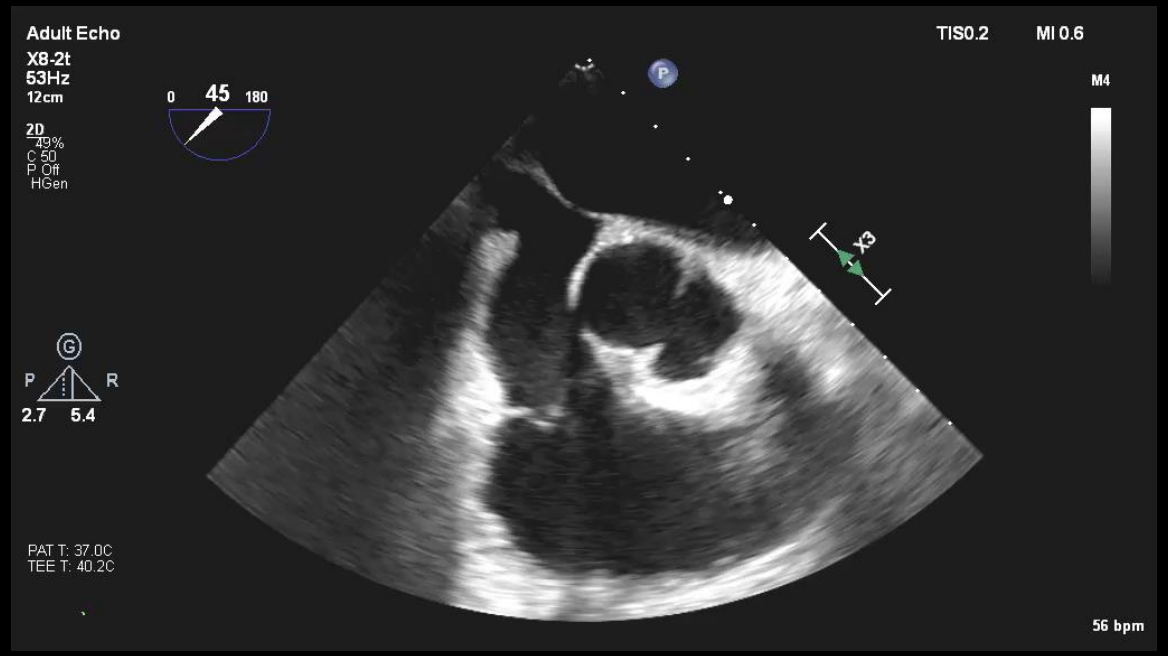


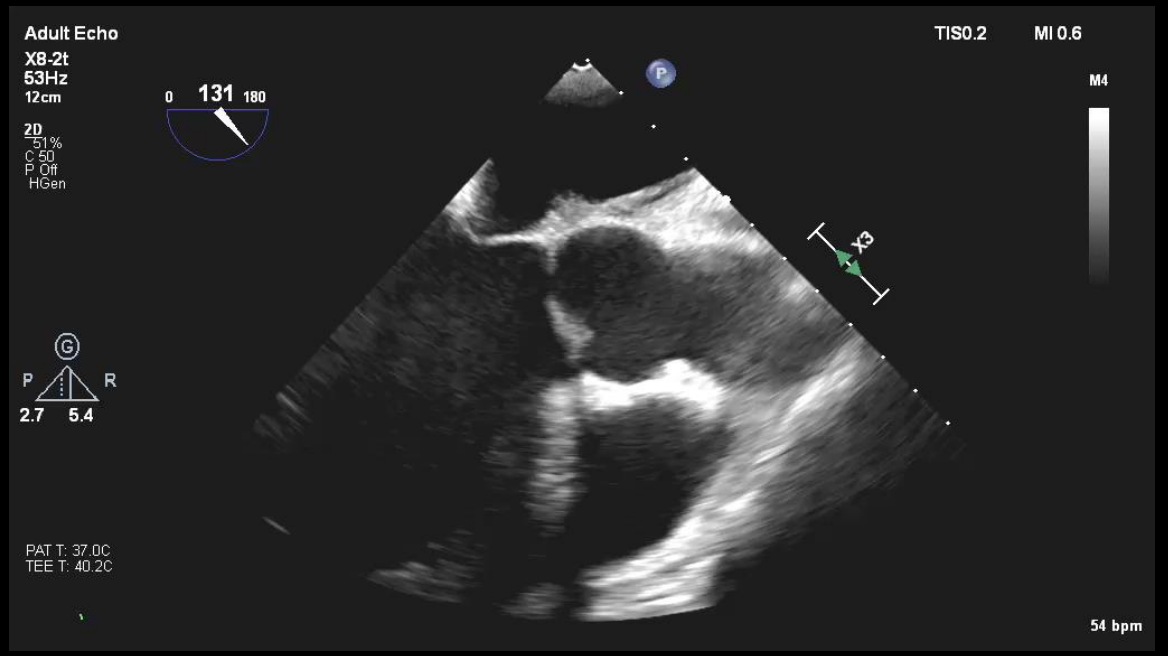

FA 50Hz
12cm
2D
77%
C 50
P Des.
Gral.
0 132 180
M4
JPEG
TEMP. PCTE.: 37.0C
TEMP. ETE: 38.8C
77 lpm


FA 17Hz
10cm
2D
79%
C 50
P Des.
Gral.
FC
59%
4.4MHz
FP Alt.
Med.
0 130 180
M4 M4
+60.2
-60.2
cm/s
JPEG
TEMP. PCTE.: 37.0C
TEMP. ETE: 38.9C
74 lpm

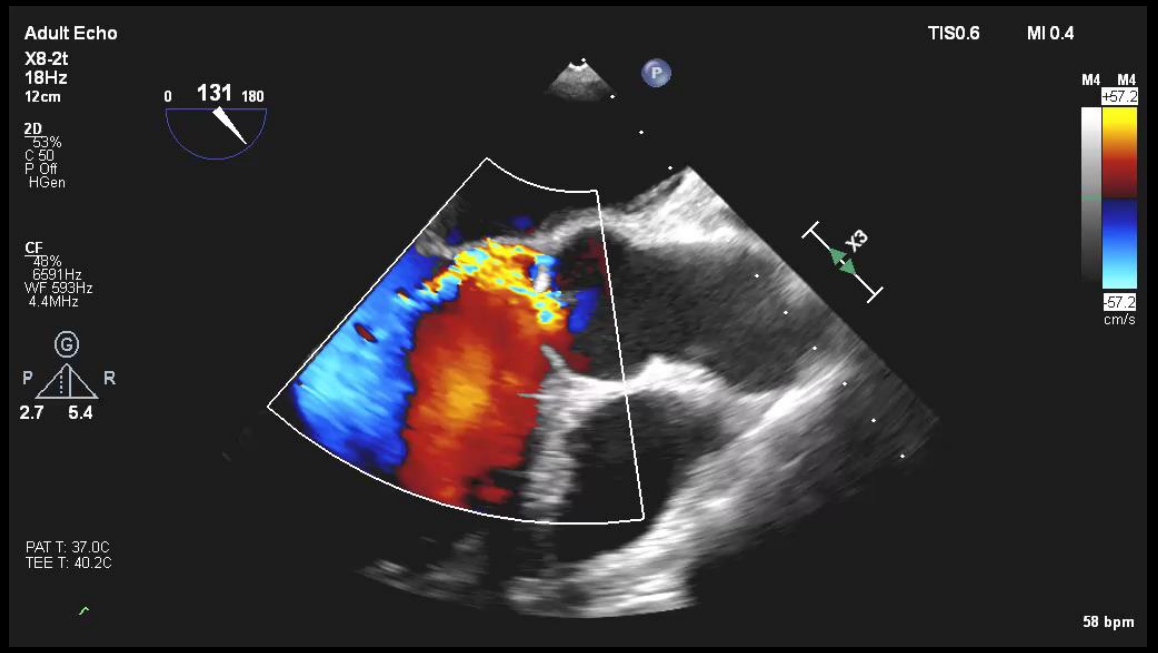

Ecocrd. adultos
X8-2t
53Hz
12cm
TIS0.2 MI 0.5
2D
57%
C 50
P Des.
Gral.
0 135 180
M4
PAT T: 37.0C
TEMP. ETE: 38.1C
81 lpm

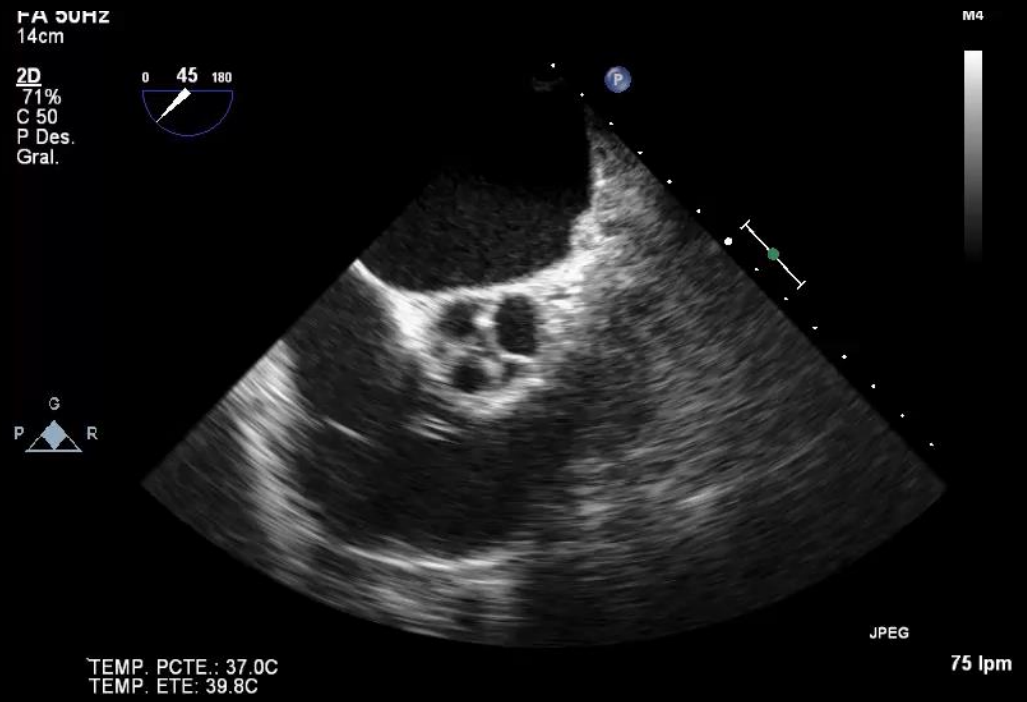

Ecocrd. adultos
X8-2t
21Hz
9.8cm
TIS0.7 MI 0.3
2D
59%
C 50
P Des.
Gral.
FC
48%
7104Hz
FP 639Hz
4.4MHz
0 136 180
M4 M4
+61.6
-61.6
cm/s
PAT T: 37.0C
TEMP. ETE: 39.4C
84 lpm

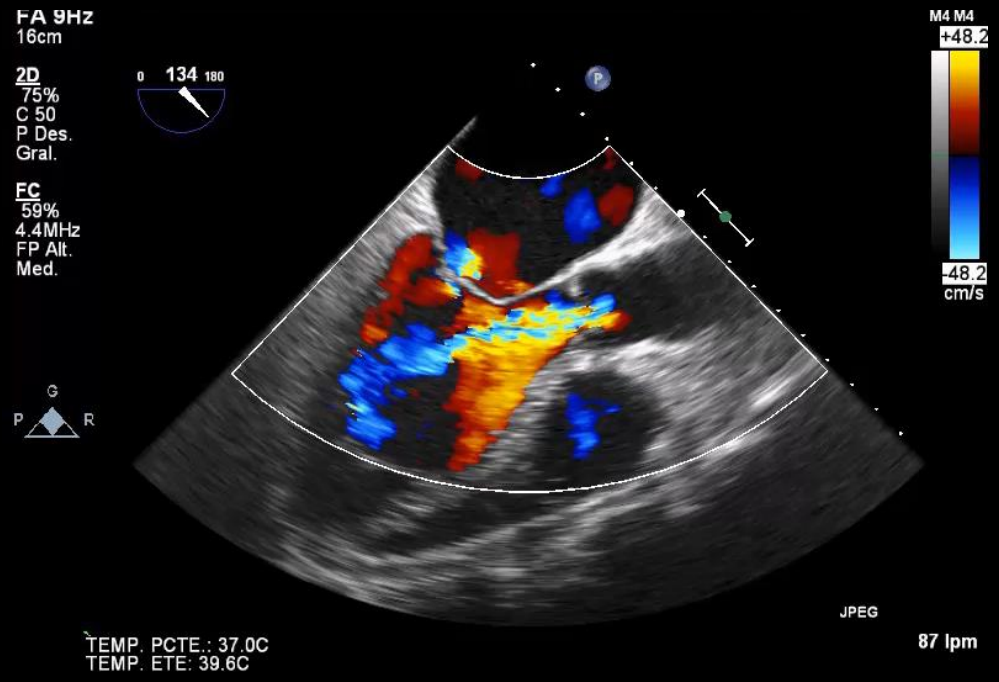

Adult Echo
X8-2t
53Hz
12cm
2D
49%
C 50
P Off
HGen
0 45 180
TIS0.2 MI 0.6
M4
X3
G
P R
2.7 5.4
PAT T: 37.0C
TEE T: 40.2C
56 bpm

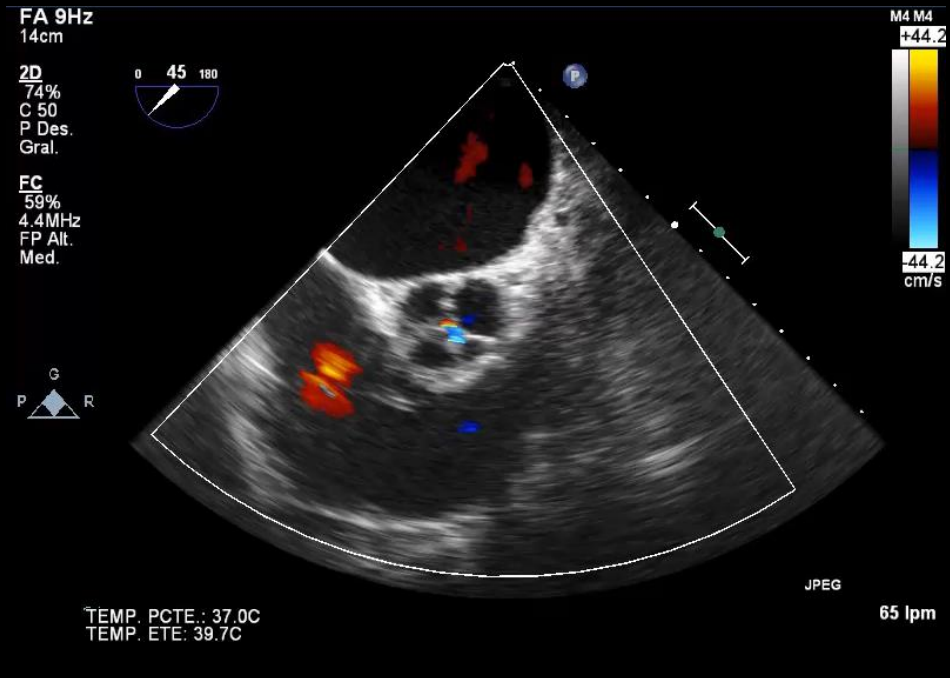

Adult Echo
X8-2t
53Hz
12cm
2D
51%
C 50
P Off
HGen
0 131 180
TIS0.2 MI 0.6
M4
X3
G
P R
2.7 5.4
PAT T: 37.0C
TEE T: 40.2C
54 bpm


Adult Echo
X8-2t
14Hz
10cm
Live 3D
2D / 3D
% 48 / 57
C 50 / 30
HGen
3D Beats 1
0 45 180
TIS0.2 MI 0.5
M4
PAT T: 37.0C
TEE T: 40.4C
59 bpm

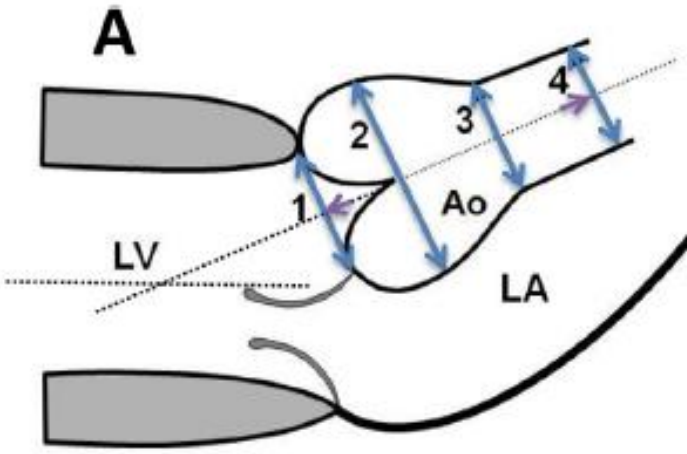

Adult Echo
X8-2t
18Hz
12cm
2D
53%
C 50
P Off
HGen
CF
48%
6591Hz
WF 593Hz
4.4MHz
0 131 180
TIS0.6 MI 0.4
M4 M4
+57.2
-57.2
cm/s
X3
G
P R
2.7 5.4
PAT T: 37.0C
TEE T: 40.2C
58 bpm


FA 50Hz
14cm
2D
71%
C 50
P Des.
Gral.
0 45 180
M4
JPEG
TEMP. PCTE.: 37.0C
TEMP. ETE: 39.8C
75 lpm


FA 9Hz
16cm
2D
75%
C 50
P Des.
Gral.
FC
59%
4.4MHz
FP Alt.
Med.
0 134 180
M4 M4
+48.2
-48.2
cm/s
JPEG
TEMP. PCTE.: 37.0C
TEMP. ETE: 39.6C
87 lpm


FA 9Hz
14cm
2D
74%
C 50
P Des.
Gral.
FC
59%
4.4MHz
FP Alt.
Med.
0 45 180
M4 M4
+44.2
-44.2
cm/s
JPEG
TEMP. PCTE.: 37.0C
TEMP. ETE: 39.7C
65 lpm

Echocardiographic criteria - AR



*Valve anatomy.

* Mechanism of AR.

*Aortic root and Ascending Ao measurements.

*Determination of the direction of the aortic regurgitation jet (long axis) and its origin (short axis).

*In severe acute AR: non-dilated LV; premature closure of the mitral valve.

*In chronic AR: progressive increase in LV volumen, progressive worsening of LV function.

AR grading. Echo criteria.

Qualitative	SEVERE
Valve morphology	Abnormal/flail/large coaptation defect
Colour flow regurgitant jet area[a]	Large in central jets, variable in eccentric jets
CW signal of regurgitant jet	Dense
Other	Holodiastolic flow reversal in descending aorta (EDV >20 cm/s)
Semiquantitative	
Vena contracta width (mm)	>6
Pressure half-time[b] (ms)	<200
Quantitative	
EROA (mm^2)	≥30
Regurgitant volume (mL/beat)	≥60
Enlargement of cardiac chambers	LV dilatation

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Integrated approach

Other imaging techniques - AR

CMR – To quantify the **regurgitant fraction** when echo measurements are equivocal.

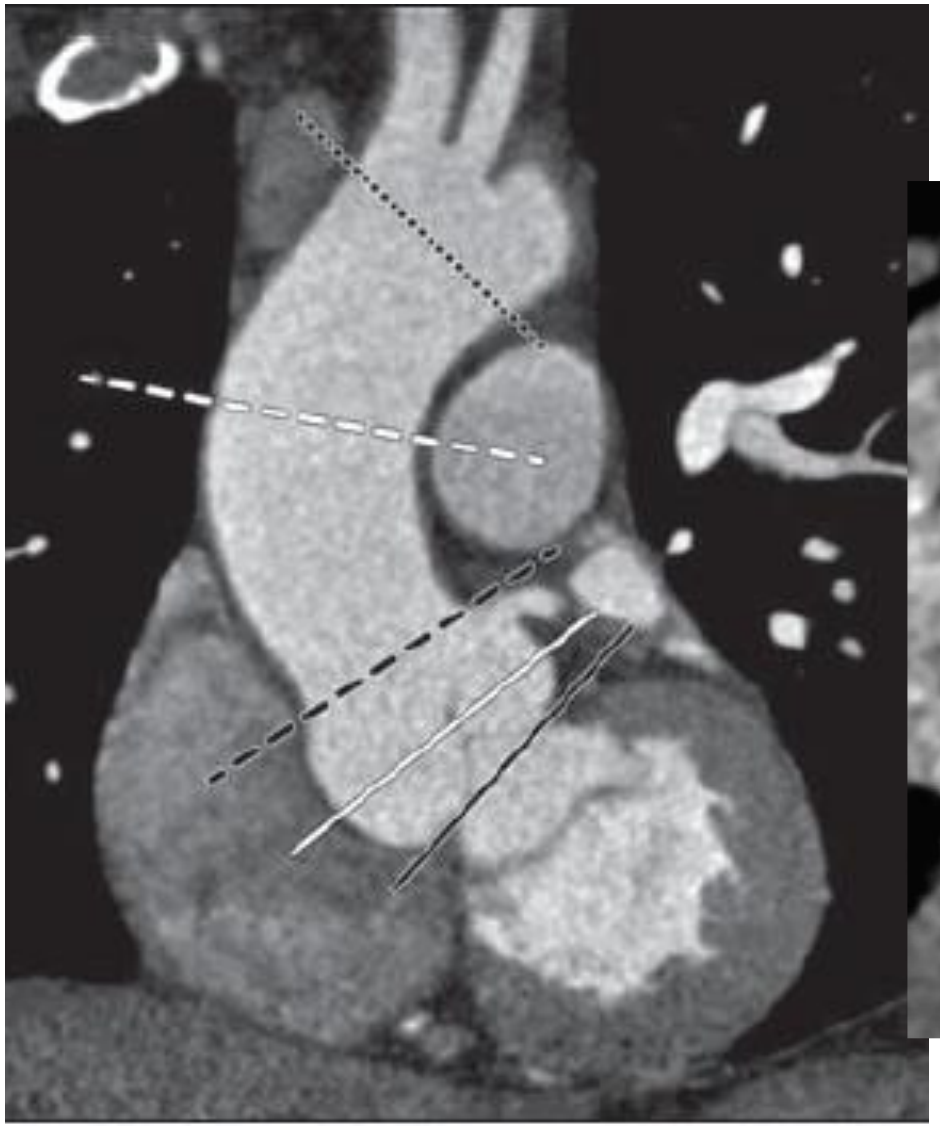
CT – To assess the máximum **aortic diameter at 4 levels**

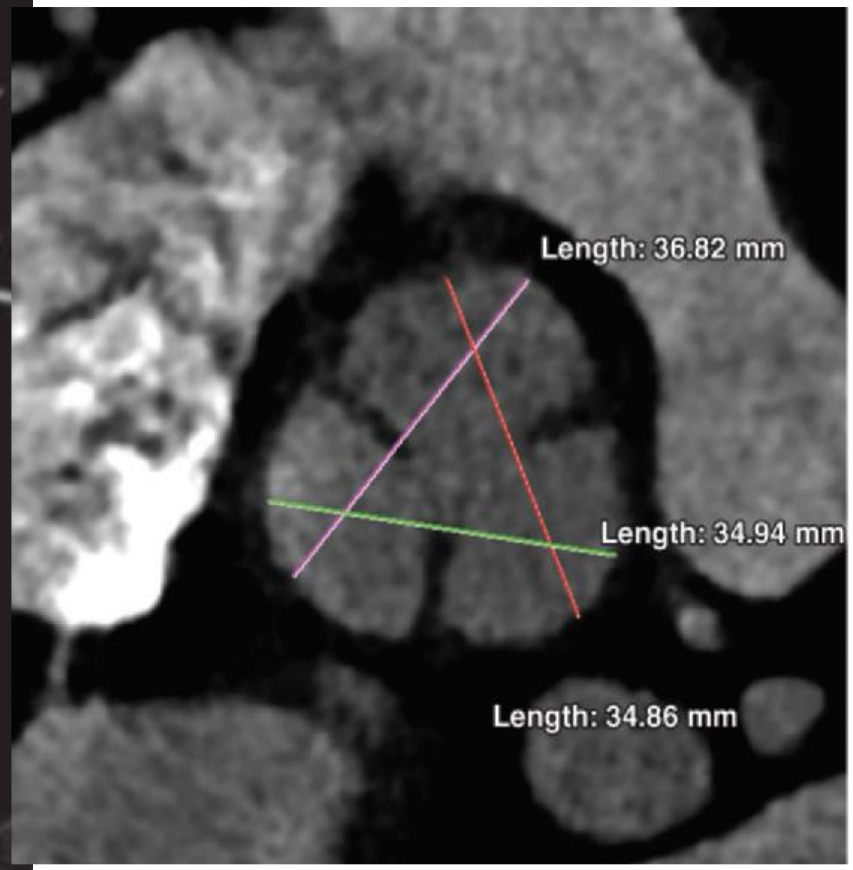
* Diameters: inner-inner edge, end diastole, transverse plane.

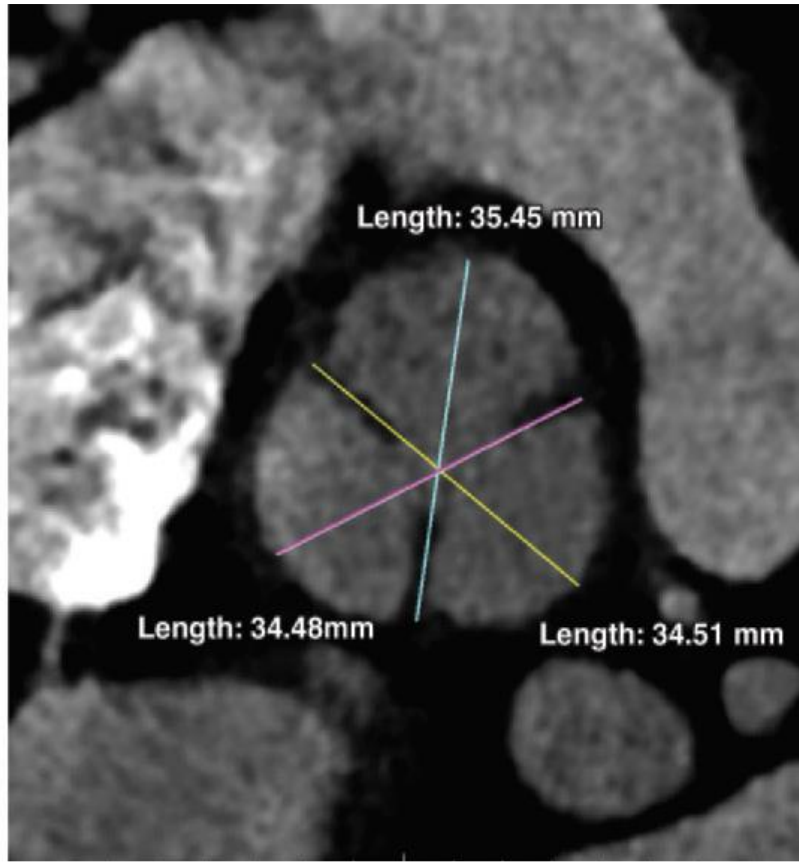
* Root diameter: **sinus-to-sinus diameter**.

Aortography – A few cases.

CARDIAC CT

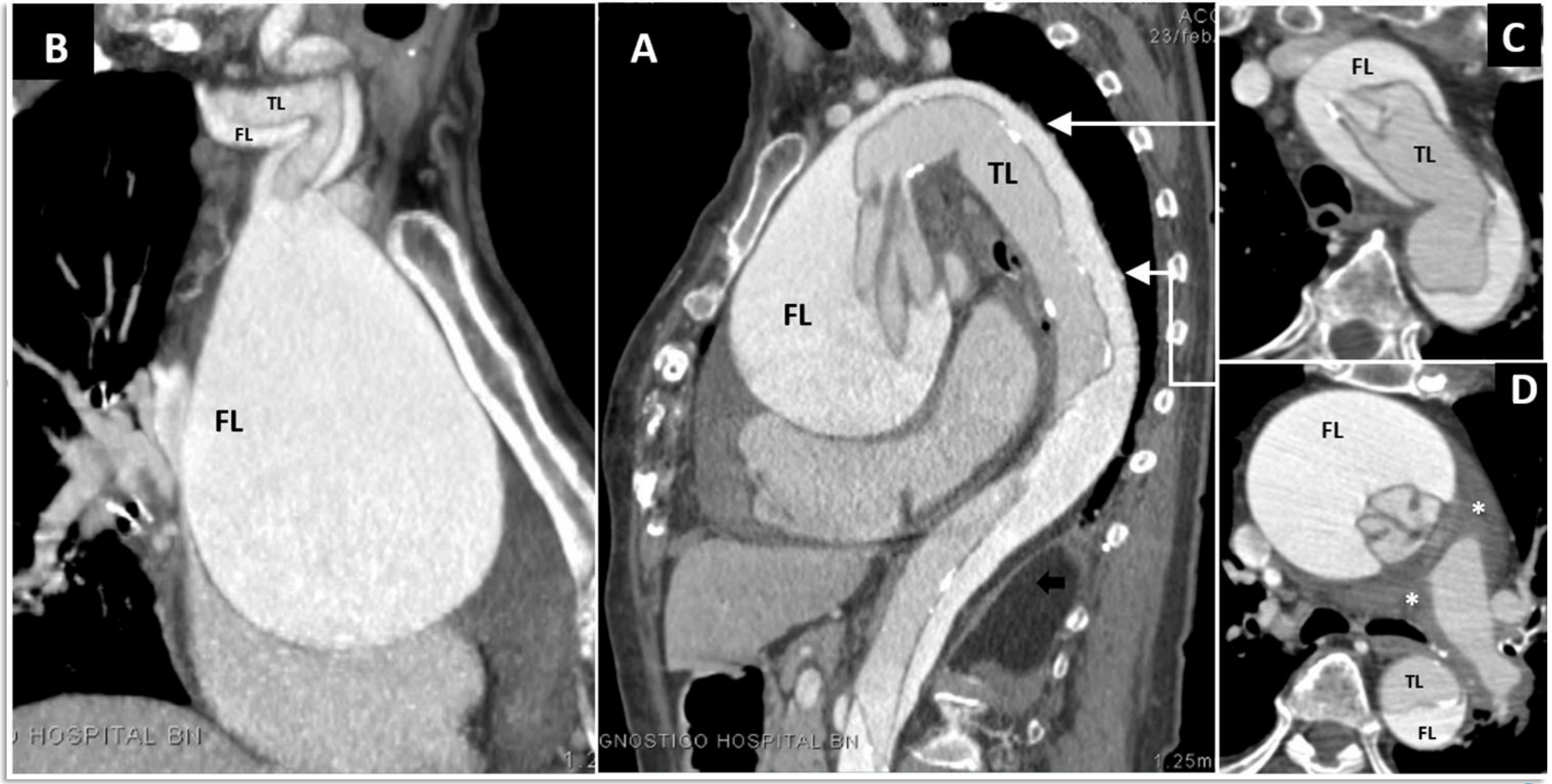






Freeman LA, et al. AJR Am J Roentgenol 2013.

Amsallem M, et al. Int J Cardiol 2015.



Ao valve repair feasibility

Team approach: Surgeon (direct vision) & Cardiologist (echo vision).

Two main questions:

What is the valve anatomy and root morphology.

Mechanisms of AR.

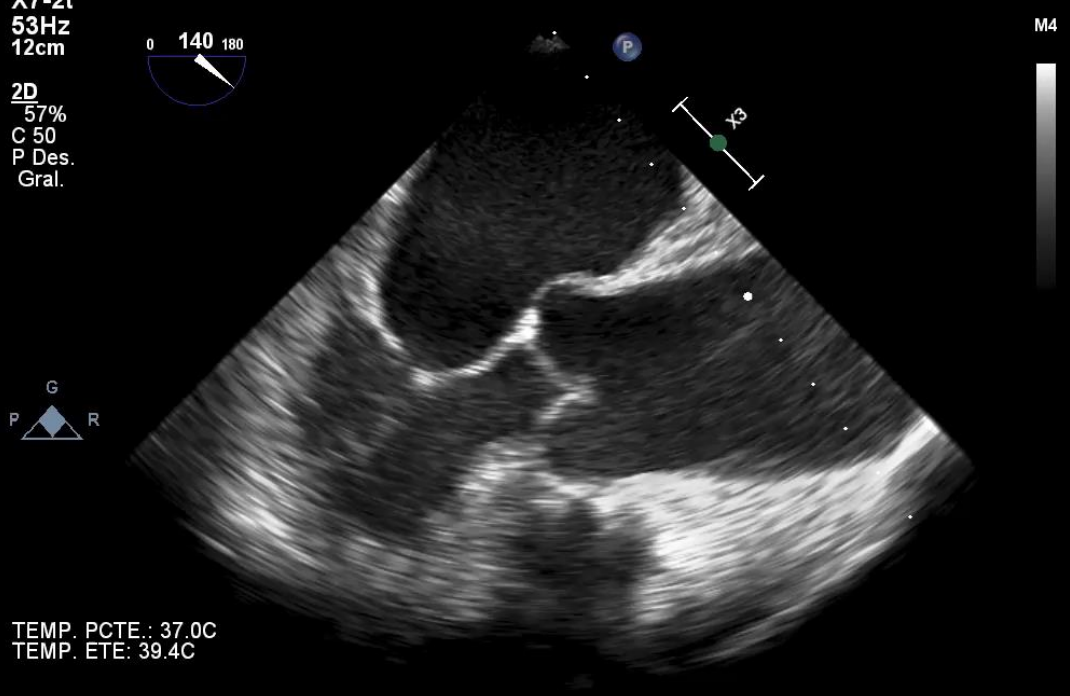
Repairability depends on tissue quality and leaflet calcifications.

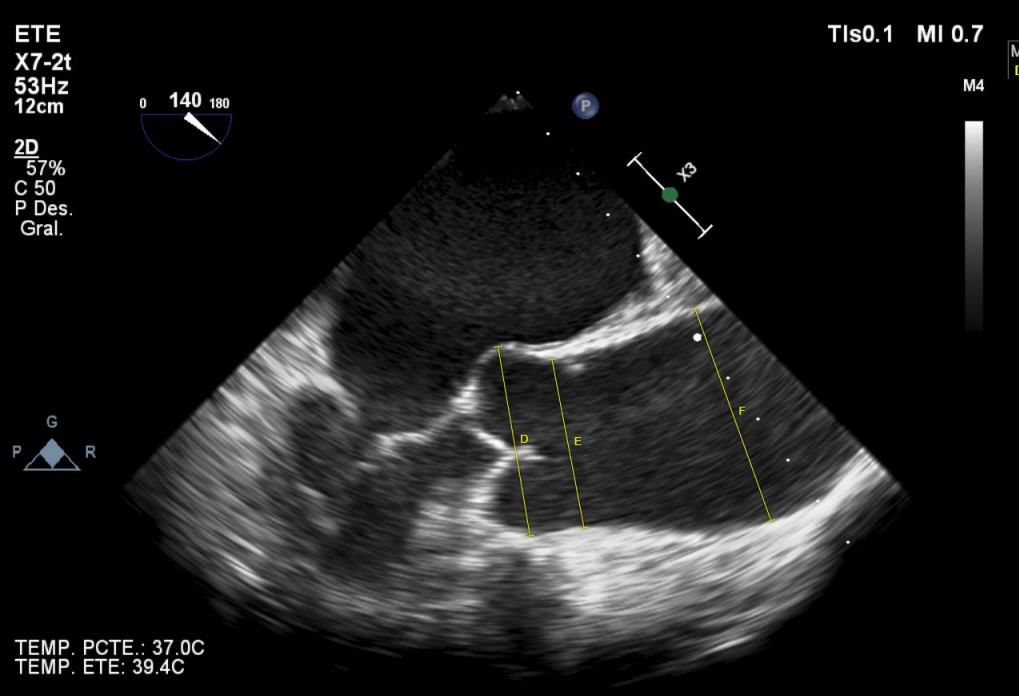
Smooth, thin and large leaflets with redundant tissue are considered as repairable.

Small, restrictive, fibrous or thickened leaflets should preclude surgical repair.

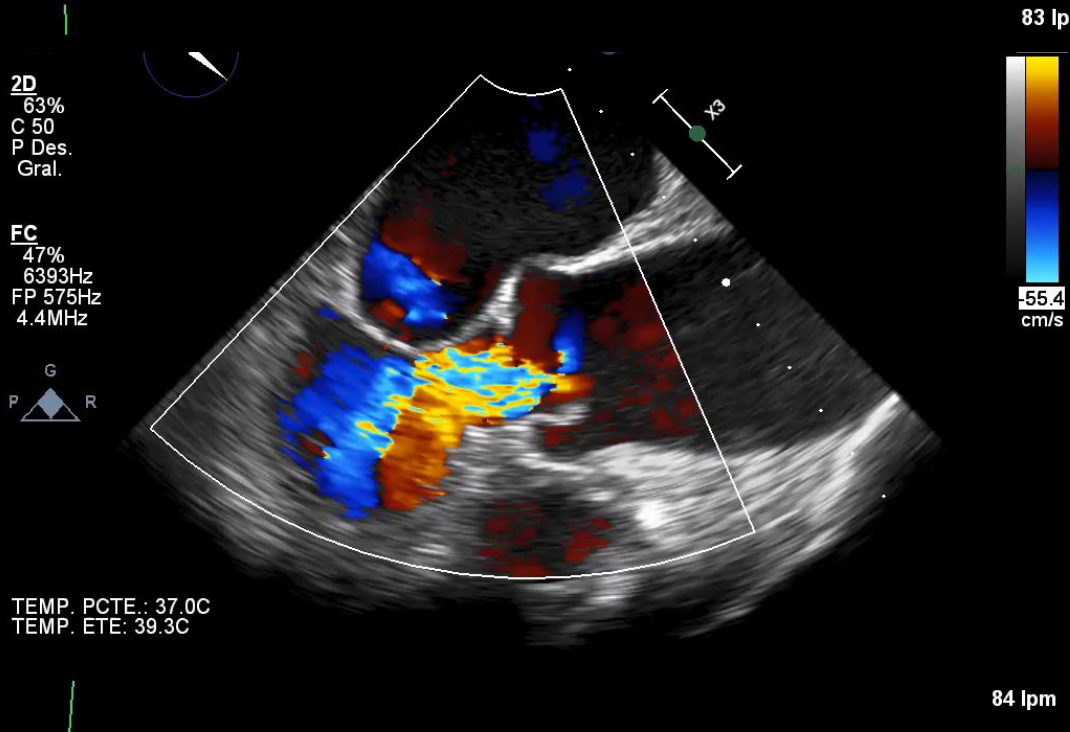
Heavily calcified valves are usually considered as non repairable (except at the free margin).

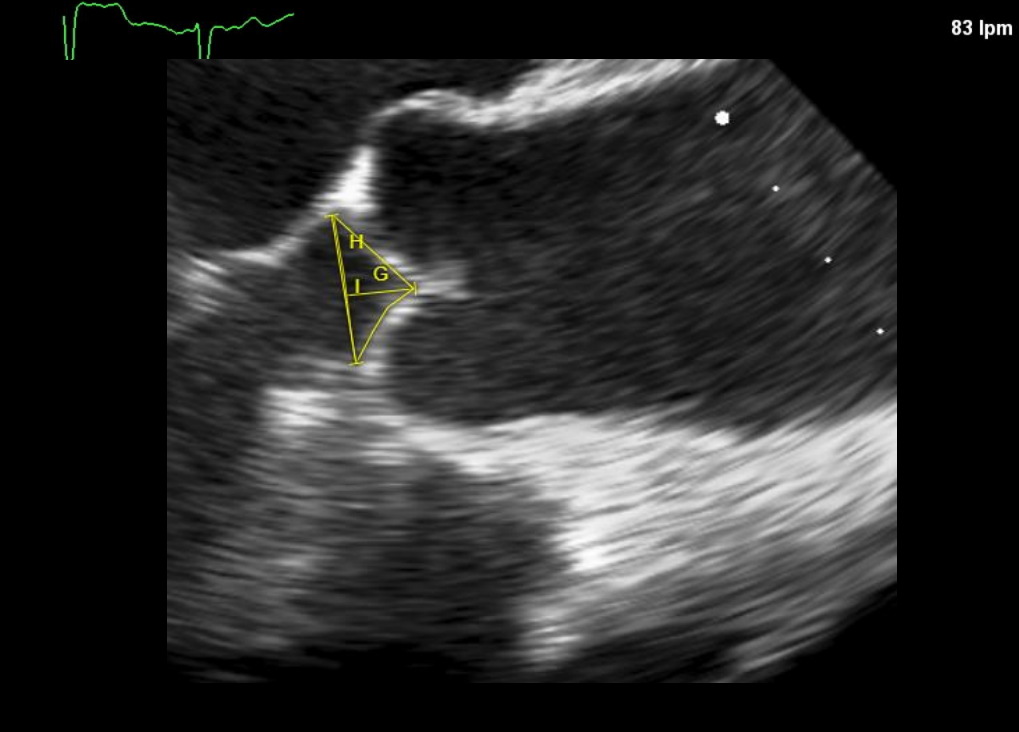
Intraoperative evaluation of repair results by TEE.





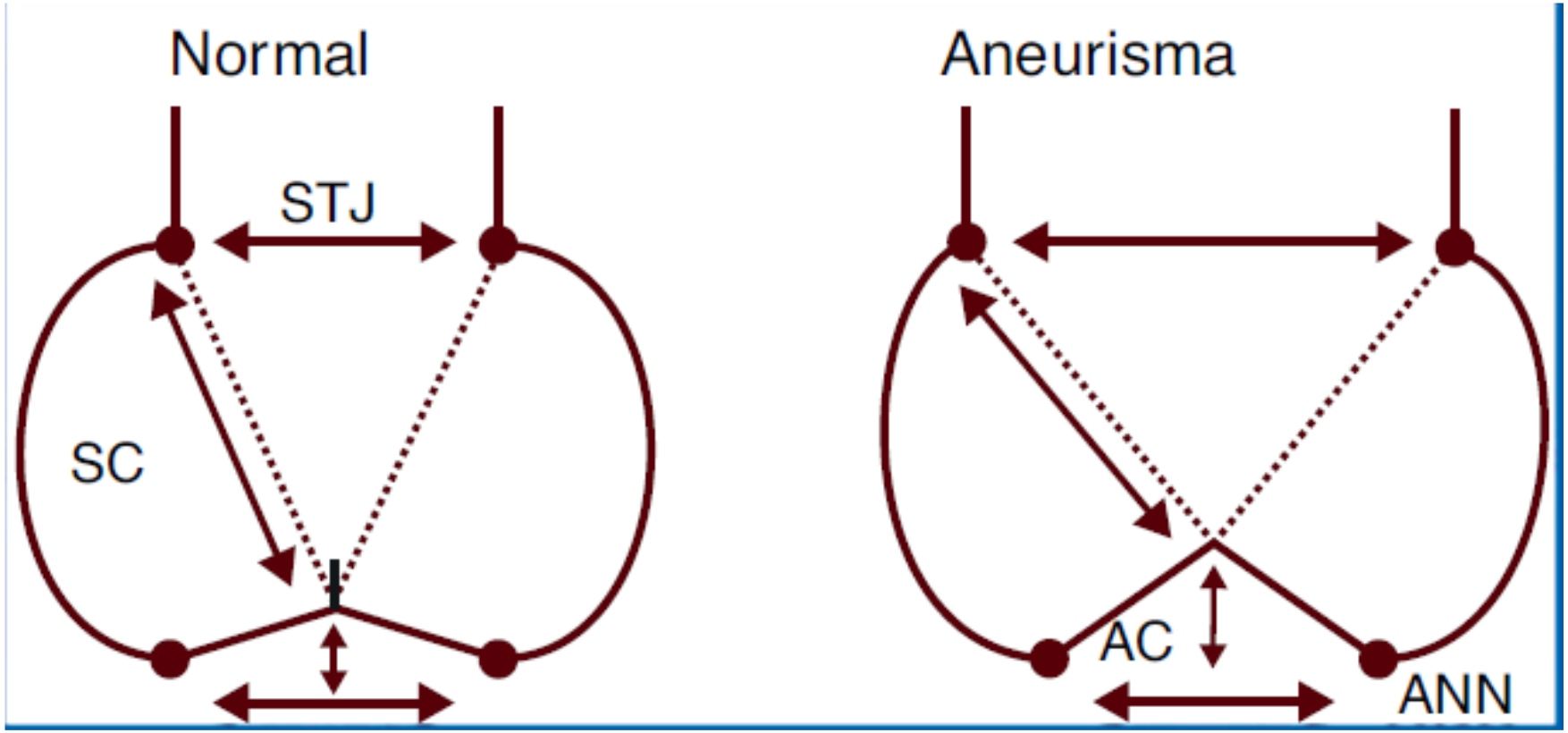
VS 38 mm
STJ 34 mm
AA 44 mm





TH 7,9 mm
TA 0,59 cm^2
AN 17 mm
R 2,23

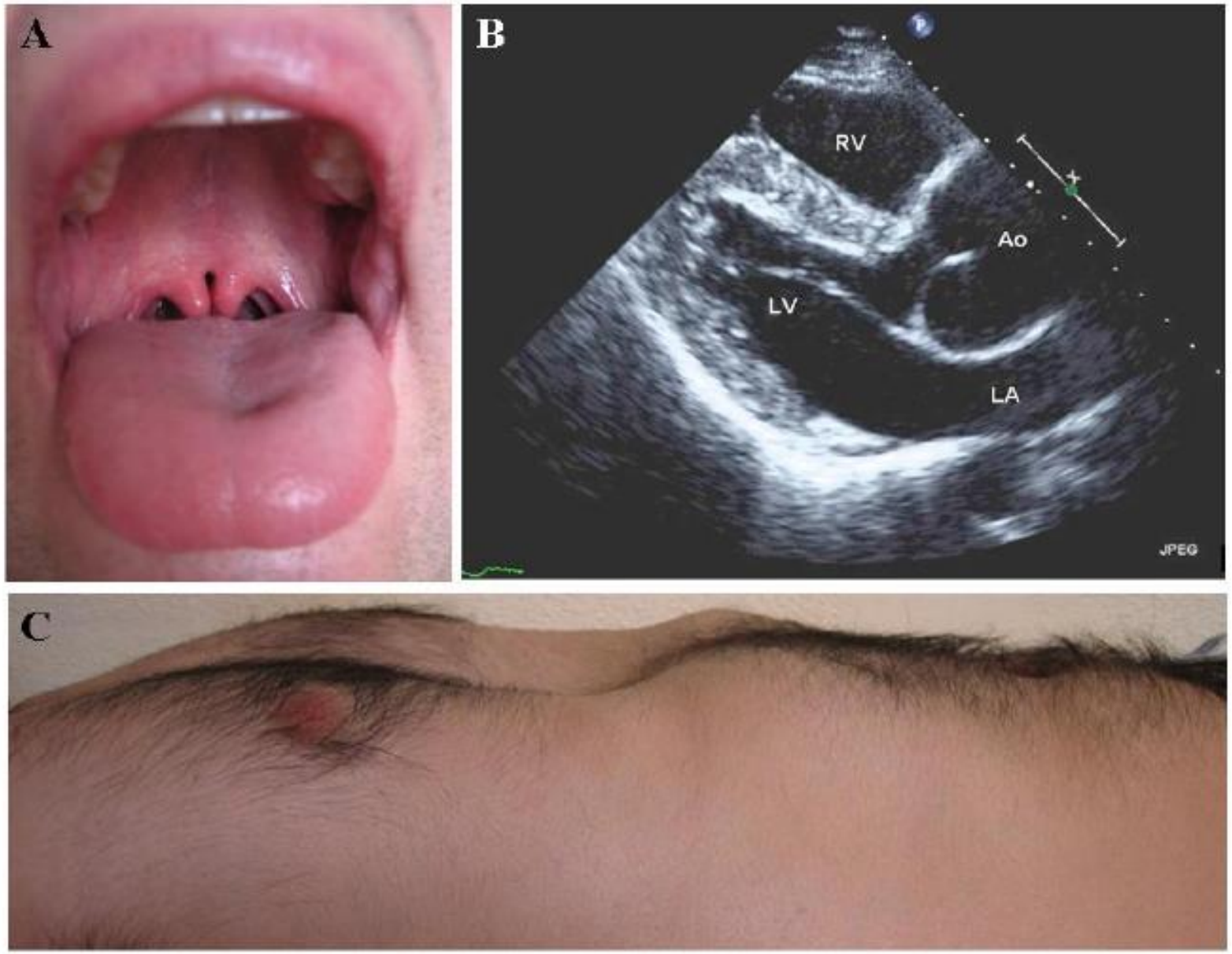
Diastolic leaflet tenting



Functional AR: STJ dilatation
STJ/Aortic annulus > 1,66

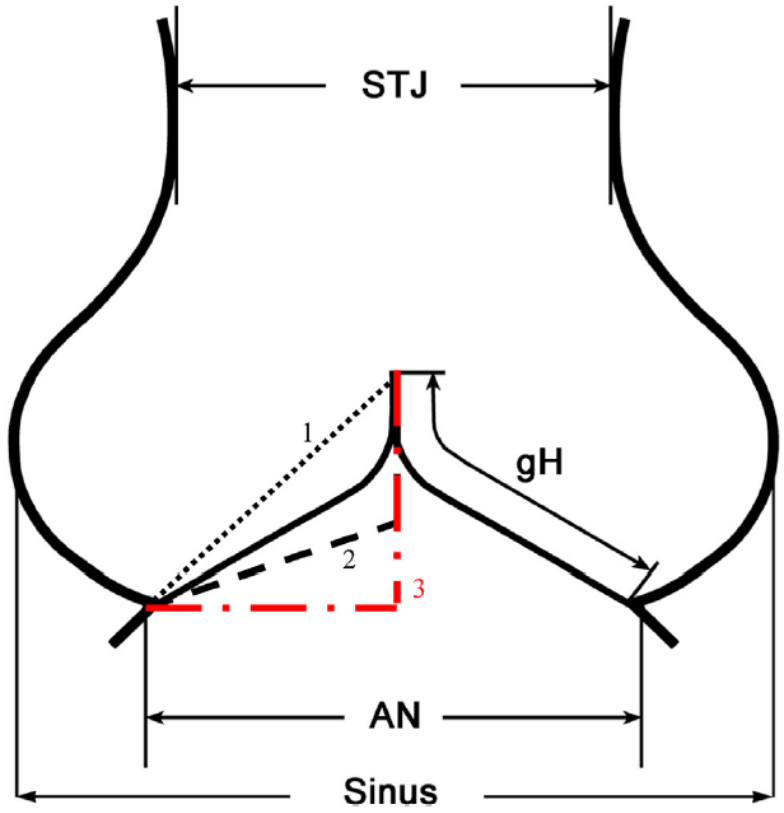
Furukawa K, et al. Ann Thorac Surg 1999
La Canna G, et al. Heart 2009

Loeys-Dietz Syndrome AR-Type IB

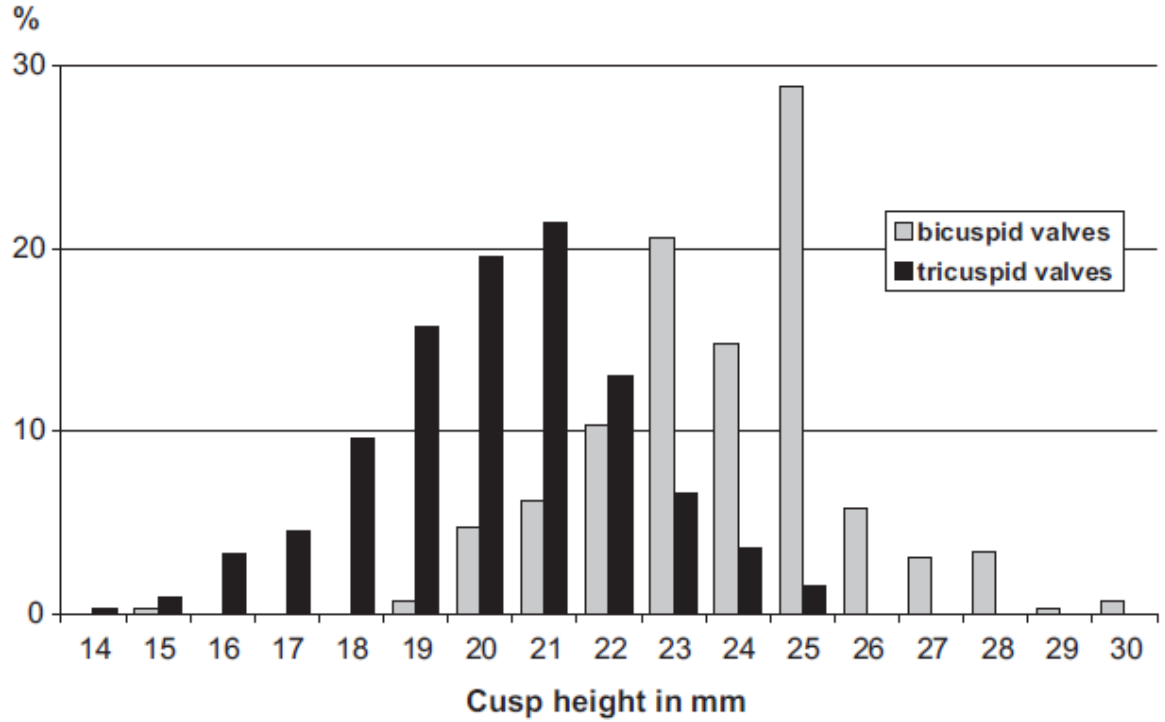


Vilacosta I, Cañadas V. N Engl J Med 2008

Other measurements in AR



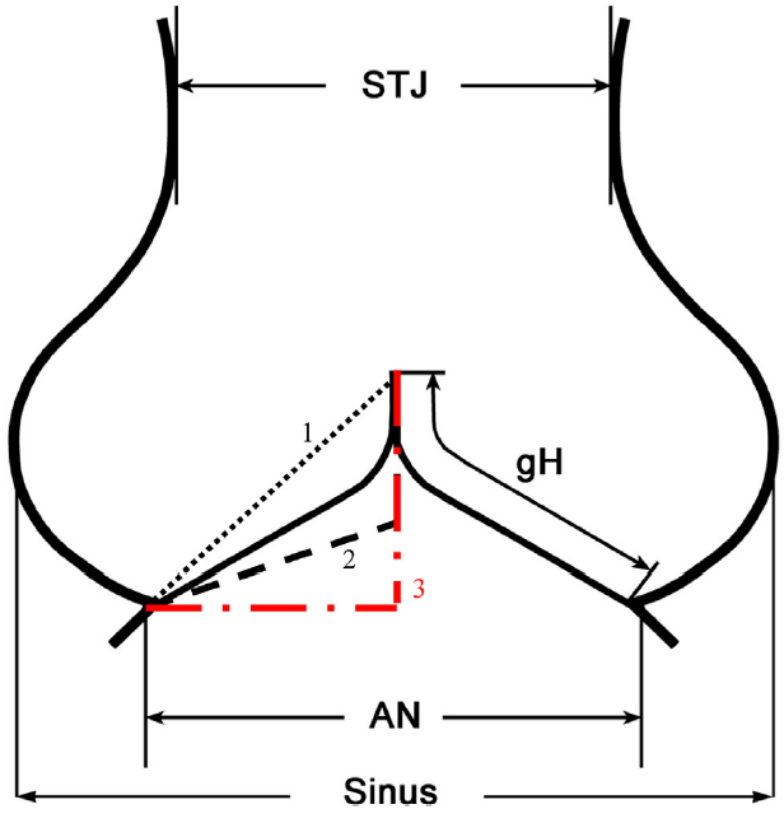
Geometric height



Marked variability of cusp height.
The size of BAV cusps were larger (3 mm) than TAV.
The noncoronary cusp was greater than the left & right cusps.

Schäfers H-J, et al. J Thorac cardiovasc Surg 2013

Other measurements in AR

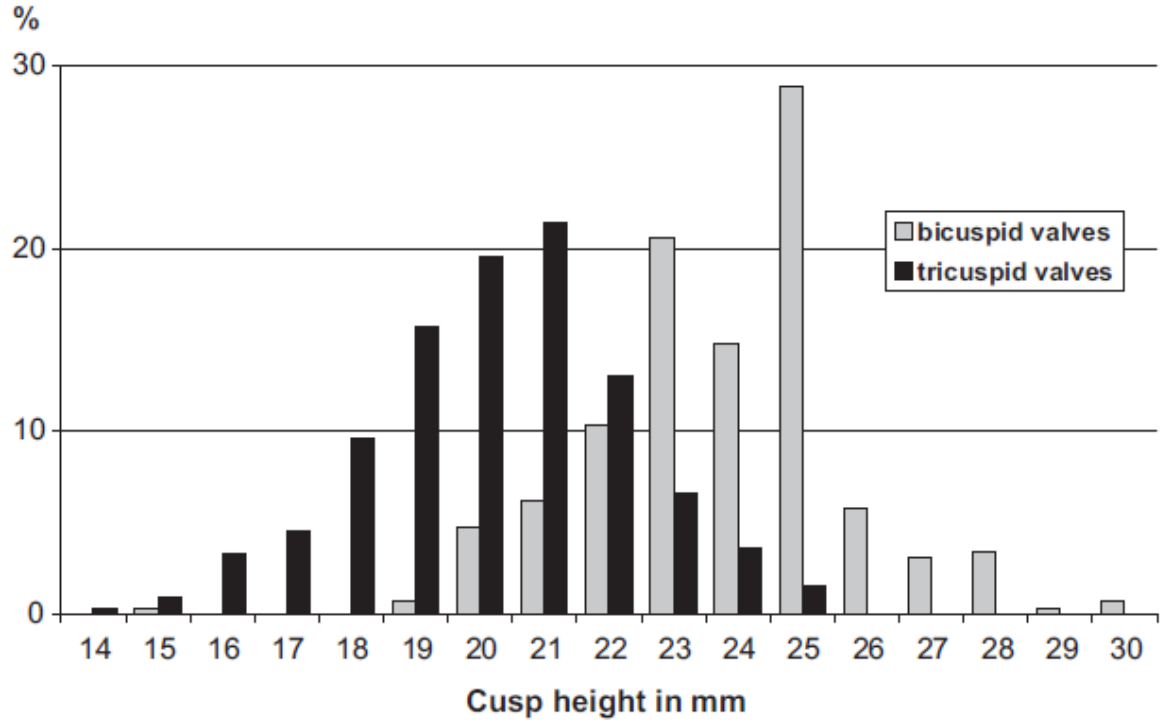


Geometric height

Repair if:

≥ 17 mm in TAV

≥ 20 mm in BAV



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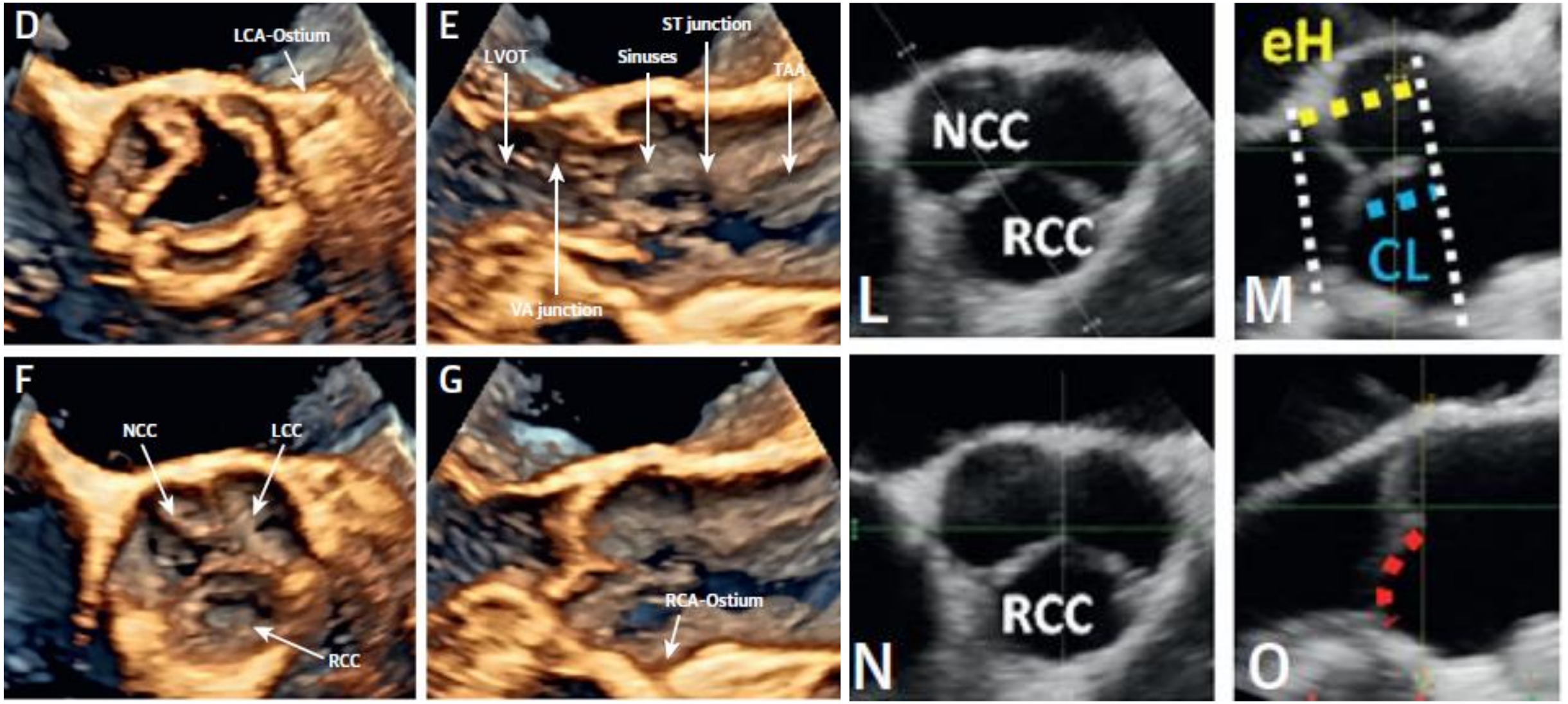
Assessment of AV and Ao. aneurysm by 3D-TEE



Hagendorff A, et al. J Am Coll Cardiol Img 2019

Satisfying AV repair

Level of cusp coaptation above the aortic annulus.

Coaptation length (long axis view): > 4 mm.

Effective height: > 9 mm.

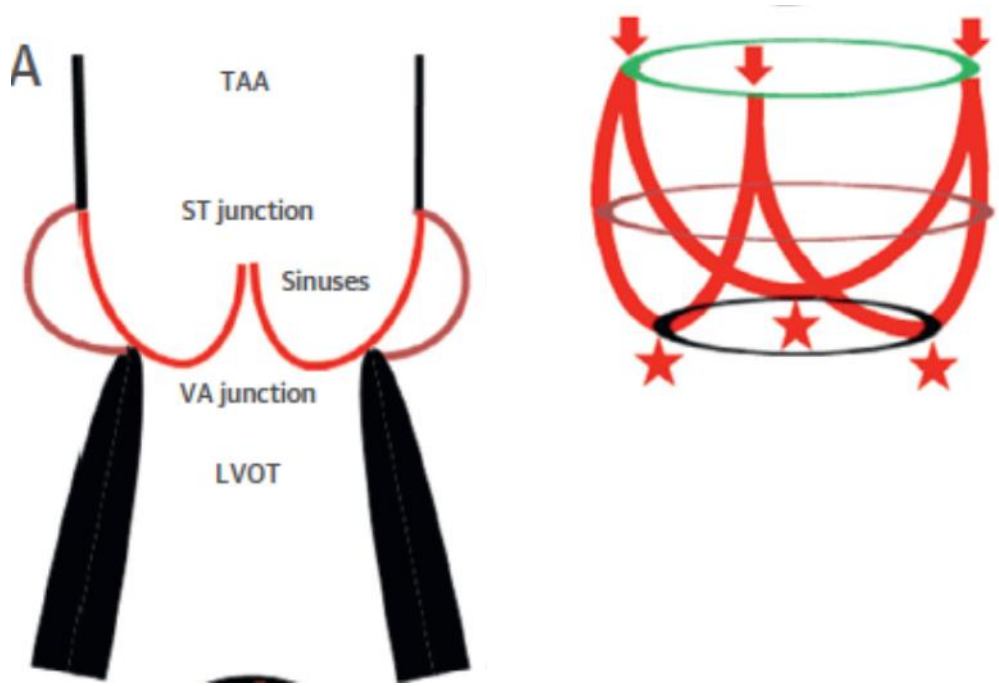
Geometric height: > 17 mm.

No or minimal residual AR.

Mean transaortic gradient < 10 mmHg.

Final remarks

- Echo to assess **valve anatomy and Ao. root** & to determine the etiology and mechanism of AR.
- The most frequent cause of AR is **aortic dilatation**.
- **Integration of multiple parameters** is required to quantify AR.
- The Ao. valve and aortic root work as a complex functional unit. The **sinotubular junction** is key in the mechanism of AR.
- Repairability depends on **tissue quality**.
- **3D-echo** is the best approach to assess aortic valve repair.


A
TAA
ST junction
Sinuses
VA junction
LVOT