Royal Brompton and
Harefield hospitals
Part of Guy's and St Thomas' NHS Foundation Trust

NHS

3DE for the tricuspid valve assessment in perspective of current European guidelines for VHD

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Disclaimer

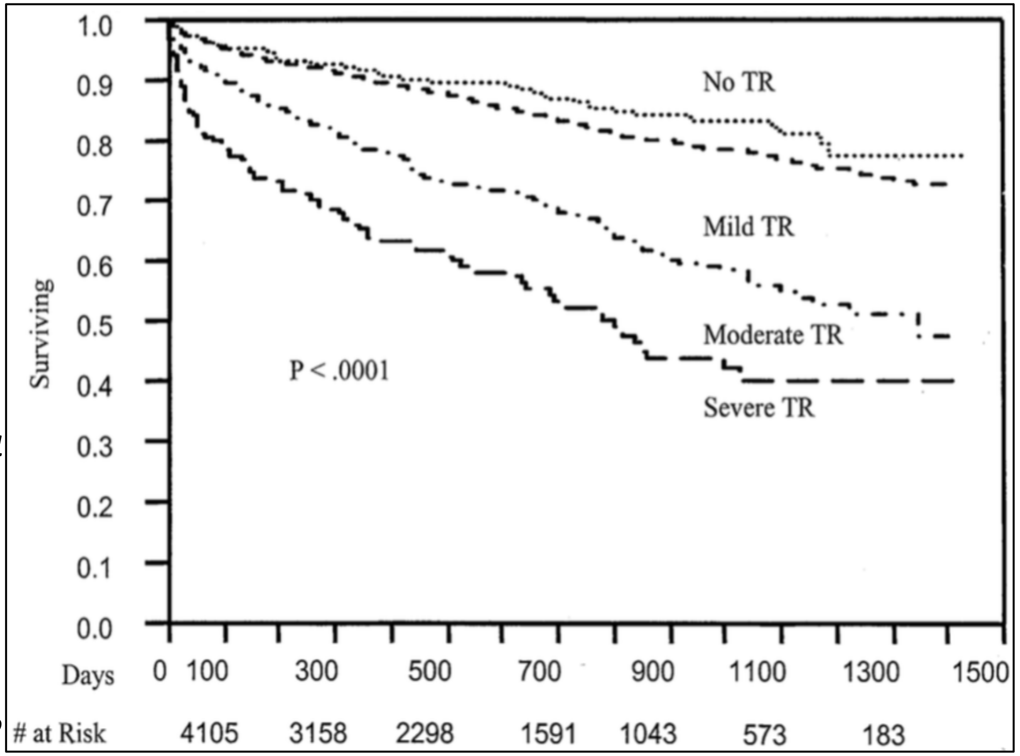
All members of the Faculty have provided a declaration of potential or actual conflict of interest

Why the TV is so special?

From clinical point of view…

- TV is not a forgotten valve any more!

Nath J, et al. JACC 2004



- TR is common: mild is frequent, moderate or severe TR observed in 0.55% of the general population and in 4% of the patients ≥75 years; >90% secondary TR

Topilsky J, et al. JACC CVI 2019; Wang T., et al. JACC CVI 2022

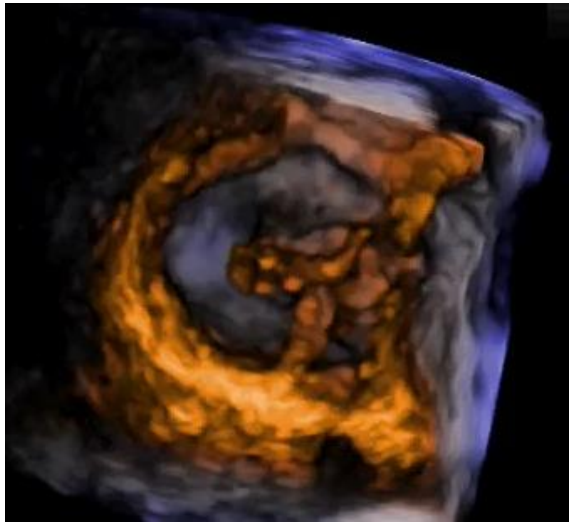
- TV surgery cares high risk *Topilsky J., 2011; Filsoufi F., 2005*

- A number of transcatheter interventions have been introduced

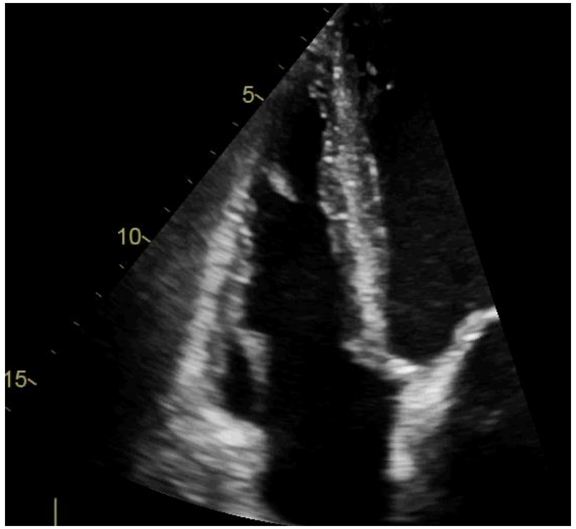
- Reliable and reproducible markers of earlier surgical referral instead of the symptom-guided indications are of utmost importance *Kim J., et al. 2013*

From echocardiographic point of view…

- absence of standard 2D views for simultaneous complete visualization of all TV leaflets and subvalvular apparatus
- anterior location in the chest posing challenges for TEE assessment
- lack of standardization of annular measurements
- limited (but growing) evidence behind the current methods and cut-off values for quantitative assessment of TR/TS severity
- New grading system has been recently introduced and used in transcatheter interventions (adding ‘massive’ and ‘torrential’ TR) showing incremental prognostic value in predicting mortality and HF rehospitalization



ADVANTAGES OF 3DE OVER 2DE



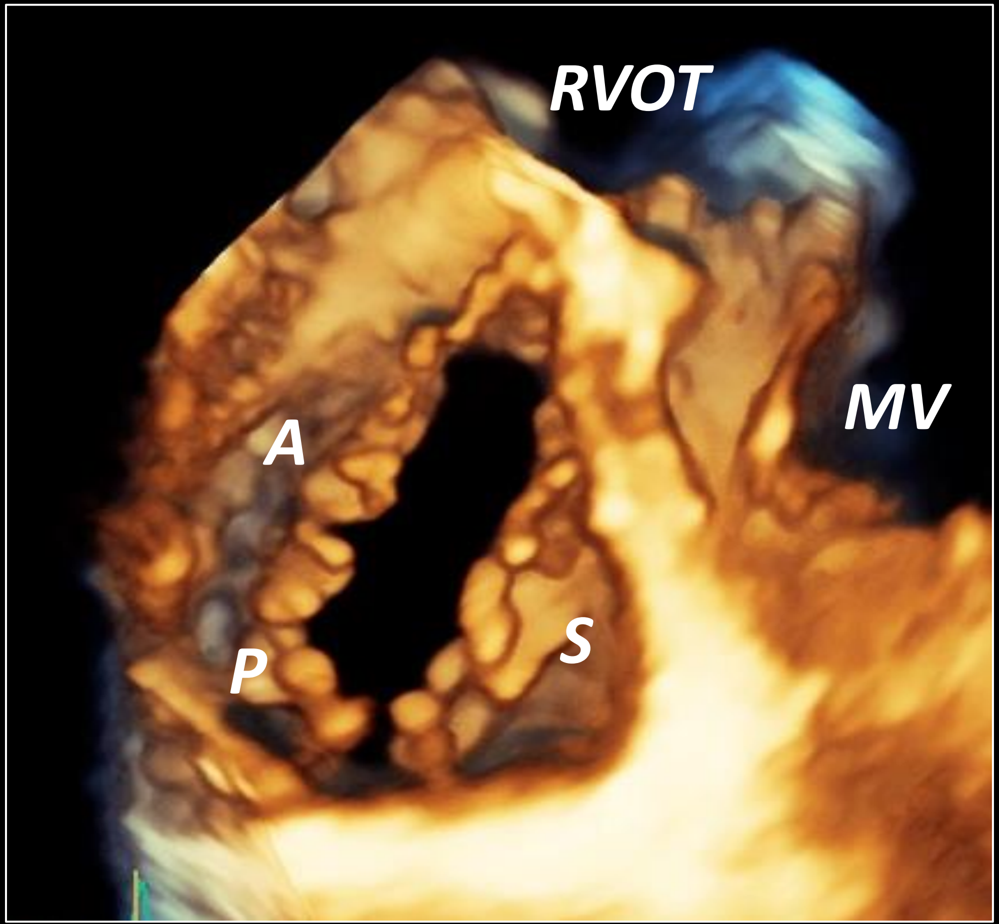
- Anatomically accurate en-face visualization of all TV leaflets, form both atrial and ventricular perspectives in the beating heart
- No geometric assumptions about annular area, valve opening area in valvular stenosis, shape of VC and PISA in valvular regurgitation
- Direct quantitative assessment of tricuspid annuls size and morphology
- Assessment of RV / RA volumes and function

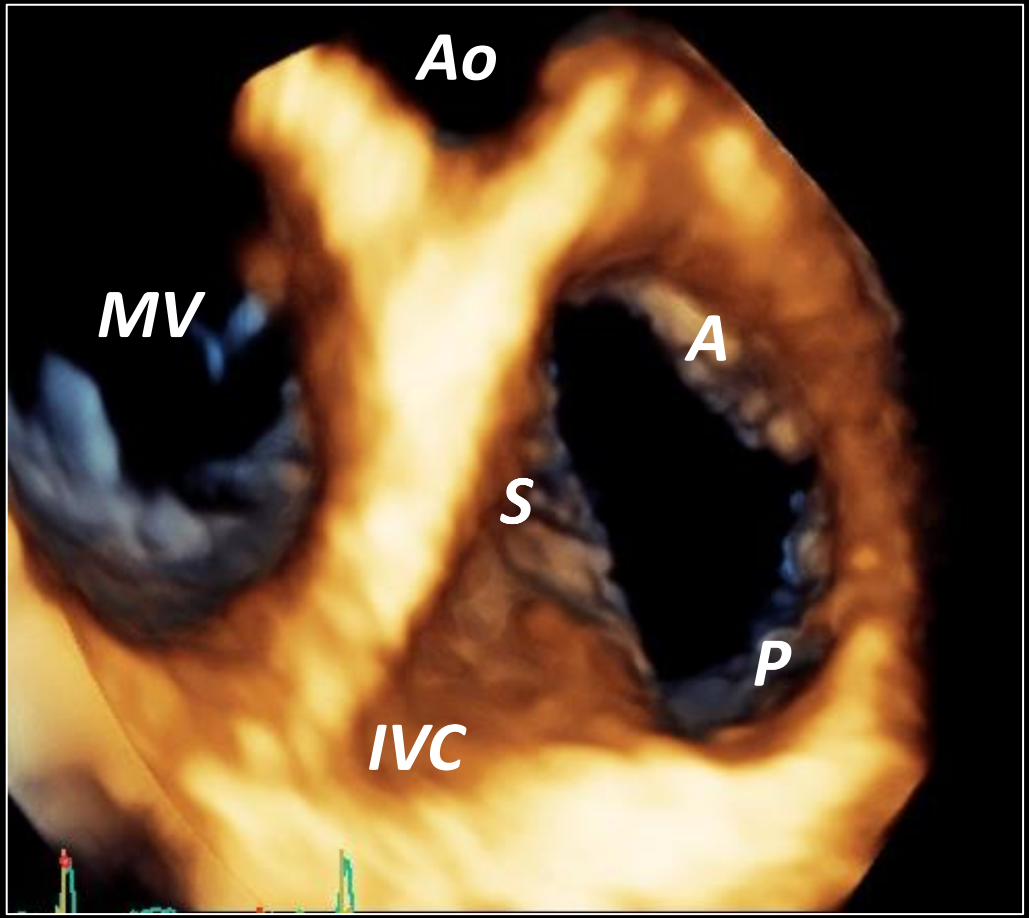
ESC Guidelines 2021 – role of 3DE

- Assessment of TV morphology
- Defining the mechanism of TV dysfunction (including the position of the intracardiac leads)
- Assessment of tricuspid annulus size
- Use of 3D VC in complex cases (although various cut-off values reported)
- Assessment of RV volumes and EF

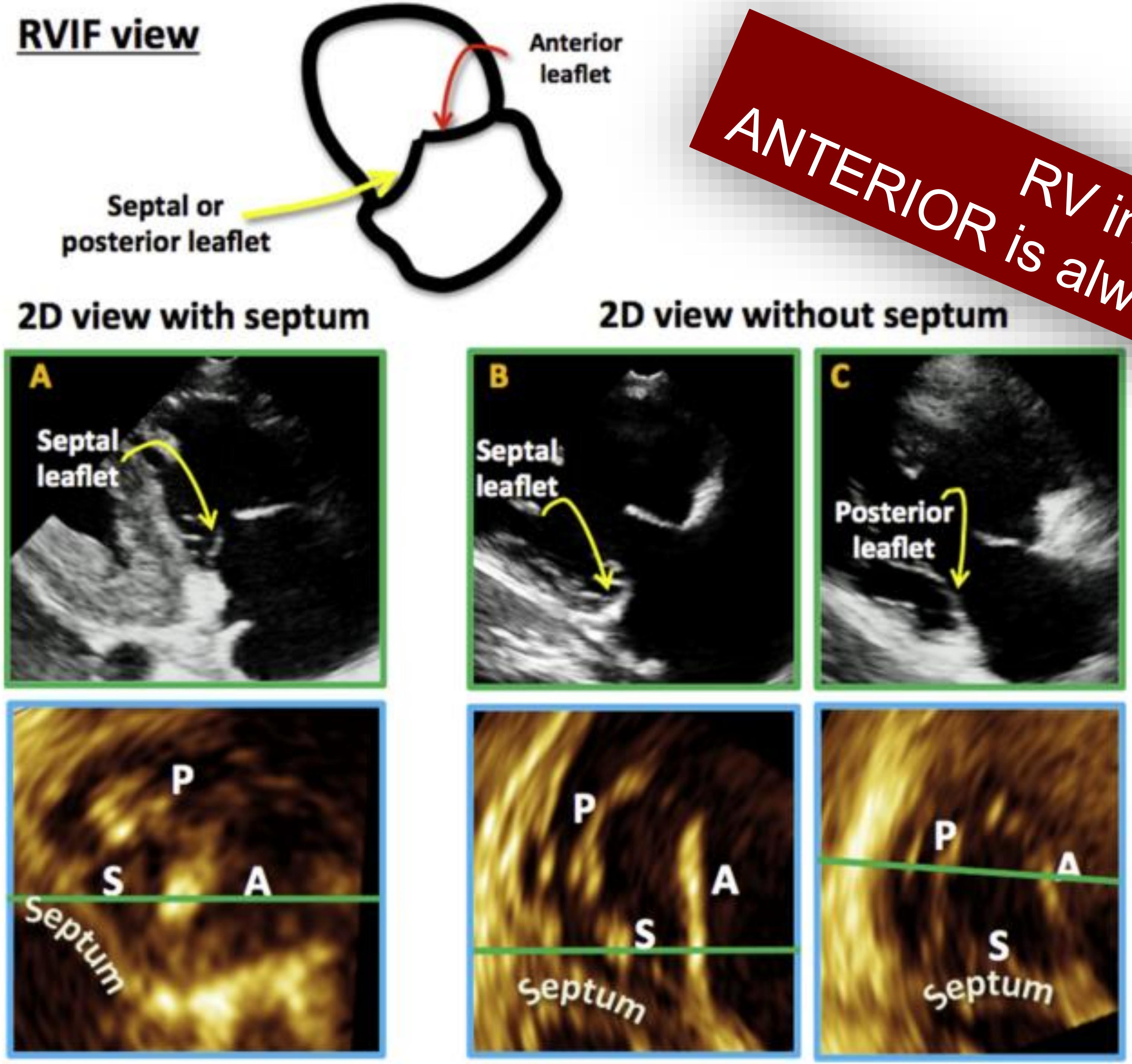
Vahannian A, et al. 2021 ESC/EACTs Guidelines. EHJ 2021

3DE Display: Normal TV Anatomy





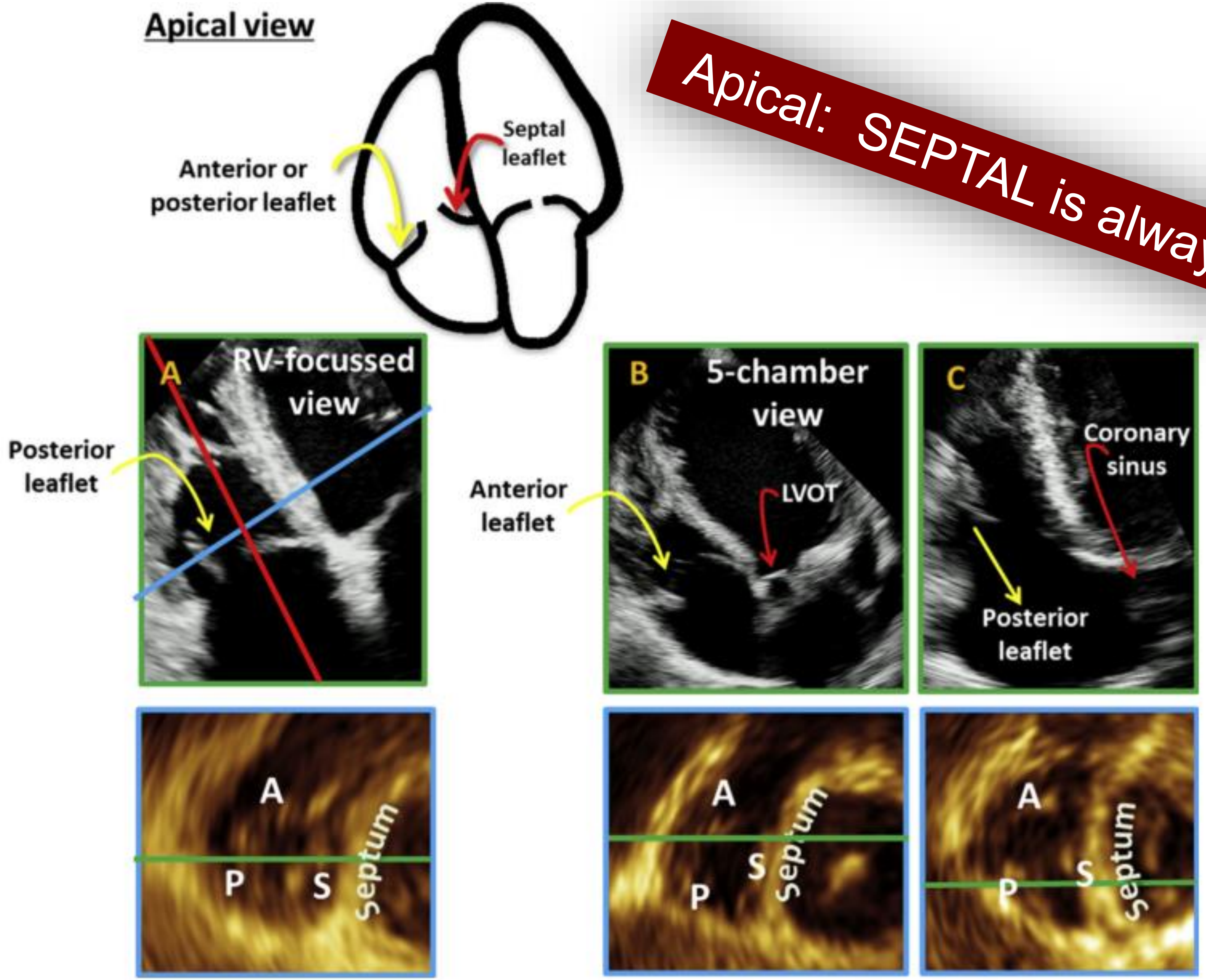
Surkova E., Muraru D, Aruta P, et al. Curr Cardiol Rep, 2016



RV inflow:
ANTERIOR is always ANTERIOR

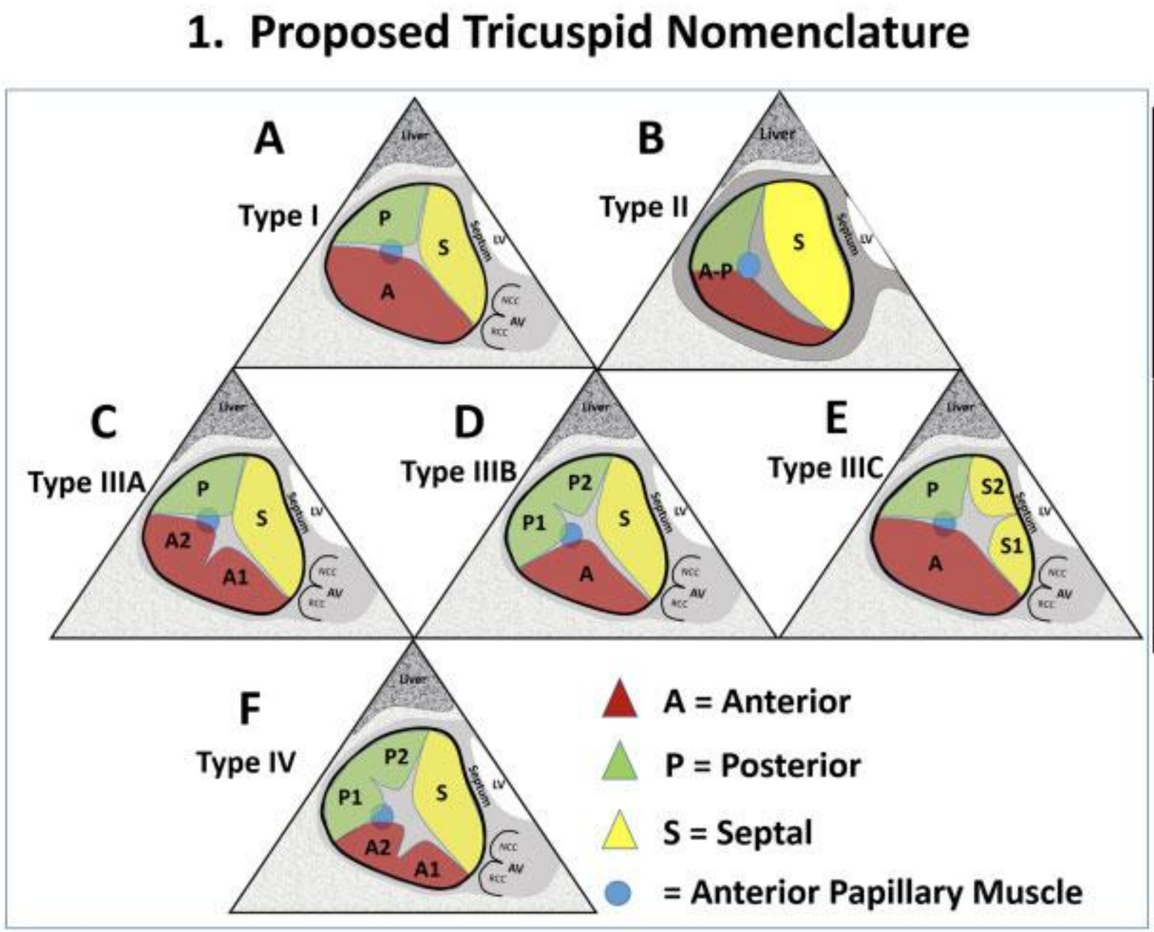
K. Addetia, et all., 2015

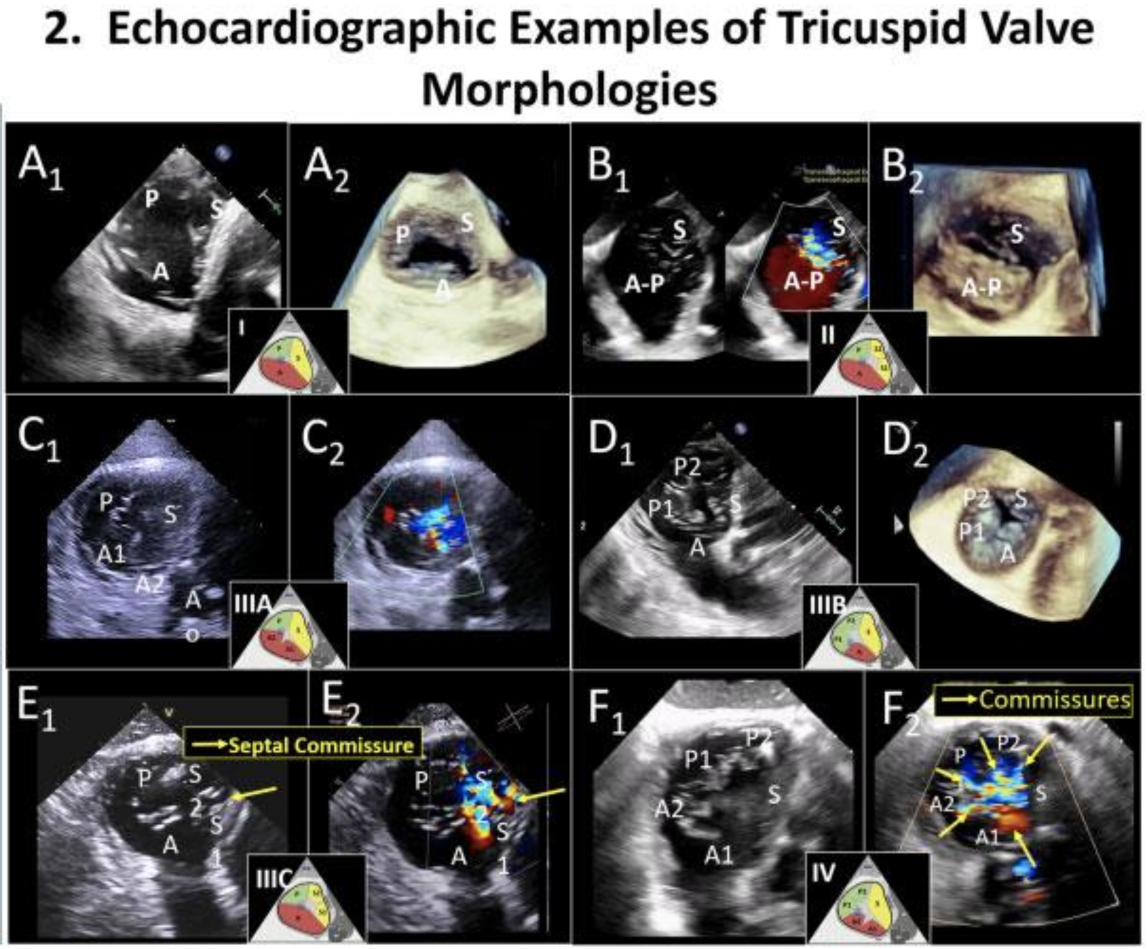
Apical: SEPTAL is always SEPTAL



K. Addetia, et all., 2015

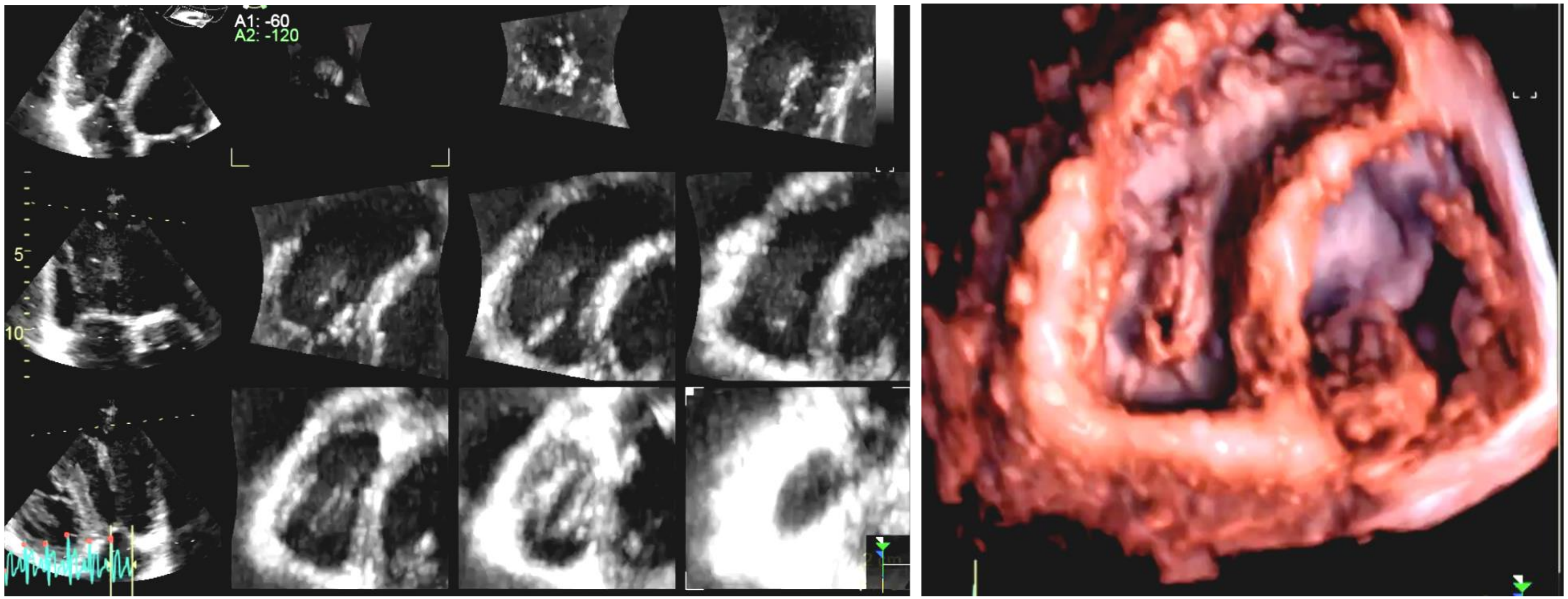
Proposal for standard TV nomenclature



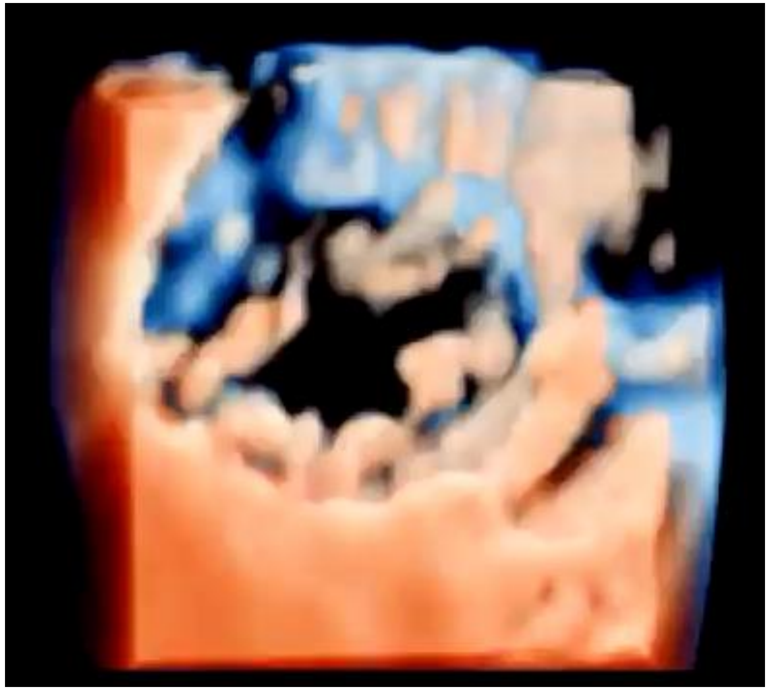


R. Hahn, et al. JACC CVI 2021
R. Hahn, et al. EHJ CVI 2022

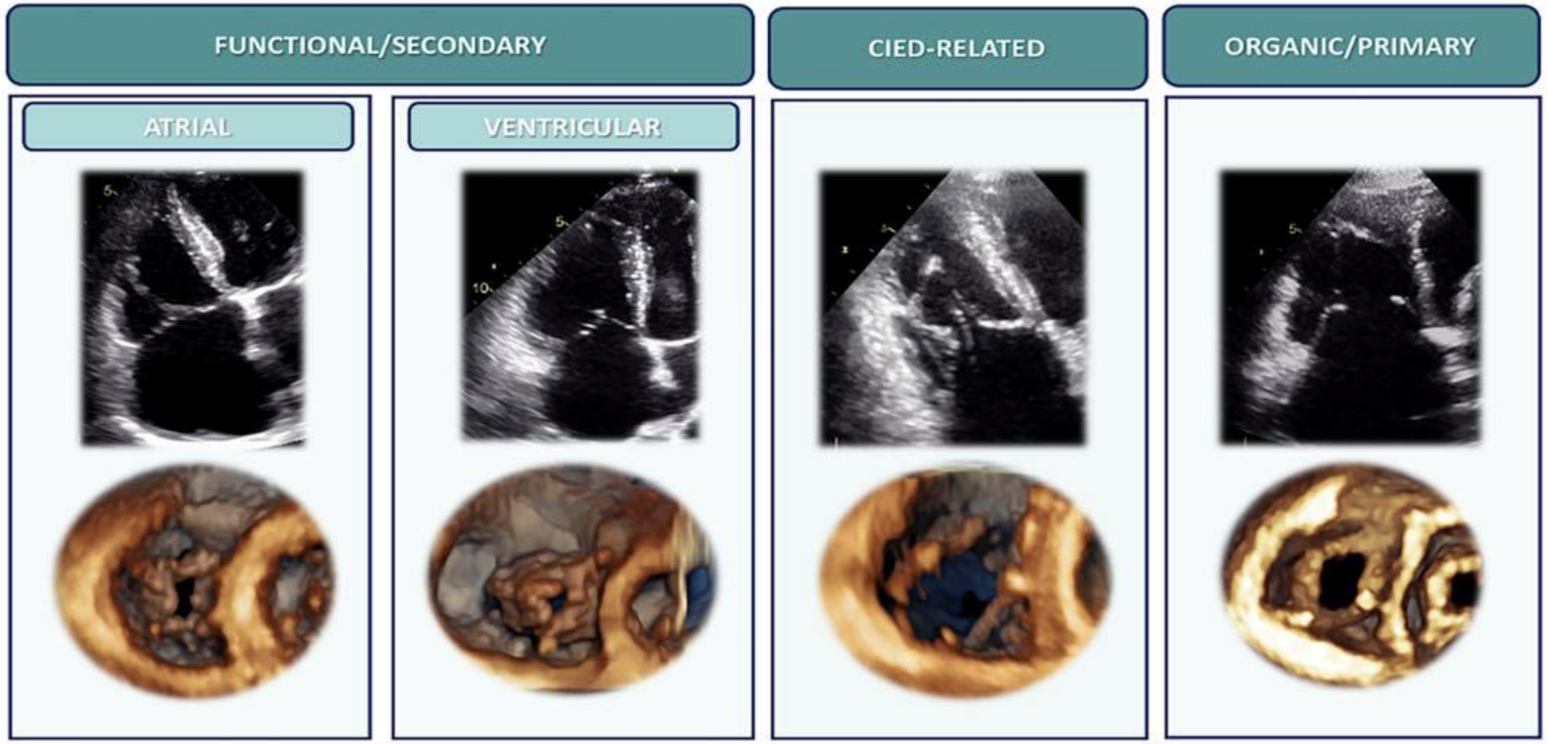
Incidental finding of
bi-leaflet tricuspid valve
in a patient with TOF
(type II)



4-leaflet tricuspid valve in a patient
with significant TR
(type III A)



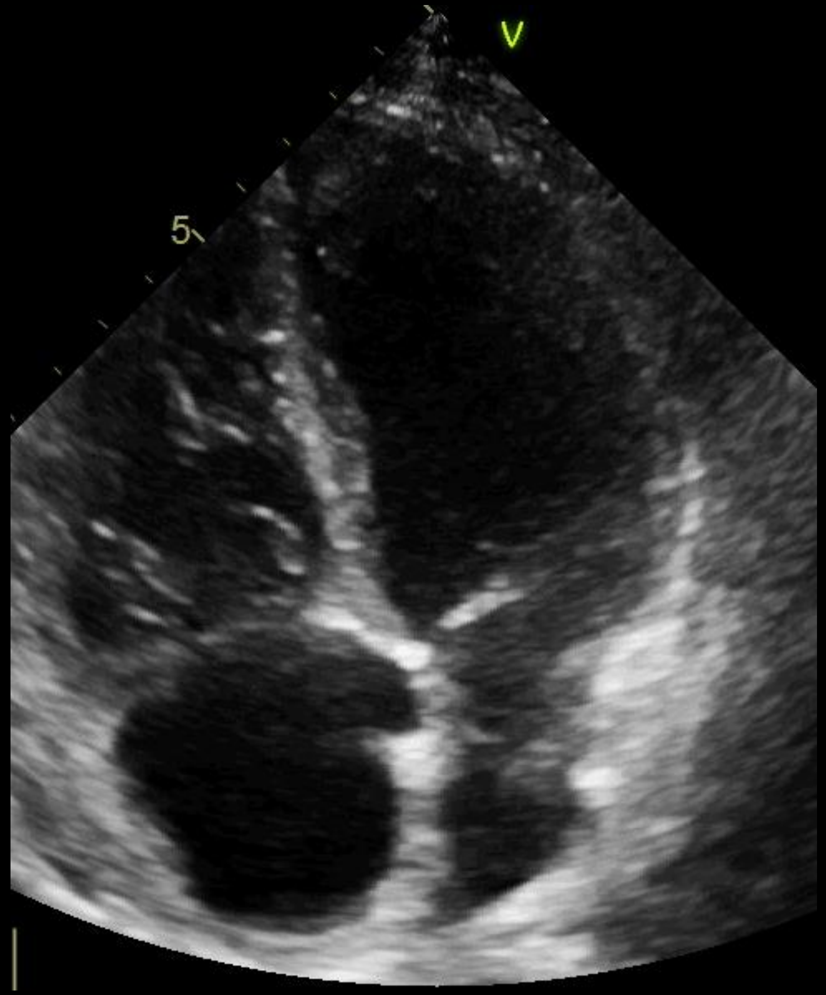
3DE for assessment of TR mechanism

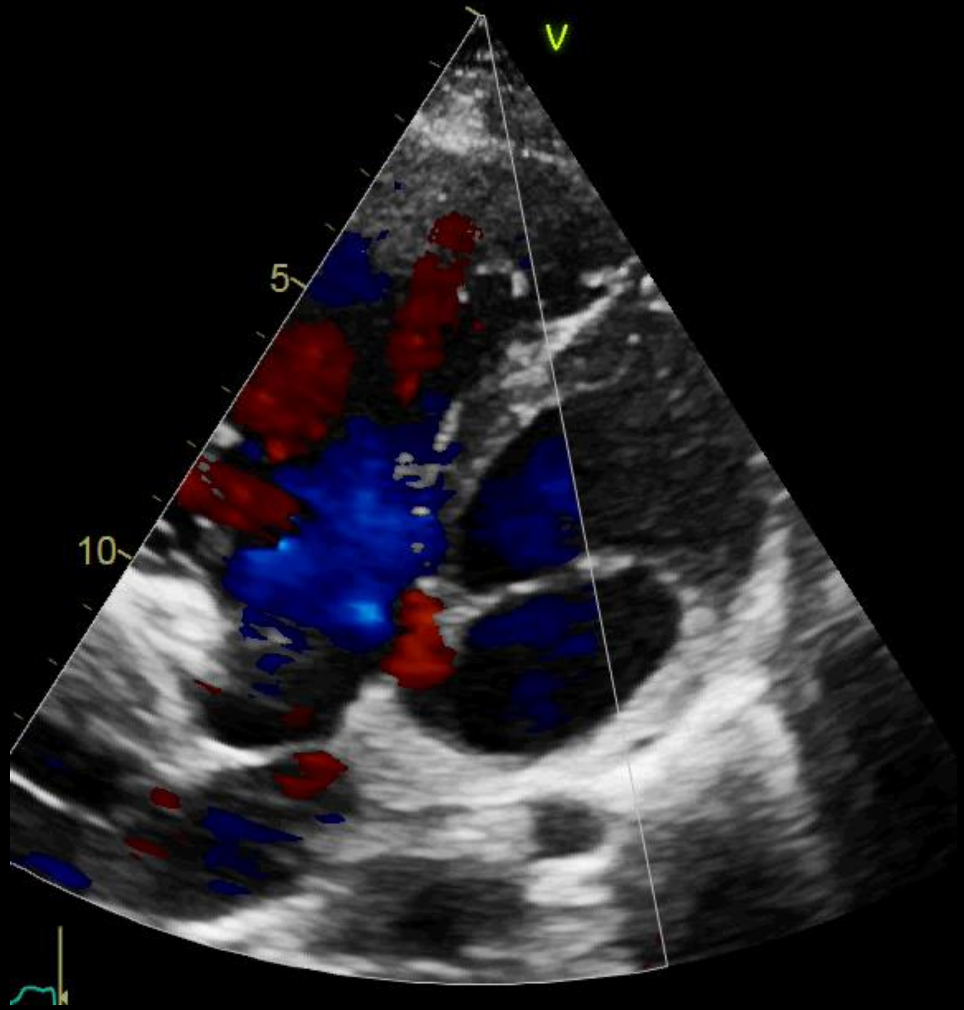


Parameter	Atrial FTR	Ventricular FTR	CIED-Related	Primary TR	
				Prolapse (I)	RHD (IIIA)
Leaflet Tethering	-	+++	++	-	-
Leaflet Restriction	-	Systole	Systole/Diastole	-	Diastole
RA/TA Dilatation	+++	++	+/-	++	++
RV Dilatation	+/-	+++	+/-	+/-	+/-
RV Dysfunction	+/-	+++	+/-	+/-	+/-

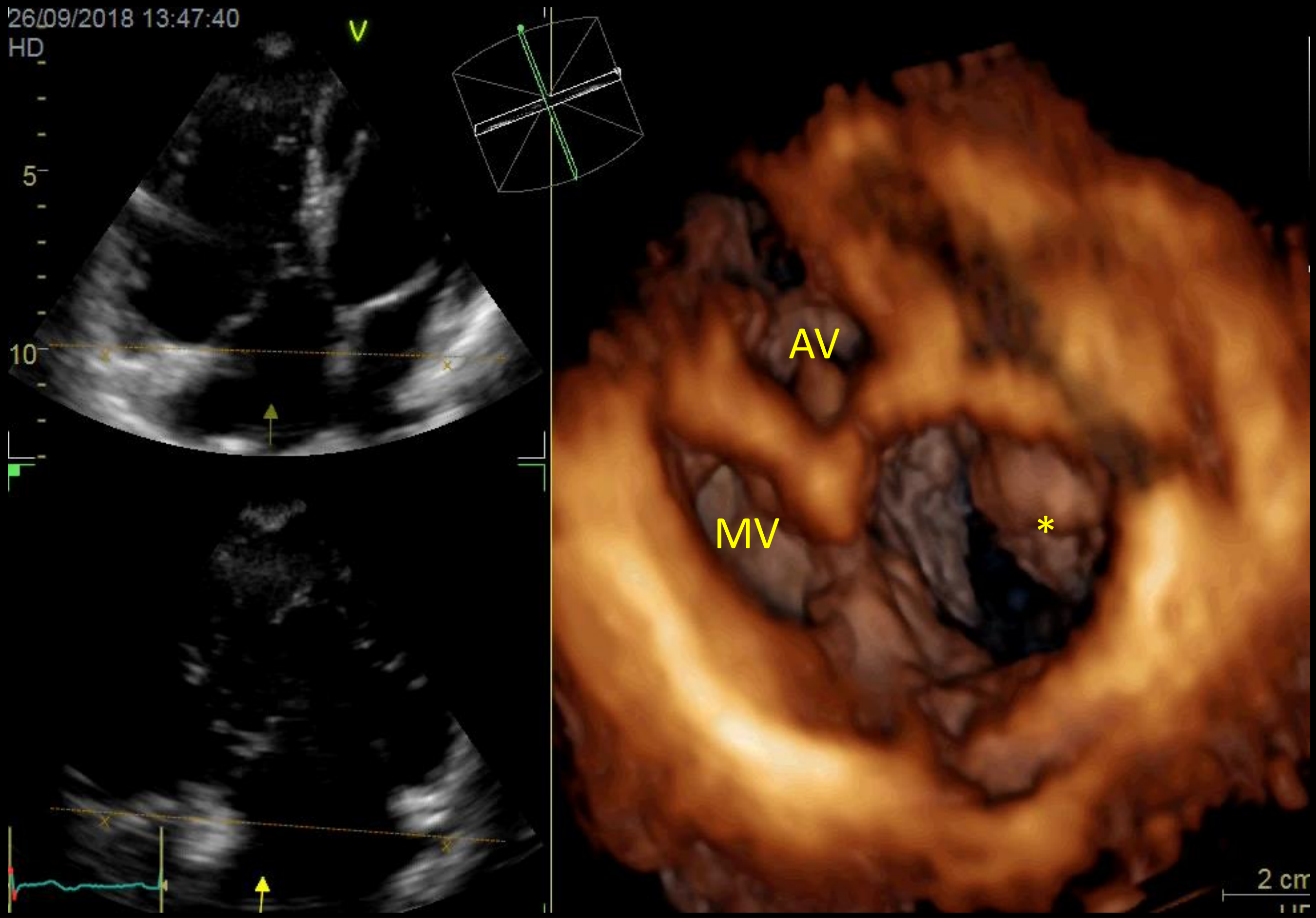
R. Hahn, et al. EHJ CVI 2022

#1 Dilated RV in a young patient with SOB





#1 Dilated RV in a young patient with SOB



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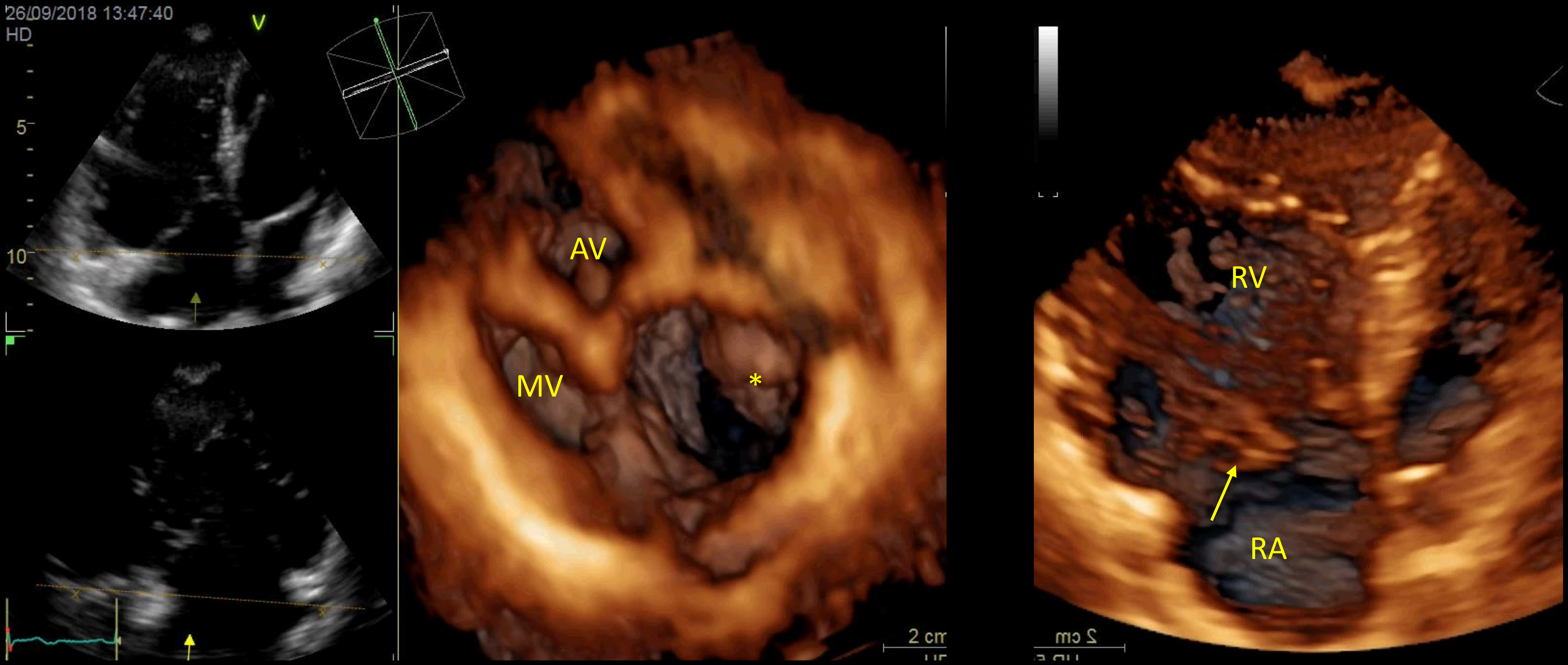
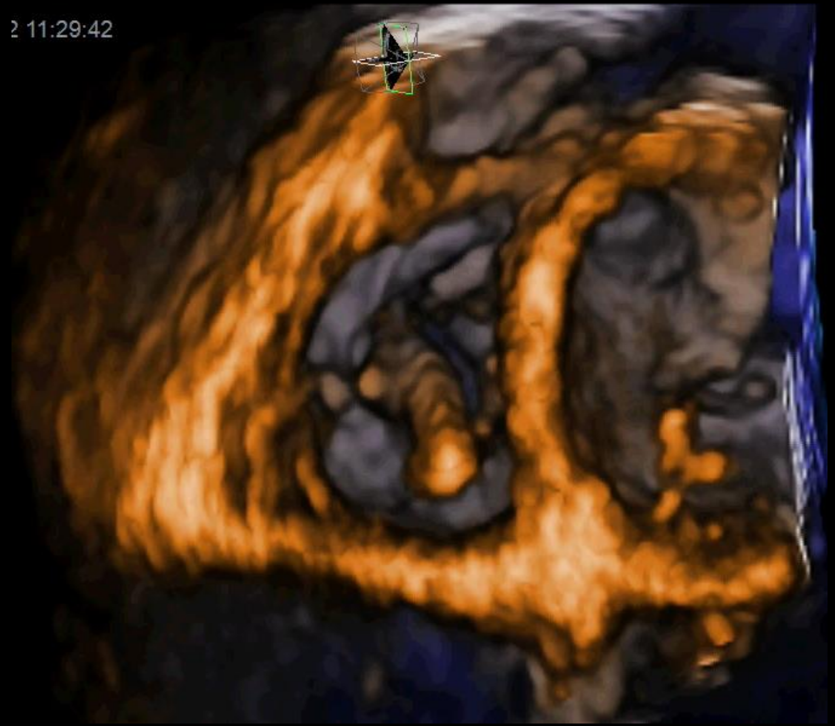
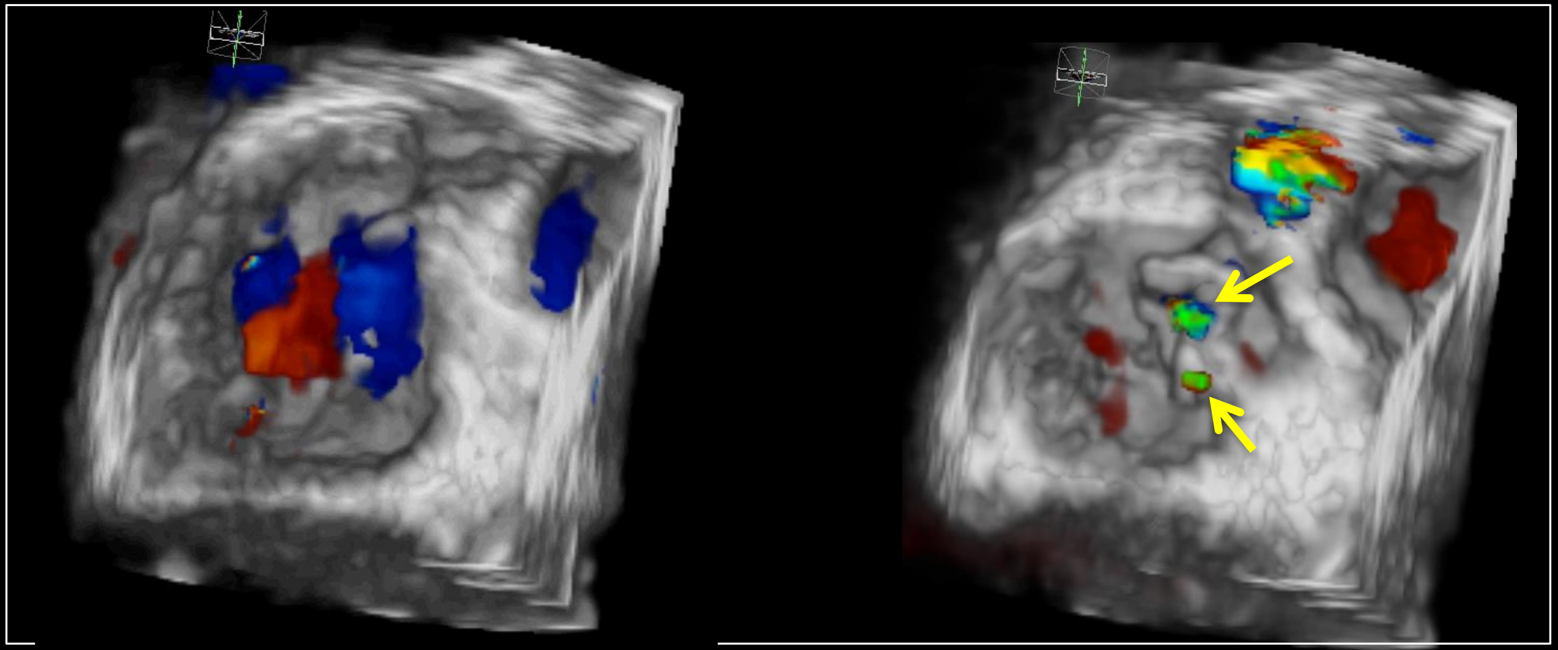
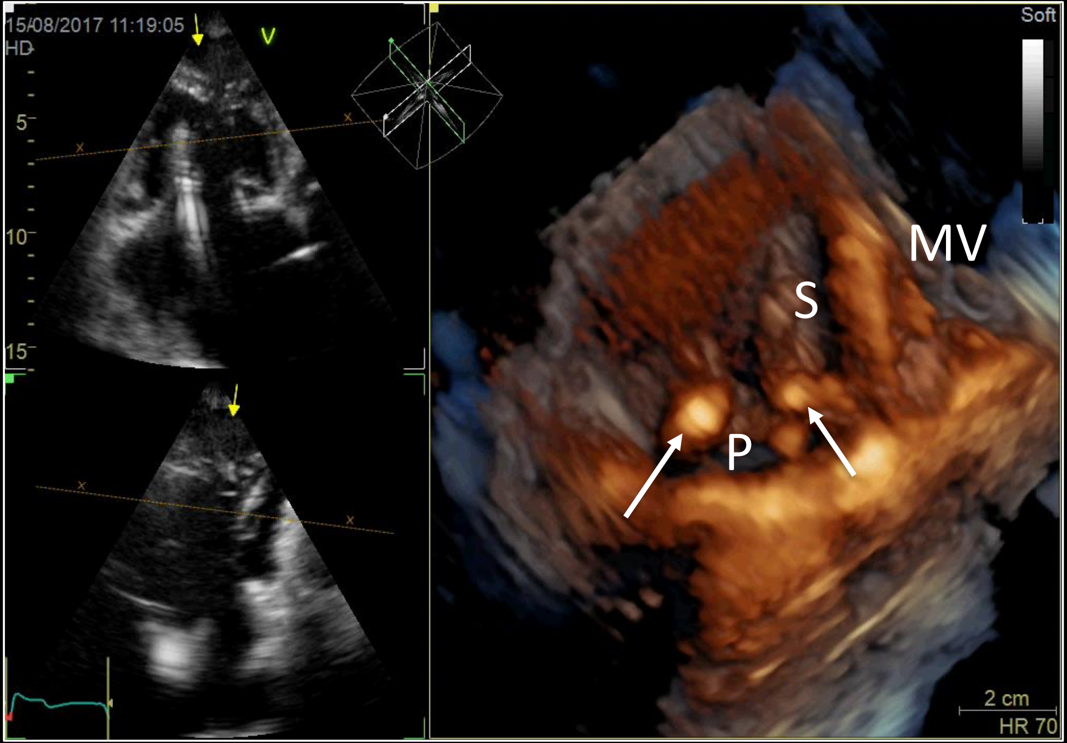


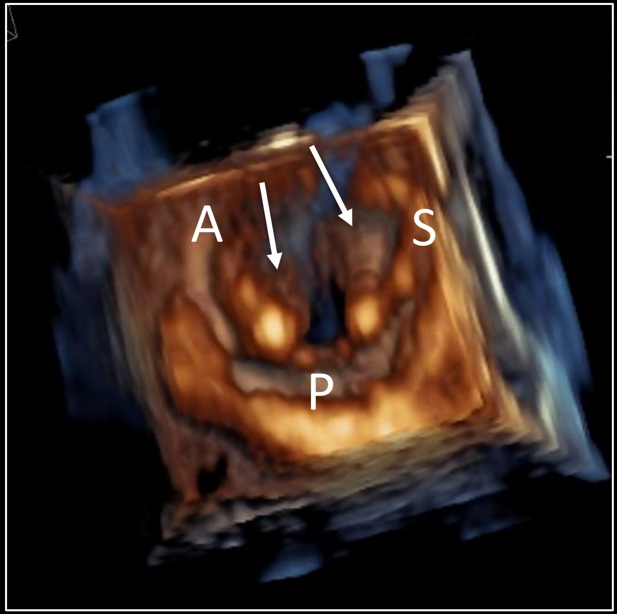
#2 Position of the PM lead

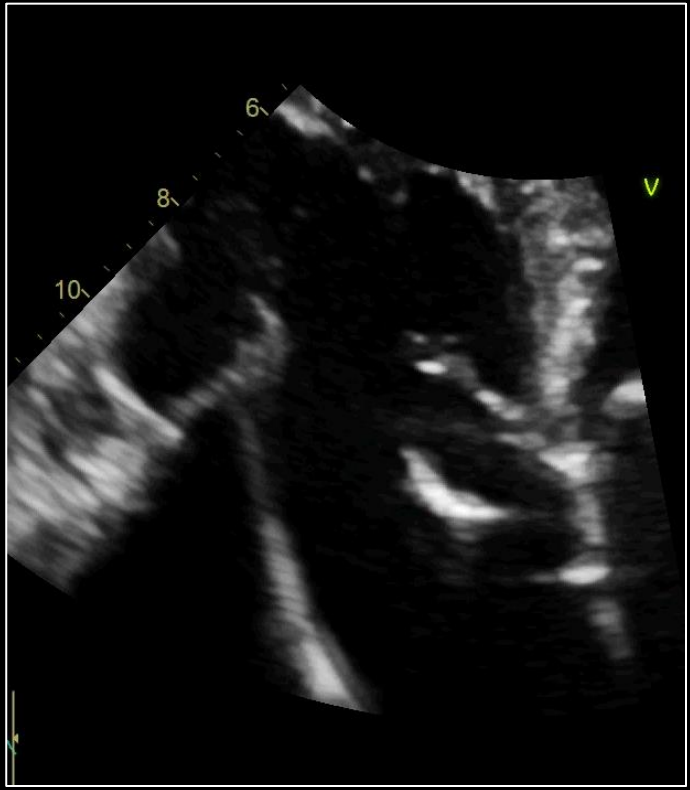


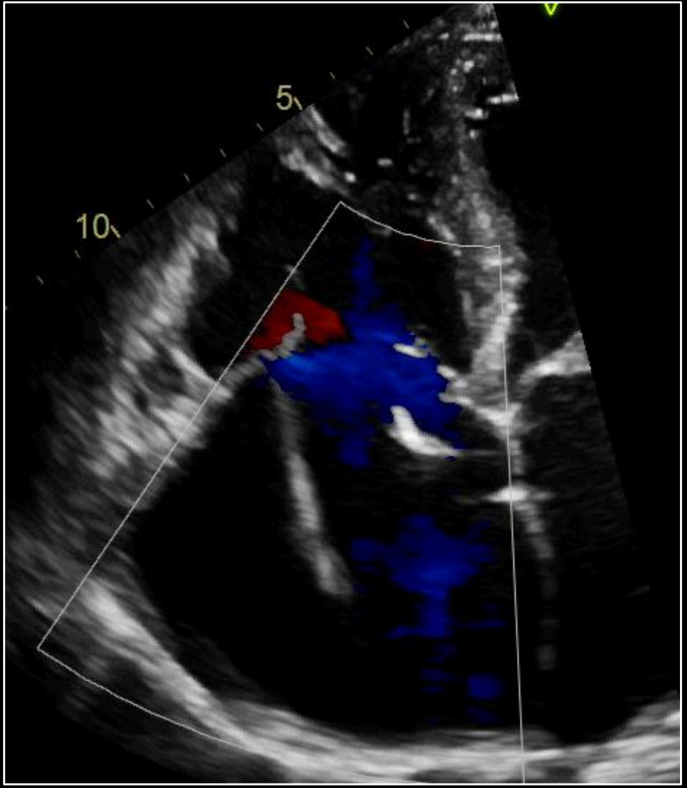


#3 Position of the PM lead









3DE for assessment of TR severity – new classification

Table 2 **Currently established and suggested (grey background) grades of tricuspid regurgitation and the respective orientation ranges for selected (semi) quantitative parameters.**

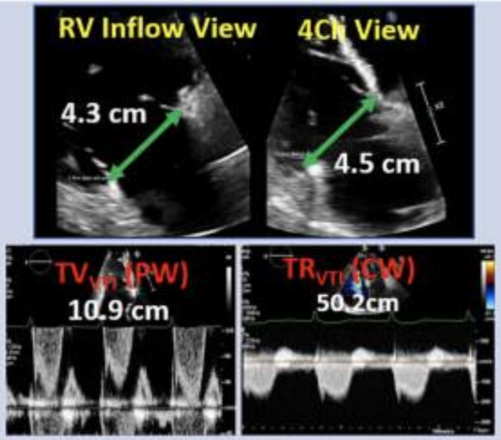
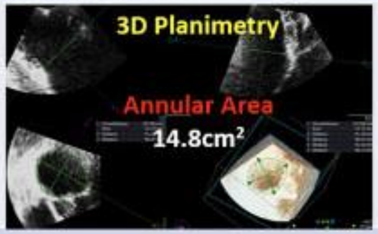
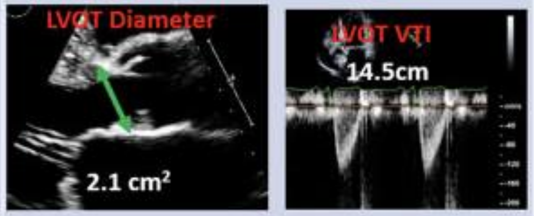
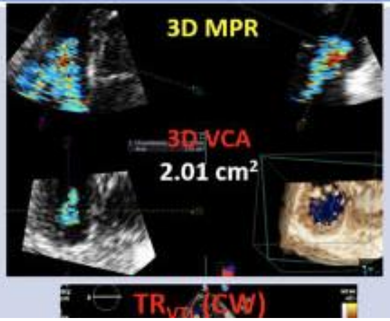
Parameters	Mild	Moderate	Severe	Massive	Torrential
Vena contracta width	<3 mm	3–6.9 mm	7–13 mm	14–20 mm	≥21 mm
EROA	20 mm^2	20–39 mm^2	40–59 mm^2	60–79 mm^2	≥80 mm^2
Regurgitant volume	<30 mL	30–44 mL	45–59	60–74	≥75
Regurgitant fraction 3D Echo (MRI)[a]	<25% (30%)[a]	25–44% (30–49%)[a]	≥45% (50%)[a]		
3D vena contracta			75–94 mm^2	95–114 mm^2	≥115 mm^2

[a]3D Echo cutoffs from Muraru et al.[76] and MRI cutoffs from Zhan et al.[97]

R. Hahn, et al. EHJ CVI 2017
R. Hahn, et al. EHJ 2022

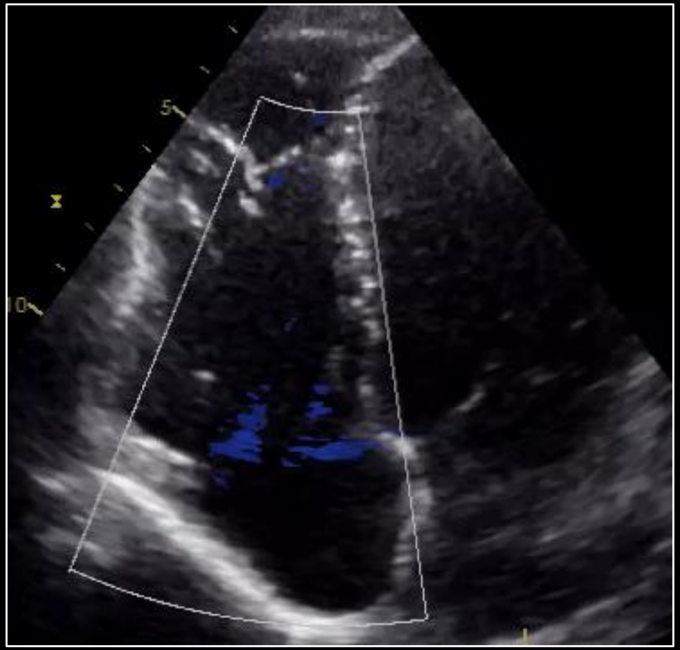
TR quantification

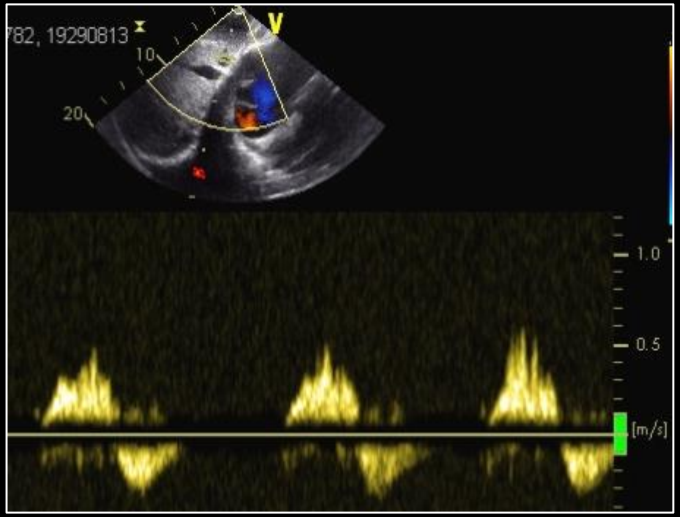
- PISA method
- Volumetric Doppler quantification (2D and 3DE)
- 3D colour Doppler vena contracta area

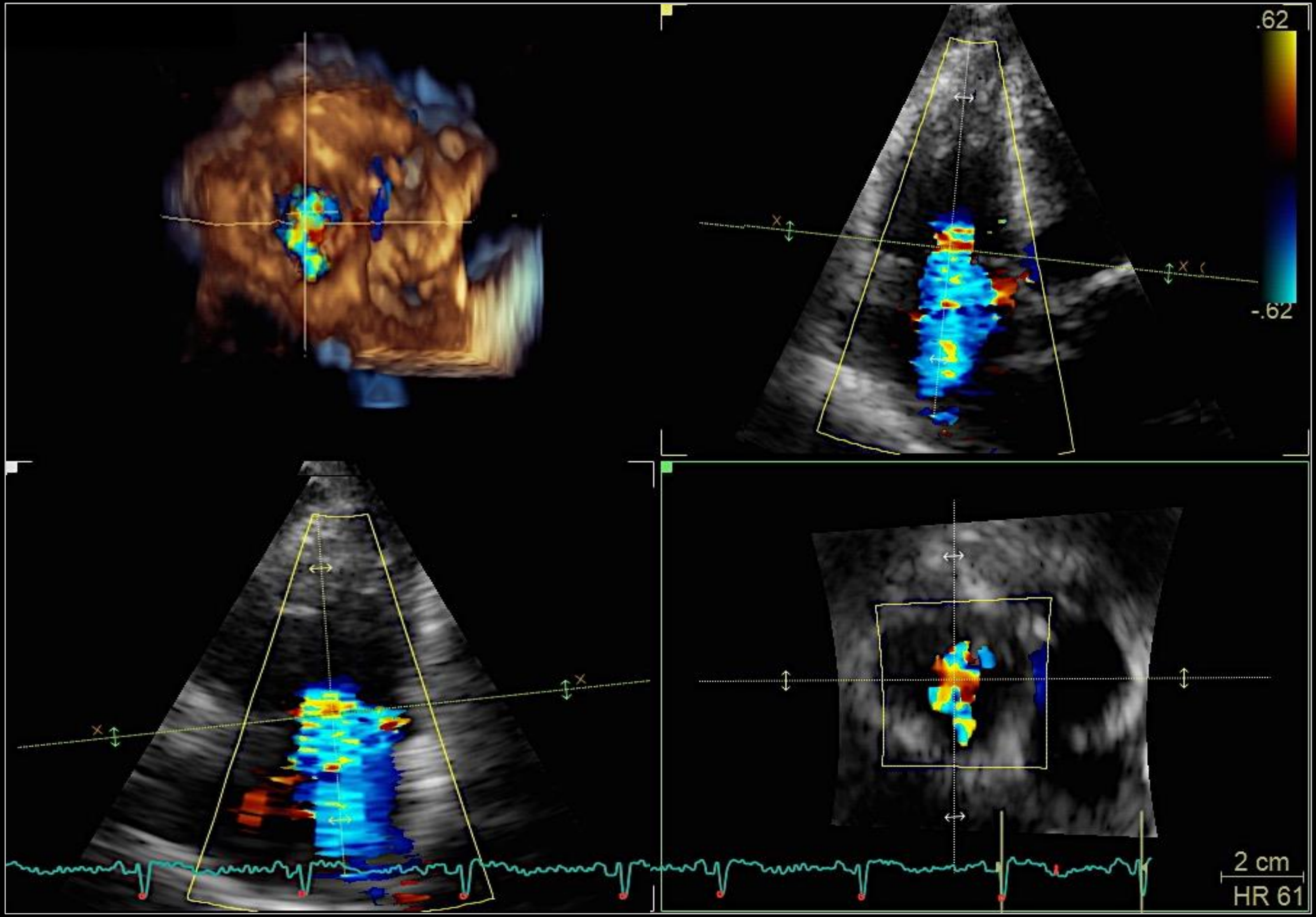
Quantitative Doppler	Measurements Required	Example	Calculation
2D Method	**2D Diastolic $TV_{Annular}$ Area** RV Inflow and 4Ch TV annular diameters in mid diastole **TV velocity time integral (TV_{VTI})** PW Doppler sample volume at the annulus **TR velocity time integral (TR_{VTI})** CW of the TR jet		**TV Diastolic Stroke Volume =** $TV_{Annulus}$ Area X TV_{VTI} **TR Regurgitation Volume =** TV diastolic volume – Forward Stroke Volume **EROA** = RegVol ÷ TR_{VTI} **Example:** • TV Diastolic SV = (0.785 X 4.3cm X 4.5cm) X 10.9cm = 165.6ml • TR Reg Vol = 115.6ml • EROA = 115.6 ml ÷ 50.2cm = 2.30cm^2
3D Method	**Direct planimetry of the 3D Annular Area**		**Example:** 3D Annular Area = 14.8cm^2 TV Diastolic Area = 14.8 X 10.9cm = 161.3ml TR Reg Vol = 111.3ml EROA = 111.3 ÷ 50.2cm = 2.22cm^2
Forward Stroke Volume used to quantify RegVol	**LVOT Stroke Volume** LVOT Diameter LVOT PW Note: Forward Stroke Volume may be either the LV or RV stroke volume.		**Forward Stroke Volume =** $LVOT_{annulus}$ Area X $LVOT_{VTI}$ **Example:** LV SV = (0.785 X [2.1cm]^2) x 14.5cm = 50.2ml
3D Color Doppler	**Measurements Required**	**Example**	**Calculation**
3D Vena Contracta Area (VCA)	**3D Color Doppler planimetry of the VCA** **TR velocity time integral (TR_{VTI})**		**EROA ≅ VCA** **TR Regurgitation Volume =** VCA X TR_{VTI} **Example:** 3D VCA = 2.01cm^2 Reg Vol = 2.01cm^2 X 50.2cm = 100.9ml

R. Hahn, et al. EHJ 2022;
P. Lancellotti, et al. EHJ CVI 2022

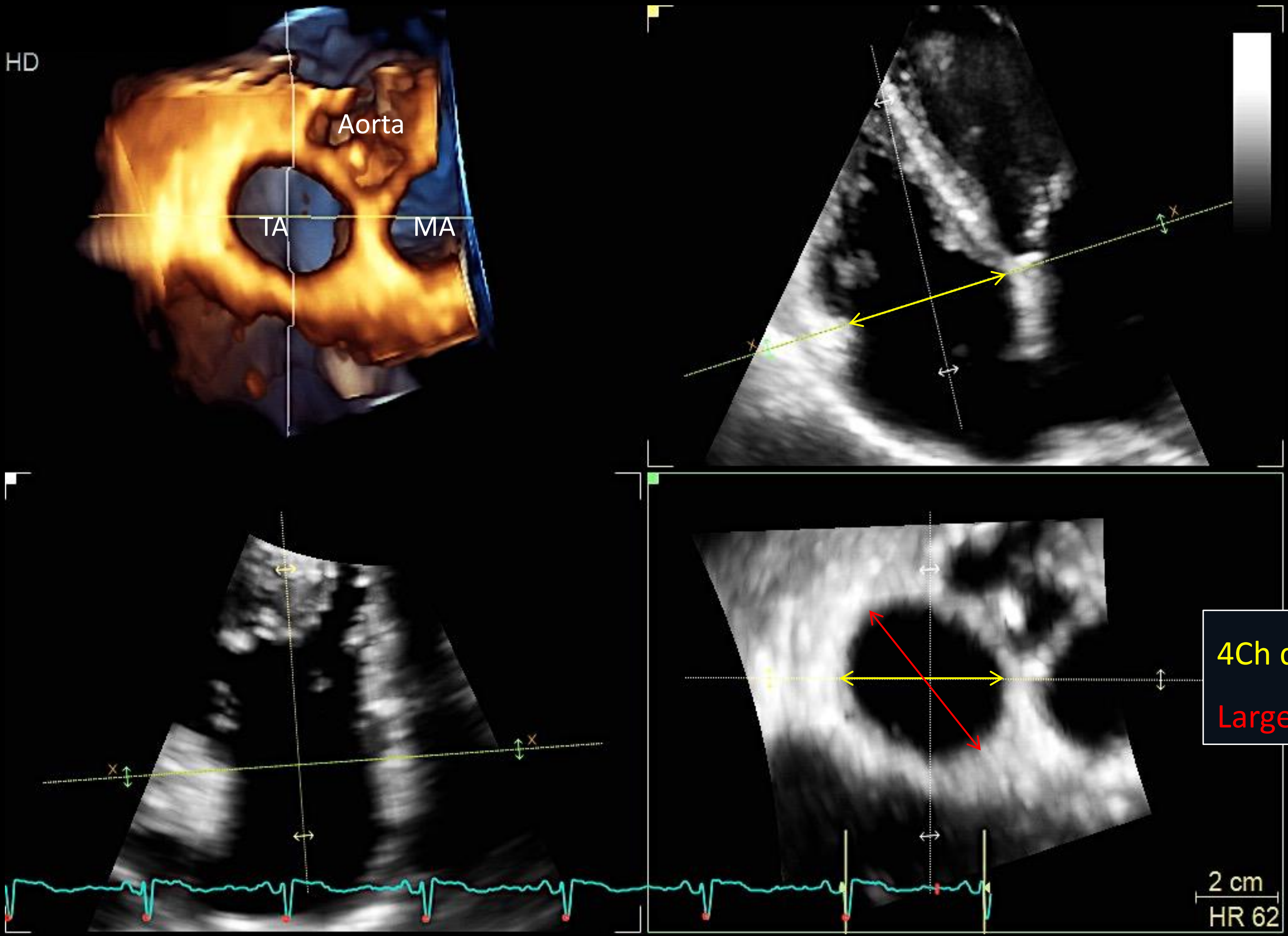
#5 Quantification of tricuspid regurgitation severity







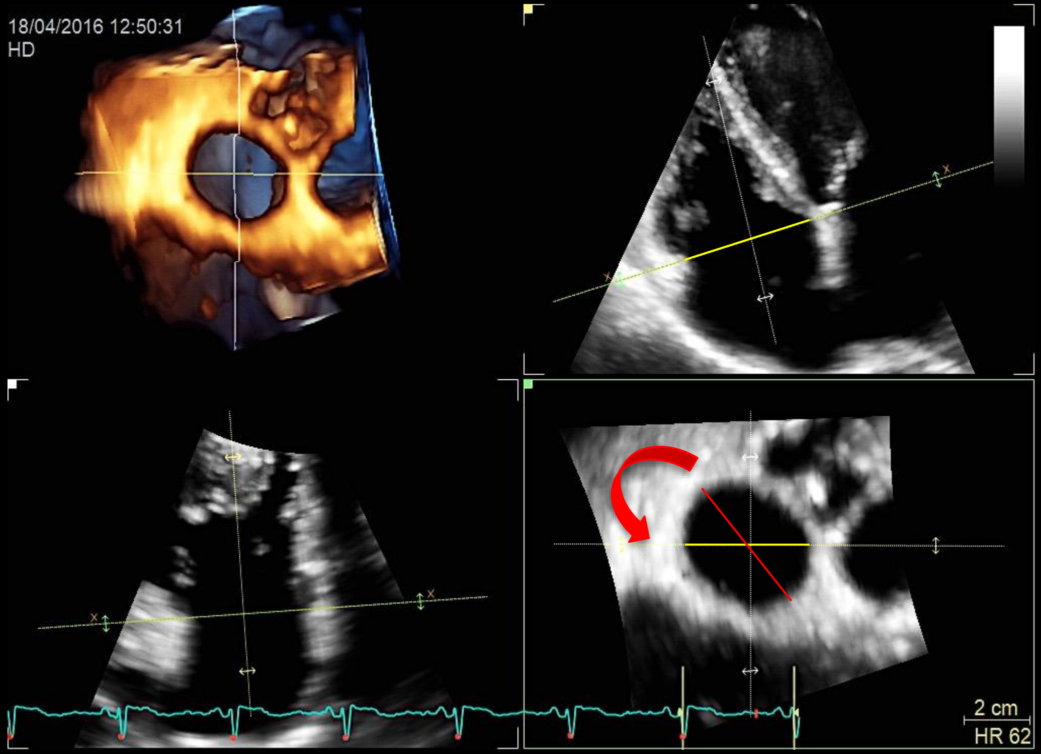
#5 Quantification of tricuspid annulus size

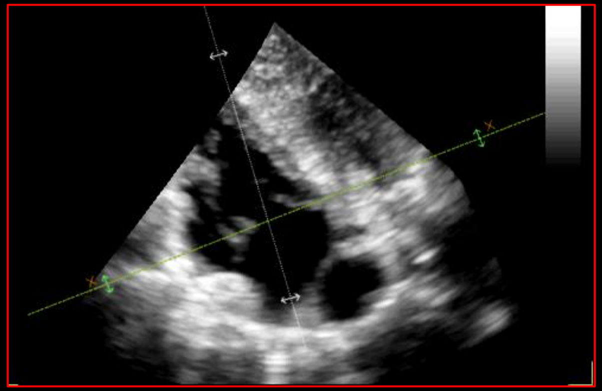


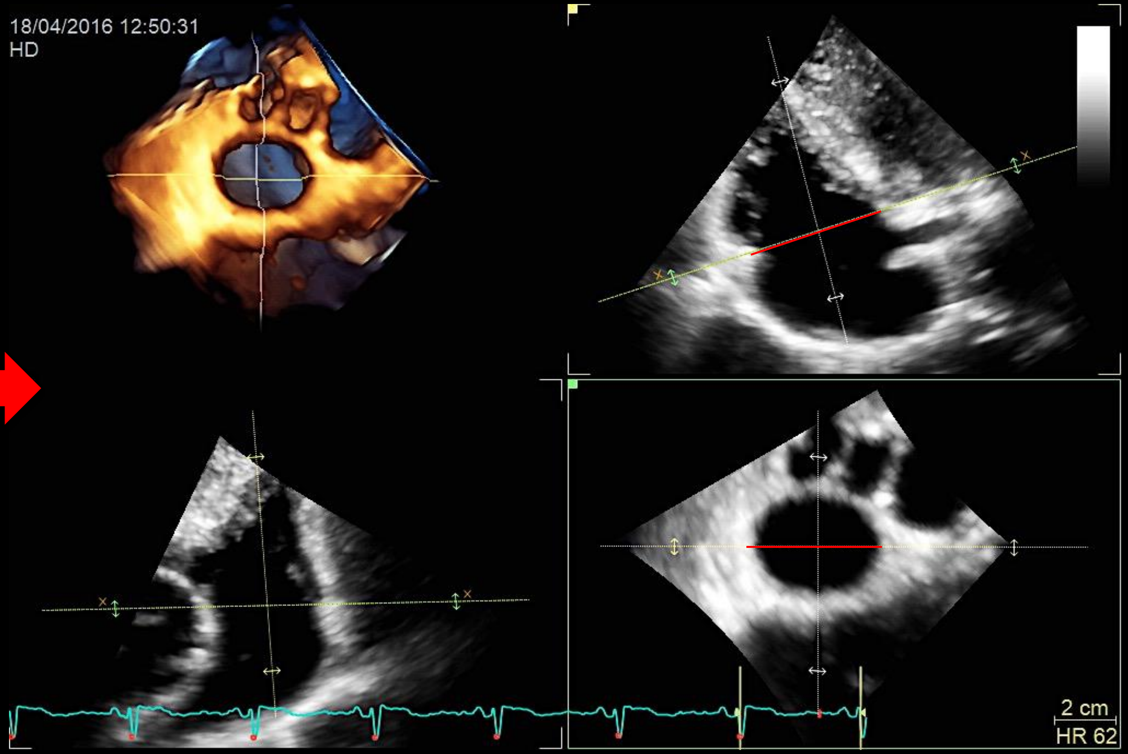
4Ch diam.   38 mm

Largest diam. 42 mm

#5 Quantification of tricuspid annulus size

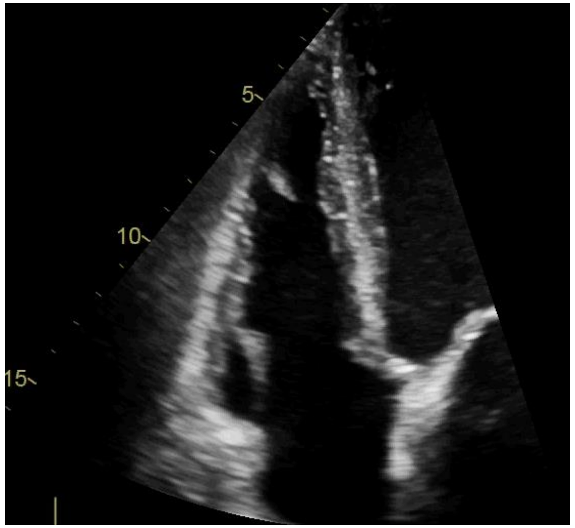




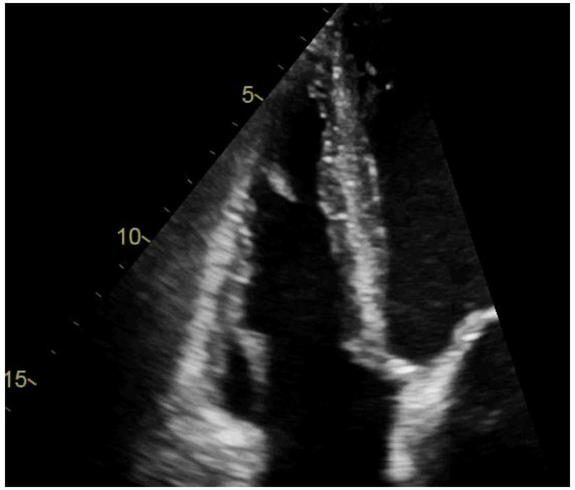


How to acquire good 3DE dataset

- clear visualization of the structure of interest in 2DE
- position of structure of interest in the center of the screen
- ensure the whole structure is within the 3D volume

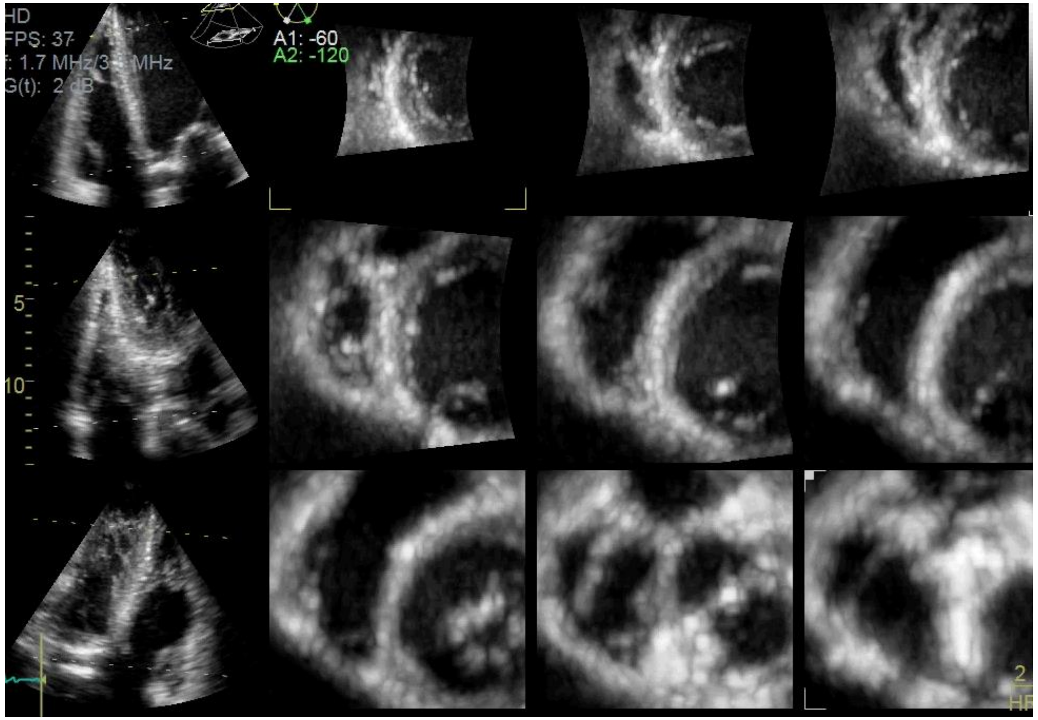


How to acquire good 3DE dataset for volumetric analysis of cardiac chambers



- clear visualization of the structure of interest in 2DE
- position of structure of interest in the center of the screen
- ensure the whole structure is within the 3D volume

  (multislice display is usually helpful)



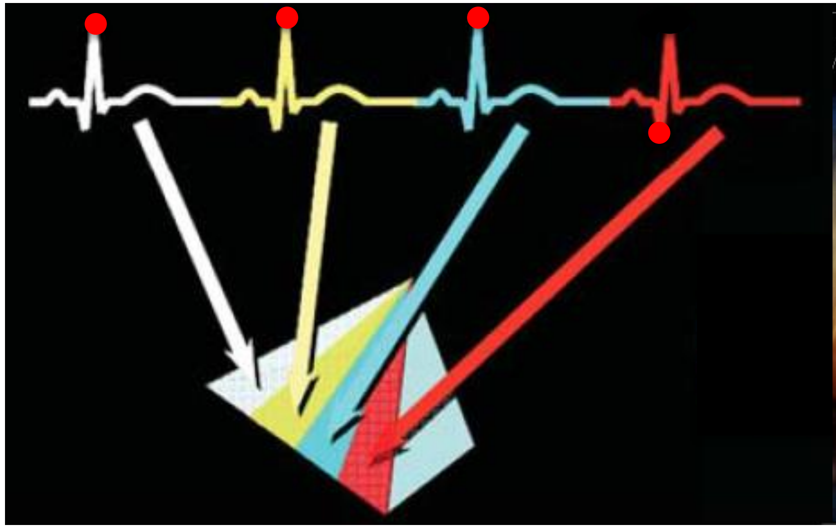
- optimization of volume width and depth

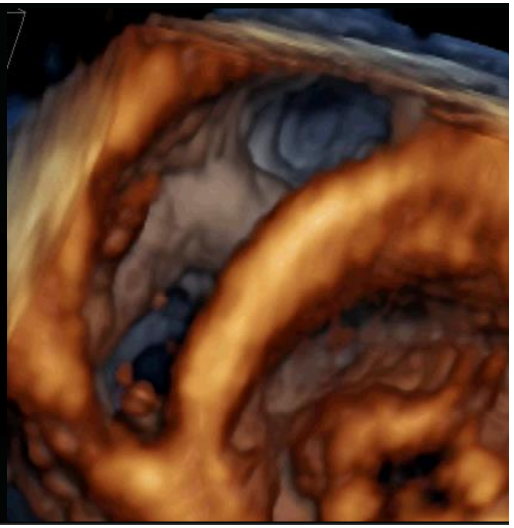
  (↑Volume size - ↓Volume rate)

- optimization of gain settings

  (avoid drop-out artefacts)

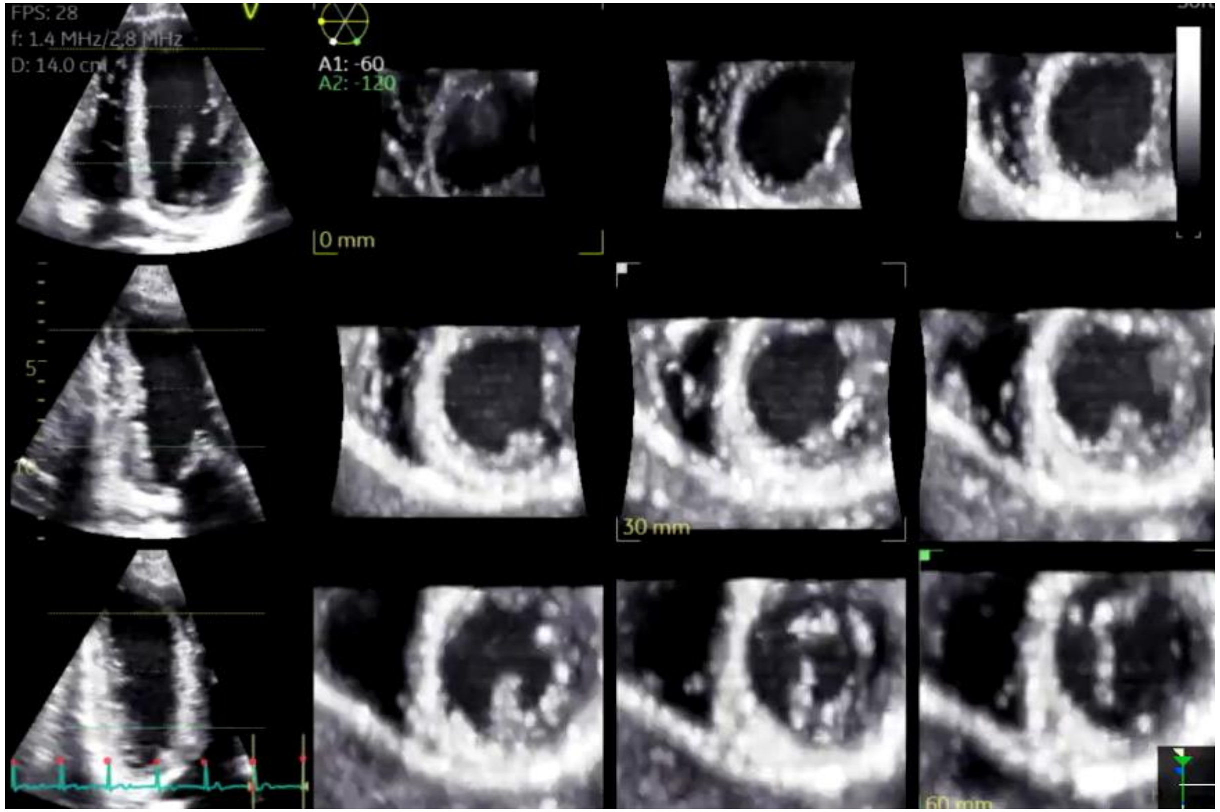
Avoiding stitching artefacts





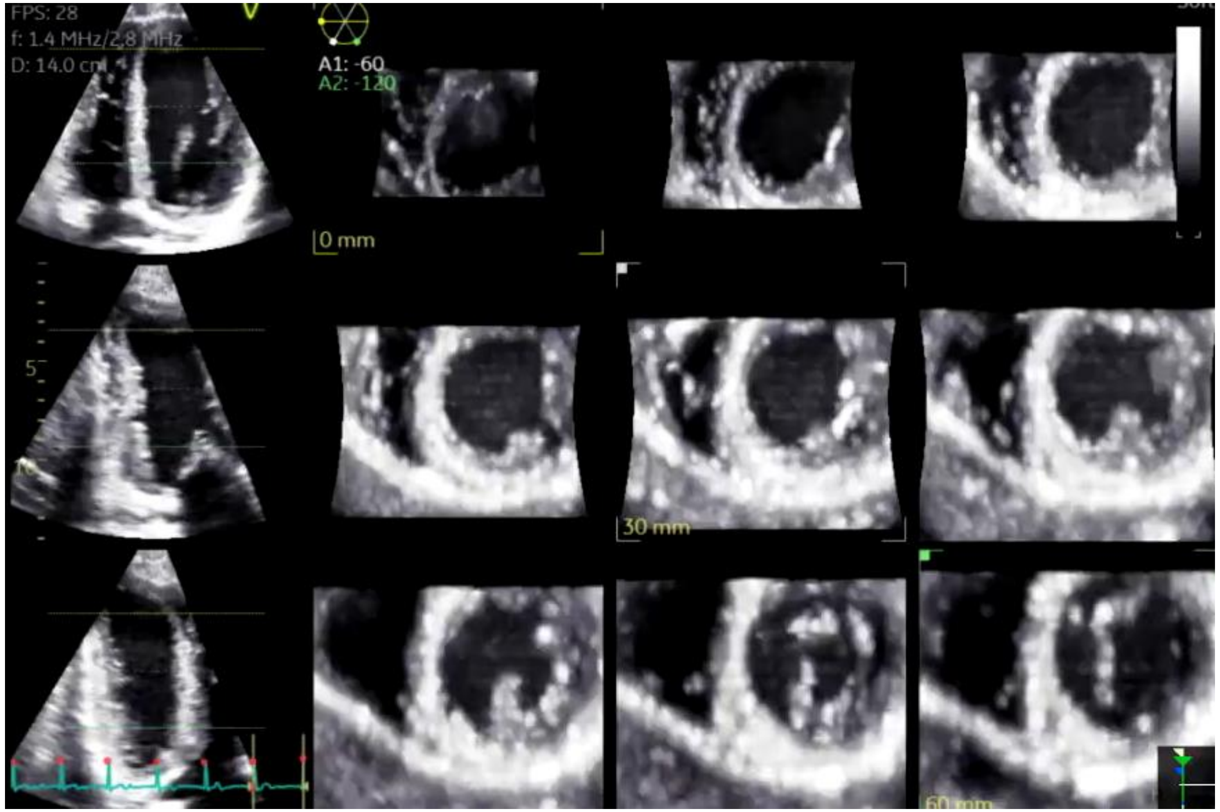
- Check ECG for regular heart rhythm and high quality ECG tracing
- Adjust for upright R waves if needed
- Position patient comfortably and instruct on breath holding
- Hold the probe firmly

Be aware of volume rate / know your machine!

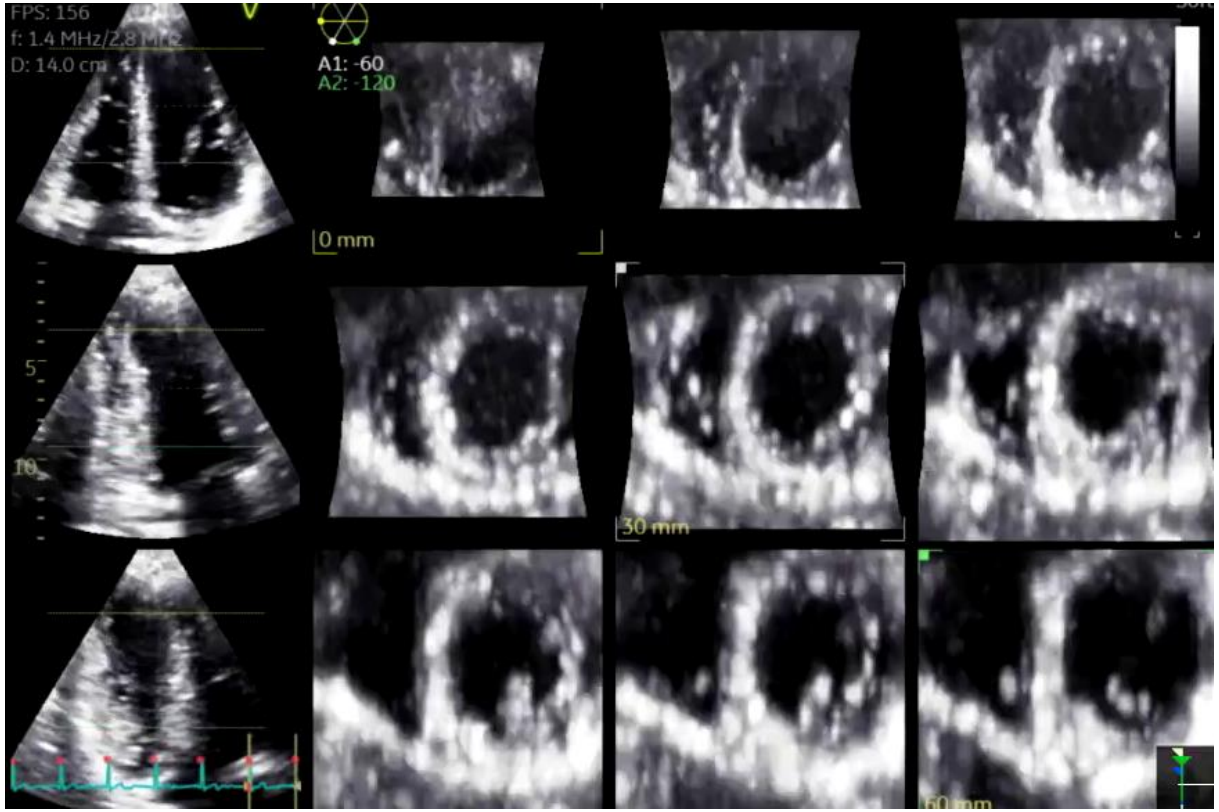


Volume Rate 28/sec

Be aware of volume rate / know your machine!



Volume Rate 28/sec

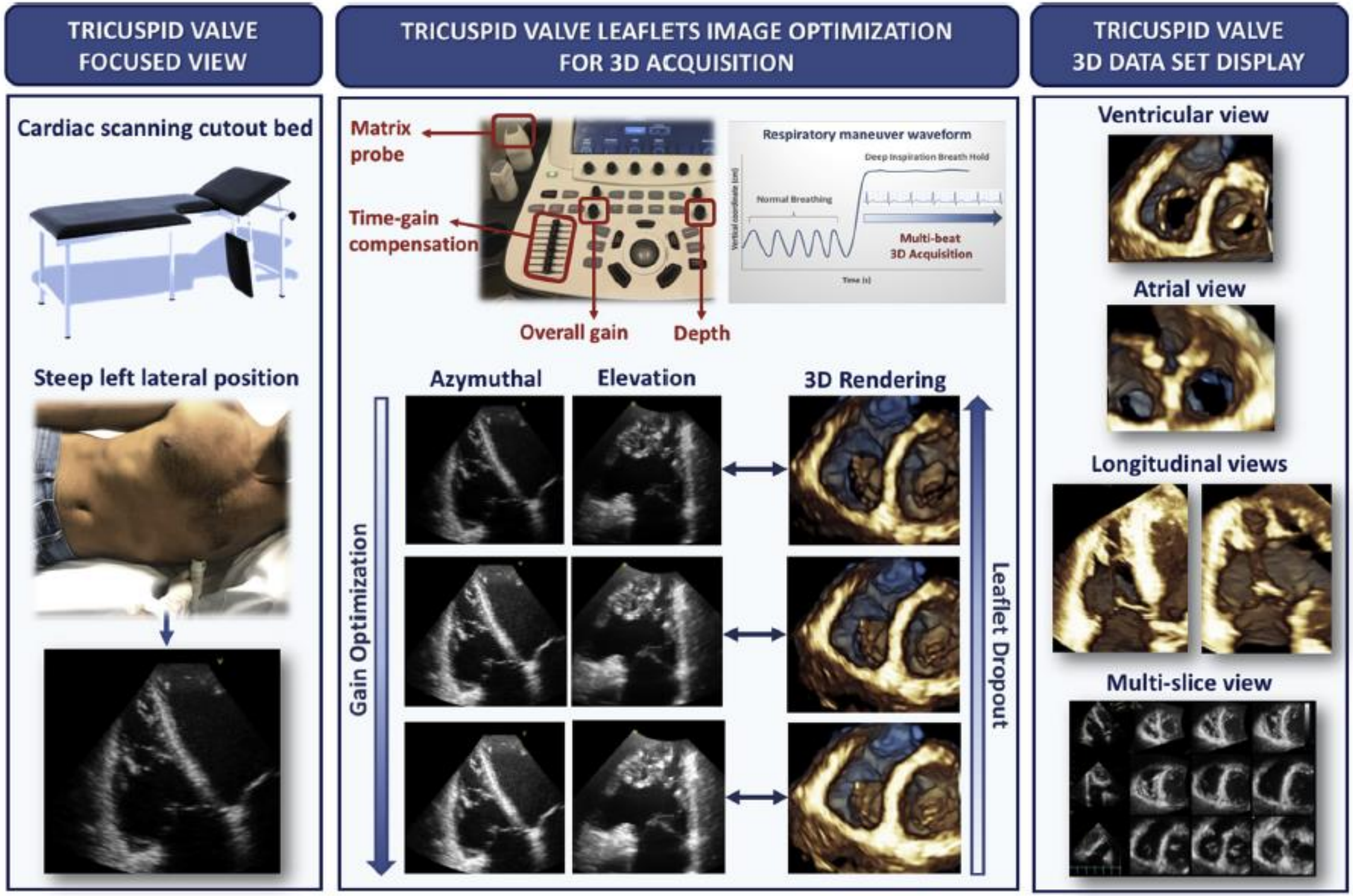


Volume Rate 156/sec

Check list for 3DE data acquisition for TV

- Clear visualization of the structure of interest in 2D
- Adjust sector depth, width, and gain settings
- Include relevant adjacent structures
- Volume size vs Volume rate; think of what is more important
- Check the ECG for upright R waves
- Use 3D color and 3D zoom when needed
- Remember, you still can get good 3DE data set even if your patient is in AF or not cooperating

CENTRAL ILLUSTRATION Stepwise Acquisition of Tricuspid Valve Complex Using the Matrix Probe by Transthoracic 3D Echocardiography



Muraru, D. et al. J Am Coll Cardiol Img. 2019;12(3):500-15.

Take-home messages

3D echocardiography of TV:

- 3D TTE is feasible in the majority of patients
- Advantages over conventional 2DE:
    - Enables anatomically accurate *En face* visualization of all TV leaflets, form both atrial and ventricular perspectives
    - No geometric assumptions about annular area, valve opening area, shape of VC and PISA
- Established clinical indications:
    - Anatomically accurate morphological assessment
    - Morphological and quantitative assessment of tricuspid stenosis
    - Analysis of the mechanisms of TR (including the position of the intracardiac leads and tricuspid annulus dilatation)

THANK YOU FOR YOUR ATTENTION

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