

10° CONGRESSO NAZIONALE



*Quello che le Linee
Guida Non Dicono*

Napoli
Hotel Excelsior
14-15 aprile 2023

ECOCARDIOGRAFIA NELLE PROCEDURE INTERVENTISTICHE STRUTTURALI
(...SULLA VALVOLA TRICUSPIDE)

Gemma Salerno



Multi-modality Imaging for diagnosis of TV disease and guidance of transcatheter therapy

- TTE
- TEE (2D/3D)
- ICE (3D)
- CCT
- Fluoroscopy
- CMR
- Navigation/Fusion imaging

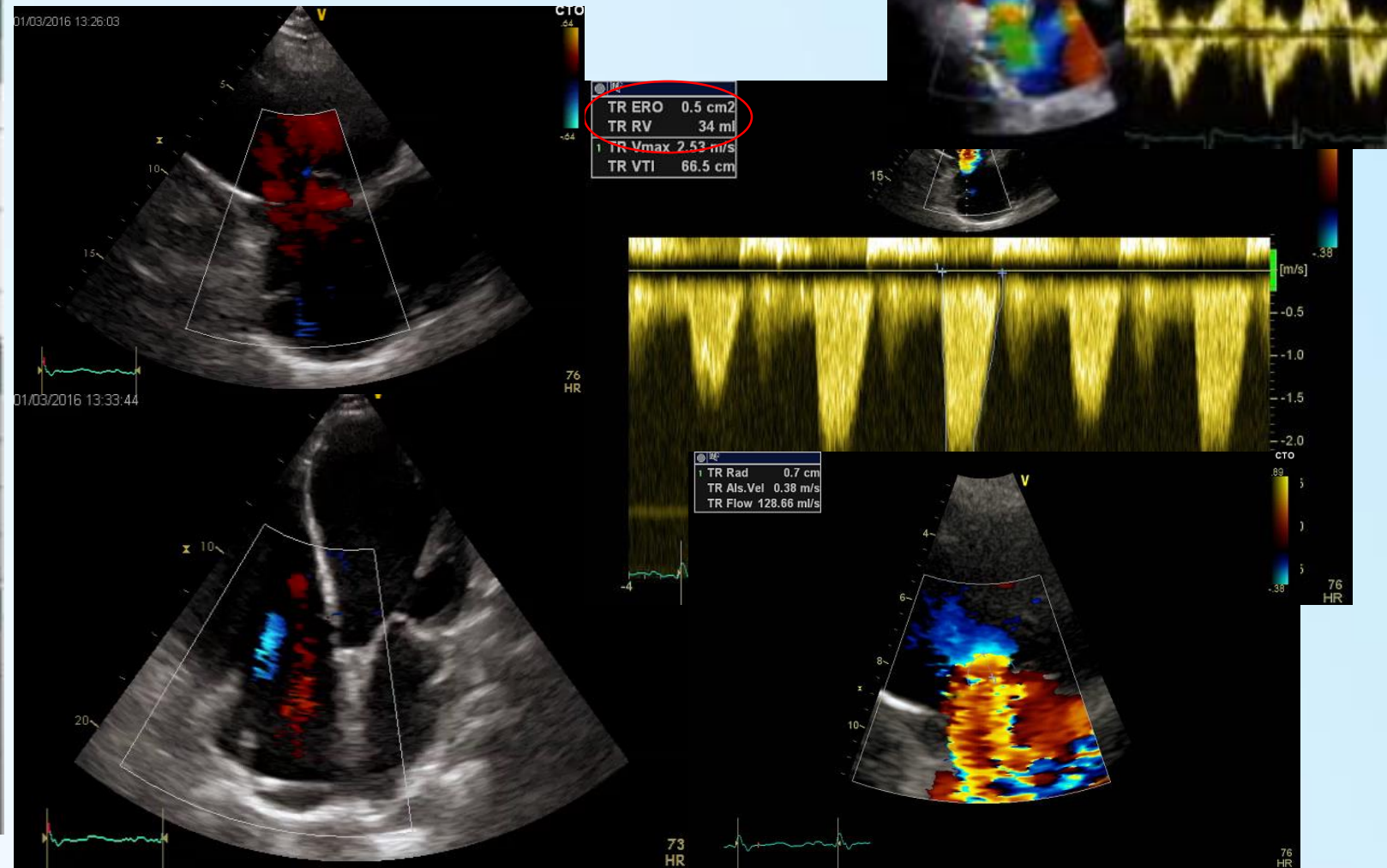


How to evaluate TR for transcatheter procedures?

- 1. What is the grading of TR?**
2. What is TR mechanism?
3. Is the anatomy of TV feasible for transcatheter treatment options?
4. How is the RV function and pulmonary pressures?

How to assess TR severity?

Tricuspid regurgitation	
Qualitative	
Valve morphology	Abnormal/flail/large coaptation defect
Colour flow regurgitant jet	Very large central jet or eccentric wall impinging jet
CW signal of regurgitant jet	Dense/triangular with early peaking (peak <2 m/s in massive TR)
Other	--
Semiquantitative	
Vena contracta width (mm)	≥7
Upstream vein flow	Systolic hepatic vein flow reversal
Inflow	E-wave dominant ≥1 m/s
Other	PISA radius >9 mmg
Quantitative	
	Primary
EROA (mm ²)	≥40
Regurgitant volume (mL/beat)	≥45
+ enlargement of cardiac chambers/vessels	RV, RA, inferior vena cava




TR Grading: the old classification

Table 2 Echocardiographic assessment of tricuspid regurgitation severity (modified from Lancellotti et al. ³⁴)

Parameters	Mild	Moderate	Severe
Qualitative			
Tricuspid valve morphology	Normal/abnormal	Normal/abnormal	Abnormal/flail/large coaptation defect
Colour flow TR jet	Small, central	Intermediate	Very large central jet or eccentric wall impinging jet
CW signal of TR jet	Faint/parabolic	Dense/parabolic	Dense/triangular with early peaking (peak < 2 m/s in massive TR)
Semi-quantitative			
VC width (mm)	Not defined	<6.5	>6.5
PISA radius (mm)	≤5	6–9	>9
Hepatic vein flow	Systolic dominance	Systolic blunting	Systolic flow reversal
Tricuspidinflow	Normal	Normal	E wave dominant (≥1 cm/s)
Quantitative			
EROA (mm ²)	Not defined	Not defined	≥40
R Vol (ml)	Not defined	Not defined	≥45
+ RA/RV/IVC dimension			

CW, continuous-wave Doppler; EROA, effective regurgitant orifice area; PISA, proximal isovelocity surface area; RA, right atrium; RV, right ventricle; R Vol, regurgitant volume; TR, tricuspid regurgitation; VC, vena contracta.

TR Grading: work in progress for a new classification!

 **ESC** European Society of Cardiology
European Heart Journal - Cardiovascular Imaging (2017) 18, 1342–1343
doi:10.1093/ehjci/jex139

EDITORIAL

The need for a new tricuspid regurgitation grading scheme

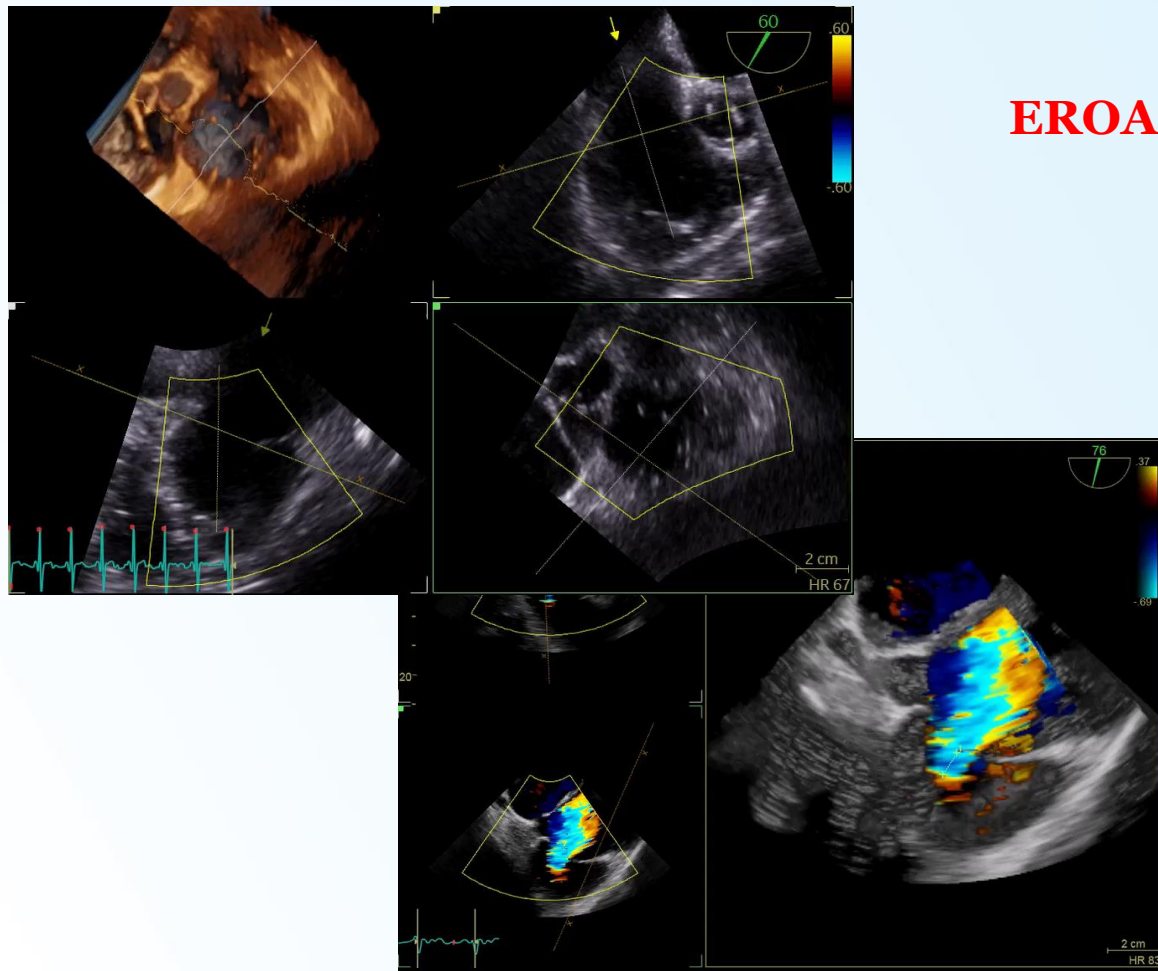
Rebecca T. Hahn¹ and Jose L. Zamorano^{2*}

Table 1 Proposed expansion of the 'Severe' grade

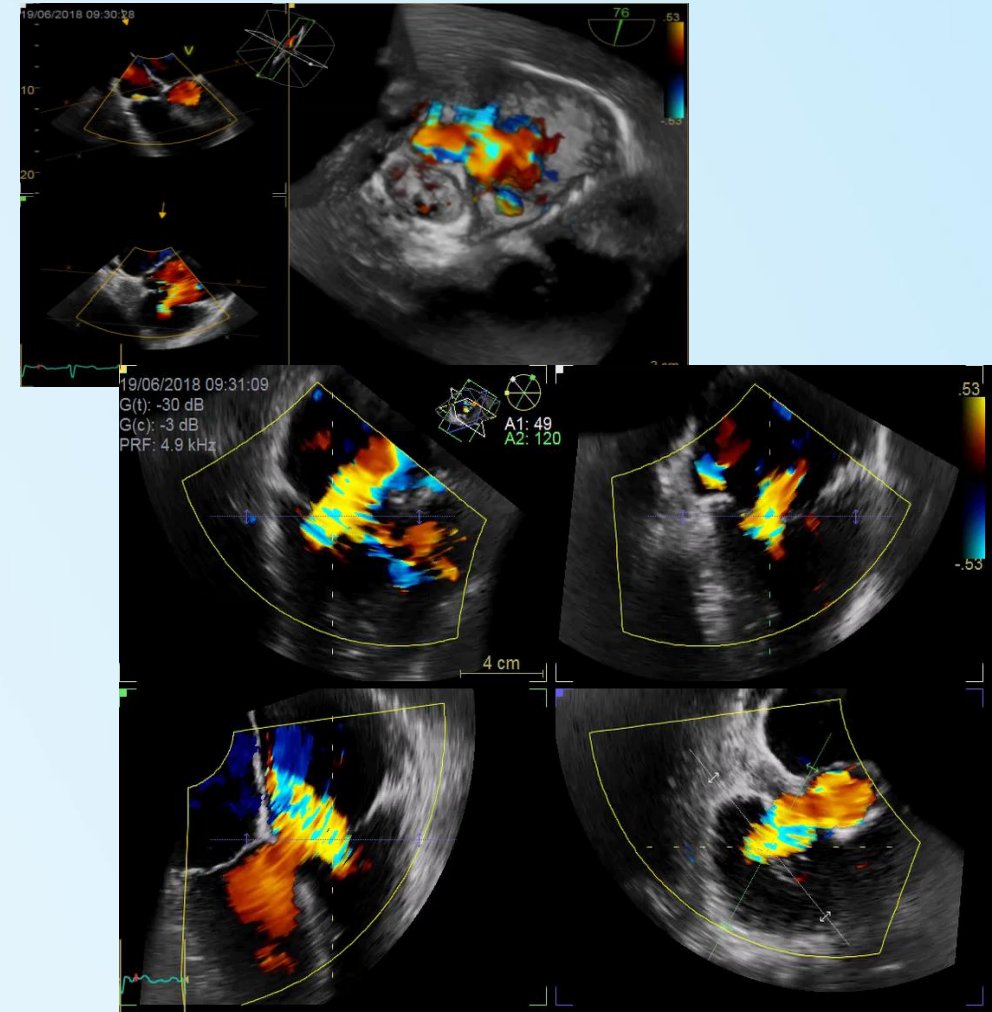
Variable	Mild	Moderate	Severe	Massive	Torrential
VC (biplane)	<3 mm	3-6.9 mm	7-13 mm	14-20 mm	≥21 mm
EROA (PISA)	<20 mm ²	20-39 mm ²	40-59 mm ²	60-79 mm ²	≥80 mm ²
3D VCA or quantitative EROA ³			75-94 mm ²	95-114 mm ²	≥115 mm ²

VC, vena contracta; EROA, effective regurgitant orifice area; 3D VCA, three-dimensional vena contracta area.
³3D VCA and quantitative Doppler EROA cut-offs may be larger than PISA EROA.

3D Color TEE (VC area, EROA)



EROA 3D 60mm²



Eur Heart J Cardiovasc Imaging. 2017 Dec 1;18(12):1342-1343

Parameters	MILD	MODERATE	SEVERE	MASSIVE	TORRENTIAL
Qualitative					
Morphology	Normal or mild abnormal leaflets	Moderately abnormal leaflets	Severe valve lesions		
Color TR jet	Narrow, central	Moderate, central	Large, Coanda ef		
CW signal	Faint, parabolic	Dense, parabolic	Dense, triangular, Early peak	Dense, triangular, Early peak <2 m/s	
RV/RA size	Normal	Mildly dilated	Dilated	Dilated	
IVC size	Usually non dilated	Variable	> 2.5 cm		
Semi-quantitative					
Jet área*	<5 cm2	5-10 cm2	> 10 cm2		
Jet área/RA área*					
VC width (biplane)*	<3 mm	3-6.9mm	7 mm - 13mm	14-20 mm	>= 21 mm
3D VCA	-	-	75-94 mm2	95-114 mm2	>=115 mm2
PISA rad**	<5	5-9	>9		
Hepatic flow	Systolic Dominance	Systolic blunt	Systolic reversal		
Tricuspid inflow	A wave dominant	Variable	E-wave > 1 cm/s		
Quantitative					
ERO (mm2)	< 20	20-39	40-59	60-79	>=80
Regurg vol (mL)	30	30-44	45-70	>70	

Not yet?!

Go

Go!?

Sorry too late..

The clinical need of a new TR grading system

How to evaluate TR for transcatheter procedures?

1. What is the grading of TR?
- 2. What is TR mechanism?**
3. Is the anatomy of TV feasible for transcatheter treatment options?
4. How is the RV function and pulmonary pressures?



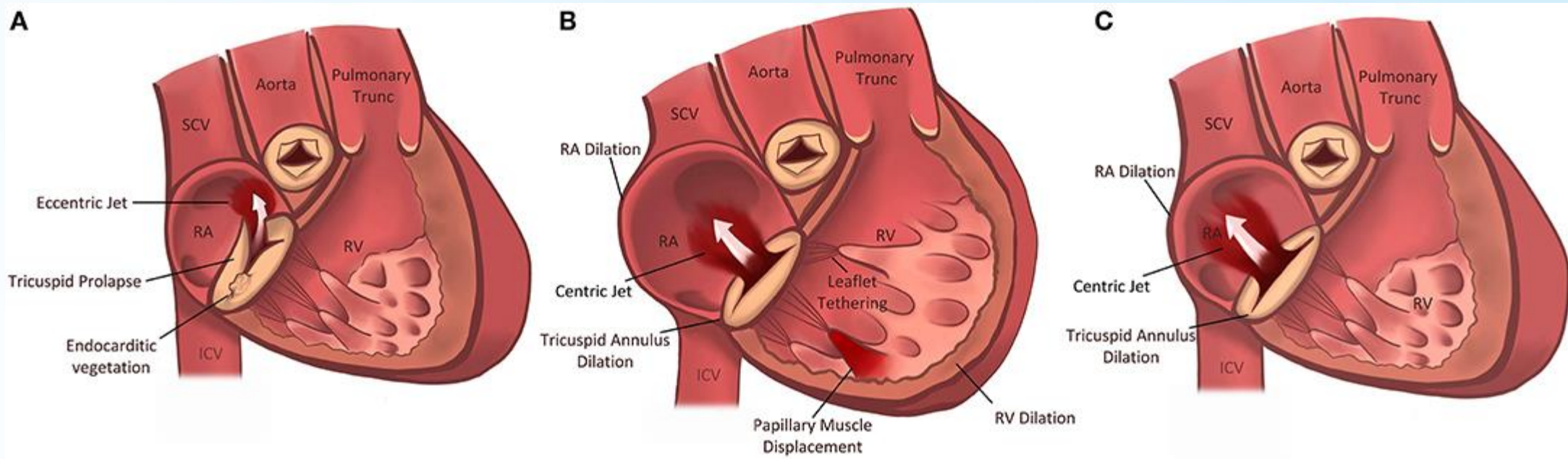
Transcatheter treatment for tricuspid valve disease

Fabien Prax^{1*}, MD; Denisa Muraru², MD; Felix Kreidel³, MD; Philipp Lurz⁴, MD; Rebecca T. Hahn⁵, MD; Victoria Delgado⁶, MD; Michele Senni⁷, MD; Ralph Stephan von Bardeleben⁸, MD; Georg Nickenig⁹, MD; Jörg Hausleiter⁹, MD; Antonio Mangieri¹⁰, MD; Jose L. Zamorano¹¹, MD; Bernard Prendergast¹², MD; Francesco Maisano¹³, MD

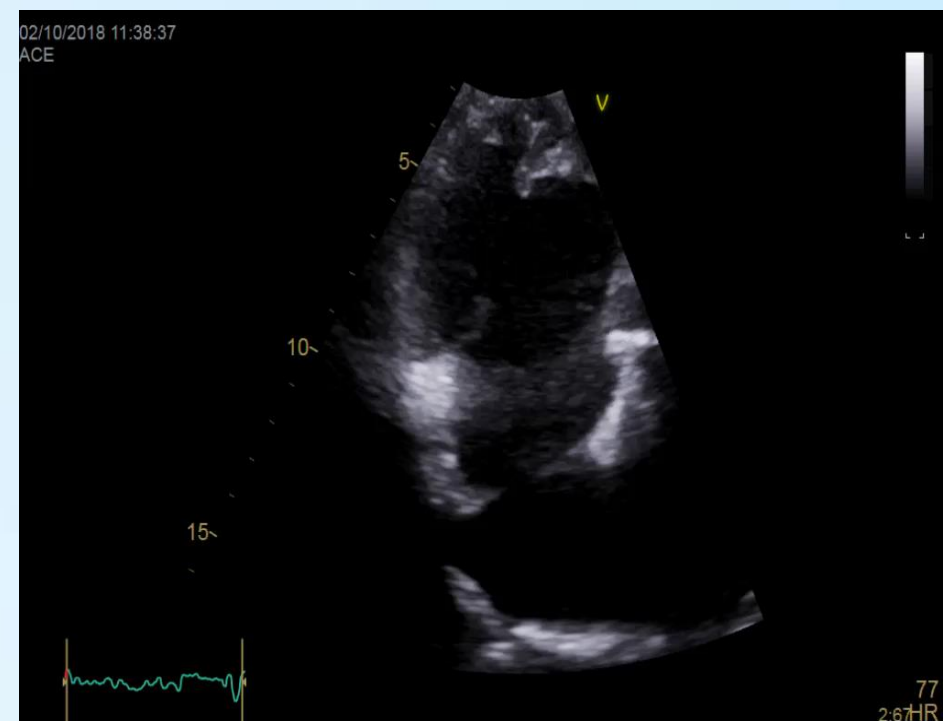
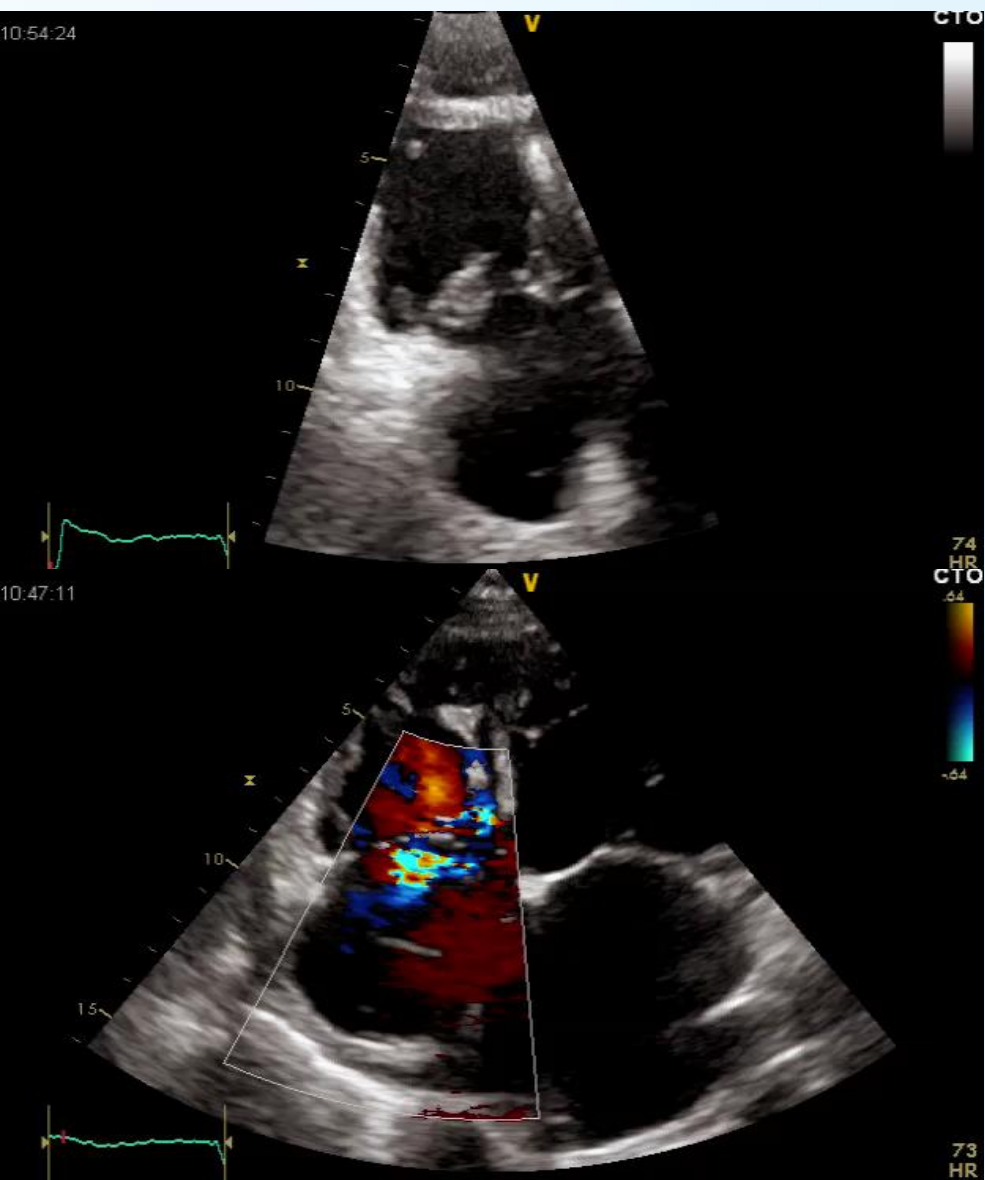
Table 1. Proposed new integrated classification of TR.

	Leaflet structure	Pathophysiology	Aetiology	Imaging
Primary (organic)	Abnormal	Lack of leaflet coaptation due to intrinsic changes leading to restricted or excessive leaflet mobility or leaflet perforation	Carpentier I: Congenital Endocarditis Carpentier II: Myxomatous disease Traumatic Post biopsy Carpentier IIIA: Carcinoid ¹²⁹ Rheumatic Radiotherapy Tumours	TV leaflet structural abnormalities characteristic of each primary aetiology are the dominant mechanisms TV leaflet mobility is variable (all Carpentier types) TV annulus, RV and RA are typically dilated (except in acute TR)

Pathophysiologic Subdivision of Tricuspid Regurgitation

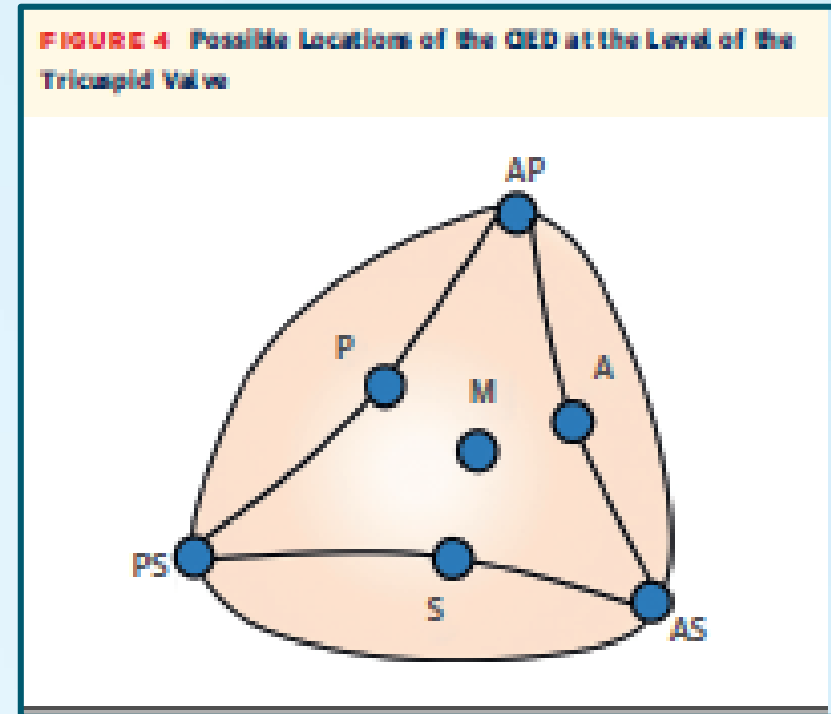
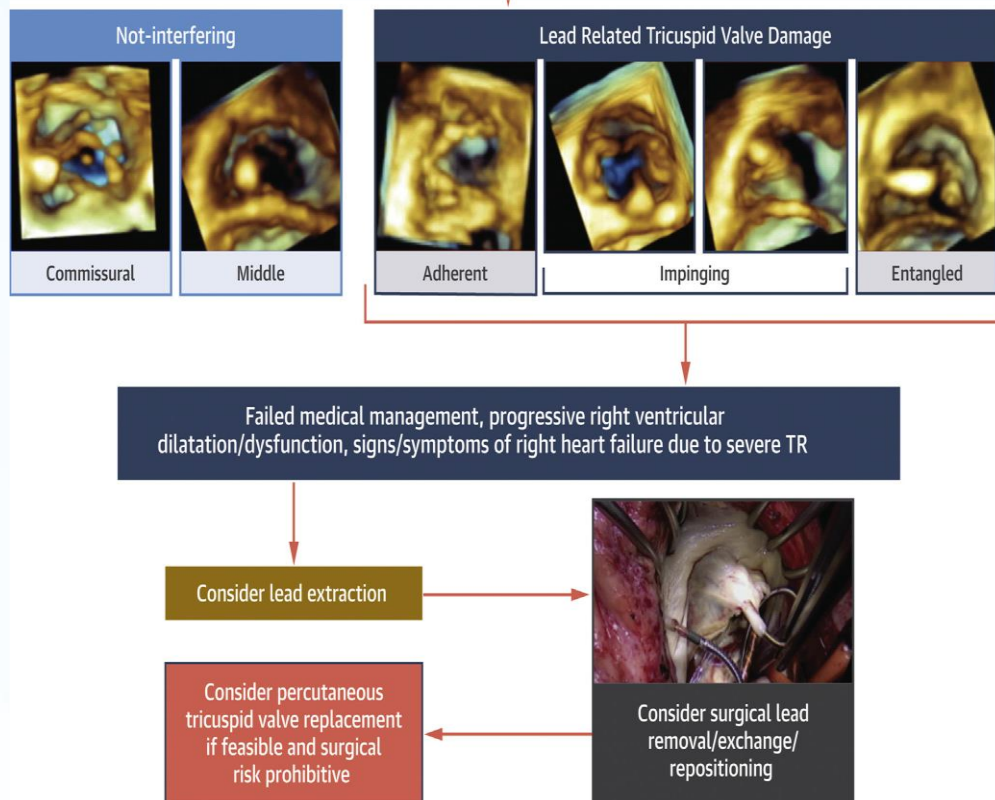


Primary TR



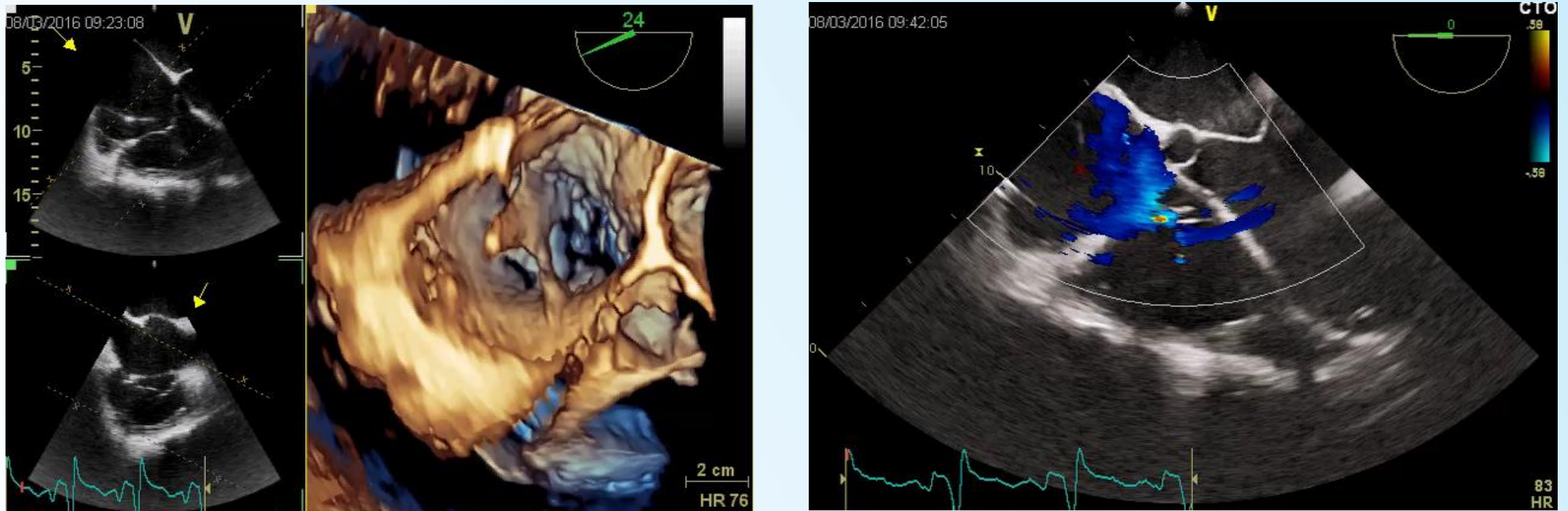
CIED related TR

3D TEE versus 2D TEE



CIED related TR

3D TEE versus 2D TEE

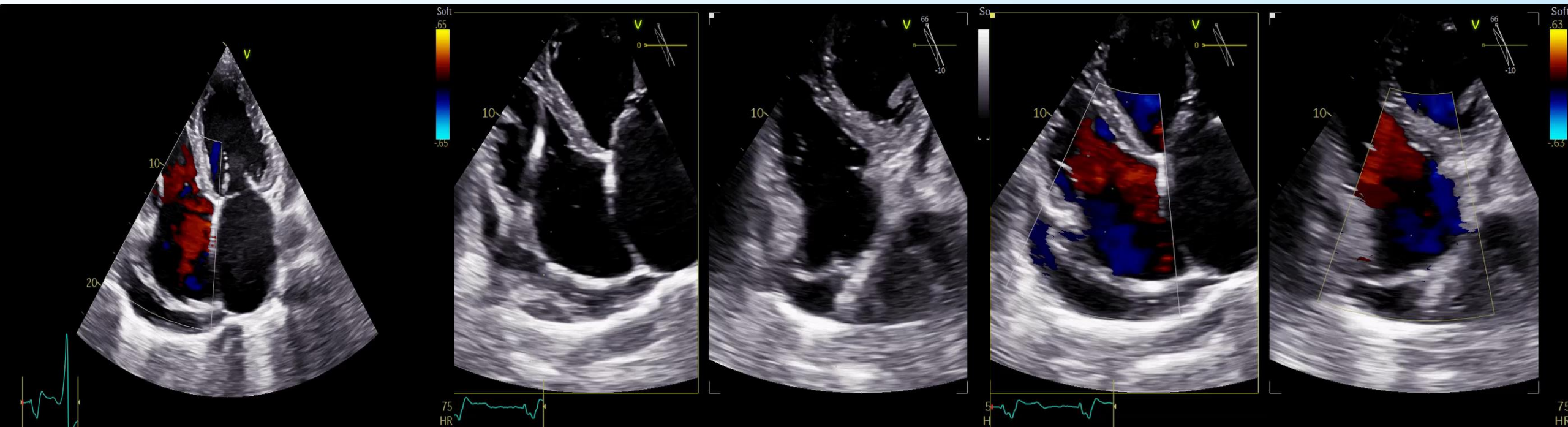


Impingement of ICD lead between posterior and septal leaflets

CIED related TR

2D TEE

Simultaneous B-plane +/- ColorDoppler



Impingement of posterior leaflet by ICD lead and lesion/flail of septal leaflet following lead extraction for endocarditis

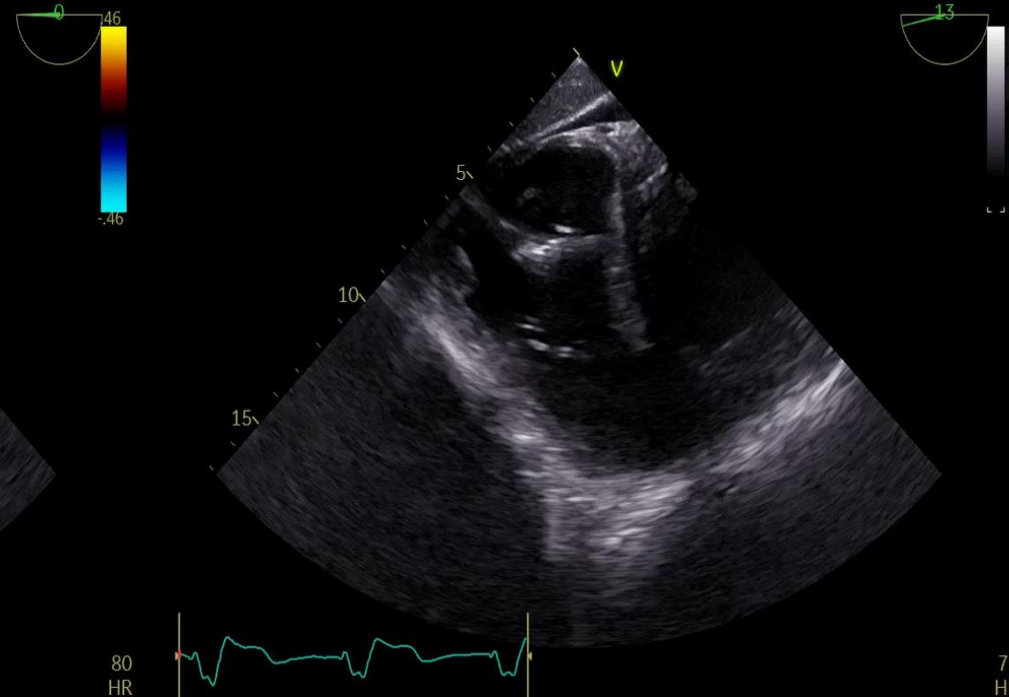
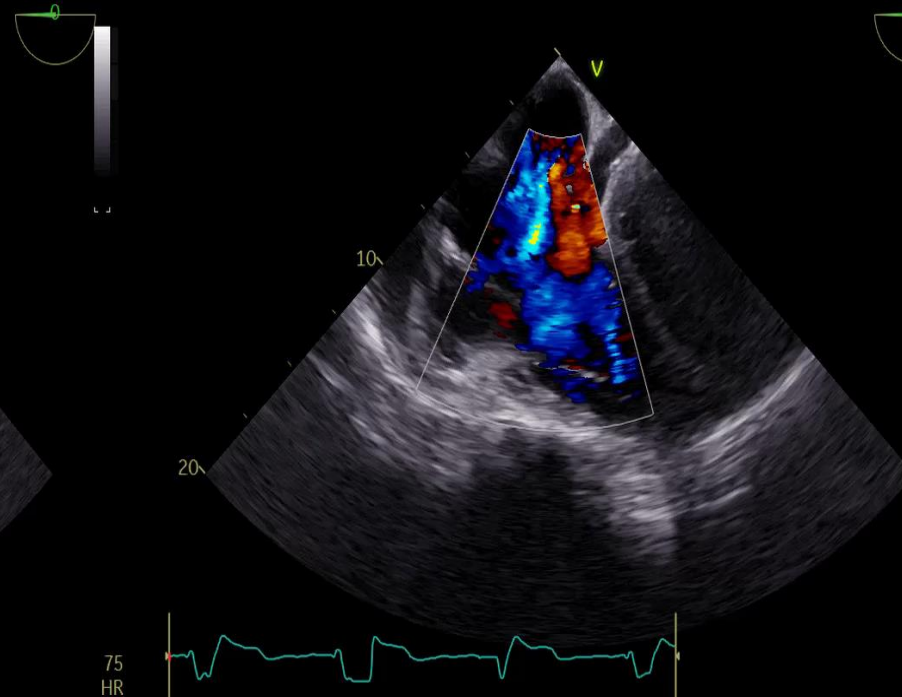
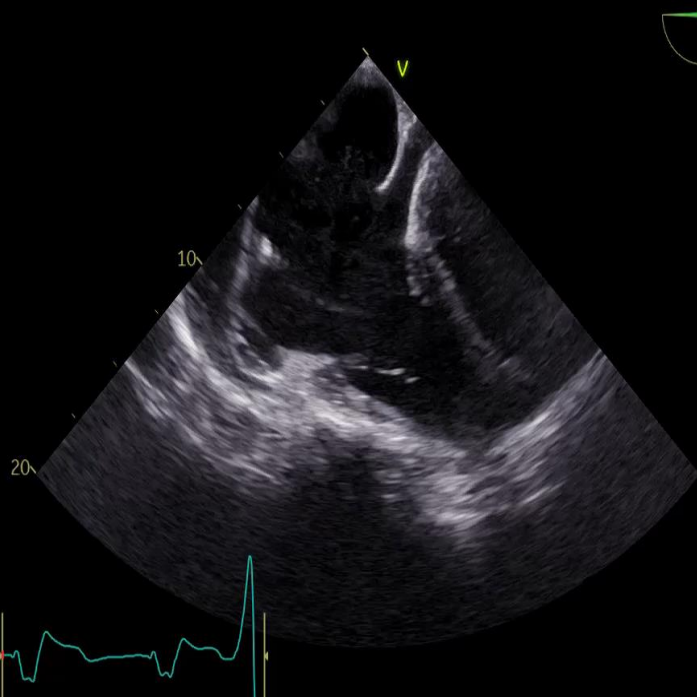
CIED related TR

2D TEE DE

-/+

ColorDoppler

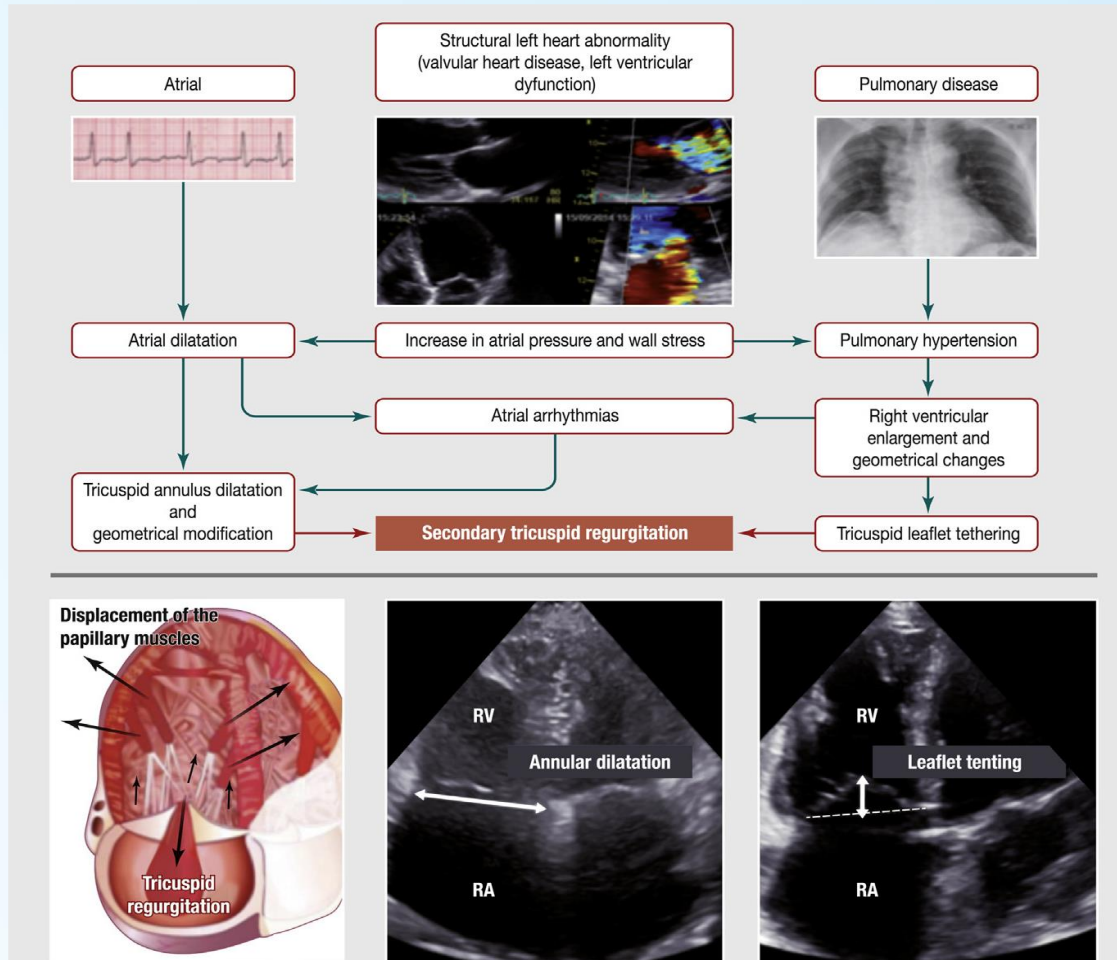
TGX Short axis

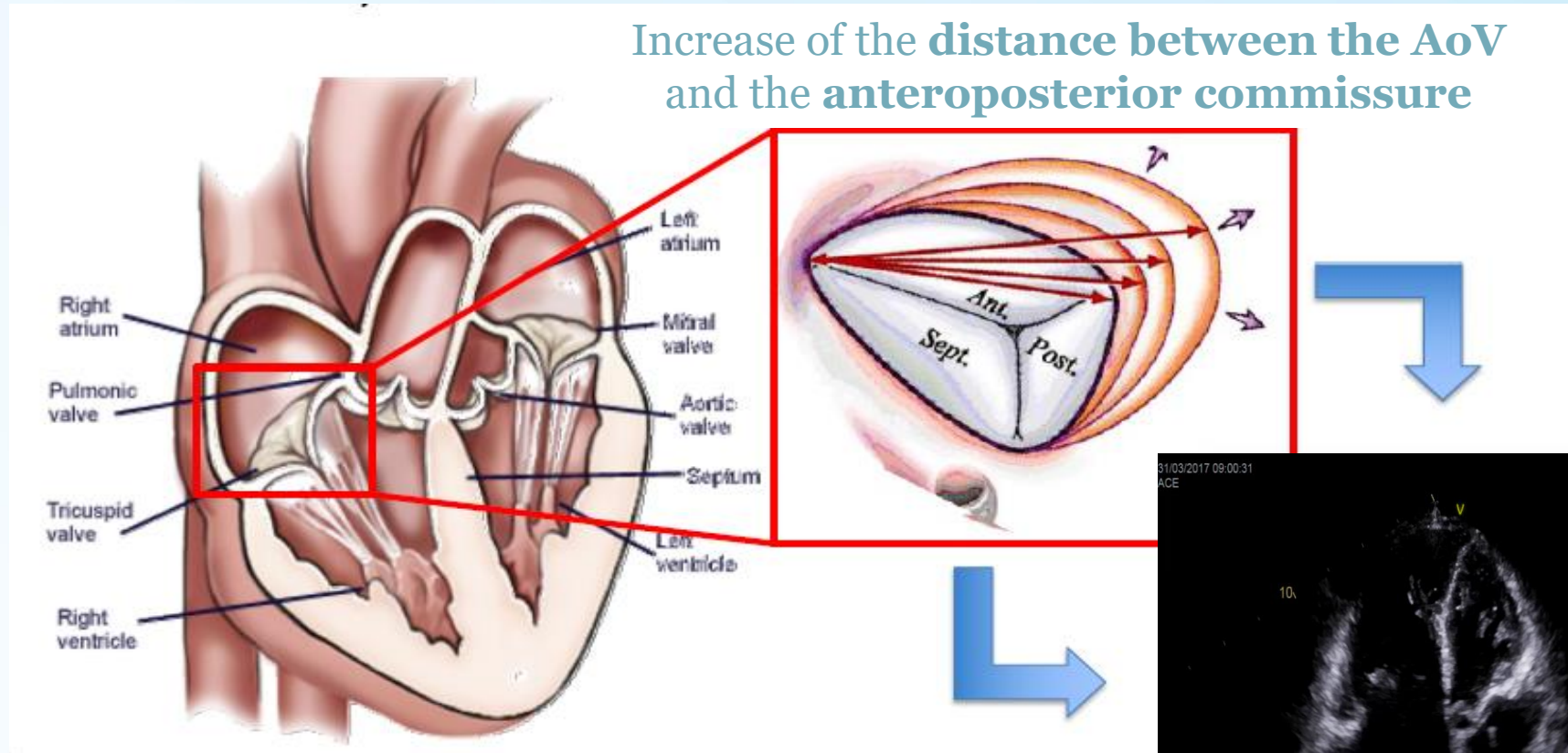


Impingement of posterior leaflet by ICD lead and lesion/flail of septal leaflet following lead extraction for endocarditis

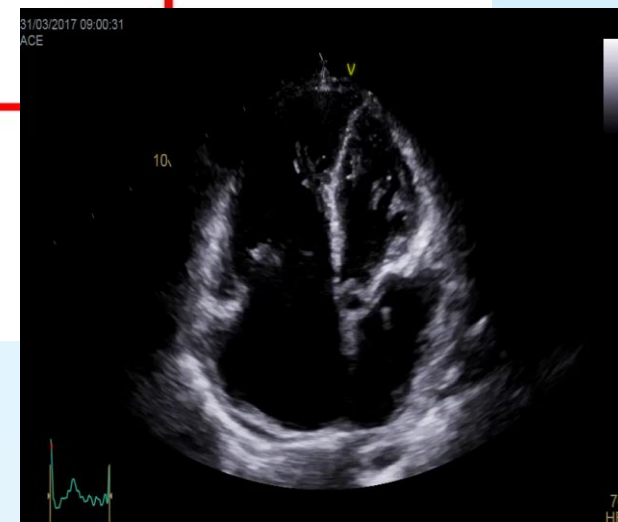
STR

TA dilatation versus leaflets tethering

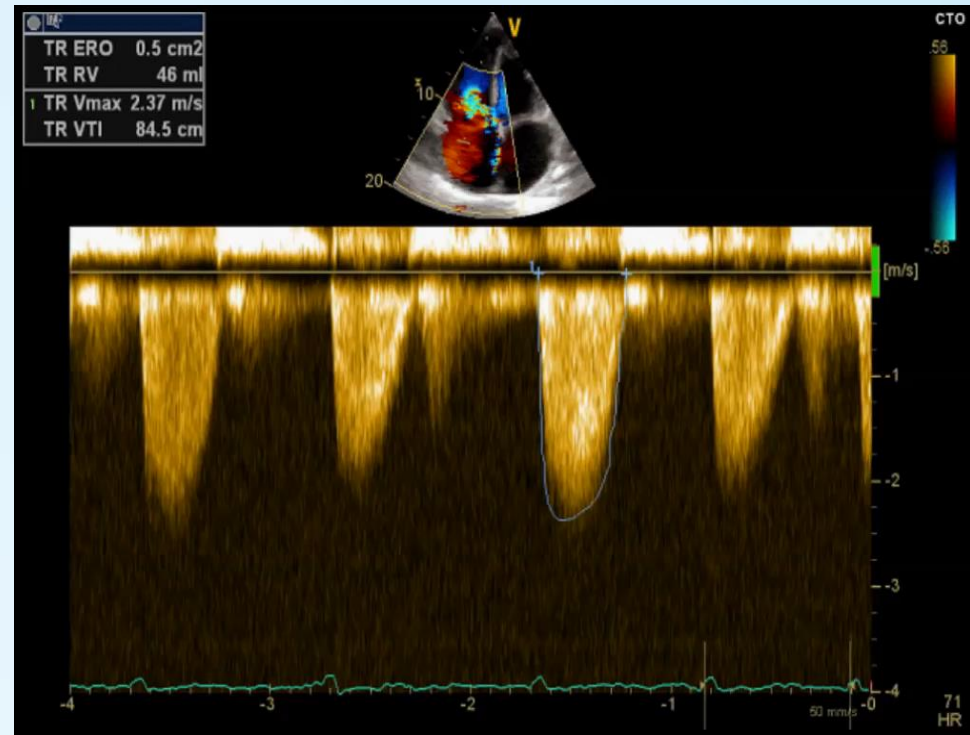
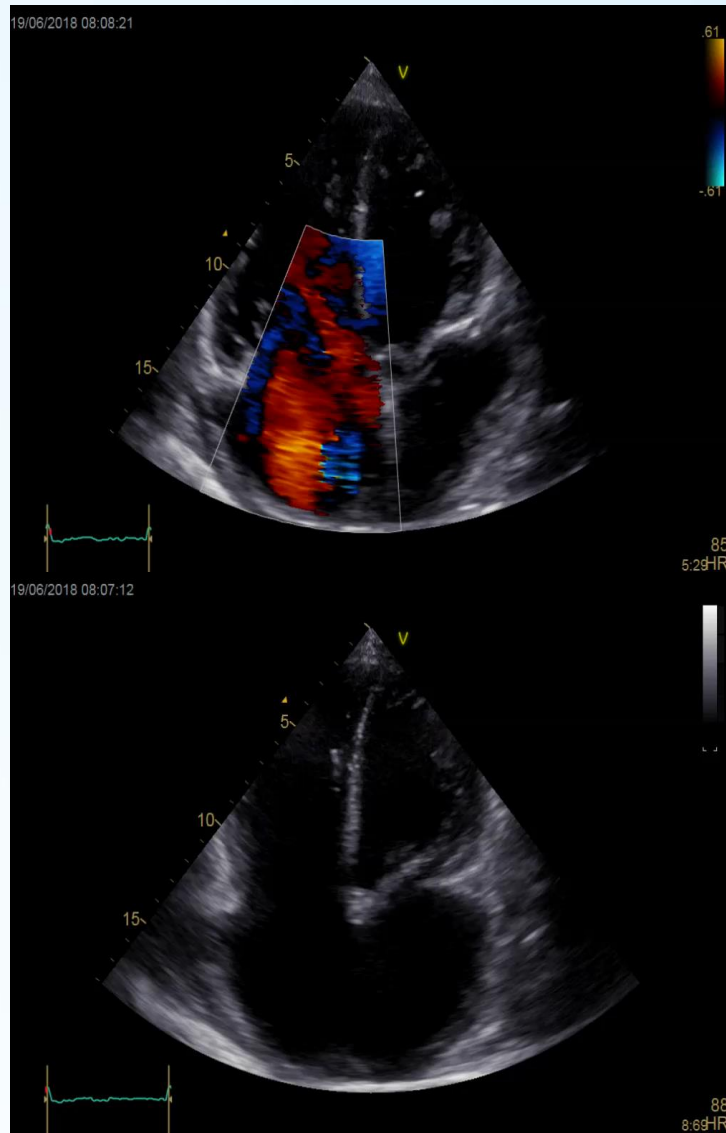




TV annular dilatation

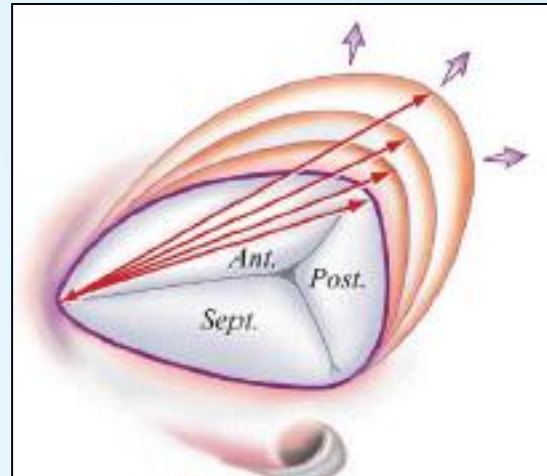
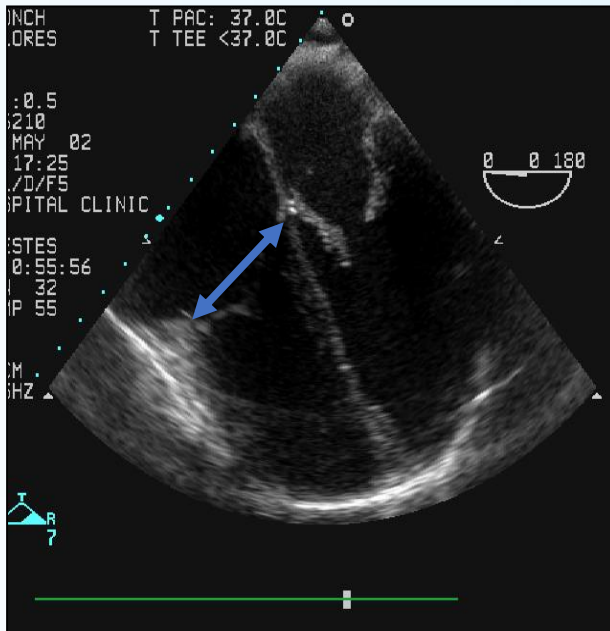


STR (AF)

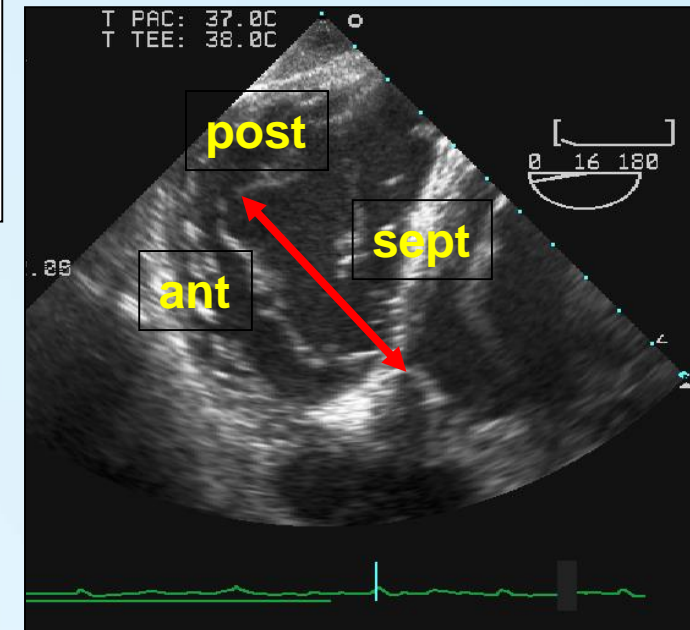
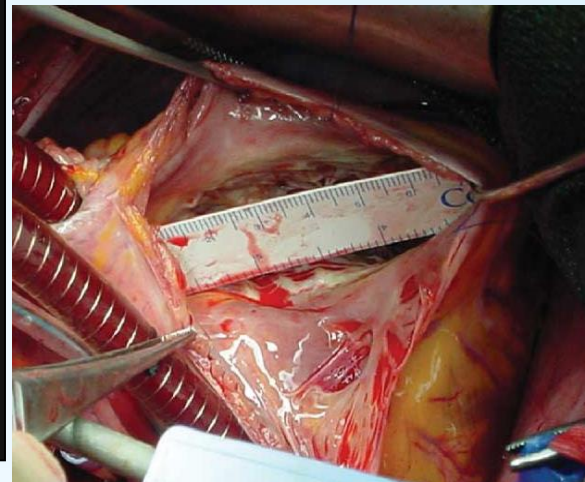


EROA: 50mm²

- **40 mm/21mm/mq**
TTE/TEE in diastole
(S – A/P)

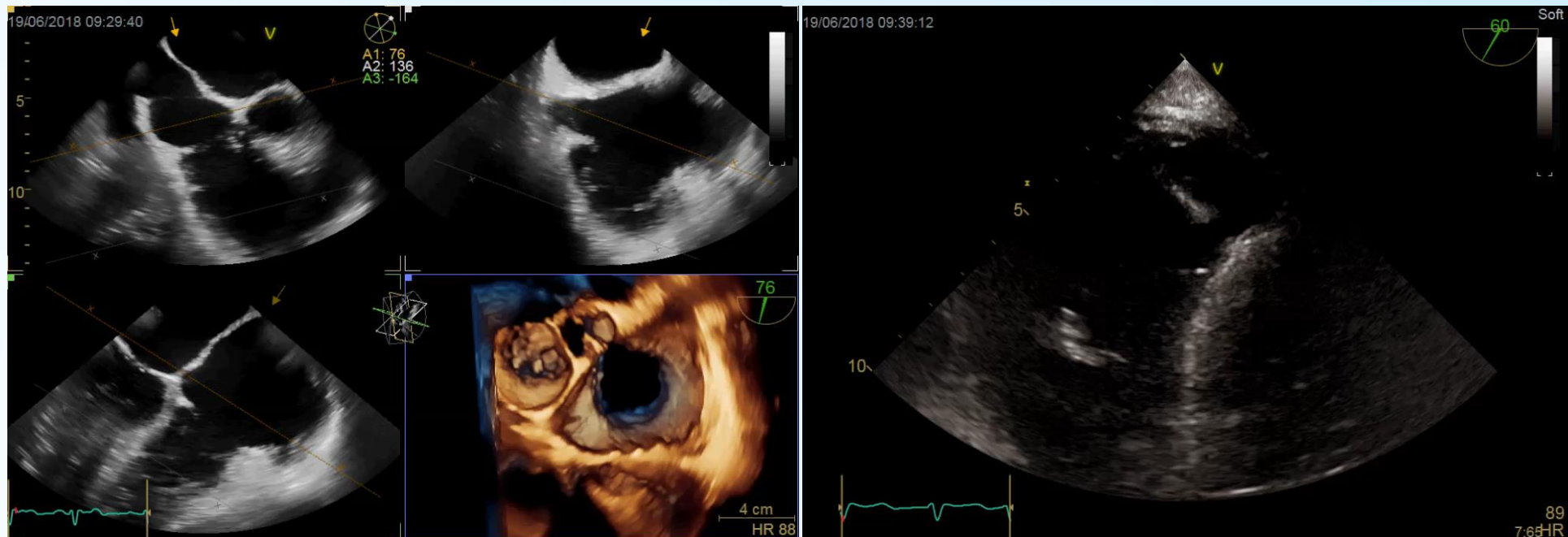


- **70 mm**
(intra operative sizing)



A-S to A-P commissure

TEE 3D (MPR) versus TEE 2D(TG)



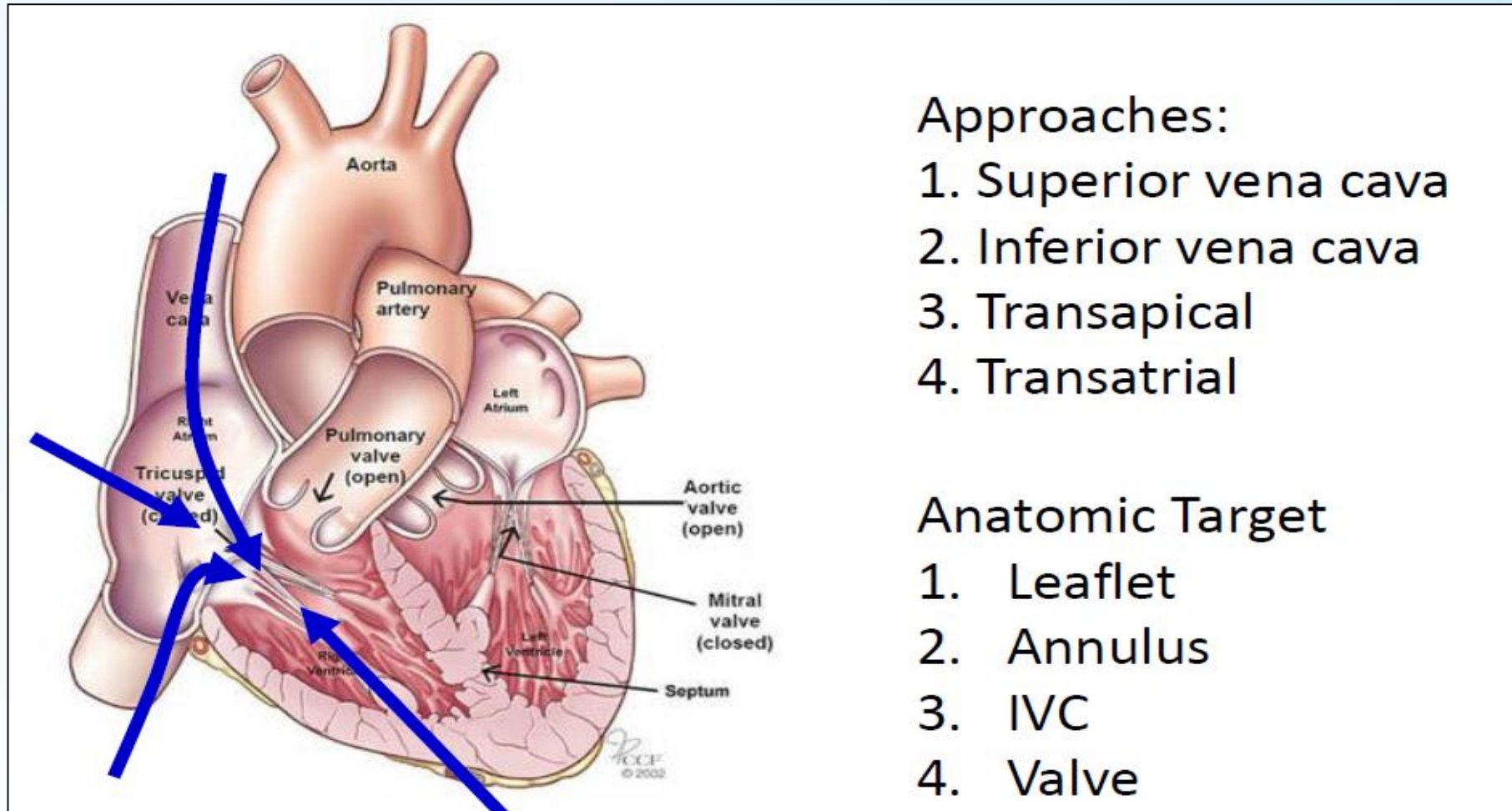
L'eco3D permette di :

- Vedere contemporaneamente tutti e tre i lembi TV sia dal versante atriale (*en face view*) che da quello ventricolare
- Misurare l'annulus (a livello delle commissure AS-AP)

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Transcatheter Tricuspid Solutions



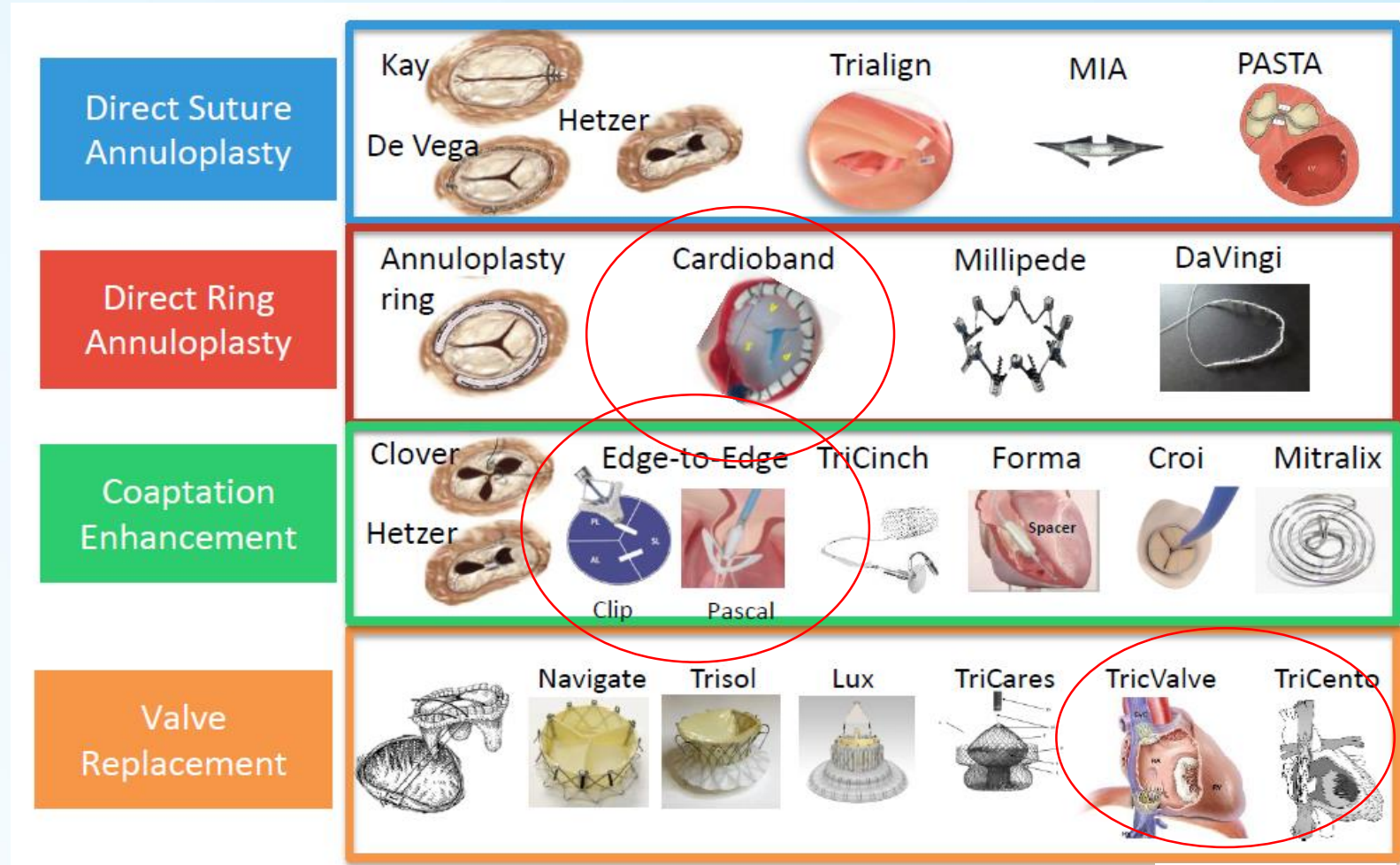
Approaches:

1. Superior vena cava
2. Inferior vena cava
3. Transapical
4. Transatrial

Anatomic Target

1. Leaflet
2. Annulus
3. IVC
4. Valve

Transcatheter
 Tricuspid
 Solutions



ORTHOTOPIC

HETEROTOPIC²⁸

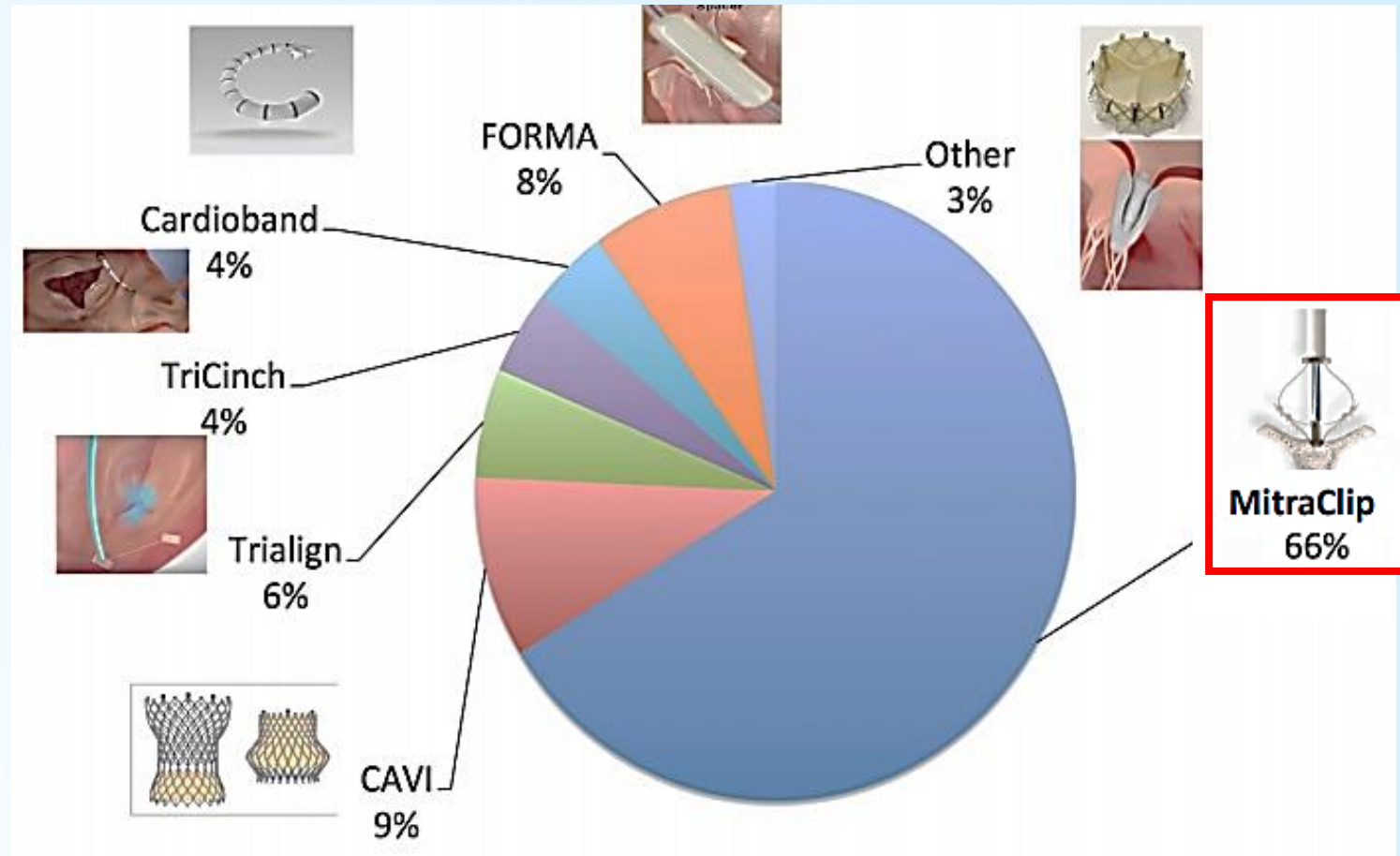
2021 ESC/EACTS Guidelines for the management of valvular heart disease

Recommendations on secondary tricuspid regurgitation		
Surgery is recommended in patients with severe secondary tricuspid regurgitation undergoing left-sided valve surgery. ^{423–427}	I	B
Surgery should be considered in patients with mild or moderate secondary tricuspid regurgitation with a dilated annulus (≥ 40 mm or > 21 mm/m ² by 2D echocardiography) undergoing left-sided valve surgery. ^{423,425–427}	IIa	B
Surgery should be considered in patients with severe secondary tricuspid regurgitation (with or without previous left-sided surgery) who are symptomatic or have RV dilatation, in the absence of severe RV or LV dysfunction and severe pulmonary vascular disease/hypertension. ^{418,433 e}	IIa	B
Transcatheter treatment of symptomatic secondary severe tricuspid regurgitation may be considered in inoperable patients at a Heart Valve Centre with expertise in the treatment of tricuspid valve disease. ^f	IIb	C

TriValve Registry

January 2014 – May 2018

N = 472



Echocardiographic Imaging for PreProcedural Planning of Transcatheter TV Interventions

Patient planning include **transthoracic (TTE)** and transesophageal echocardiography (TEE)

STATE-OF-THE-ART REVIEW

Key Echocardiographic Considerations for Tricuspid Valve Transcatheter Edge-to-Edge Repair



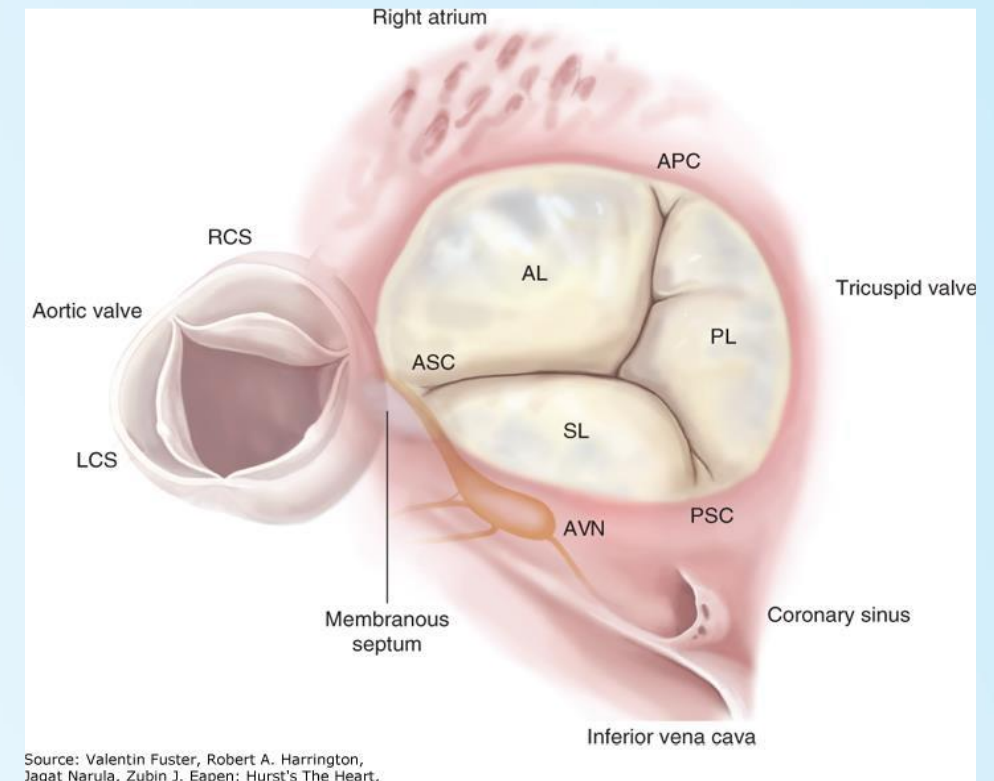
Sara L. Hungerford, MBBS, PhD, Eleanor E. Rye, MBBS, Peter S. Hansen, MBBS, PhD,
Ravinay Bhindi, MBBS, MSc, PhD, and Christopher Choong, MBBChir(Cantab), PhD, *Sydney, Australia; and
Boston, Massachusetts*

imaging is essential to optimal patient selection and procedural success. The current review will provide a comprehensive overview of TV anatomy, the updated mechanistic classification of TR, and key echocardiographic considerations in the evaluation, management, and follow-up of patients undergoing TV TEER. (J Am Soc Echocardiogr 2023;36:366-80.)

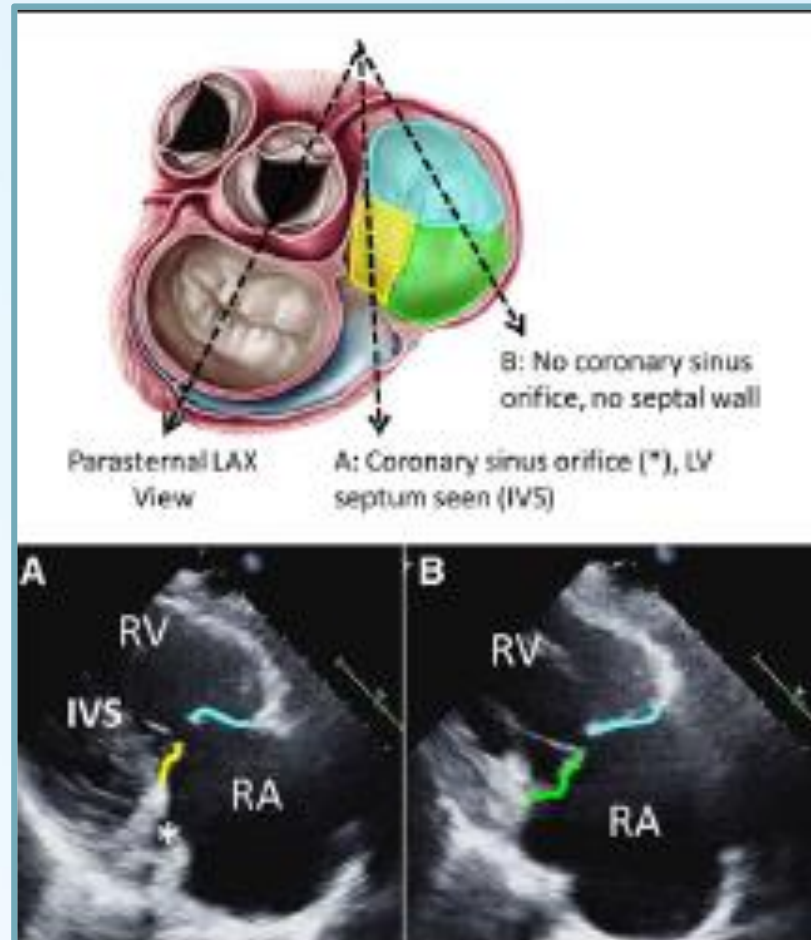
Essential Procedure References- Anatomical Landmarks

Landmarks used to orient on echo:

- **Aorta**
 - Septal-Anterior Commissure in TGSX or in 3D
- **Coronary Sinus**
 - Septal-Posterior Commissure

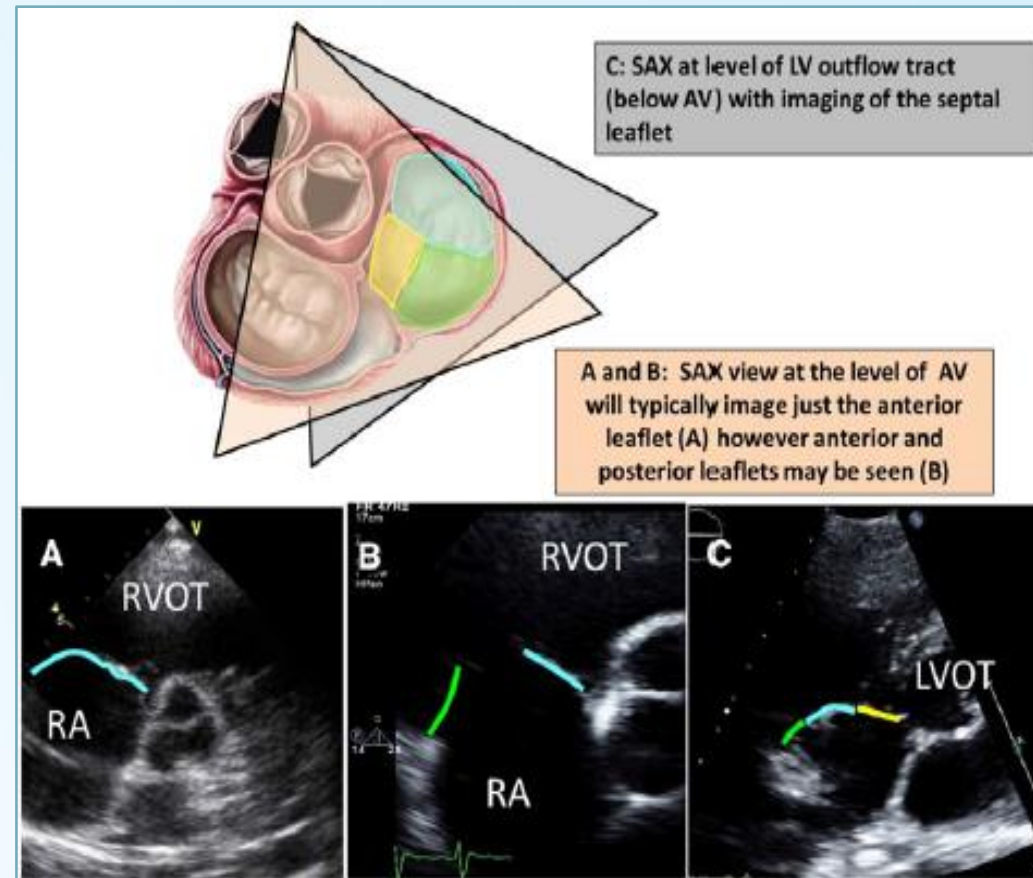


2TTE: Parasternal inflow views/RV Inflow View



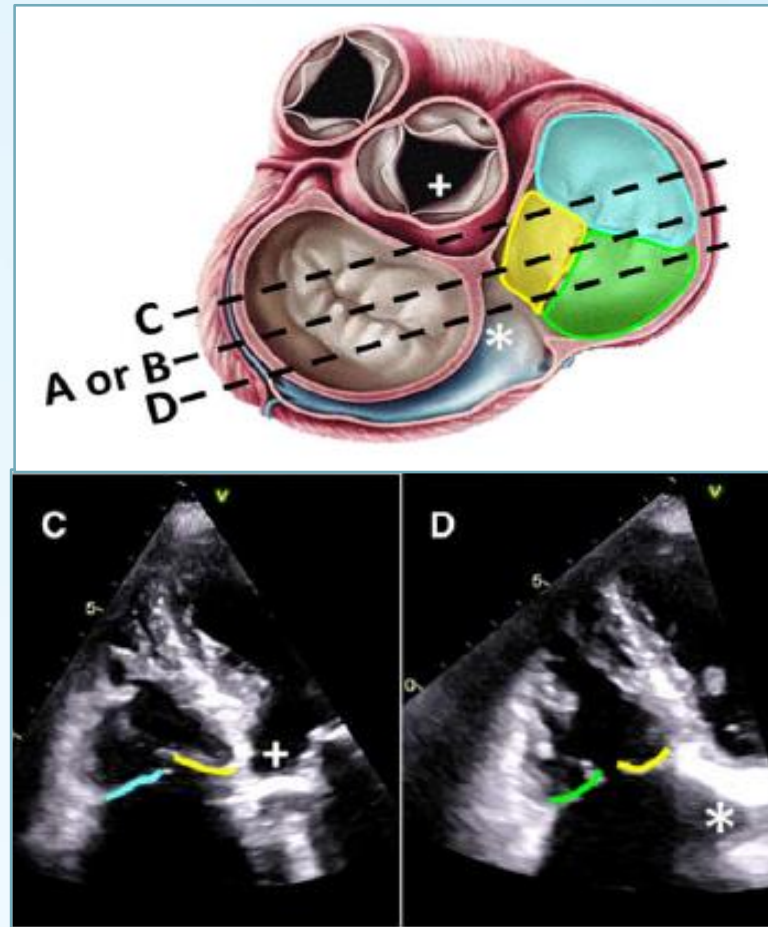
SL: septal leaflet
AL: anterior leaflet
PL: posterior leaflet (mural)

2TTE: Parasternal short axis views



SL: septal leaflet
AL: anterior leaflet
PL: posterior leaflet (mural)

2TTE: Apical chamber views



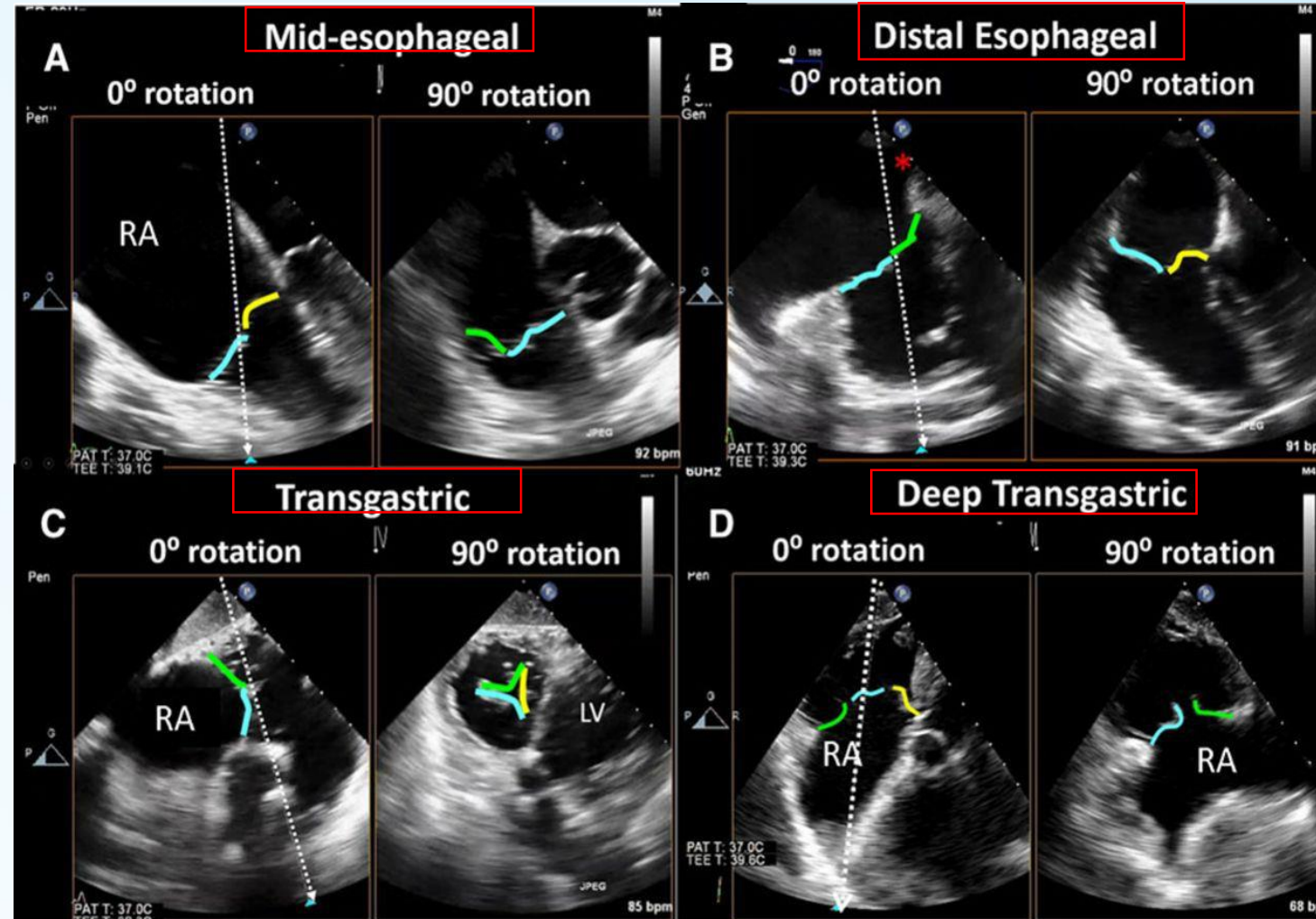
SL: septal leaflet
AL: anterior leaflet
PL: posterior leaflet (mural)

TEE: Multilevel imaging of TV

SL: septal leaflet
 AL: anterior leaflet
 PL: posterior leaflet

ME

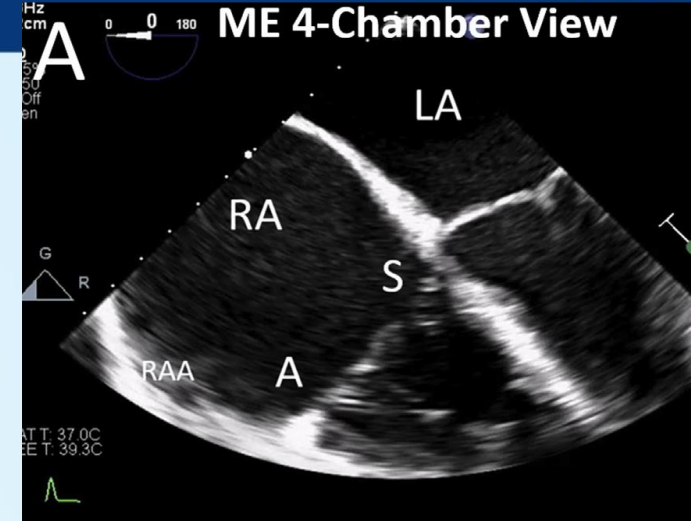
TG



DE

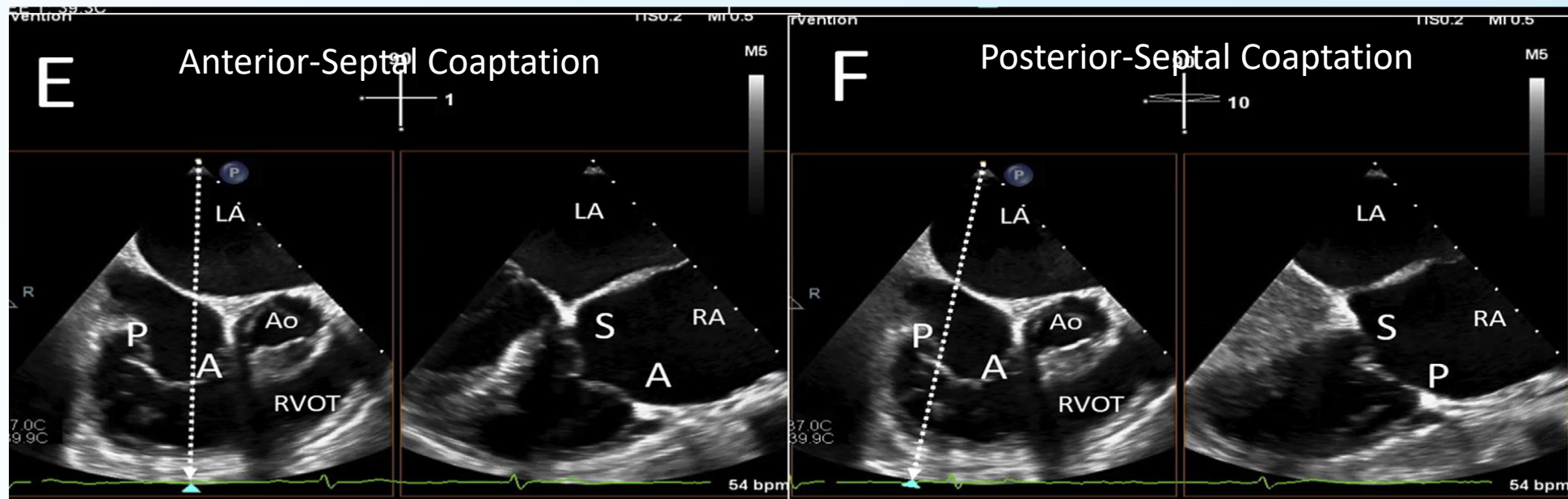
DT

TEE (2D/3D MultiD) Mid-esophageal
 (4-chamber view at 0°)

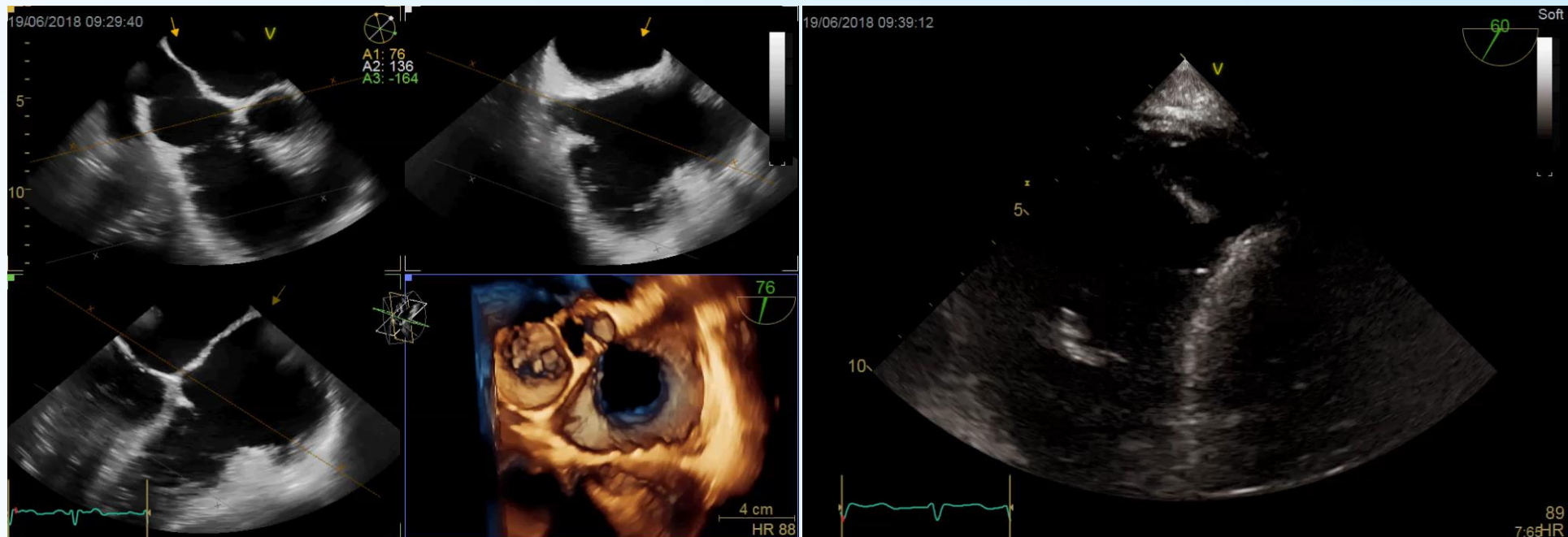


RV inflow-outflow view at 60°

SIMULTANEOUS BIPLANE VIEW
TV Commisural «Home»View



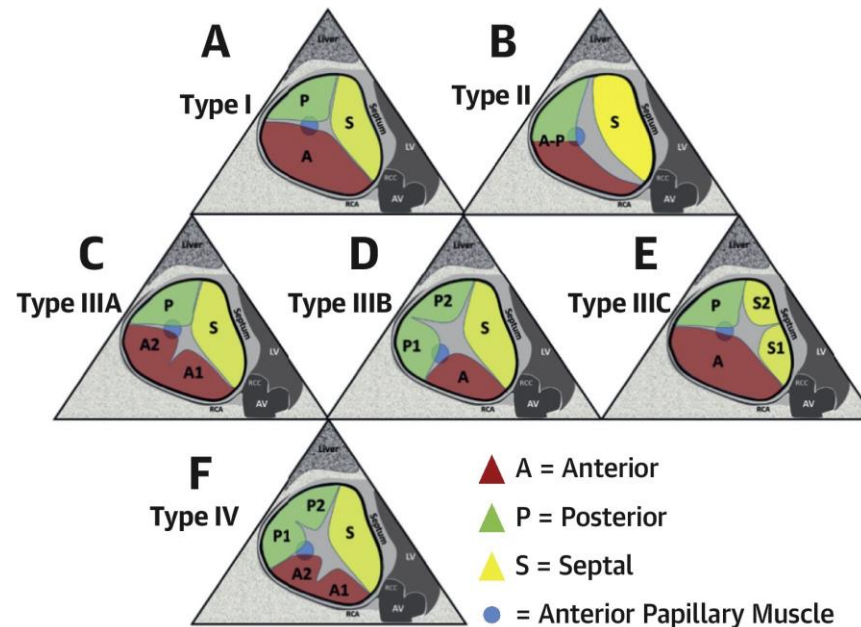
TEE 3D (MPR) versus TEE 2D (TG)



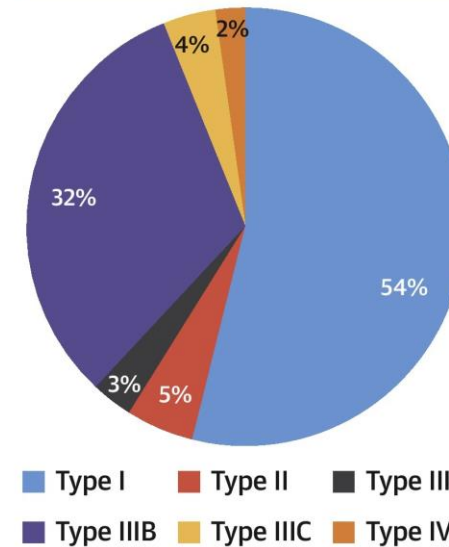
If 3D imaging is adequate to see the leaflet tips, **measurement of leaflet lengths, coaptation gaps, and color Doppler vena contracta width or area at the site of malcoaptation** can be performed using **3D multiplanar reconstruction** (either real time or offline).

The anatomic variability of the TV

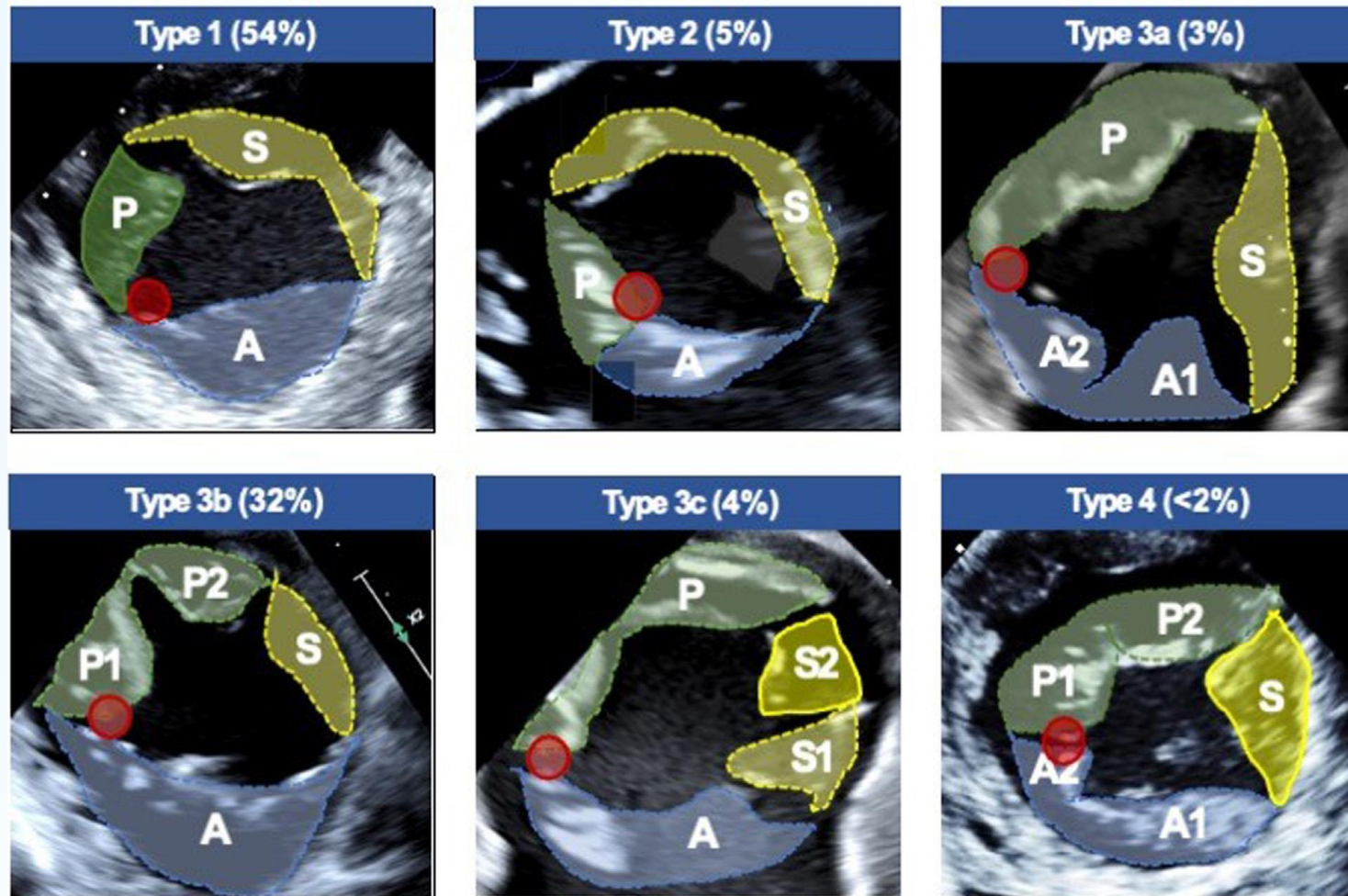
CENTRAL ILLUSTRATION: Tricuspid Valve Nomenclature Classification Scheme



Incidence of Tricuspid Morphologies

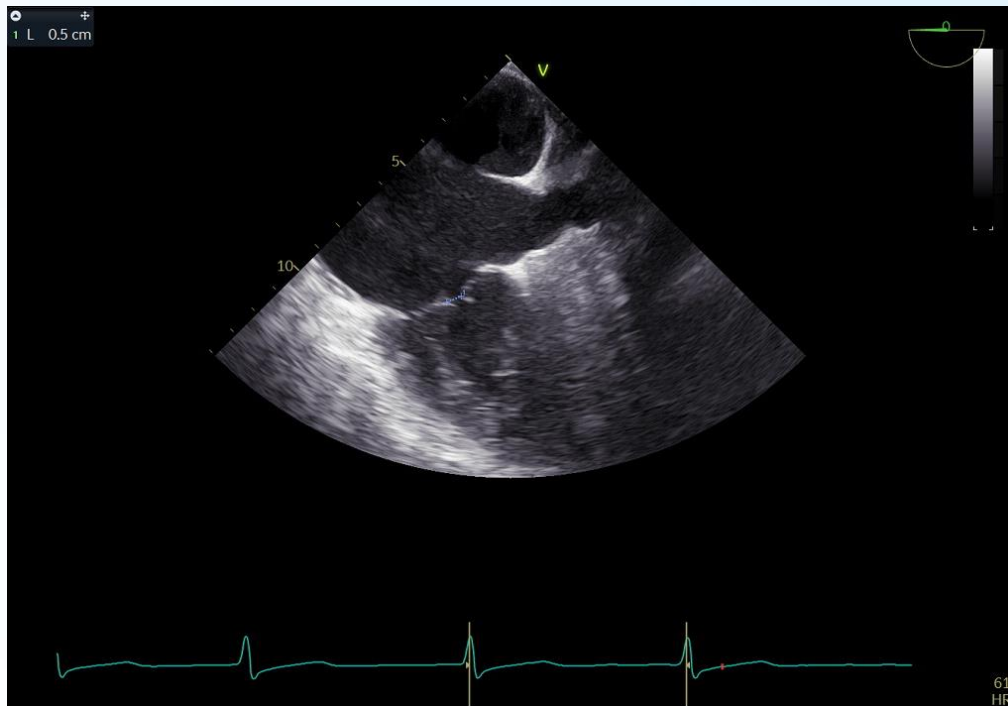


Classification of Tricuspid Valve Leaflet Morphology

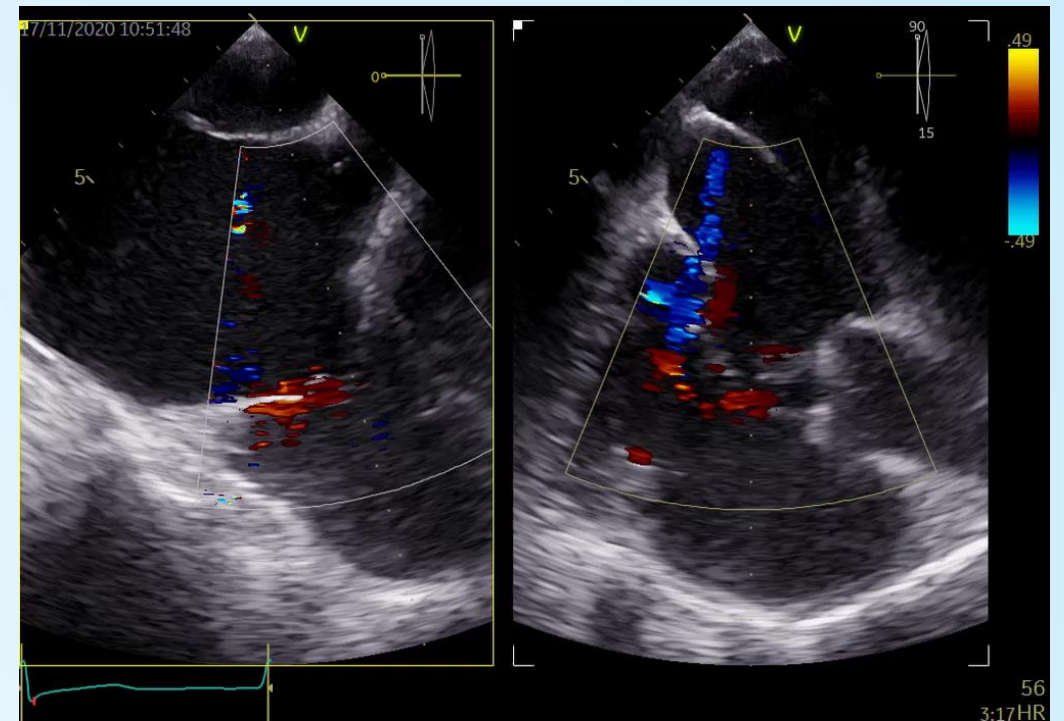


TEE (2D/3D MultiD)

Distal(Deep)-esophageal view

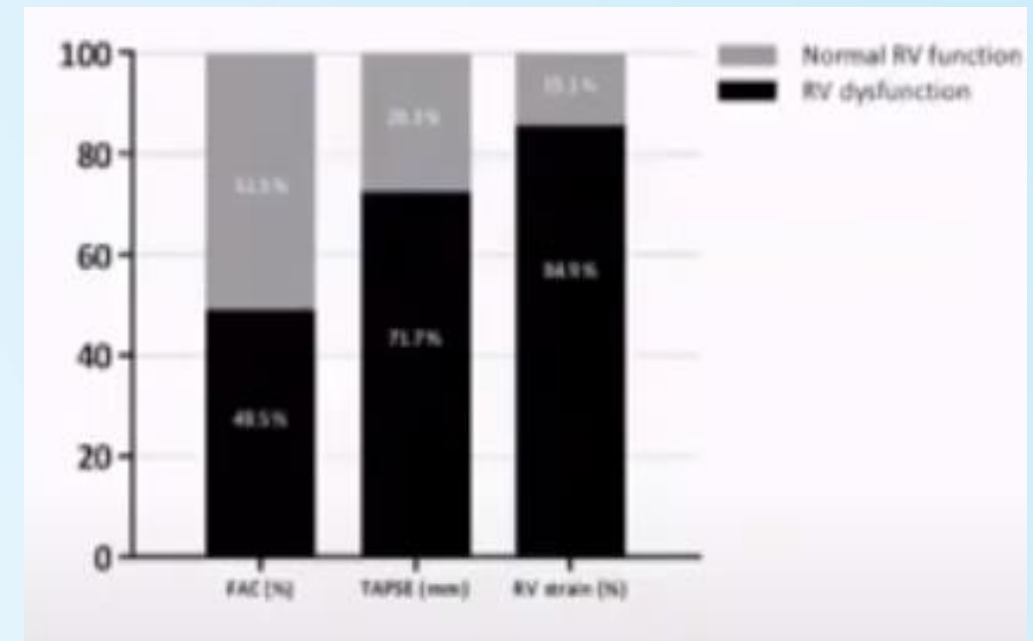
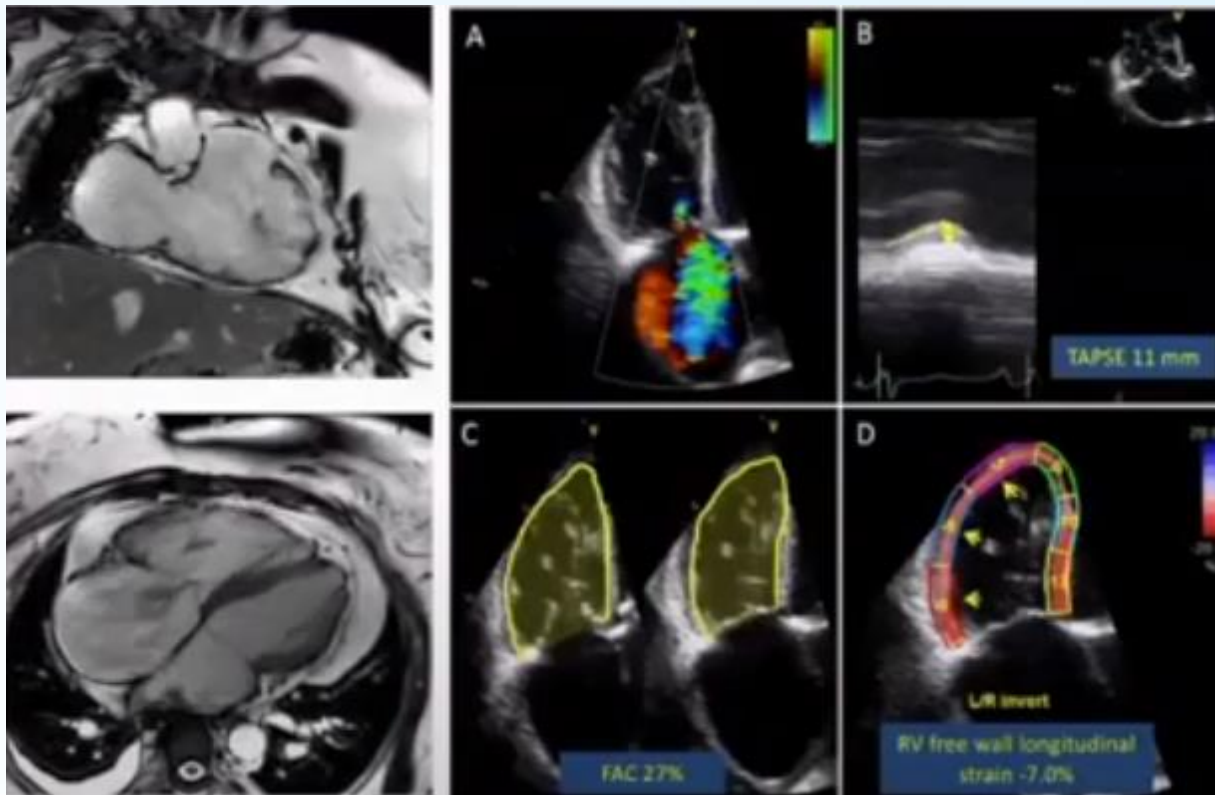


Simultaneous Biplane View

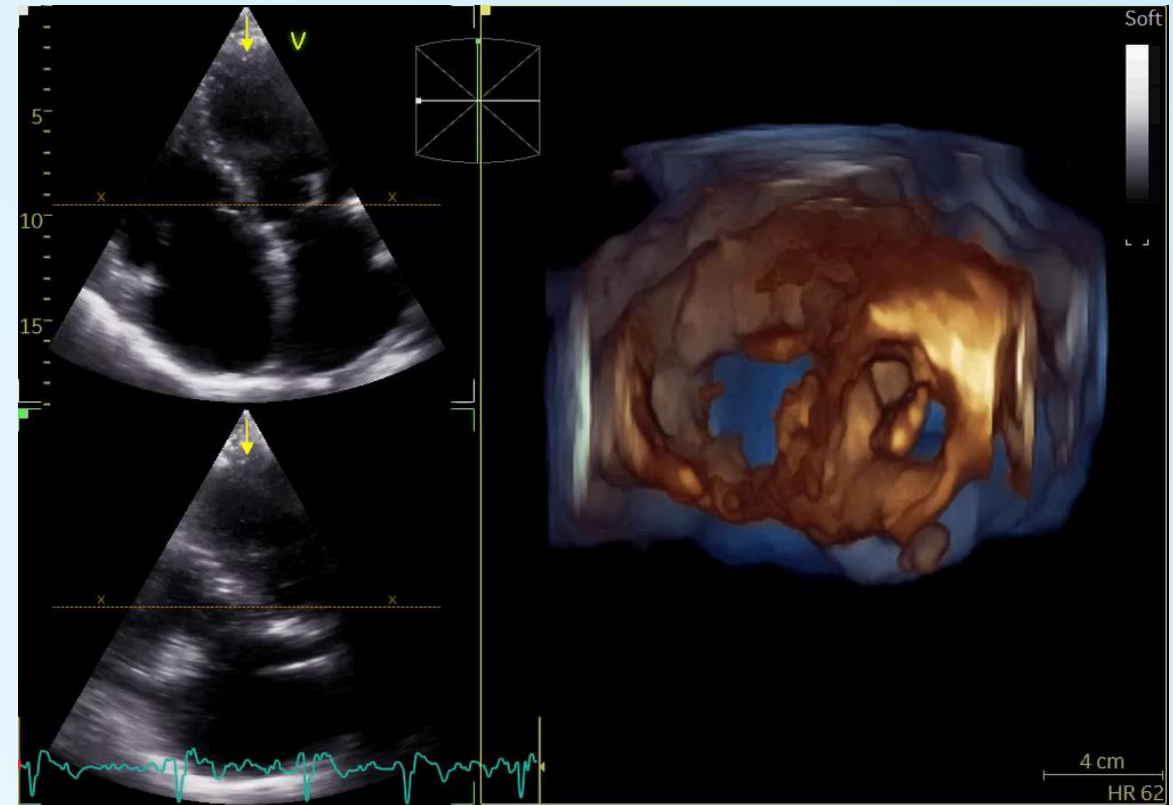
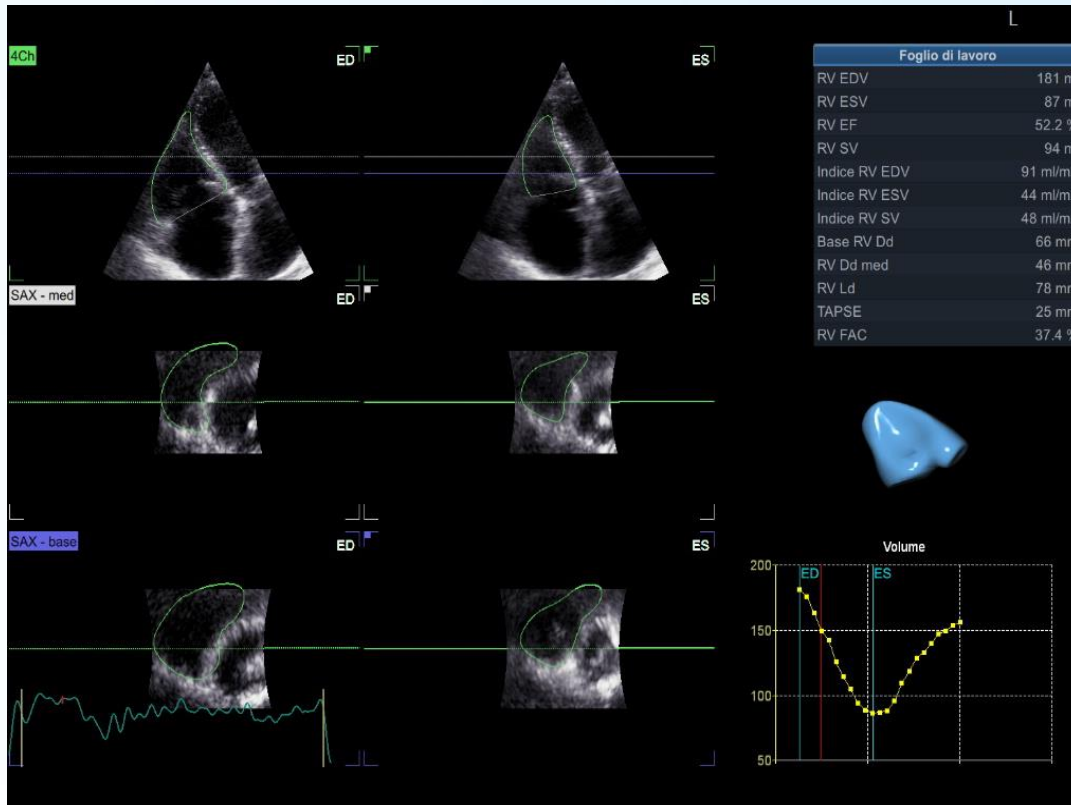


- **GE junction**
- **Eliminates LA from view**
- **Closer to TV**

RV function (2DTTE, 3DTTE, DTI, RV longitudinal Strain)



RV function: 3D methods Volumes/EF%/Stroke volume



Transcatheter treatment for tricuspid valve disease

Fabien Prax^{1*}, MD; Denisa Muraru², MD; Felix Kreidel³, MD; Philipp Lurz⁴, MD; Rebecca T. Hahn⁵, MD; Victoria Delgado⁶, MD; Michele Senni⁷, MD; Ralph Stephan von Bardeleben⁸, MD; Georg Nickenig⁹, MD; Jörg Hausleiter⁹, MD; Antonio Mangiari¹⁰, MD; Jose L. Zamorano¹¹, MD; Bernard Prendergast¹², MD; Francesco Maisano¹³, MD

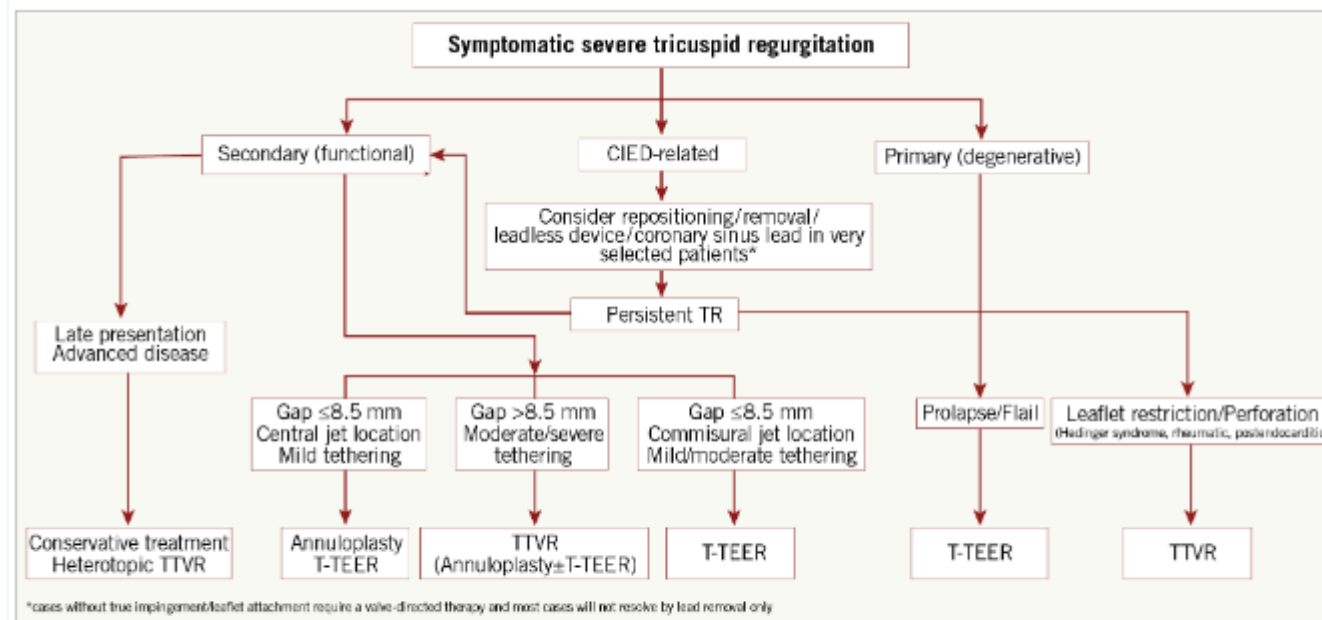


Figure 6. Proposed algorithm for the selection of TTVI systems. CIED: cardiac implantable electronic device; T-TEER: tricuspid transcatheter edge-to-edge repair; TTVR: transcatheter tricuspid valve replacement

General eligibility criteria for T-TEER

Severe TR: (VC width >7 mm, EROA >40 mm², RV >45 ml)

No severe LV dysfunction (LVEF <30%)

No severe RV dysfunction

No severe PAH (systolic PAP < 60 mm Hg)

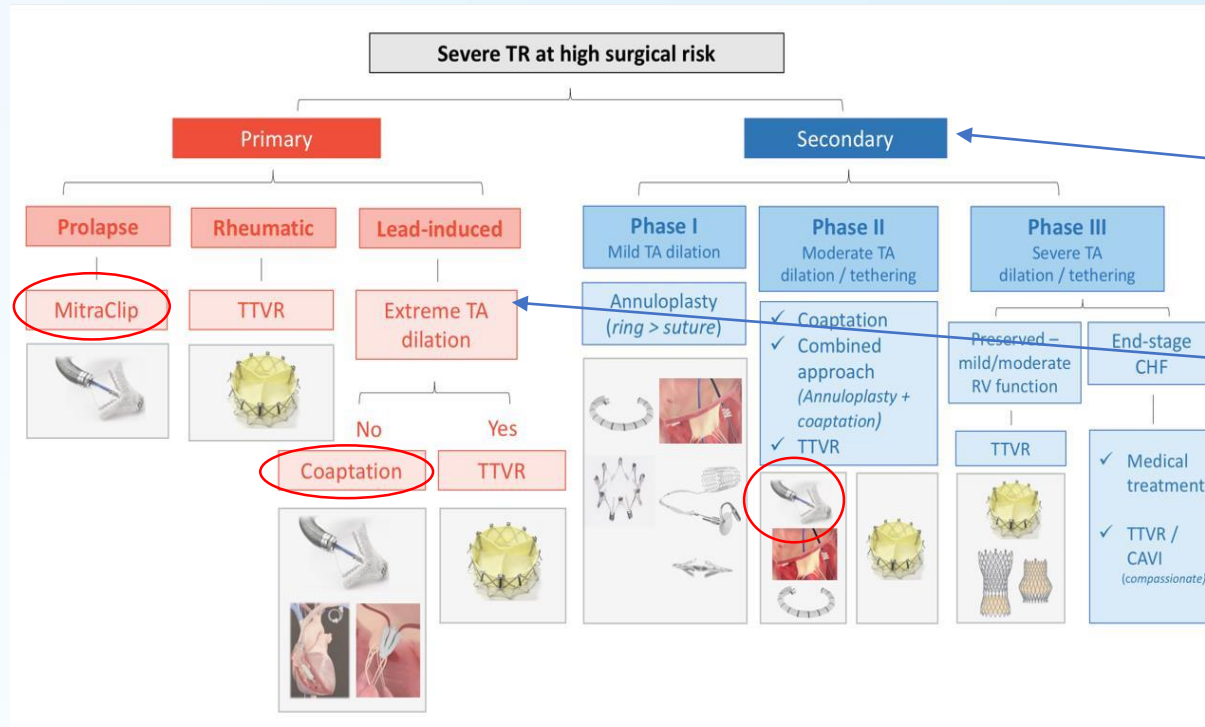
Specific TriClip eligibility criteria, views, and measures

Use mid- and deep-esophageal and transgastric (short- and long-axis) views

Secondary TR with normal leaflets or primary TR with valve prolapse

- Coaptation depth <10 mm
- **Coaptation gap <7.2 mm (ideally <4.0 mm) using MitraClipNT**
- **CGS ≤8.4 mm using MitraClip XTR**
- Leaflet length >10 mm
- Location of main TR jet: central/antero-septal
- No pacemaker leads or no interaction between pacemaker leads and tricuspid valve leaflets

Algorithm for TTVR device selection based on mechanism and pathoanatomy of TR

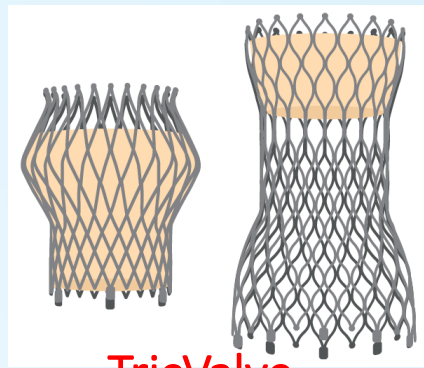


When Tricuspid annulus severely dilated or prior pacemaker leads (~11%)³
↓
Caval valve implantation (CAVI) might be the preferred option

CAVI (Tricvalve) or Tricento

Key message: for progressed right heart disease Tricvalve/TRICENTO can be a therapeutic option

Transcatheter solution for patients with advanced TV disease



TriCento



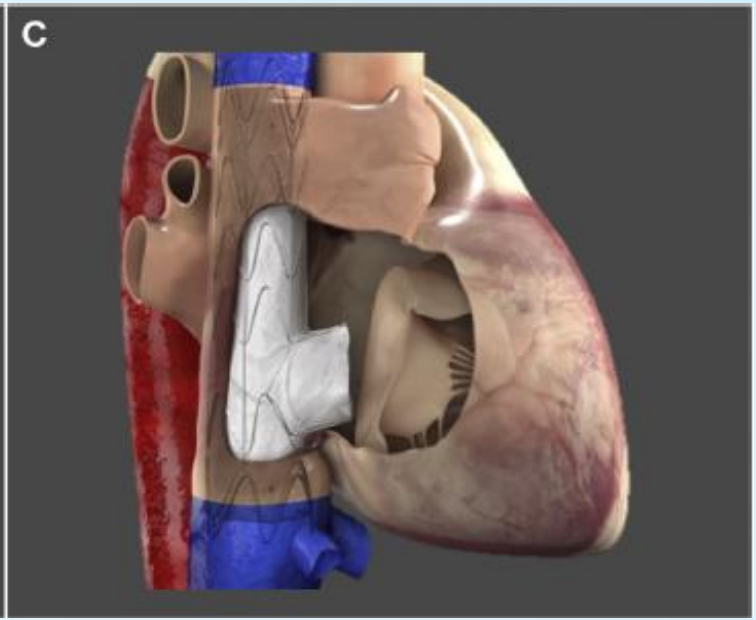
B



A

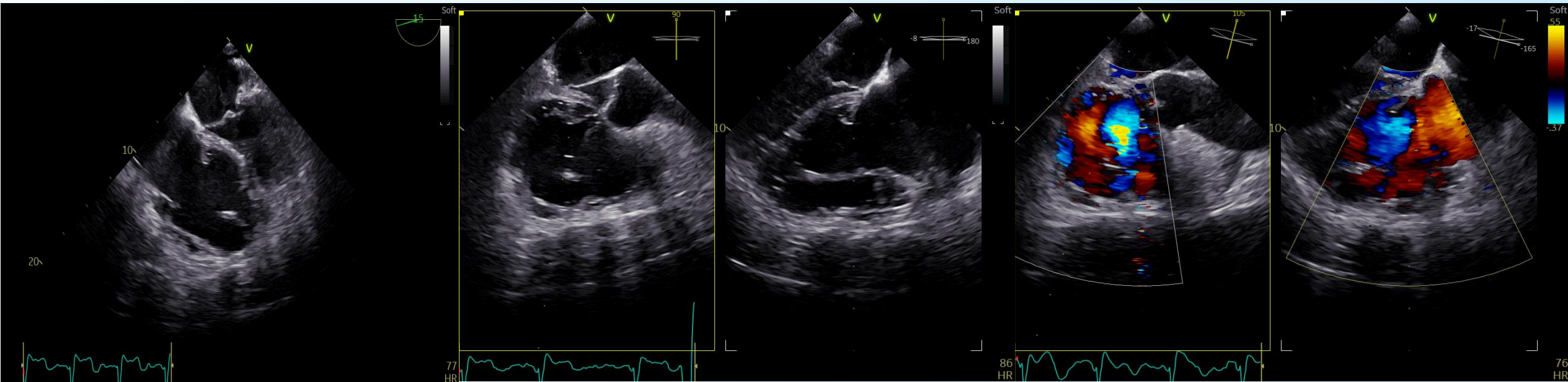


B



C

TTVR device selection based on mechanism and pathoanatomy of TR

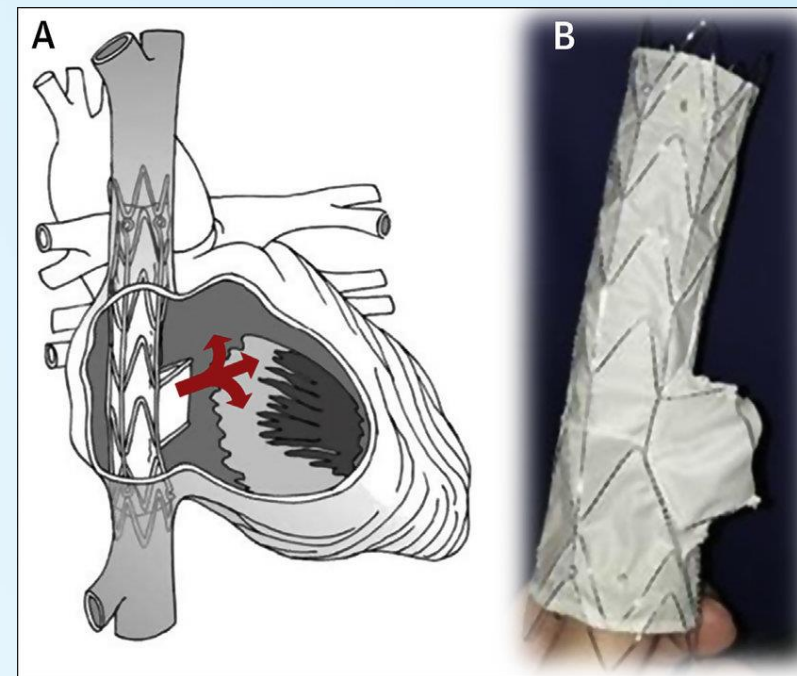


- 84 y, female
- Pulmonary hypertension, dyslipidemia
- Permanent AF
- Diabetes type 2
- IRC IV stage
- Actually NYHA III
- B-blockers, spironolactone 50 mg, furosemide 125 mg, apixaban 2.5 mg x 2, atorvastatin 40 mg

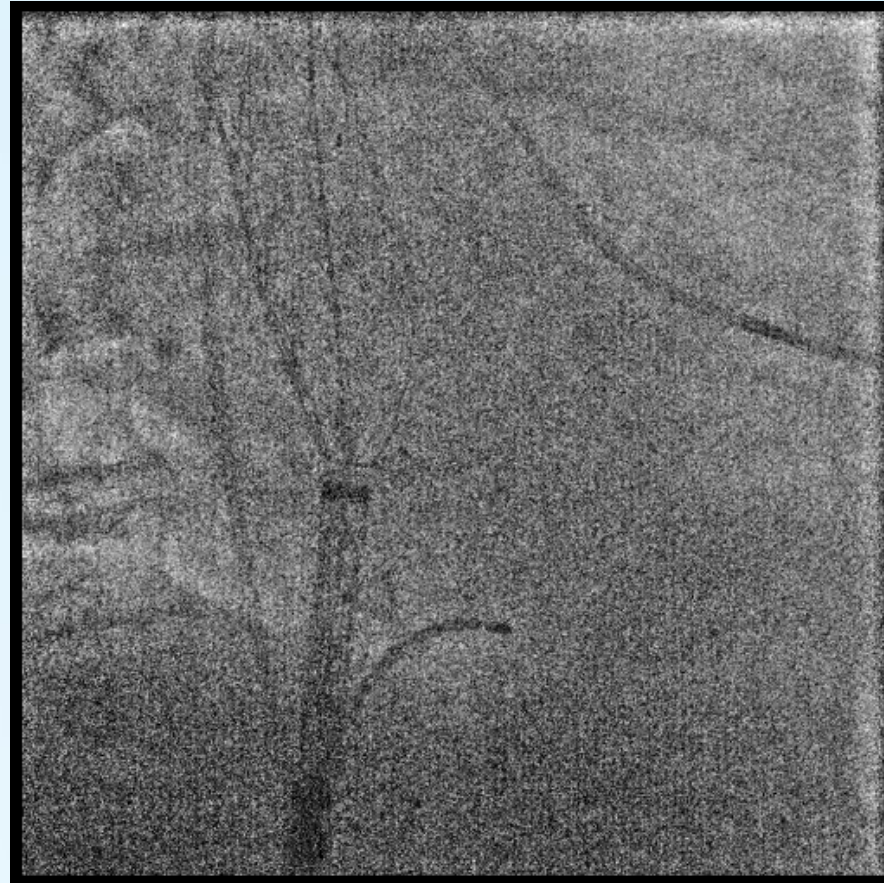
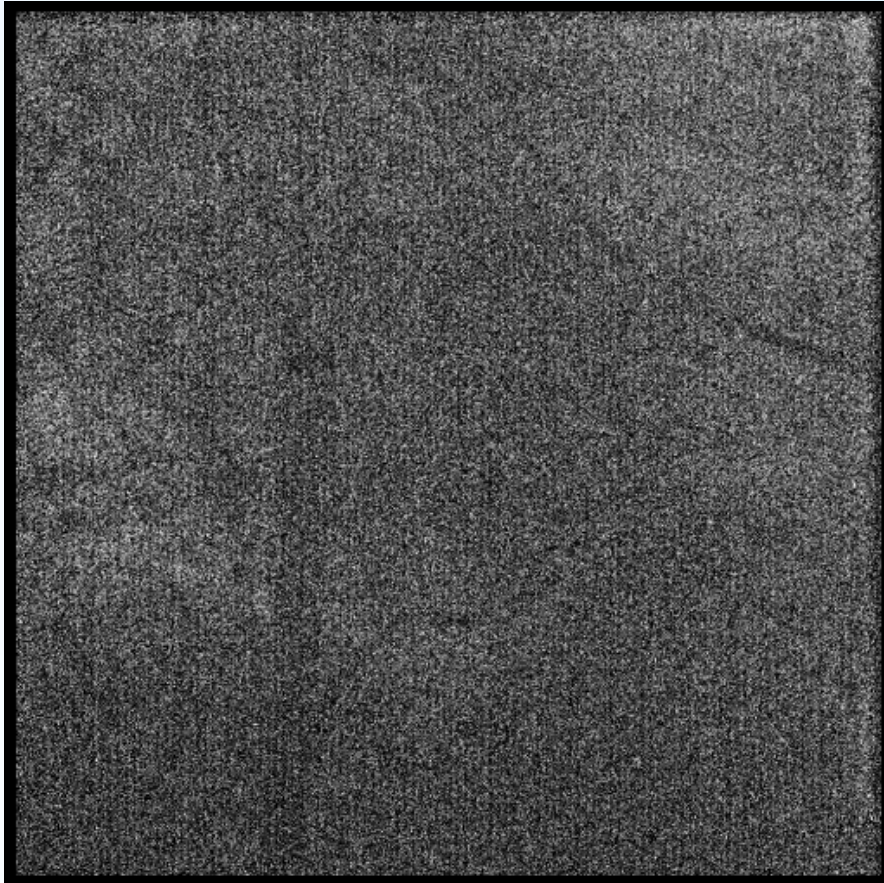
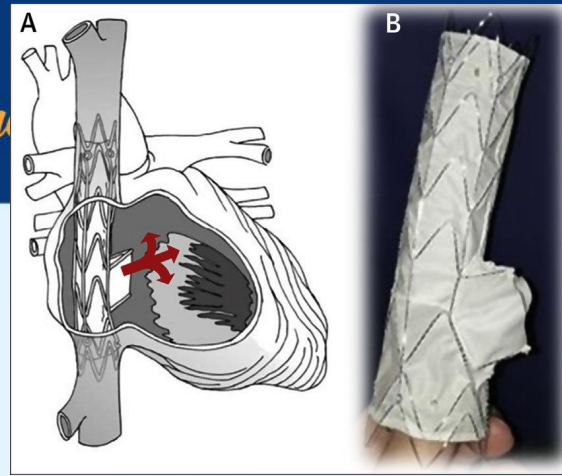
ECHO TTE

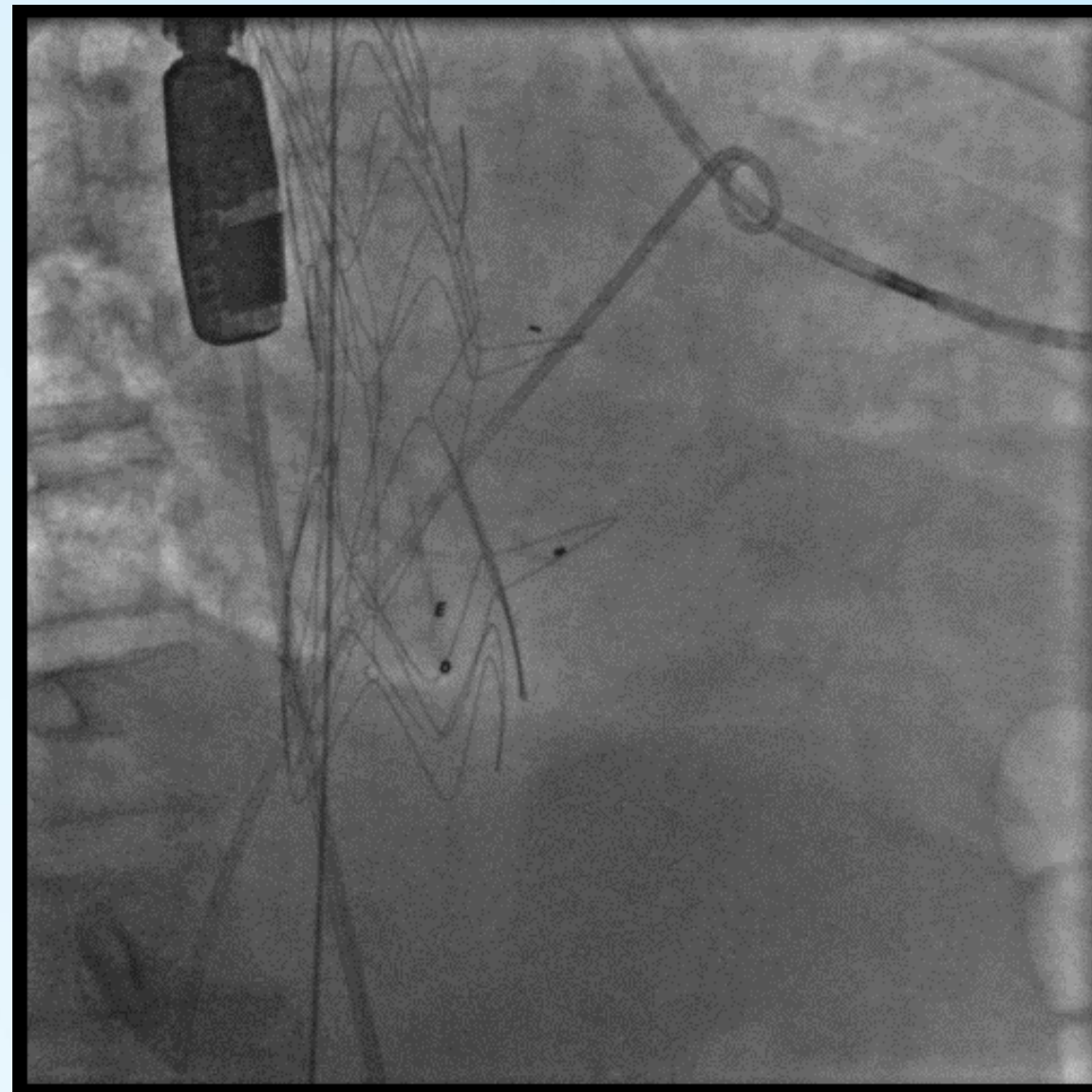
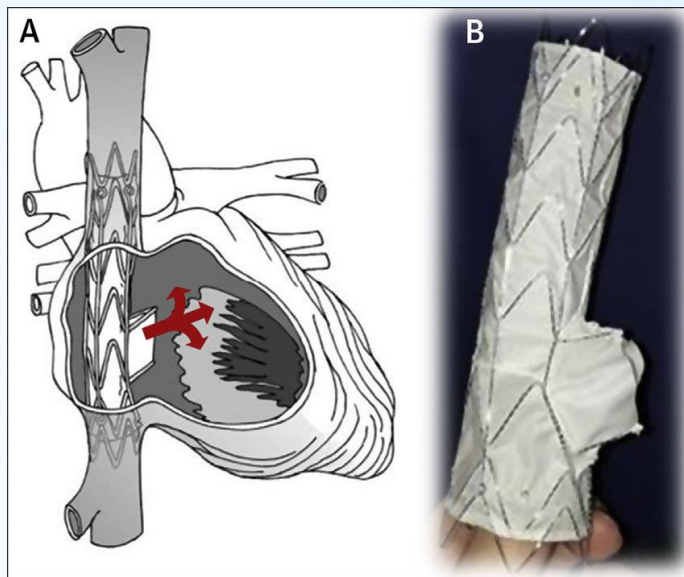
- FE 60%
- IM 1+/4+
- IT 4+/5+
- RA and LA dilatation
- Severe RV dilatation
- TAPSE 18 mm
- PAPs 50 mmHg
- IVC dilatation (21 mm)
- Large septolateral coaptation gap (12 mm)
- Unfavourable anatomy for Triclip

TRICENTO



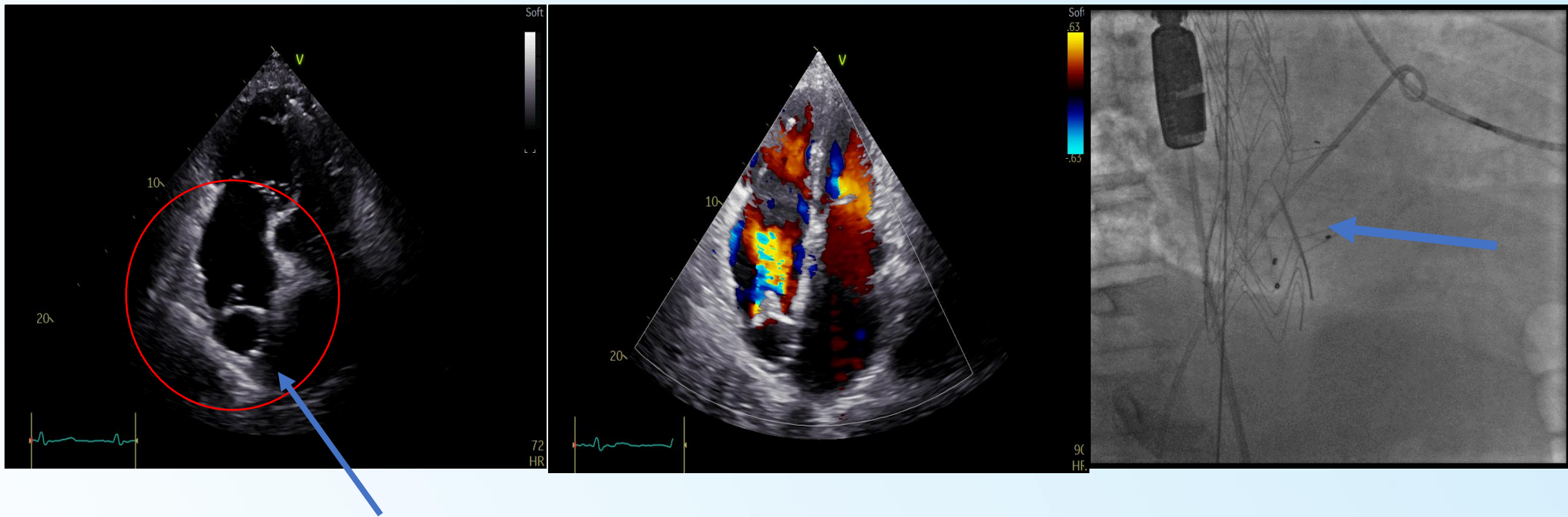
Almost 70 implants worldwide
Cardiologia Vanvitelli 6 implants





TTVR device selection based on mechanism and pathoanatomy of TR

CAVI (Tricento)



Key message: for progressed right heart disease TRICENTO can be a therapeutic option

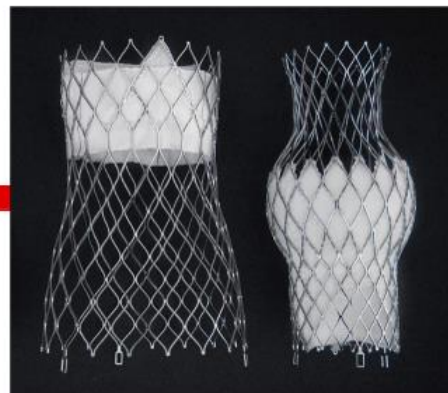
INFERIOR VENA CAVA

SHORT SKIRT to prevent hepatic vein occlusion

BOVINE PERICARDIUM leaflets and skirt

High strength NITINOL frame

PTFE suture line



SUPERIOR VENA CAVA

LONG SKIRT to prevent PVL

BOVINE PERICARDIUM leaflets and skirt

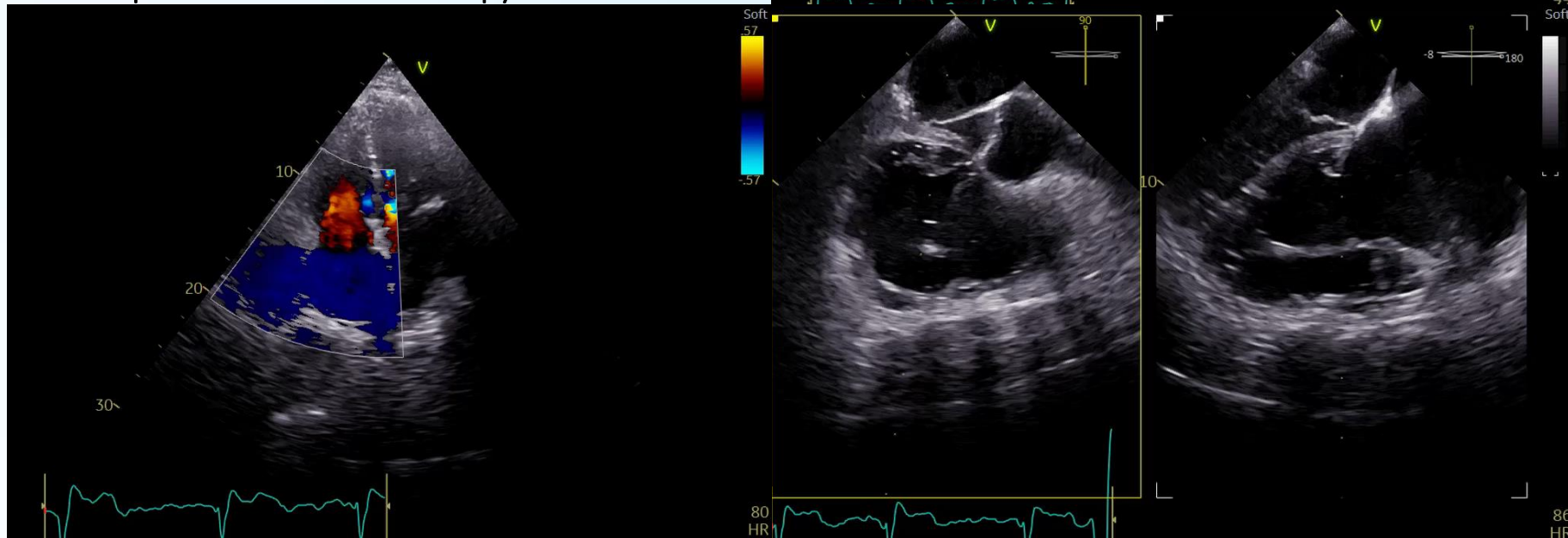
High strength NITINOL frame

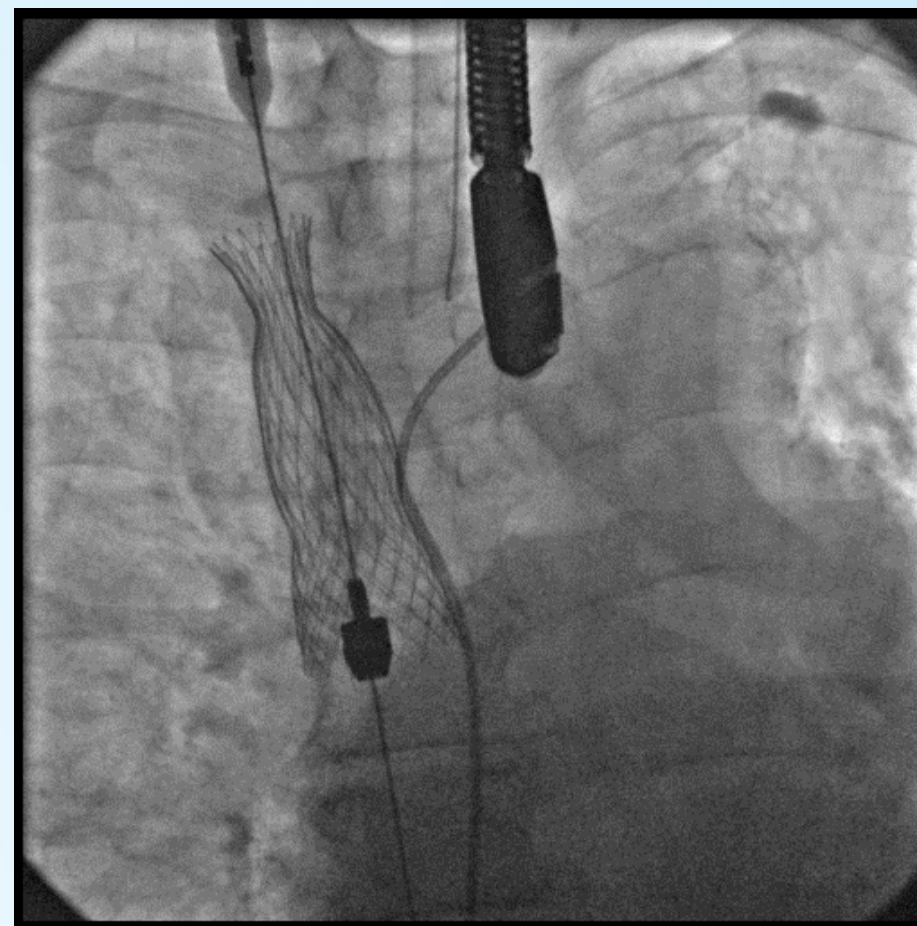
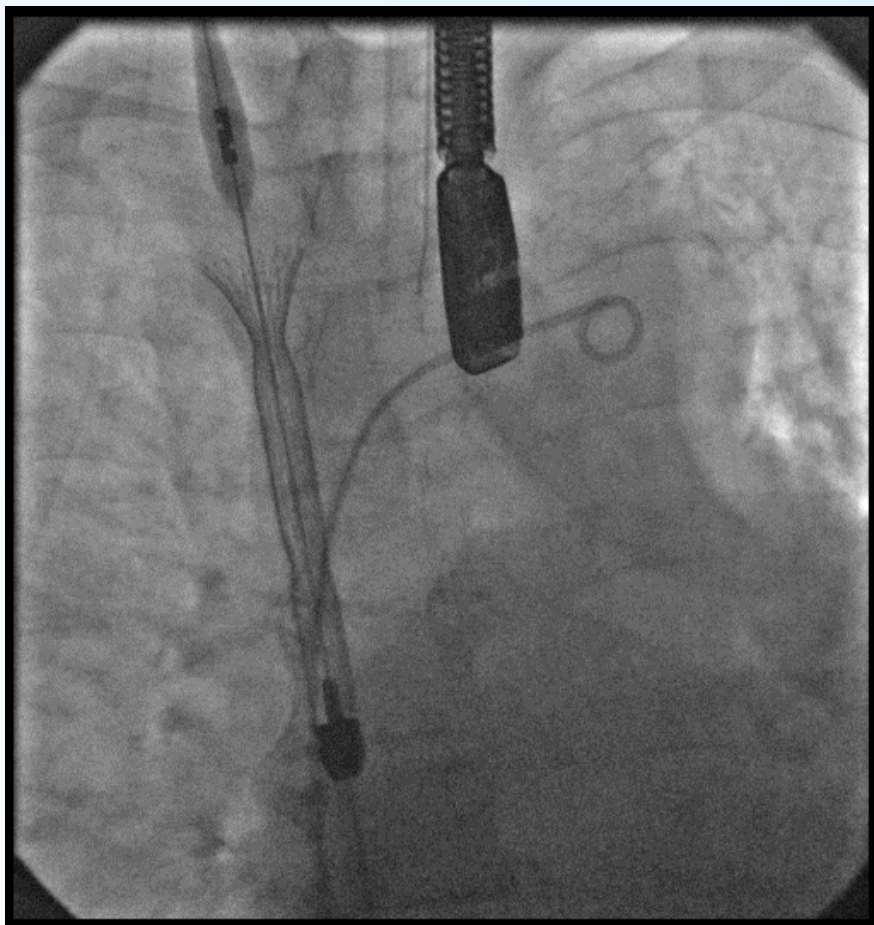
PTFE suture line

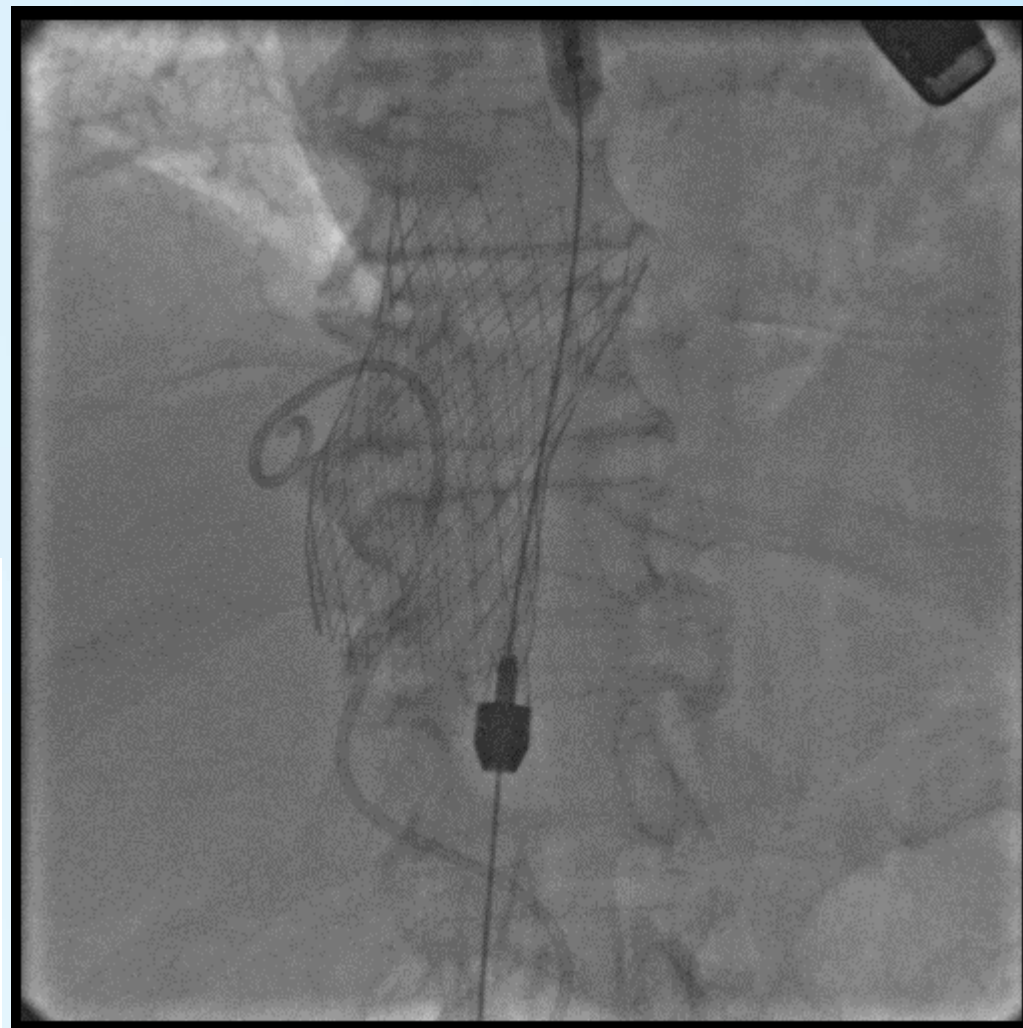
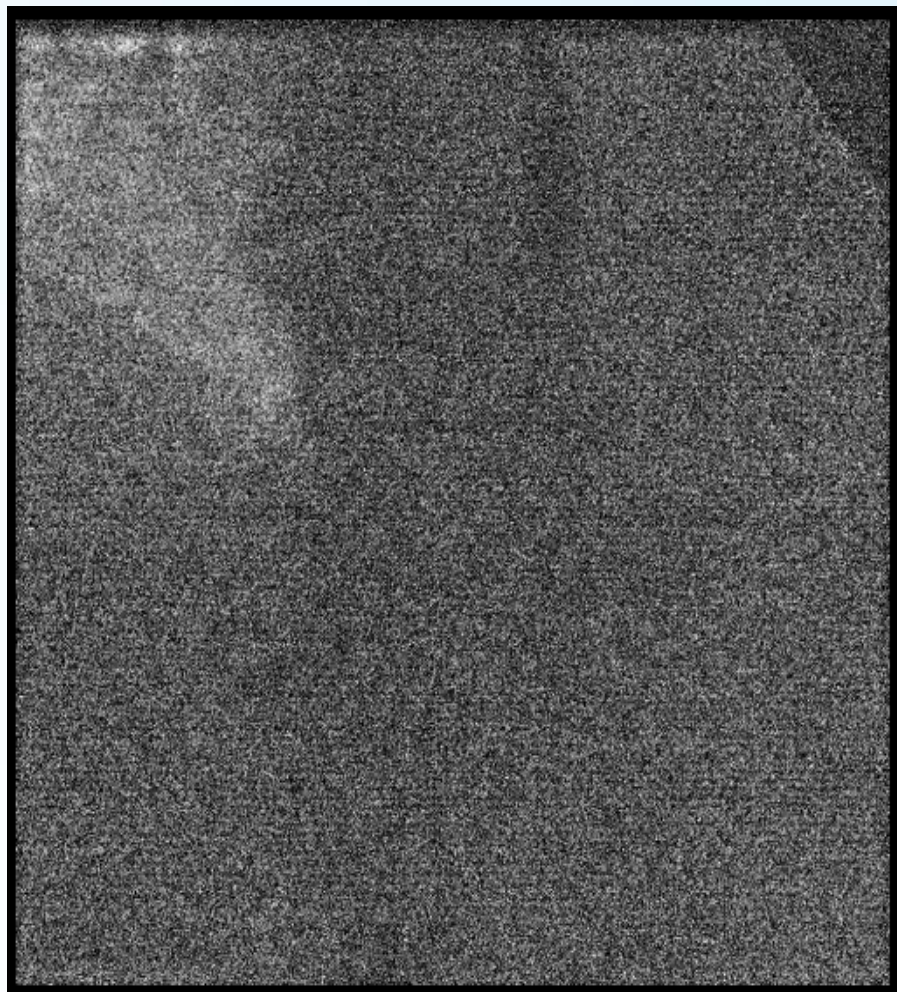


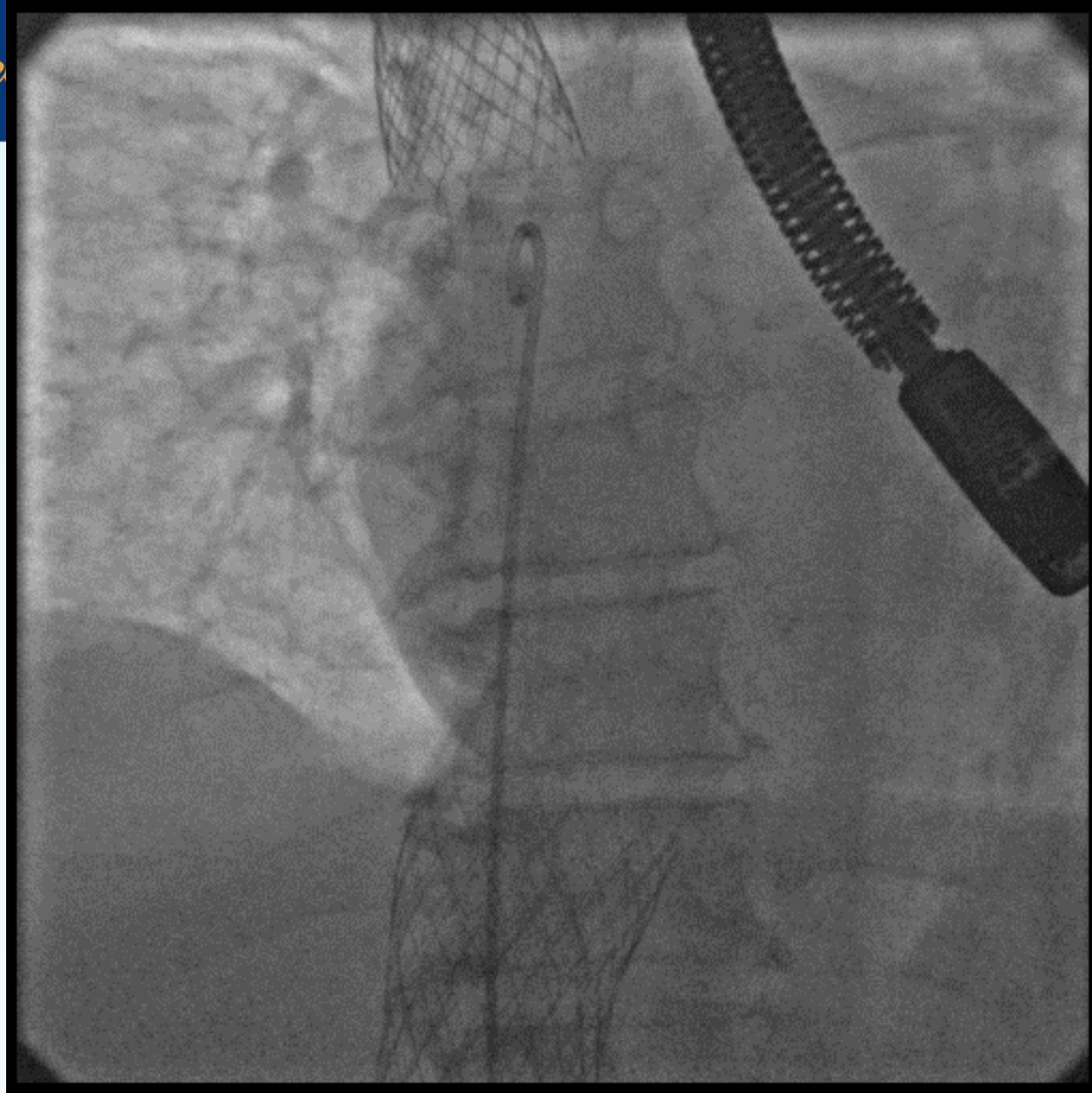
Almost 470 implants worldwide
Cardiologia Vanvitelli 3 implants

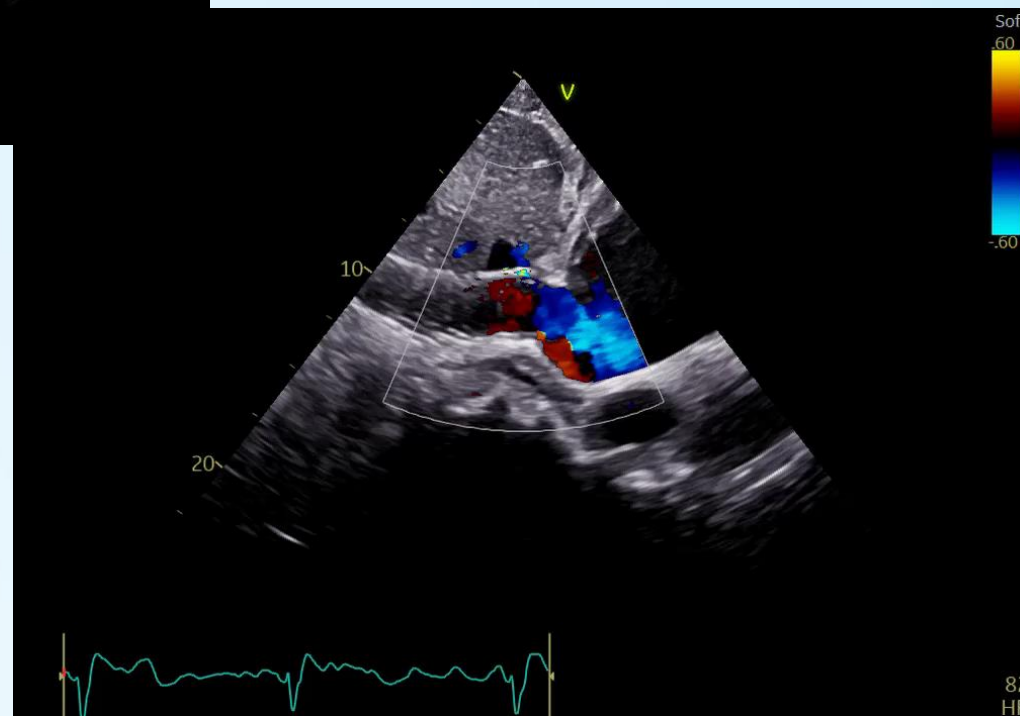
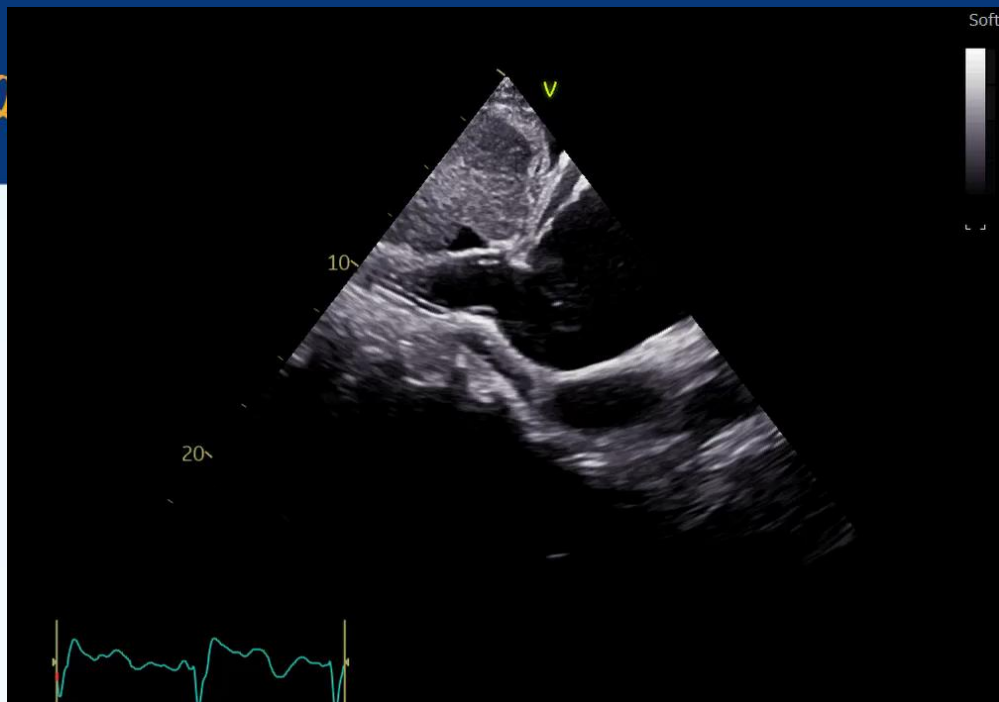
- 75 y, male
- Pulmonary hypertension, Permanent AF
- Diabetes type 2
- IRC III stage
- Actually NYHA III
- IT 4+/5+
- Pleuric effusion
- Ascites
- Not responder to medical therapy

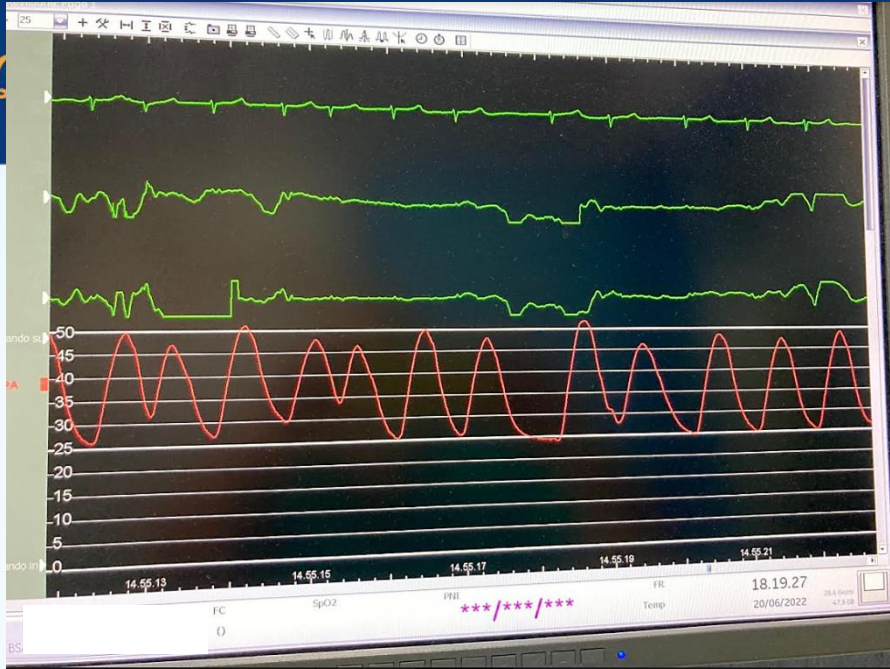




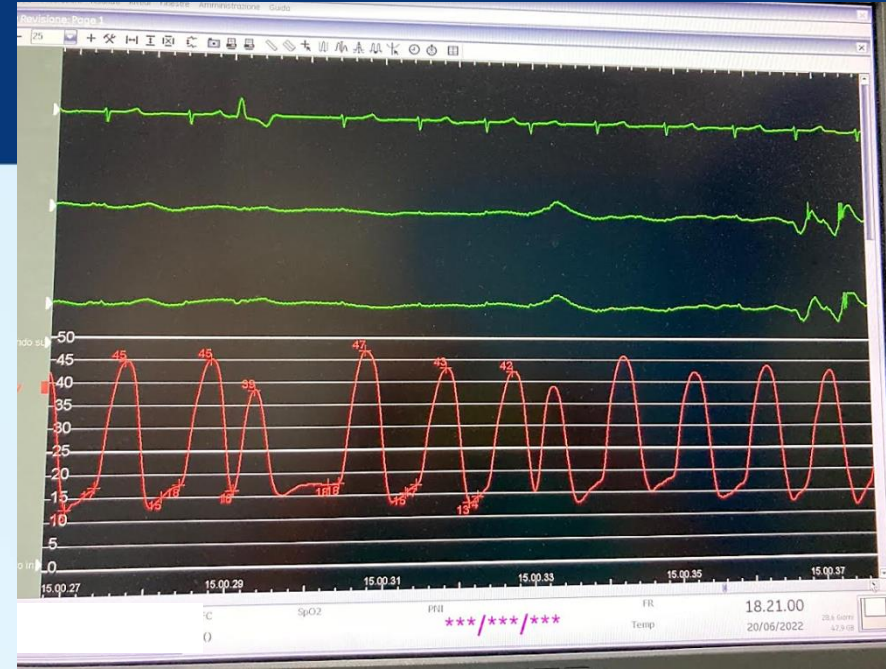




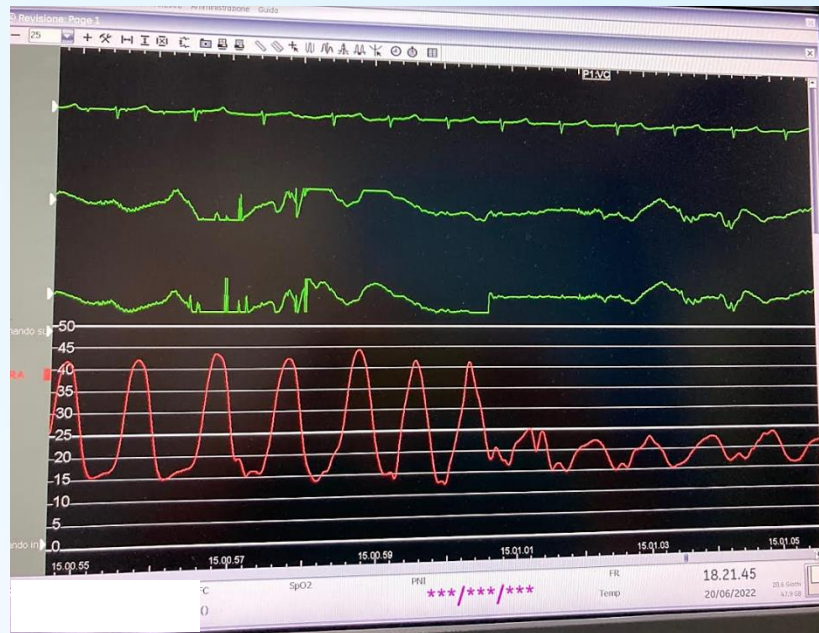




Pulmonary Artery



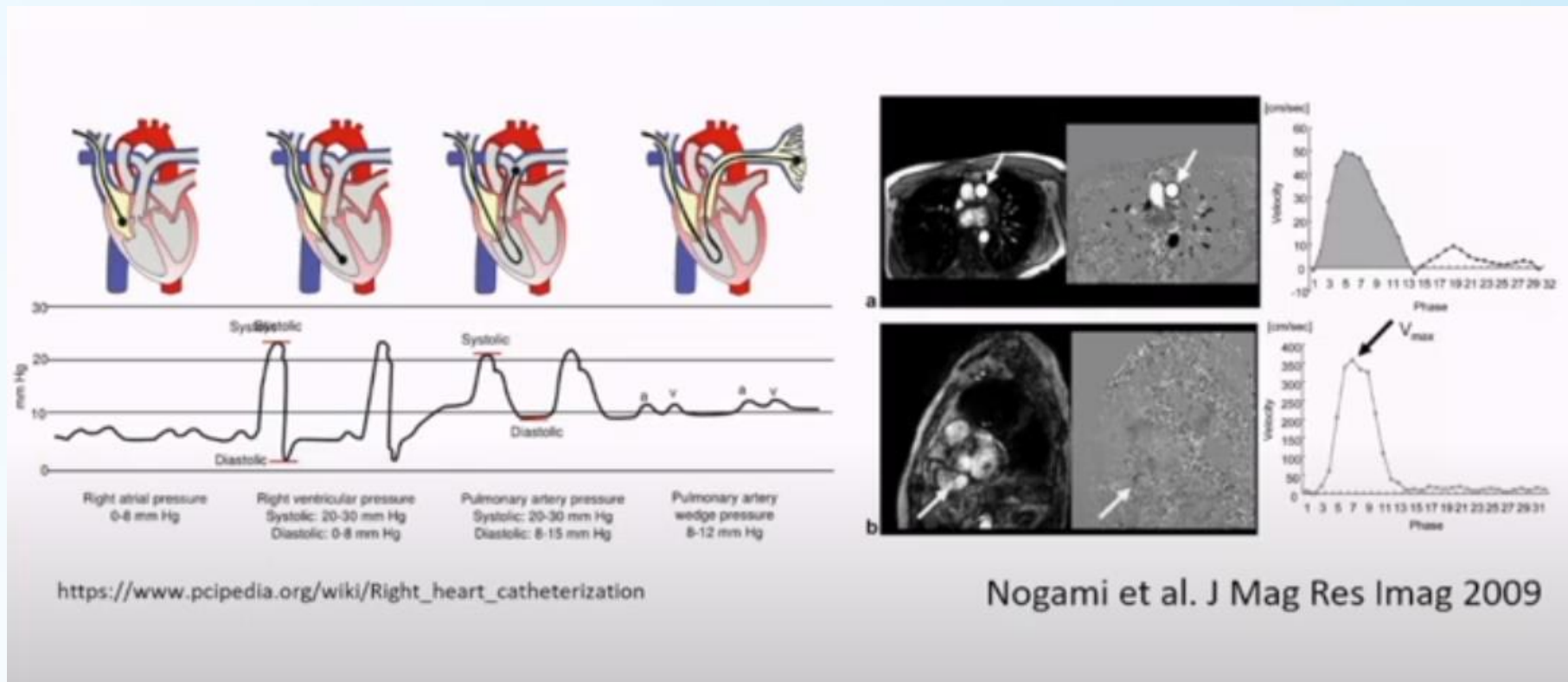
Right Ventricle



Right Atrium

Inf. Vena Cava

RV function and... pulmonary pressures?

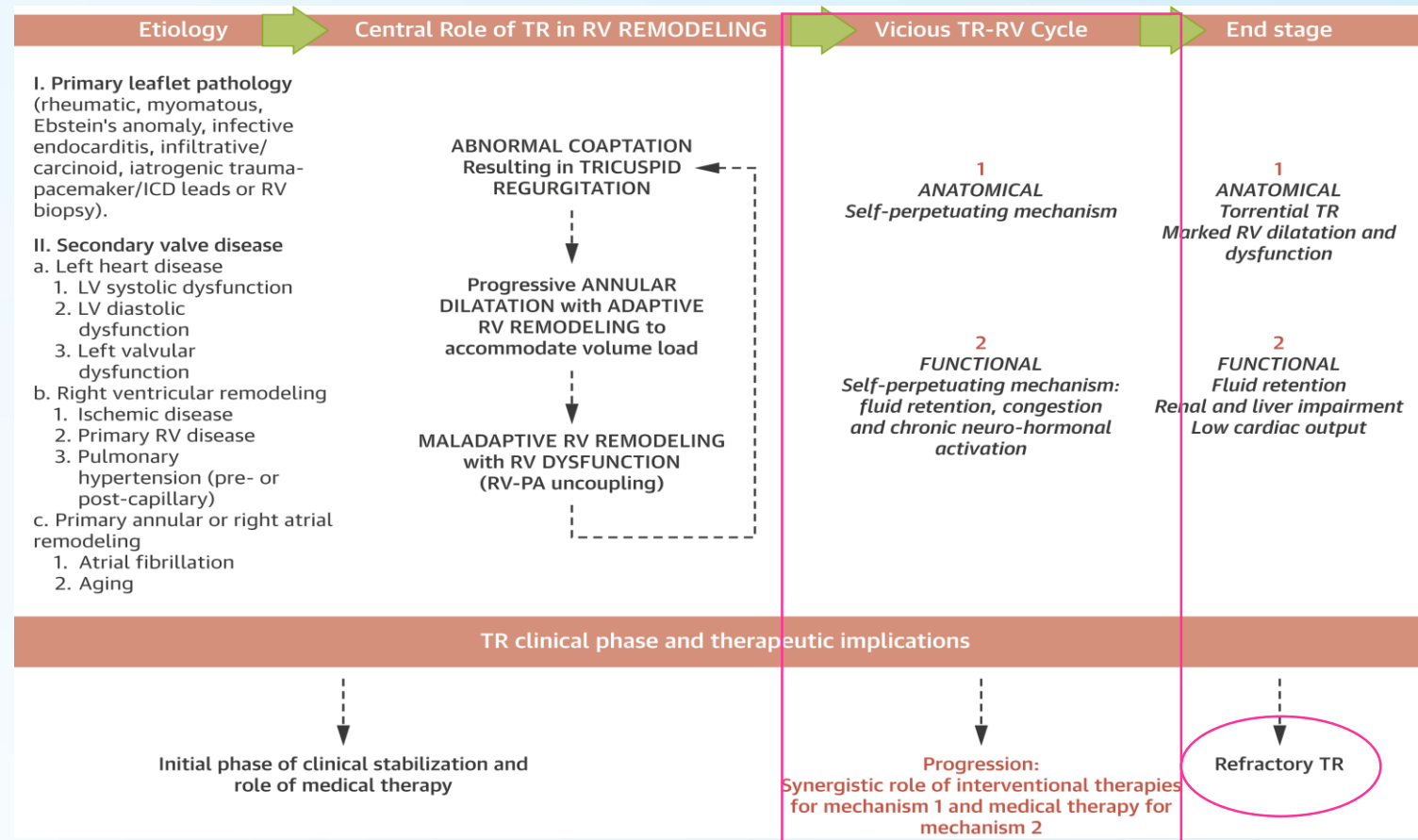


RV-PA coupling

- TAPSE/SPAP ratio (echocardiography)
- Invasive measurements (right heart catheterisation)

The right time to interview on TV

Right time for procedure, is based on mainly **clinical judgment!**



Conclusioni

- L'Imaging della TV è spesso *challenging!*
- Pianificare una procedura di correzione (percutanea/chirurgica) della IT prevede un valutazione anatomica, morfologica della TV e funzionale precisa che non può basarsi solo sull'Eco2D(TTE/TEE) ma deve avvalersi anche di tecniche imaging più avanzate.



Grazie per l'attenzione!

Thanks for the
attention