Tricuspid valve assessment: CT findings

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Potential Conflicts of Interest

☑ I have no potential conflict of interest to declare

affidea

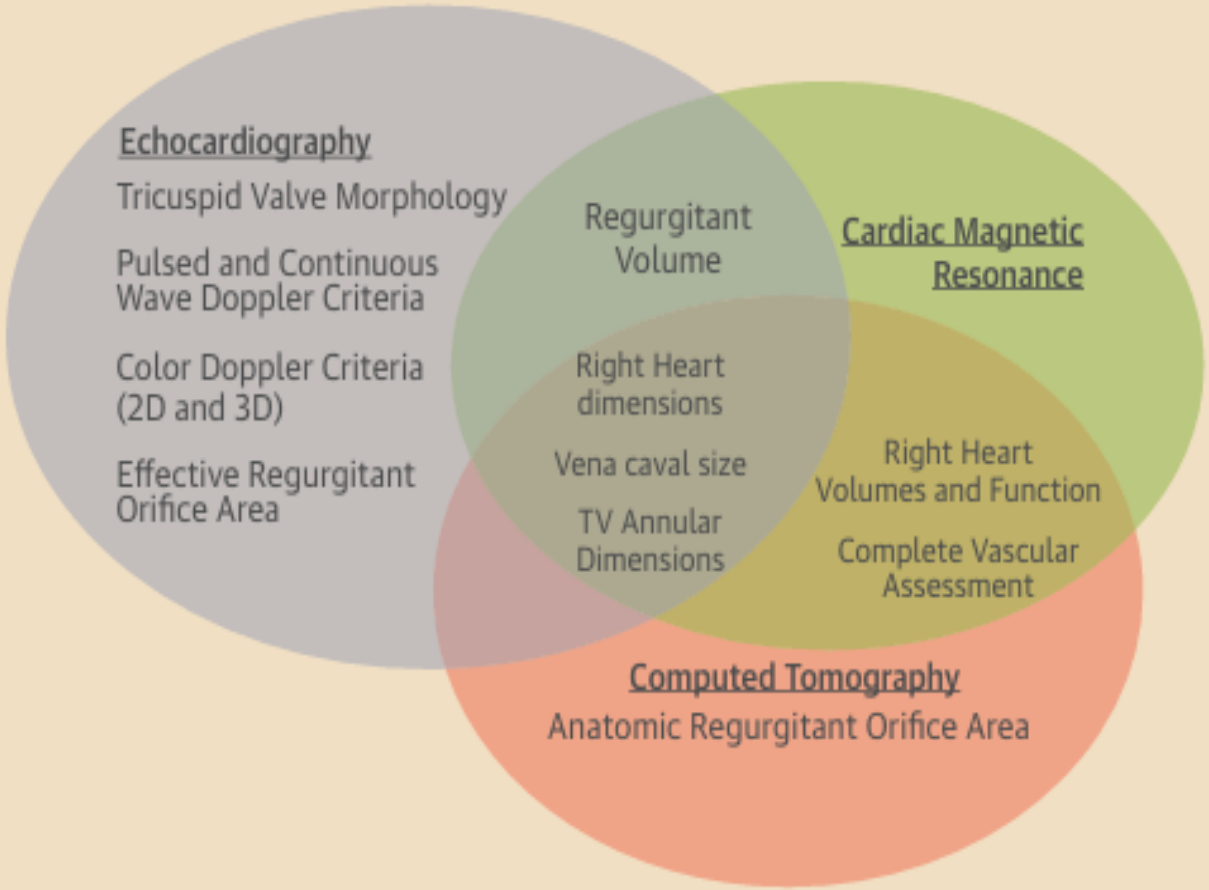
Royal Brompton and Harefield hospitals

NHS
Guy's and St Thomas'
NHS Foundation Trust

Why CT in TV disease (and other structural heart diseases)

- high spatial resolution
- Overcome many of the limitations of 2D echocardiography (acoustic windows, anterior orientation of the TV)
- providing excellent anatomical and functional analysis of the TV apparatus
- its relationship to surrounding cardiac structures
- minimize procedural complications, exposure time

Multi-modality Imaging for Assessment of Tricuspid Regurgitation Severity



Relative Utility of Each Imaging Modality

Parameters	Echocardiography (TTE or TEE)		Cardiac Magnetic Resonance	Computed Tomography Angiography
	2D/Doppler	3D/Color		
Structural Parameters				
TV Morphology	+++	+++	++	++
RV and RA size	++	+++	+++	+++
SVC and IVC Size	+++ (proximal cavae only)	+++	+++	+++
Comprehensive vascular assessment	-	-	+++	+++
Semi-Quantitative parameters				
Jet Area	+++	+++	++	-
Vena Contracta Width	+++	+++	++	-
Vena Contracta Area	-	+++	++	-
Anatomic Orifice Area	-	+	++	+++
Quantitative Parameters				
Effective Regurgitant Orifice Area	++ (PISA and Doppler SV)	- (see VCA)	-	-
Regurgitant Volume	++ (PISA and Doppler SV)	++ (from VCA)	++	-

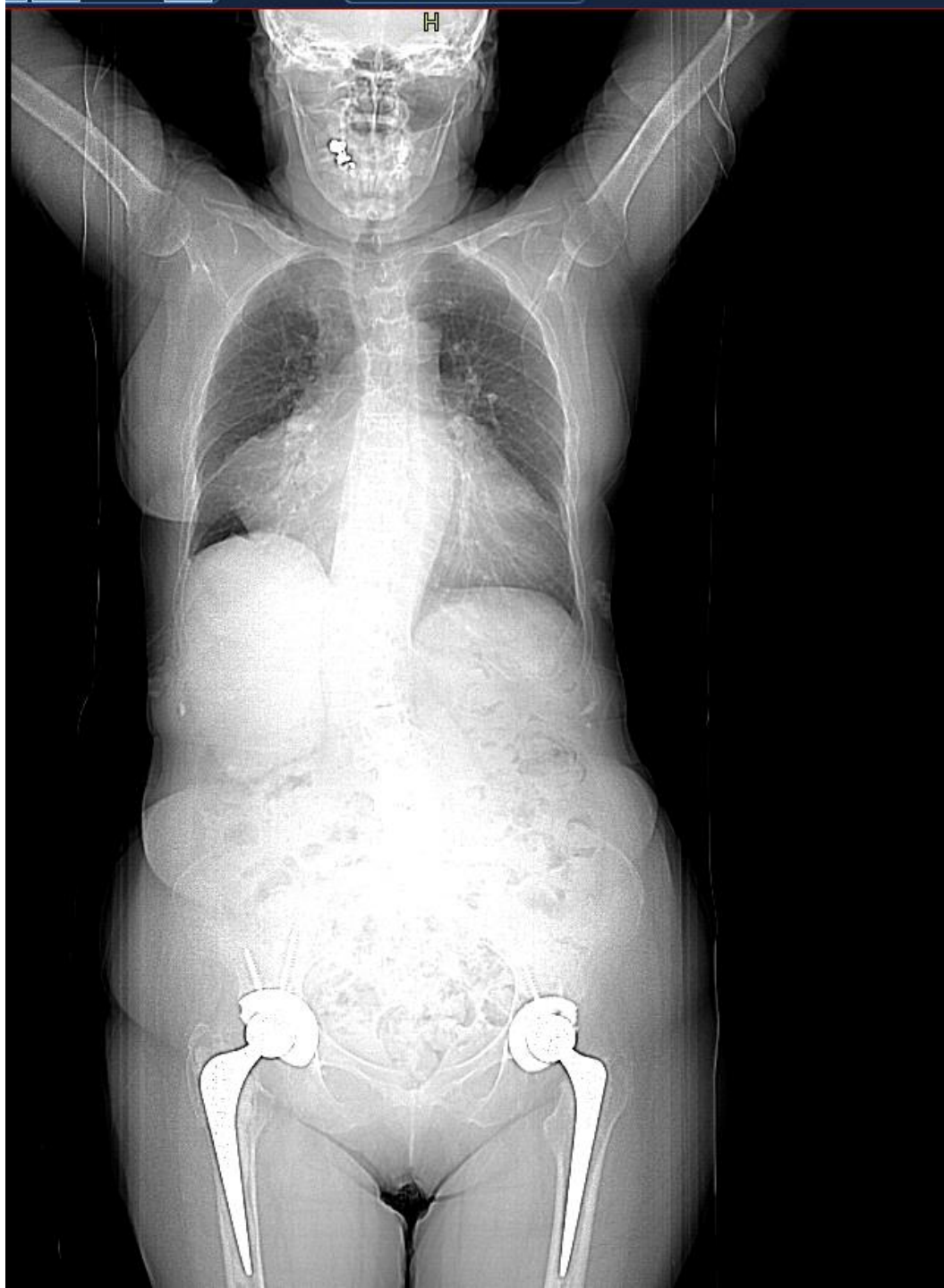
Hahn, R.T. et al. J Am Coll Cardiol Img. 2019;12(3):469-90.

CT scanner

- 64-slice CT or more advanced technology (dual-source CT or volume CT scanners).
- Large Z-axis coverage (greater number of detectors)- short temporal resolution- to freeze cardiac motion, mitigating breathing/ motion artifacts.
- Acquisition of the entire heart cycle, allowing reconstructions every 5%–10% of the R-R cycle.

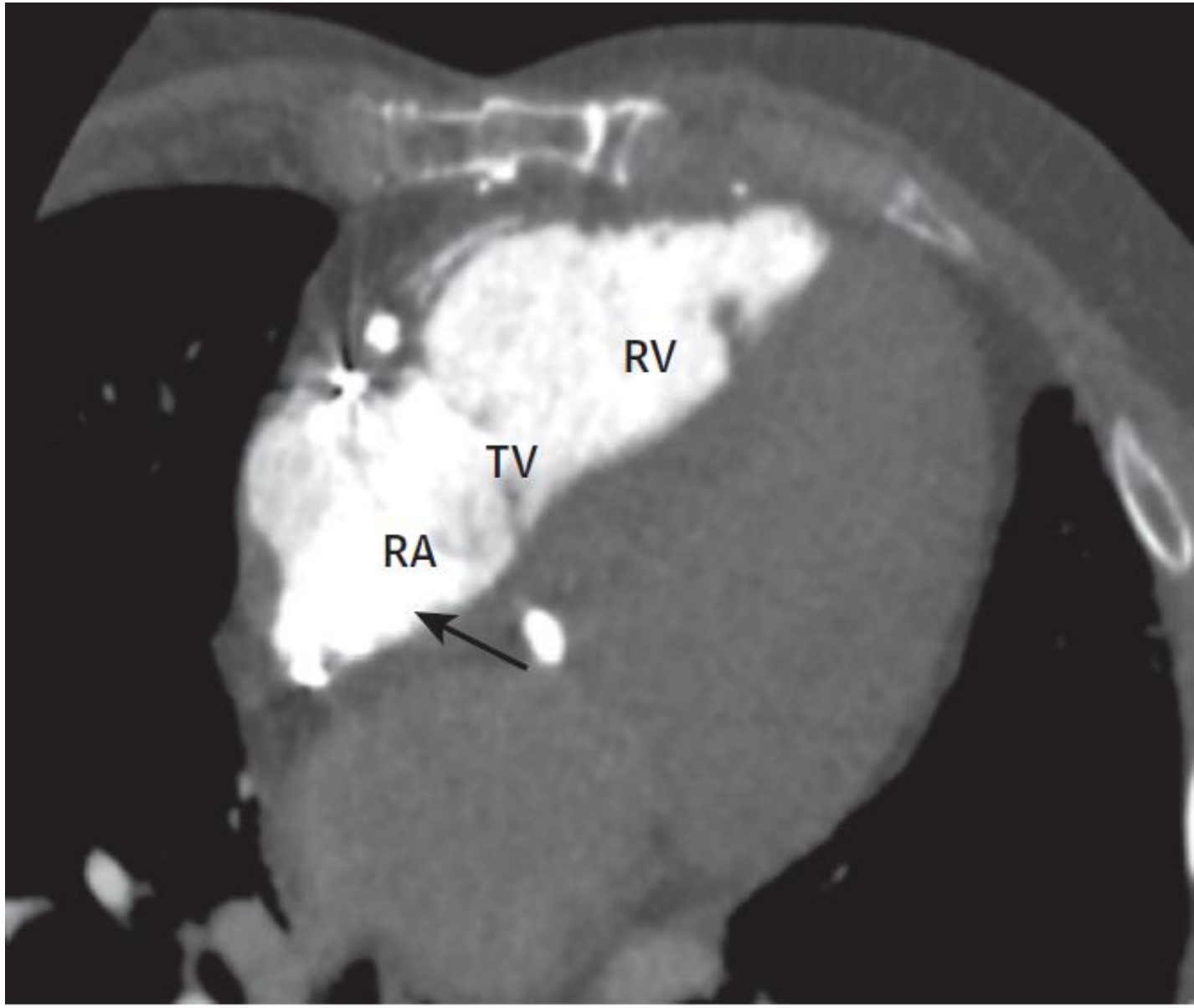
CT protocol

- Scout: External auditory canal to lesser trochanter.
- Often large RA-not to be missed
- Additional delayed nongated scans for venous access



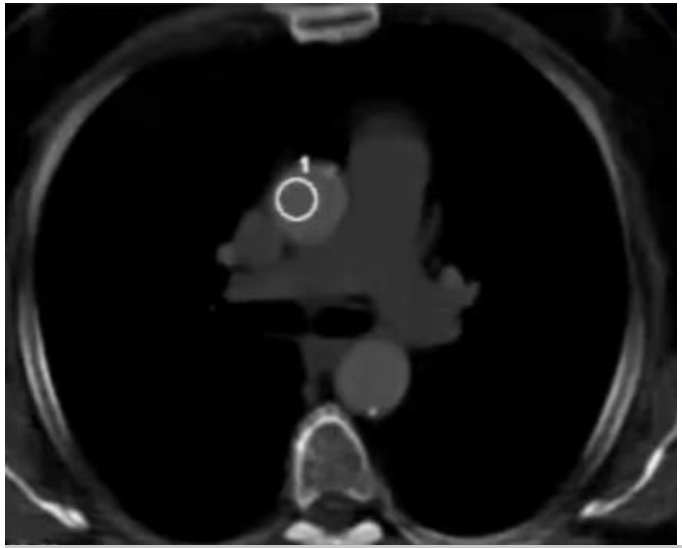
Homogenous and smooth right heart opacification

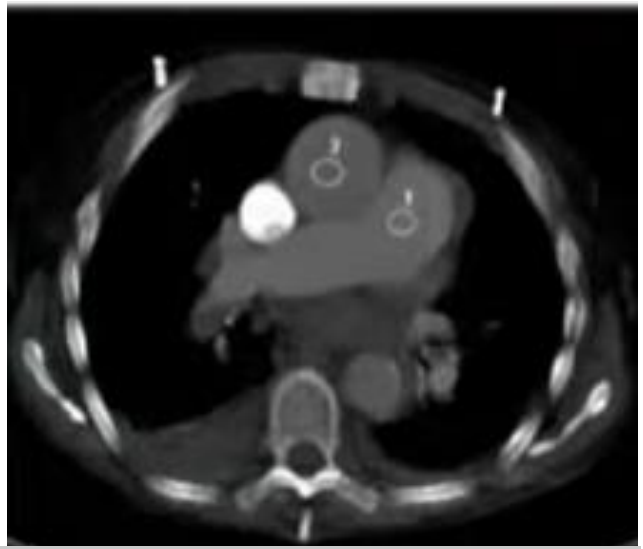
- Avoid streak and beam hardening artifacts

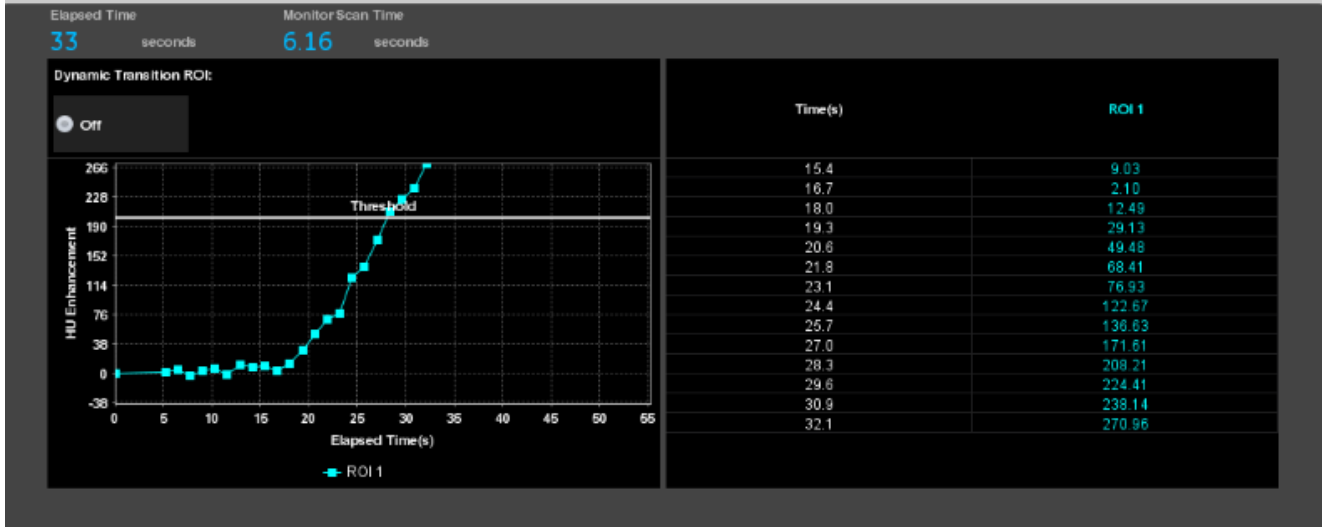


Triphasic (biventricular) contrast injection

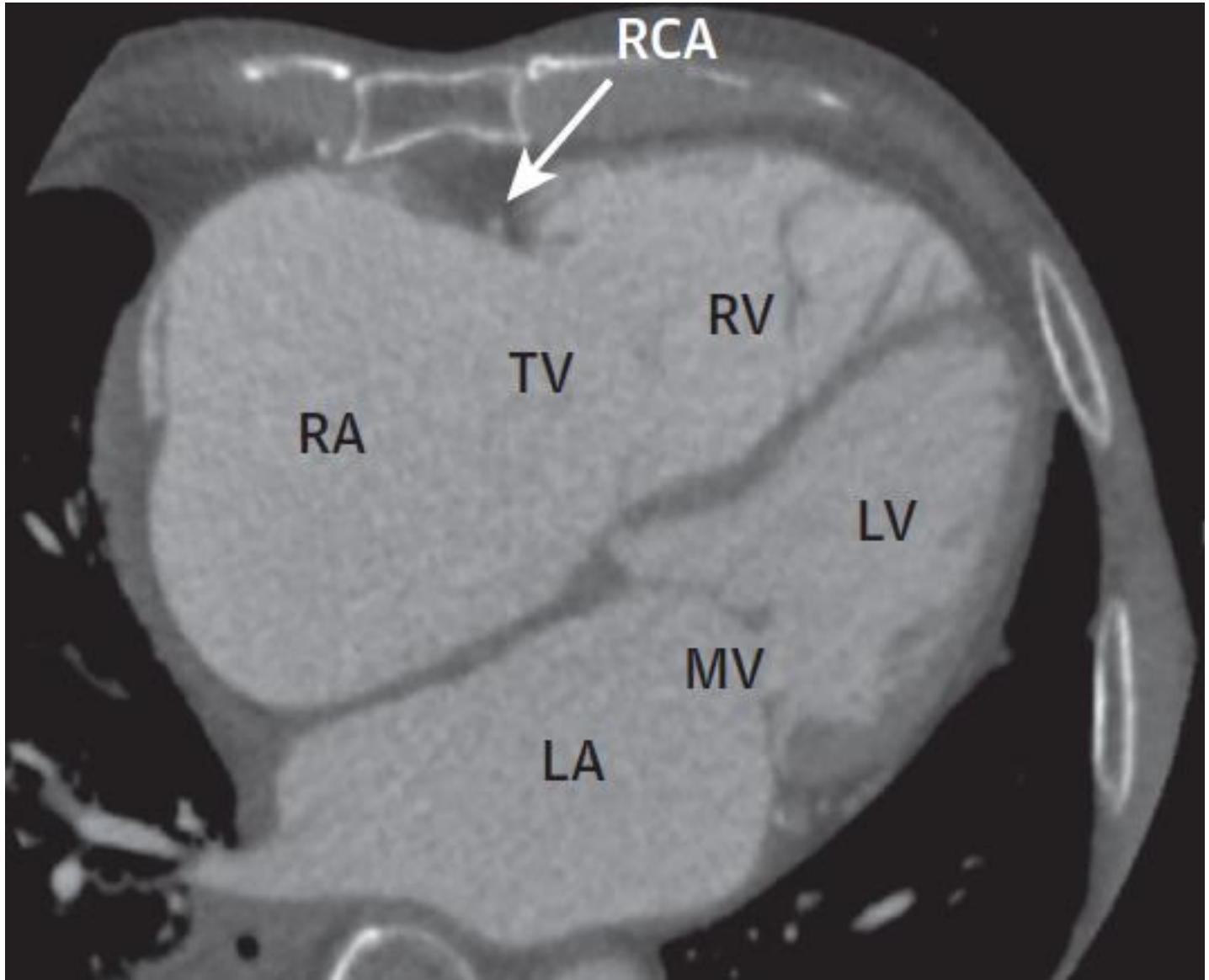
a mixed contrast/saline approach.

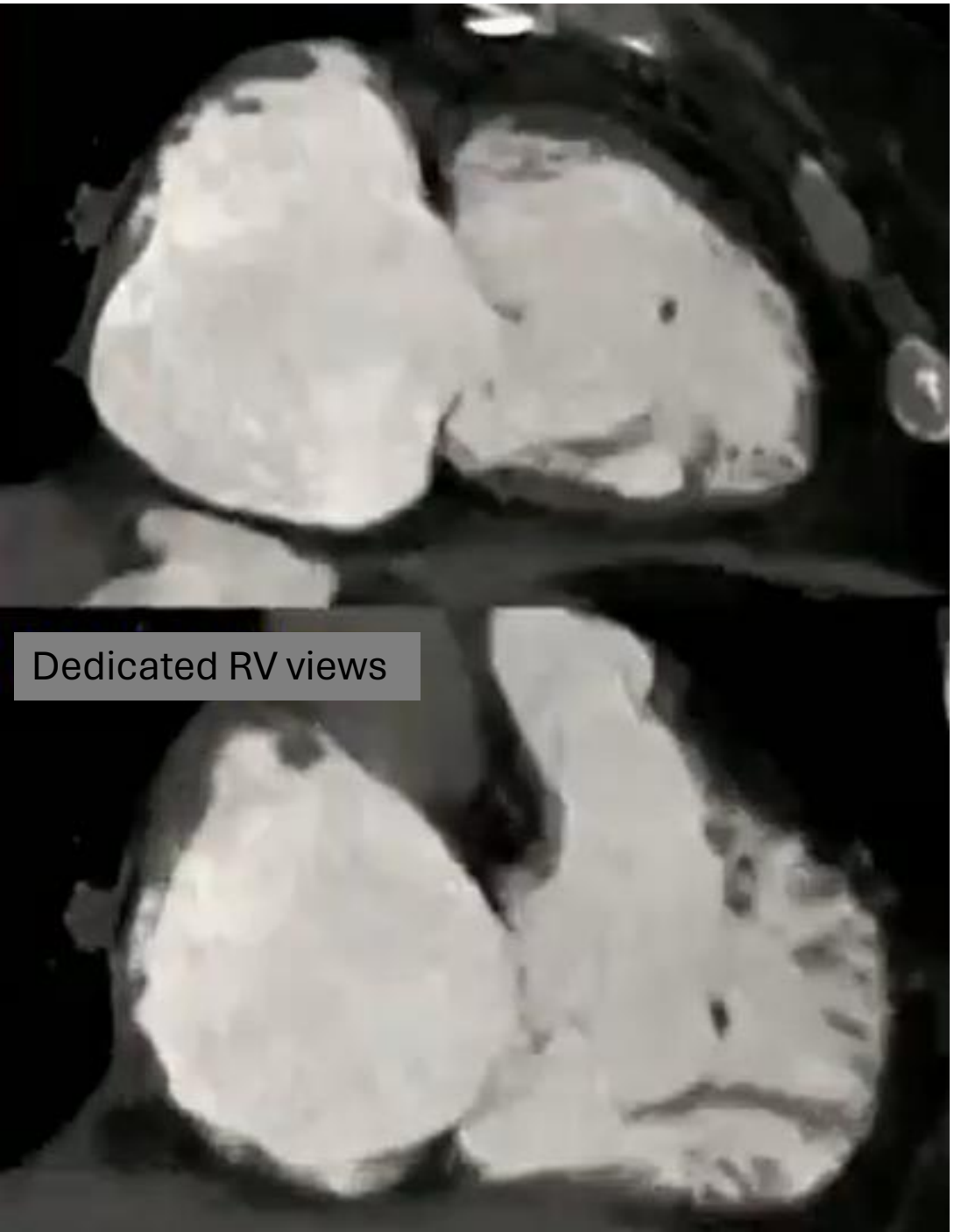




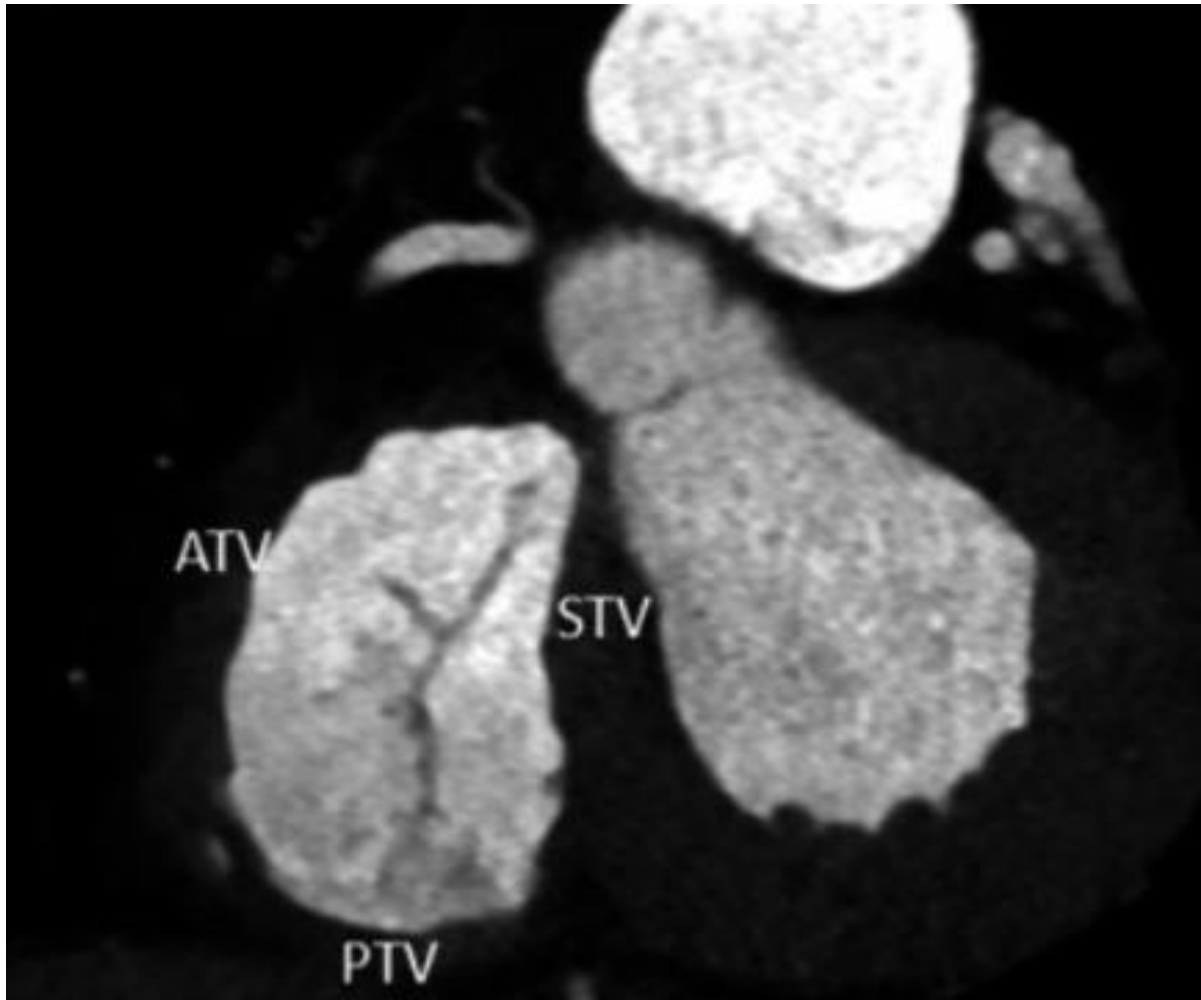


Simultaneous right and left opacification

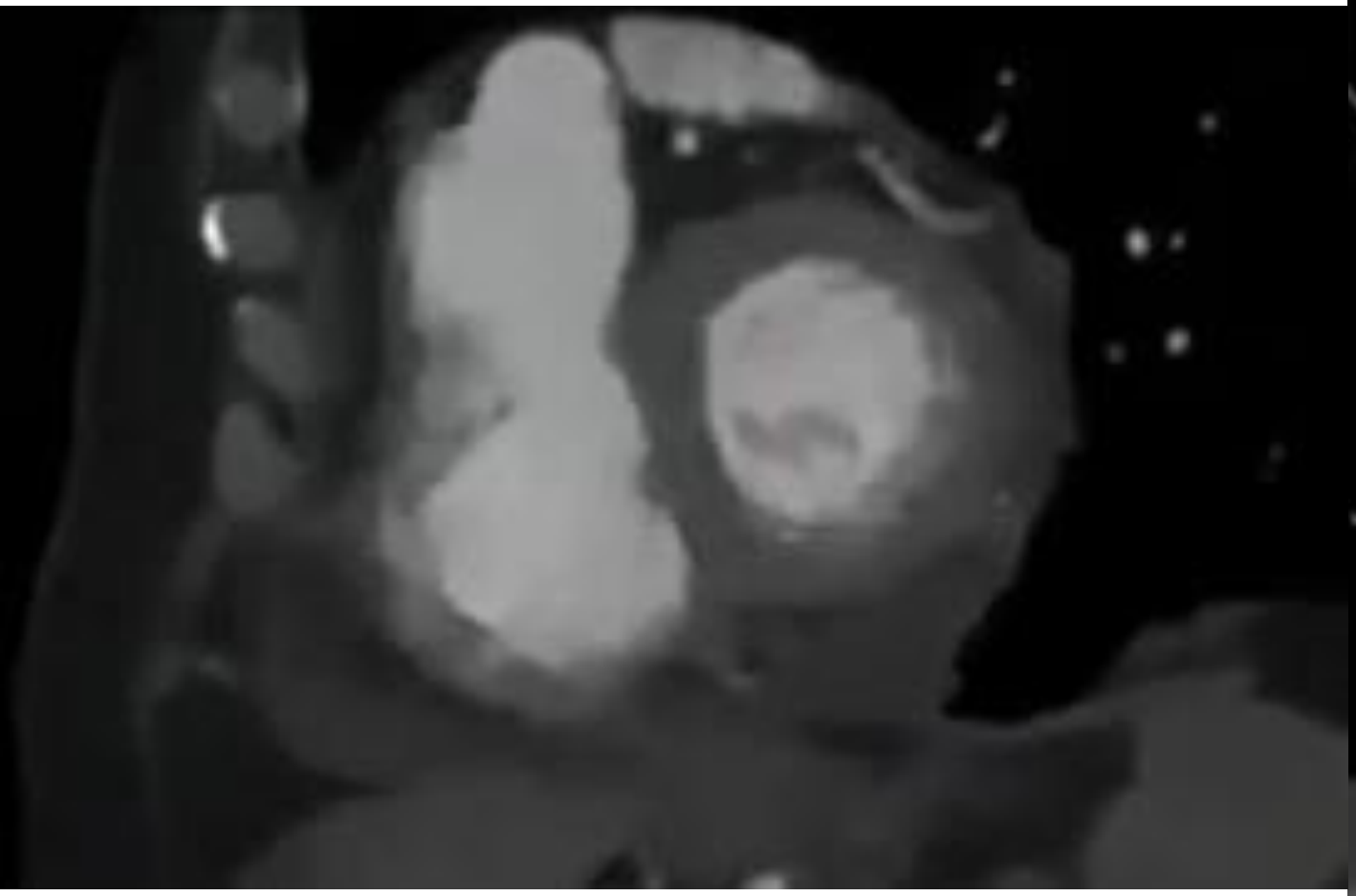


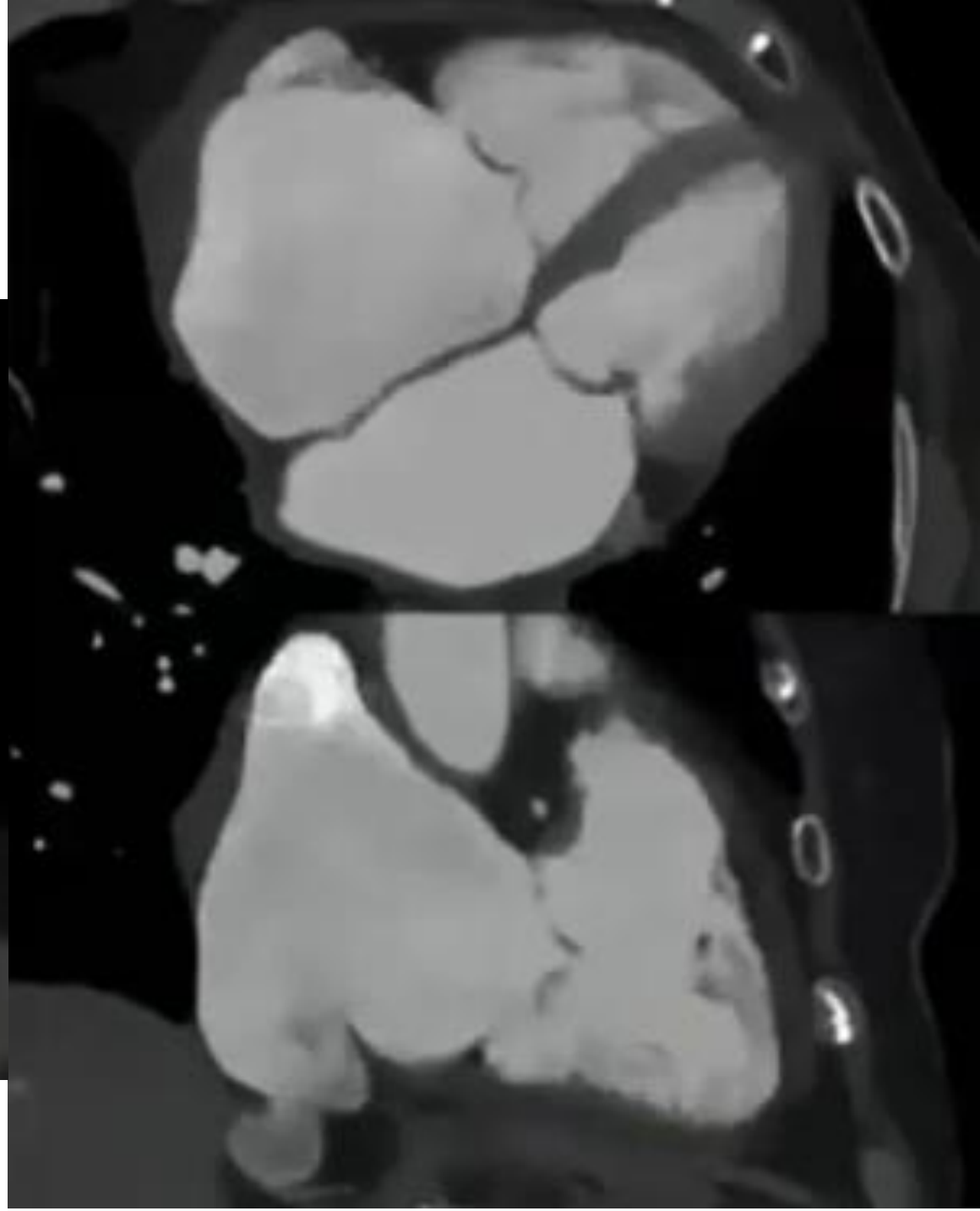


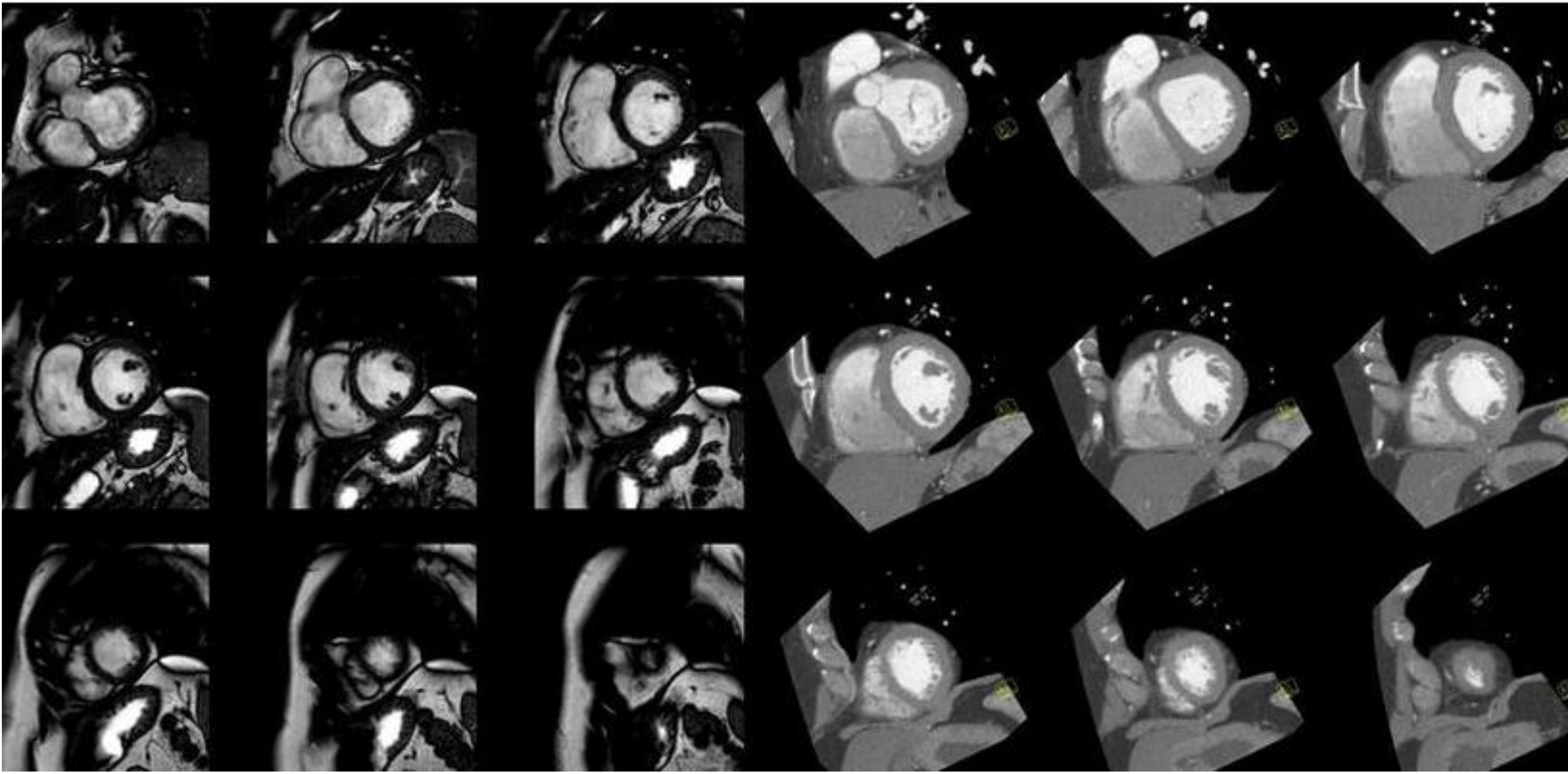
Subvalvular apparatus leaflets and commissures



RV volumes assessment





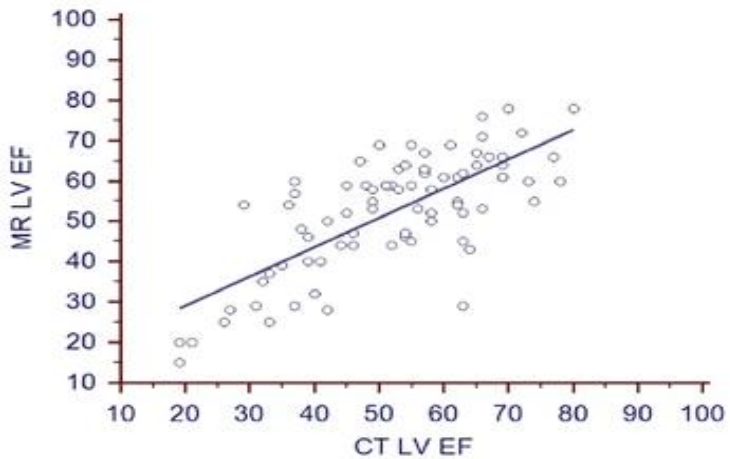


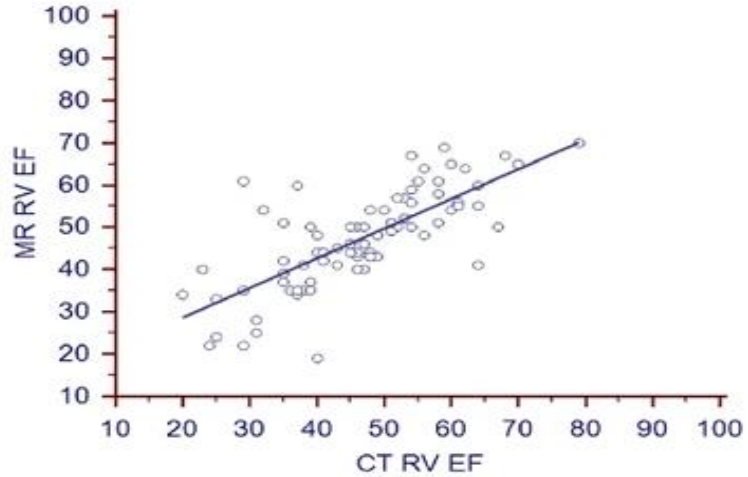
Eur Radiol (2012) 22:1041–1049
DOI 10.1007/s00330-011-2345-6

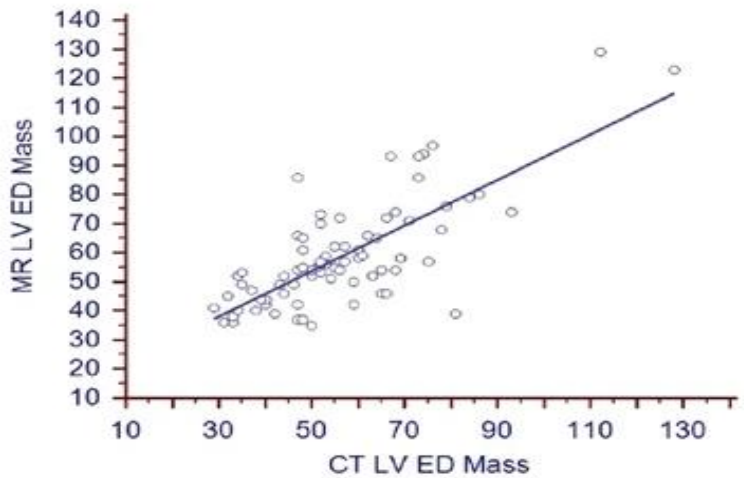
CARDIAC

Left and right ventricle assessment with Cardiac CT: validation study vs. Cardiac MR

Erica Maffei · Giancarlo Messalli · Chiara Martini · Koen Nieman · Onofrio Catalano · Alexia Rossi · Sara Seitun · Andrea I Guaricci · Carlo Tedeschi · Nico R. Mollet · Filippo Cademartiri



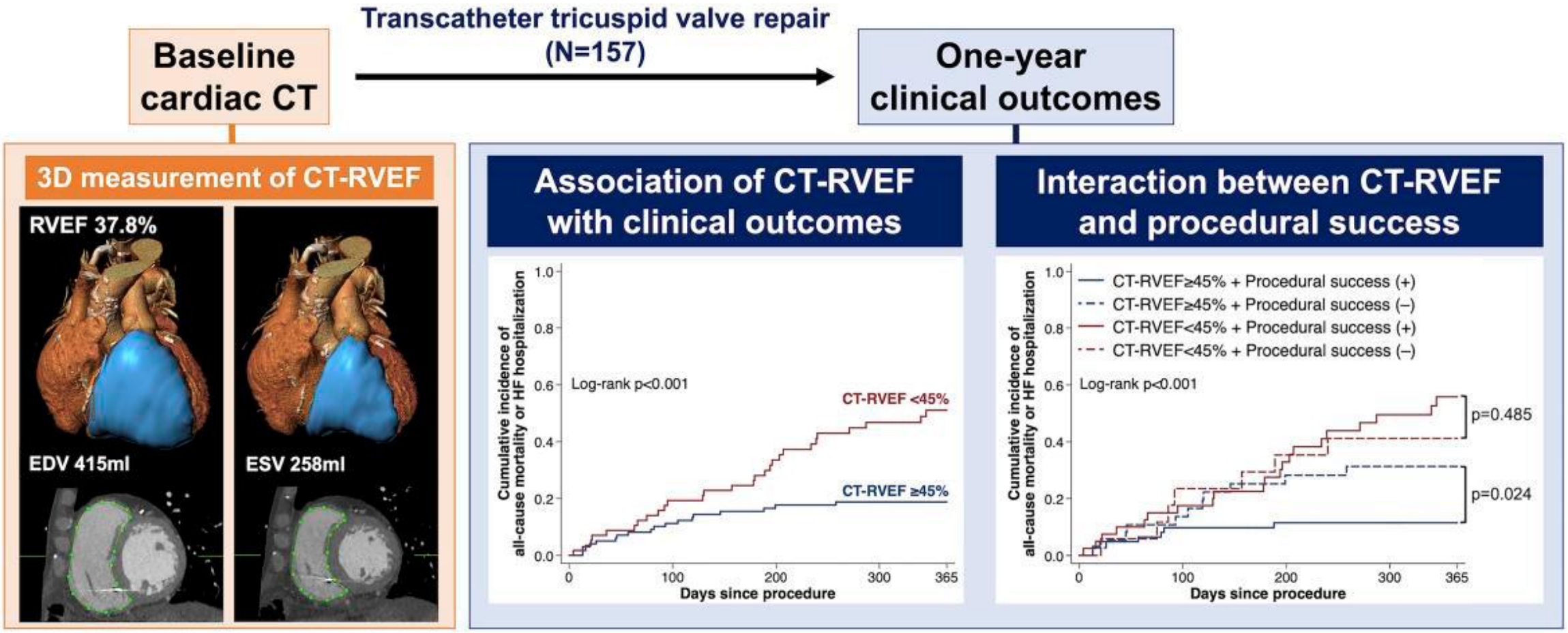




ESC European Society of Cardiology
European Heart Journal - Cardiovascular Imaging (2023) **24**, 1501–1508
https://doi.org/10.1093/ehjci/jead102
ORIGINAL PAPER

Right ventricular ejection fraction assessed by computed tomography in patients undergoing transcatheter tricuspid valve repair

Tetsu Tanaka [1], Atsushi Sugiura[1], Refik Kavsur [1], Can Öztürk [1], Johanna Vogelhuber [1], Nihal Wilde [1], Daniel Kütting[2], Carsten Meyer[2], Sebastian Zimmer [1], Eberhard Grube[1], Farhad Bakhtiary[3], Georg Nickenig[1], and Marcel Weber[1]*



TR severity

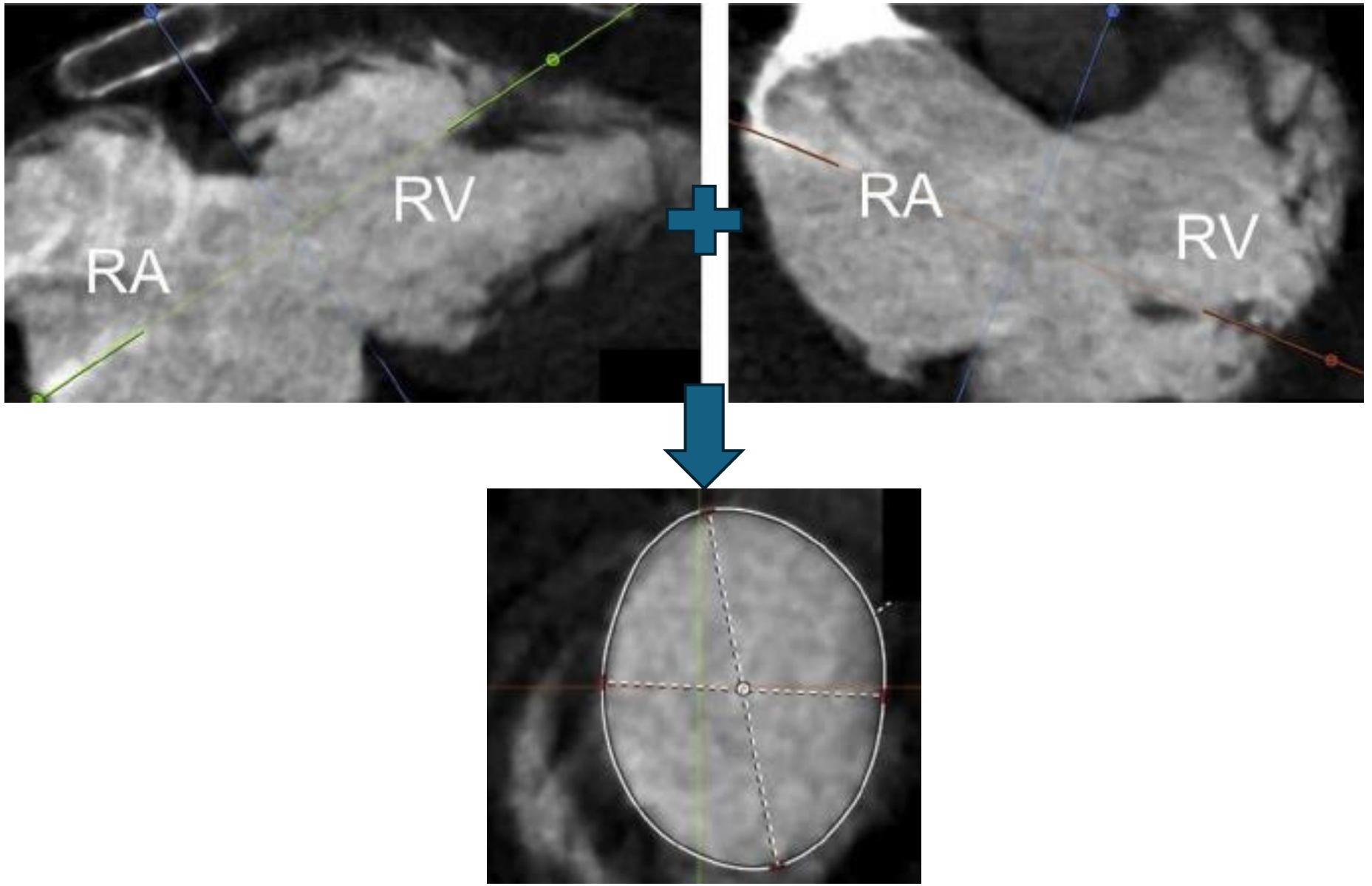
- Indirect method as per CMR
- Patients with unfavourable Echo acoustic window/ CMR unsuitable
- Discrepancy between different echocardiographic parameters
- Early opacification of the IVC or hepatic veins

Anatomical surrogates for TR severity

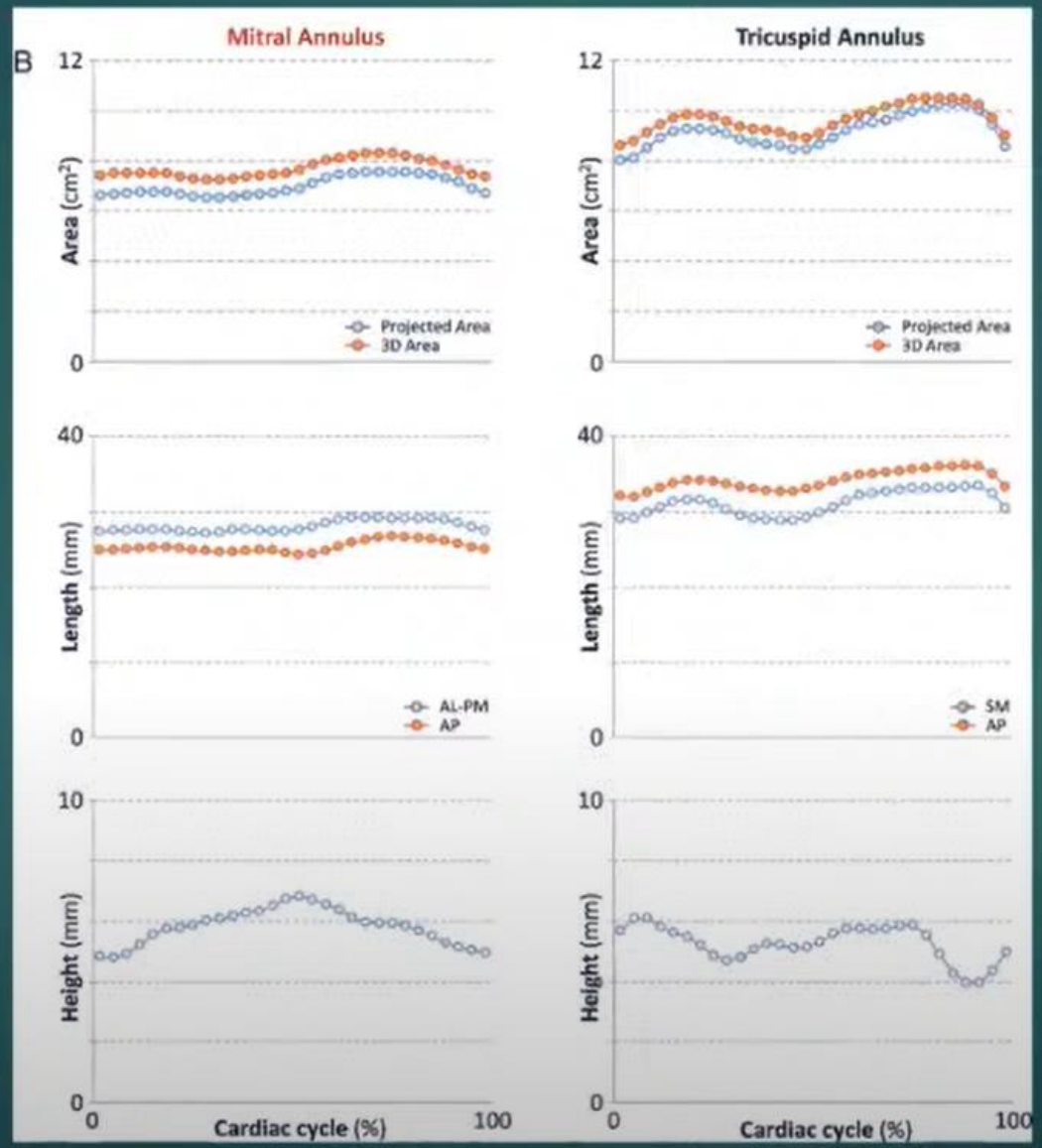
- Anatomic regurgitant orifice area (AROA) during mid-end systole (0%–30% of the R-R interval)

- Tricuspid annular area during mid-end diastole (60%–80% of the R-R interval)

Tricuspid annulus size - direct method

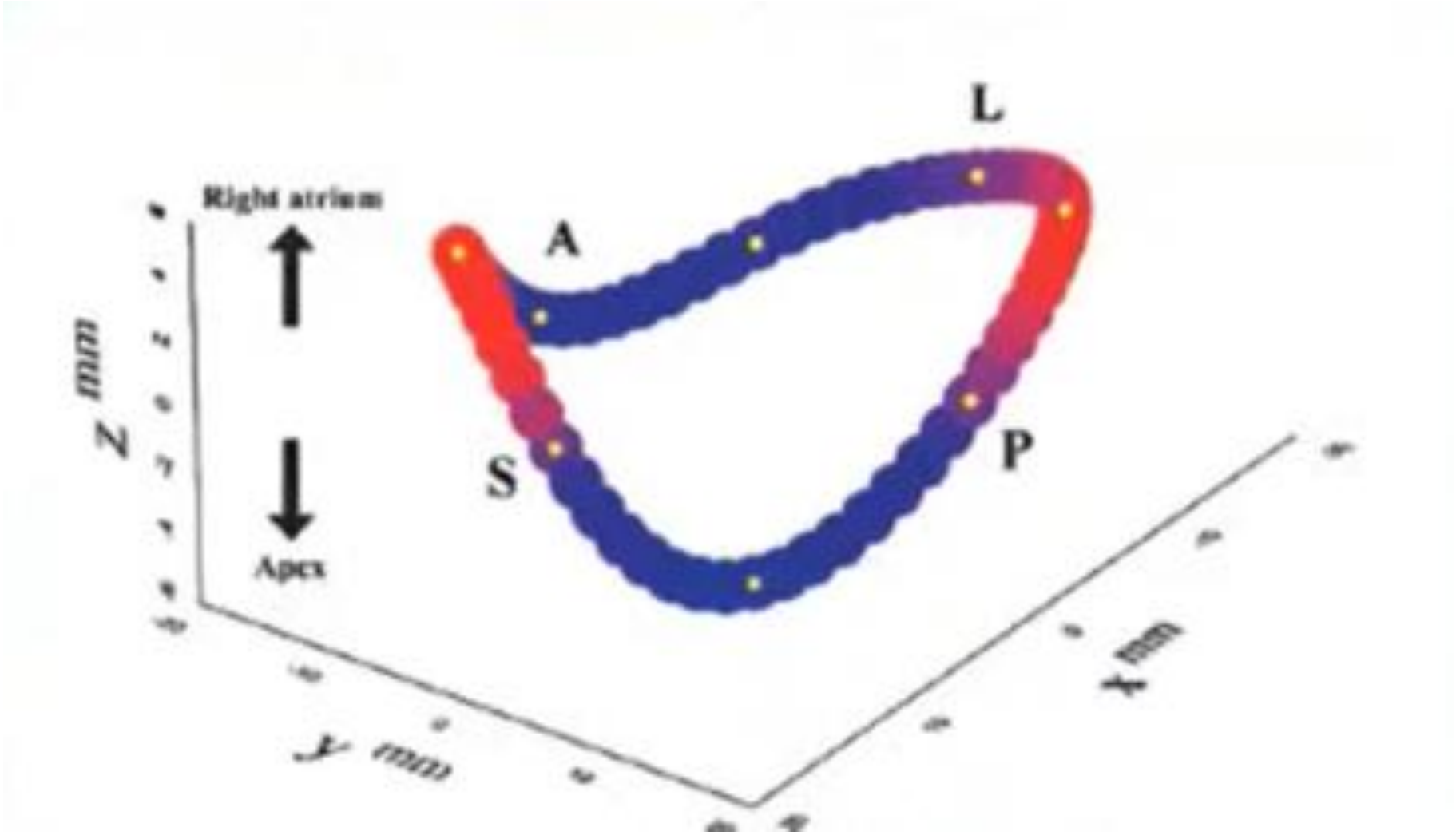


Annulus dynamics

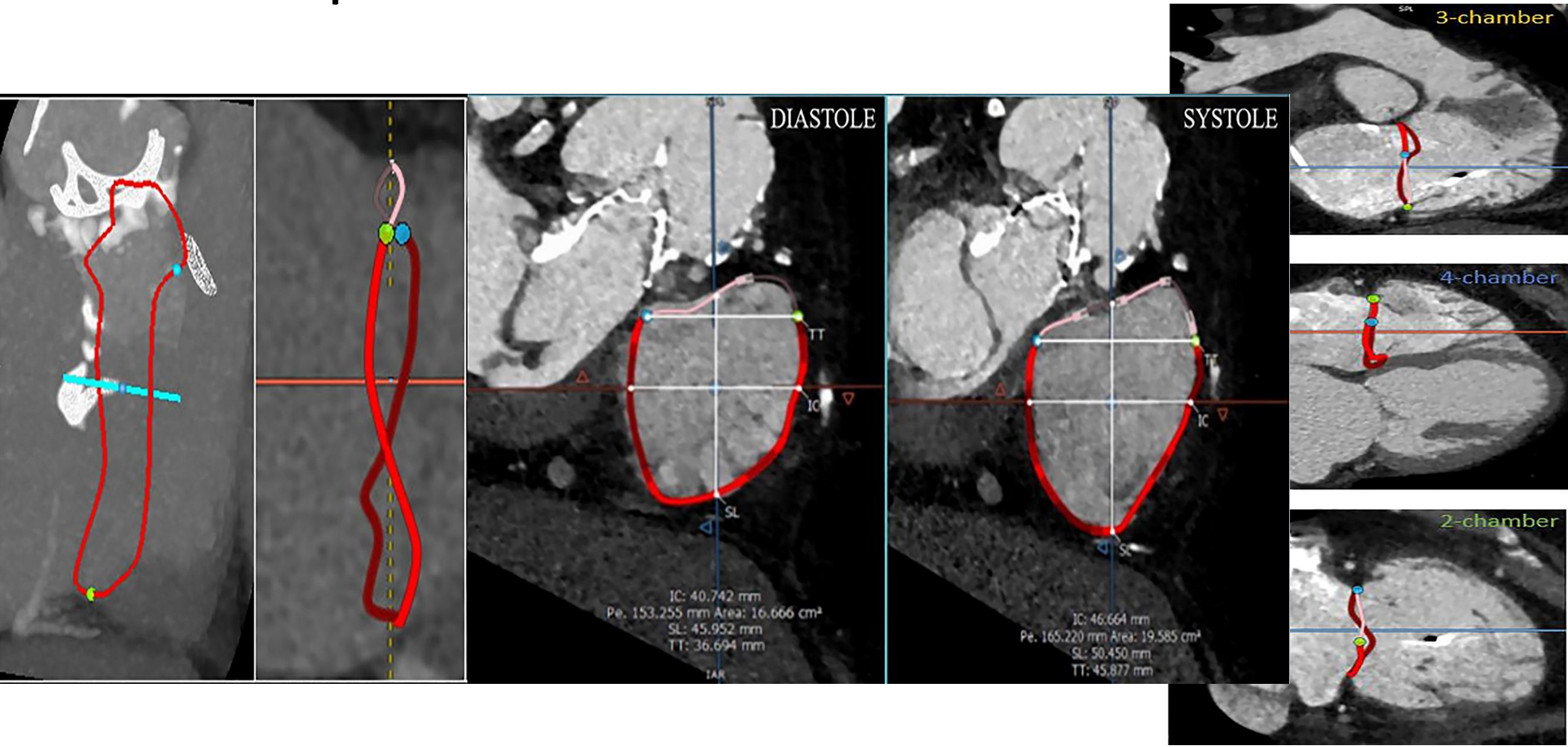


European Heart Journal – Cardiovascular Imaging (2013) 14, 986–995

Complex shape of the tricuspid annulus

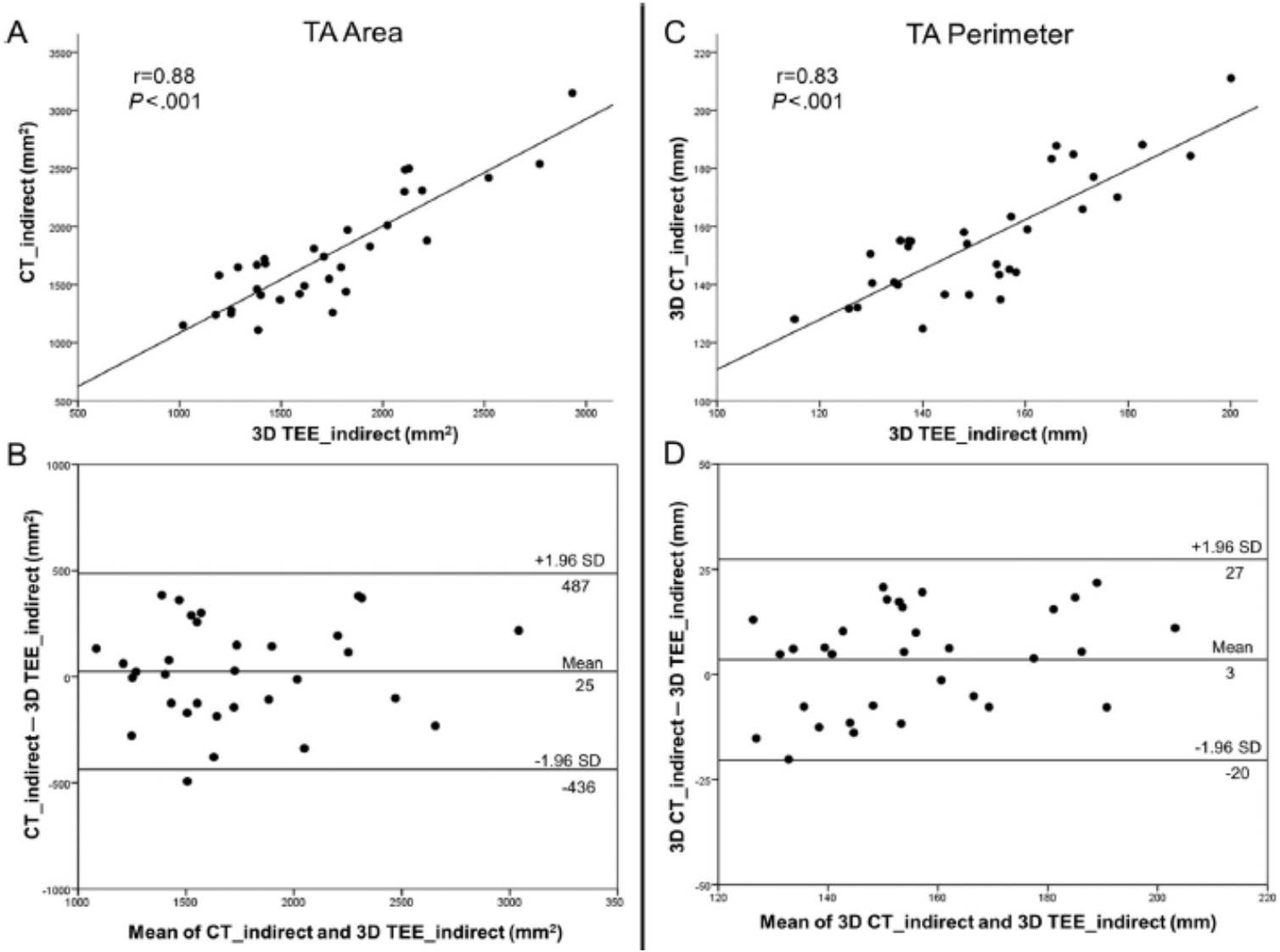


Tricuspid annulus size –indirect method



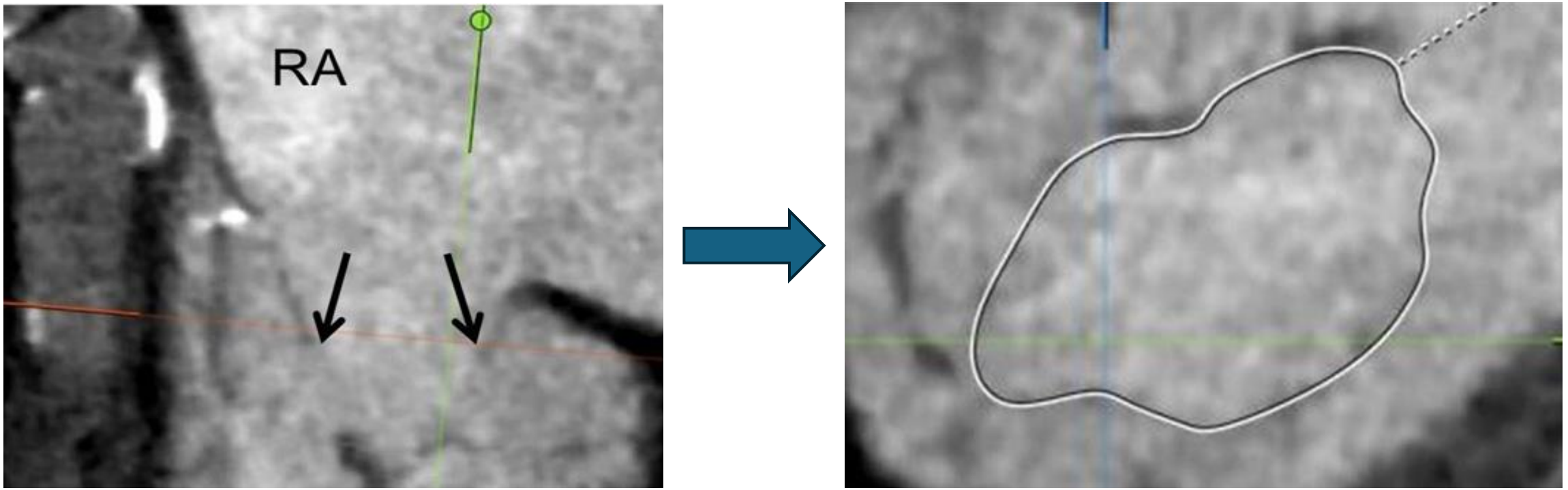
RadioGraphics Rajiah PS et al. Published Online: June 29, 2023 https://doi.org/10.1148/rg.220153

Comparison between TEE and CT for measurements of TA area and perimeter.

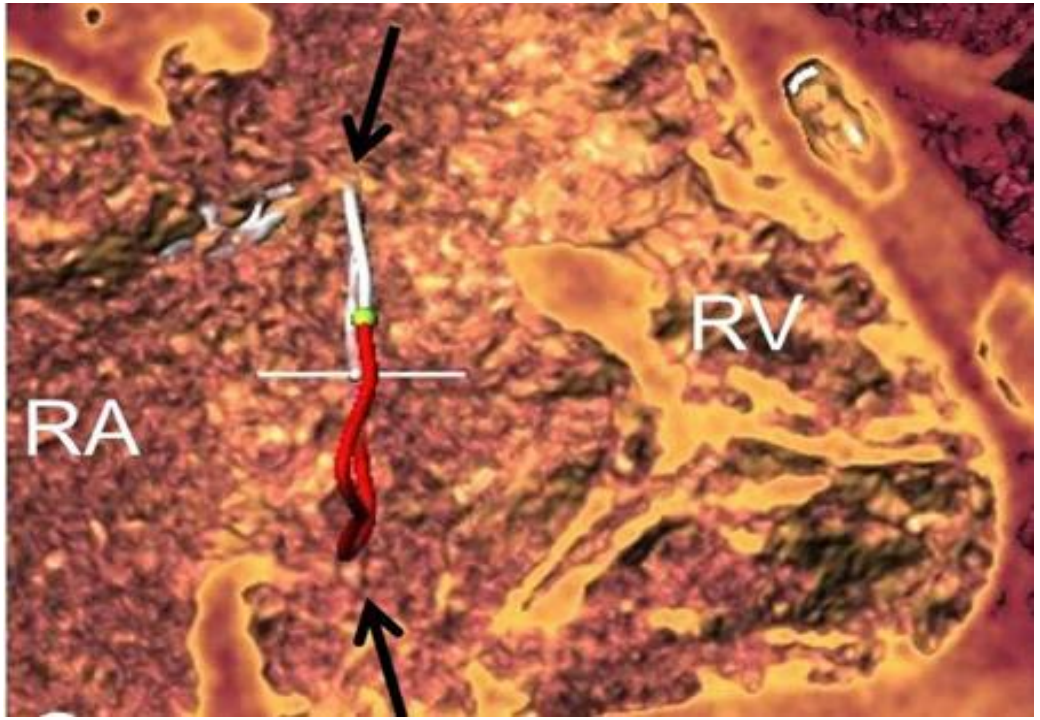


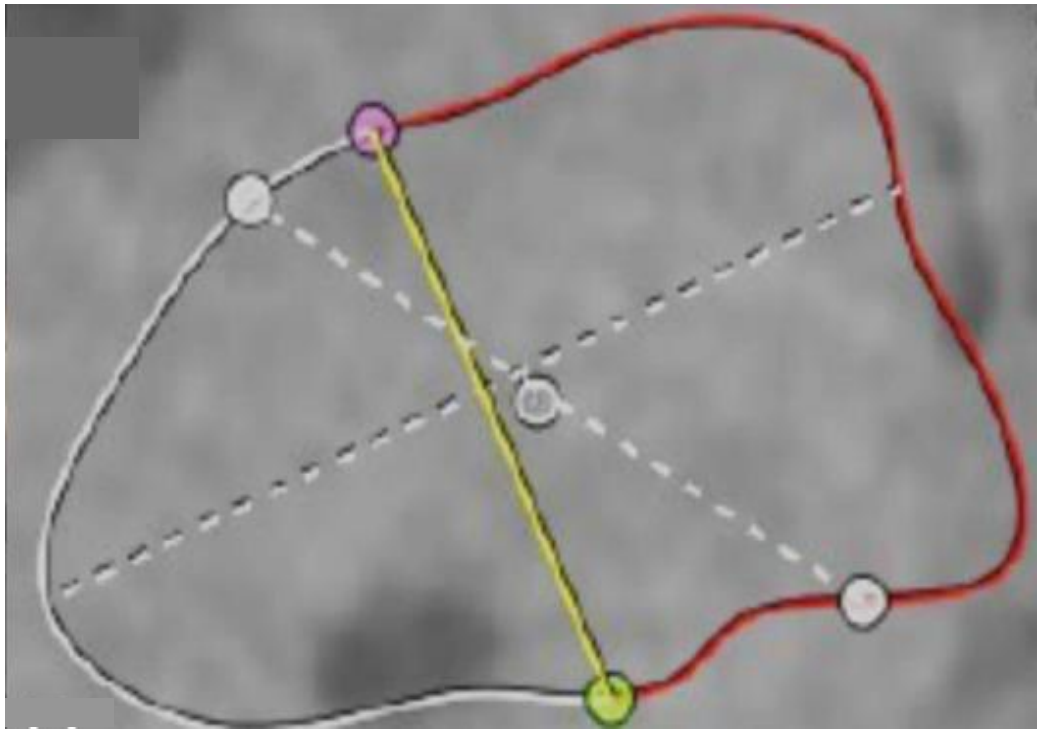
Praz et al., JASE, 2018

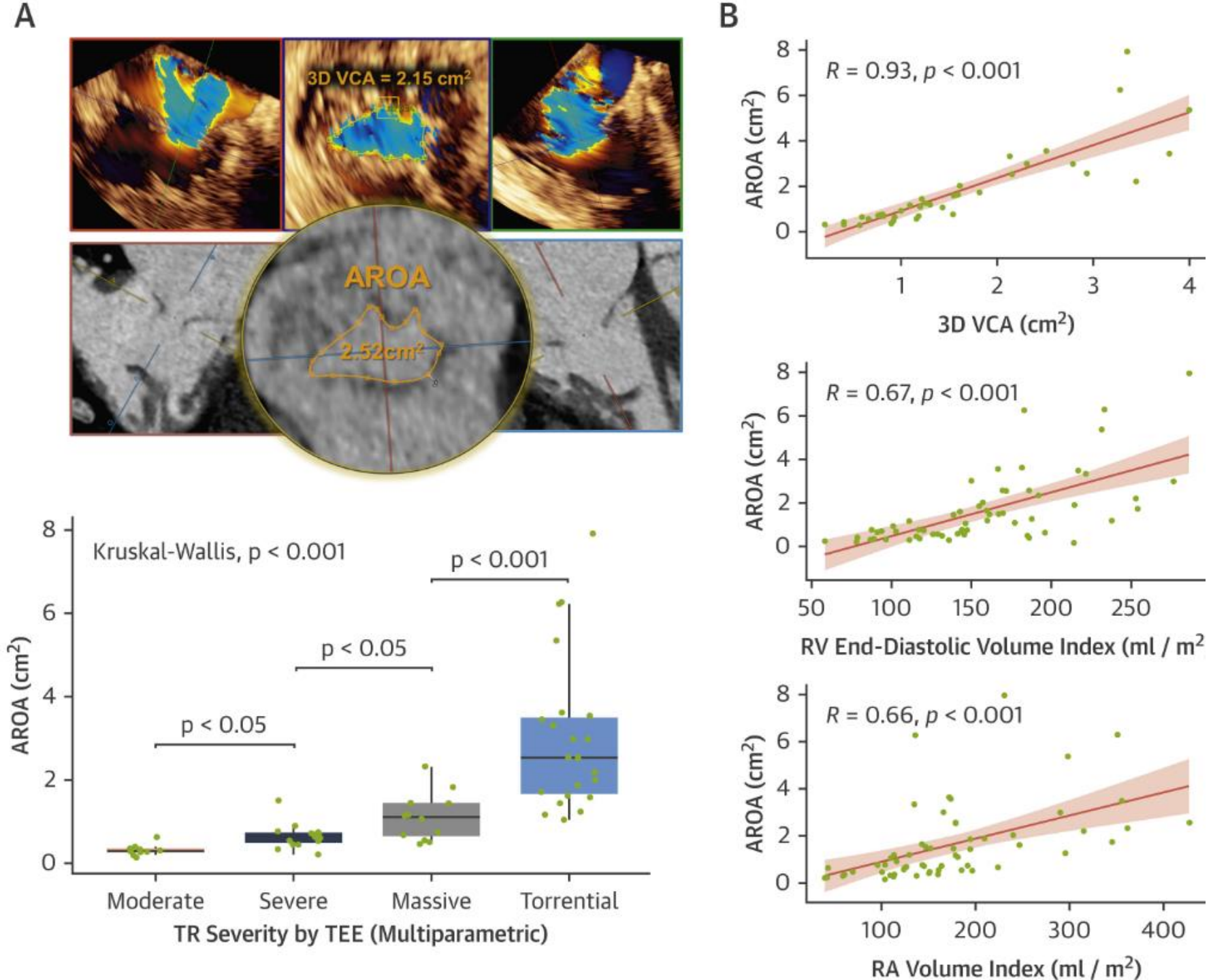
Tricuspid valve area- direct method



Tricuspid valve area - indirect method





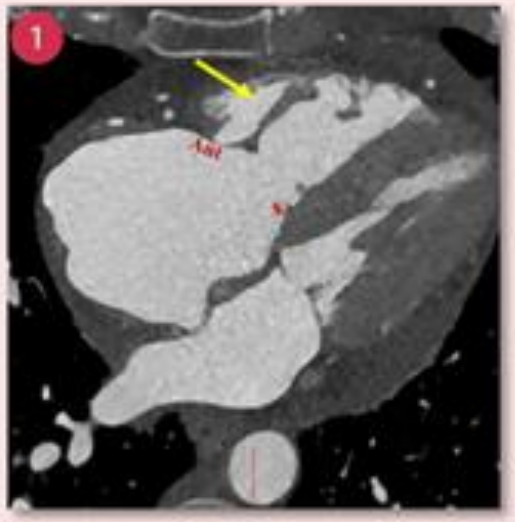


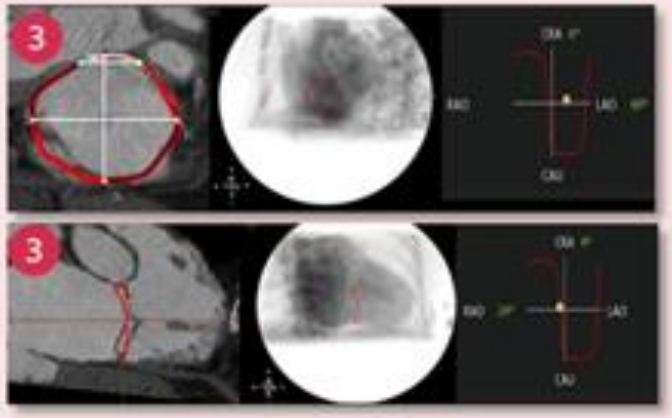
Lopes et al. JACC Cardiovascular imaging 2021 Mar

Utility of CT and MRI in Tricuspid Valve Interventions

Role of CT

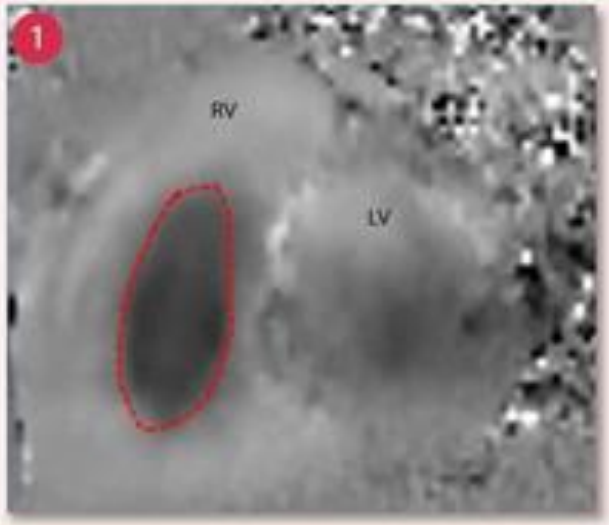
1. Evaluation of tricuspid valve apparatus morphology
2. 3D relationships with adjacent structures
3. Measurements for procedural planning

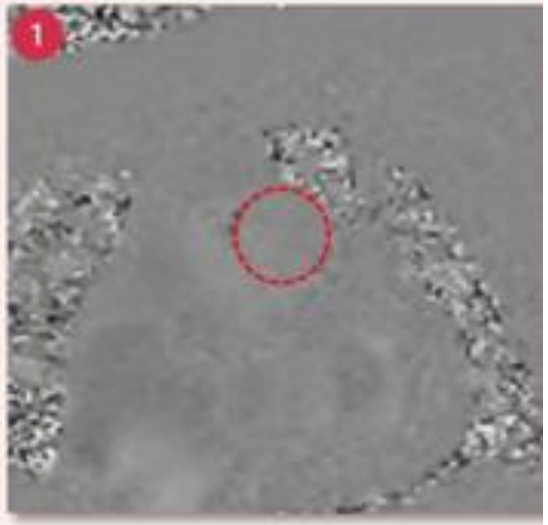




Role of MRI

1. Quantification of tricuspid regurgitation (velocity-encoded phase-contrast and cine steady-state free precession sequences)
2. Quantification of right ventricular function and volumes





Rajiah PS et al. Published online: June 29, 2023
https://doi.org/10.1148/rg.220153

RadioGraphics

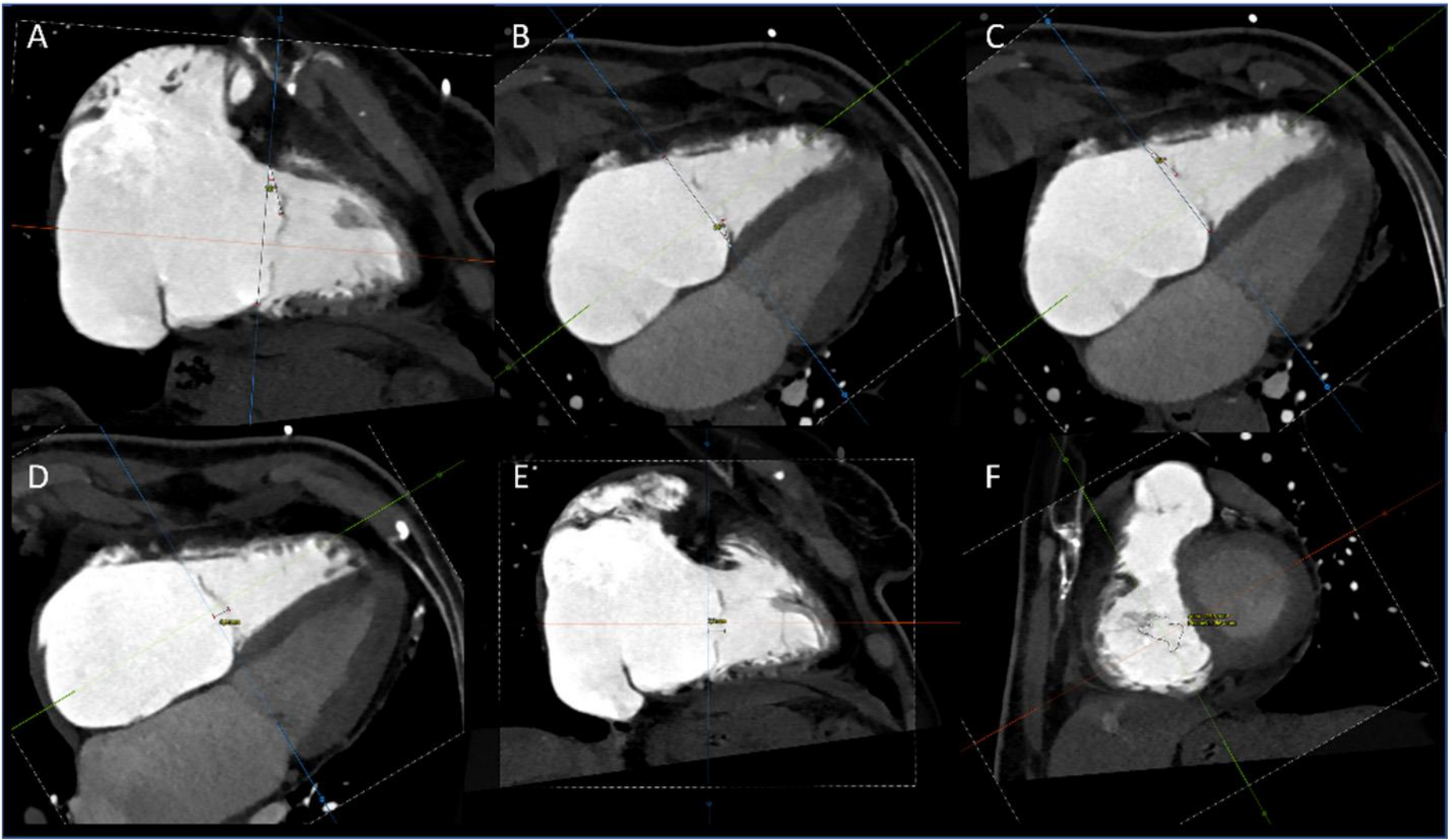
TABLE 2 Pre-Procedural Multimodality Imaging in Tricuspid Valve Interventions

Eligibility Criteria	Device Type	Echocardiography (TTE/TEE)	Computed Tomography
General eligibility criteria			
	All	Use mid- and deep-esophageal and transgastric (short- and long-axis) views Severe TR: (VC width ≥7 mm, EROA ≥40 mm^2, RV ≥45 ml) No severe LV dysfunction (LVEF ≥30%) No severe RV dysfunction No severe PAH (systolic PAP < 60 mm Hg)	Required for some devices: see below
Specific eligibility criteria, views, and measures			
	Edge[illegible]ir	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) 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.	Not required
	Coaptation device	Use mid- and deep-esophageal and transgastric (short- and long-axis) views Coaptation depth <10 mm Coaptation gap <18 mm EROA and largest VC Avoid: severely thickened leaflets, commissural jets If pacemaker lead: not adherent and not interfering with the native leaflet motion	Left subclavian/axillary vein ≥7.1 mm (12-mm Spacer) or 8.3 mm (15-, 18-mm Spacer) Papillary muscle to TA distance >20 mm Papillary muscle to septum distance >15 or 18 mm (for 15-mm and 18-mm devices, respectively) Measure TA to RV apex distance Identify target anchoring site Assess RV dimensions and subvalvular structures
	Restrictive annuloplasty	Use mid- and deep-esophageal and transgastric (short- and long-axis) views Adequate TA dimensions (e.g., TA diameter ≤55 mm and ≥2-4 mm posterior annular depth required for Trialign implantation) If pacemaker lead: not adherent and not interfering with the native leaflet motion	TA dimensions Evaluate risk of RCA injury (RCA course and distance to TA) Target anchoring area (e.g., TriCinch, between the mid-anterior TA and the anteroposterior commissure) Predicting optimal fluoroscopic planes
	Heterotopic tricuspid valve implantation caval devices	Use mid- and deep-esophageal views of the cavo-atrial junction Use transgastric views of the inferior vena cava and hepatic vein Confirm presence of significant backward flow in the venae cavae	Measure SVC at the level of the innominate vein confluence, of the pulmonary artery and of SVC-RA junction; measure IVC at the level of IVC-RA junction, at top of hepatic veins and at 5 cm below IVC-RA transition Landing zone ≤ 35 mm for TricValve and <42 mm for Tricento Height between IVC-RA junction and hepatic veins >10 mm
	Tricuspid valve replacement	Identification of TR mechanism by TTE and TEE Preserved native leaflet mobility (if prior pacemaker lead) to ensure leaflet capture Use 2D and 3D mid- and deep-esophageal and transgastric views 3D planar cross-sectional area of the TA in early systole and mid-diastole	TA diameter: 36-52 mm with valve oversizing <10% RA length ≥6 or 7 cm for transatrial or transjugular access RIJV to SVC distance ≥14 mm Assess RCA course and distance to TA Assess Risk of RVOT obstruction Co-axial deployment angle
	Surgical [illegible]ve repair/replacement	Assess TR mechanism and severity by TTE Consider TEE/CMR if indeterminate TR severity Assess RV size/function and indirect signs of PAH TA diameter ≥40 mm in 4-chamber view in patients with mild/moderate TR undergoing left-sided valve surgery Coaptation depth <10 mm Tethering distance <0.76 cm, tethering area >1.63 cm^2 RV end-systolic area <20 cm^2 Use mid- and deep-esophageal and transgastric (short- and long-axis) views	Not required

Diameter and tortuosity of the femoral /iliac vein/IVC sheath to Femoral Vein Perimeter Ratio

Agricola, E. et al. J Am Coll Cardiol Img. 2021;14(1):61-111.

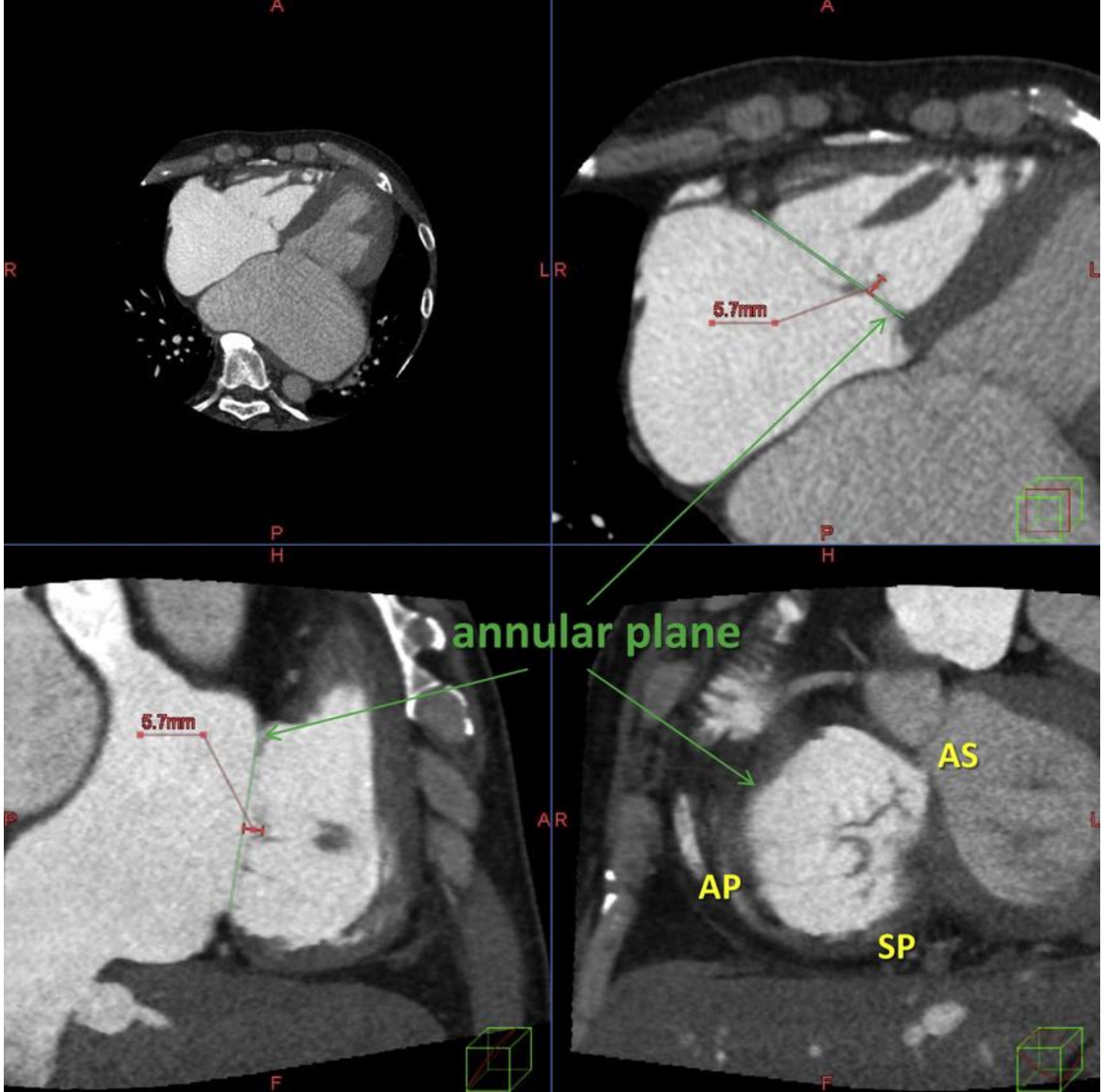
Tethering



Article

Novel Computed Tomography Variables for Assessing Tricuspid Valve Morphology: Results from the TRIMA (Tricuspid Regurgitation IMAging) Study

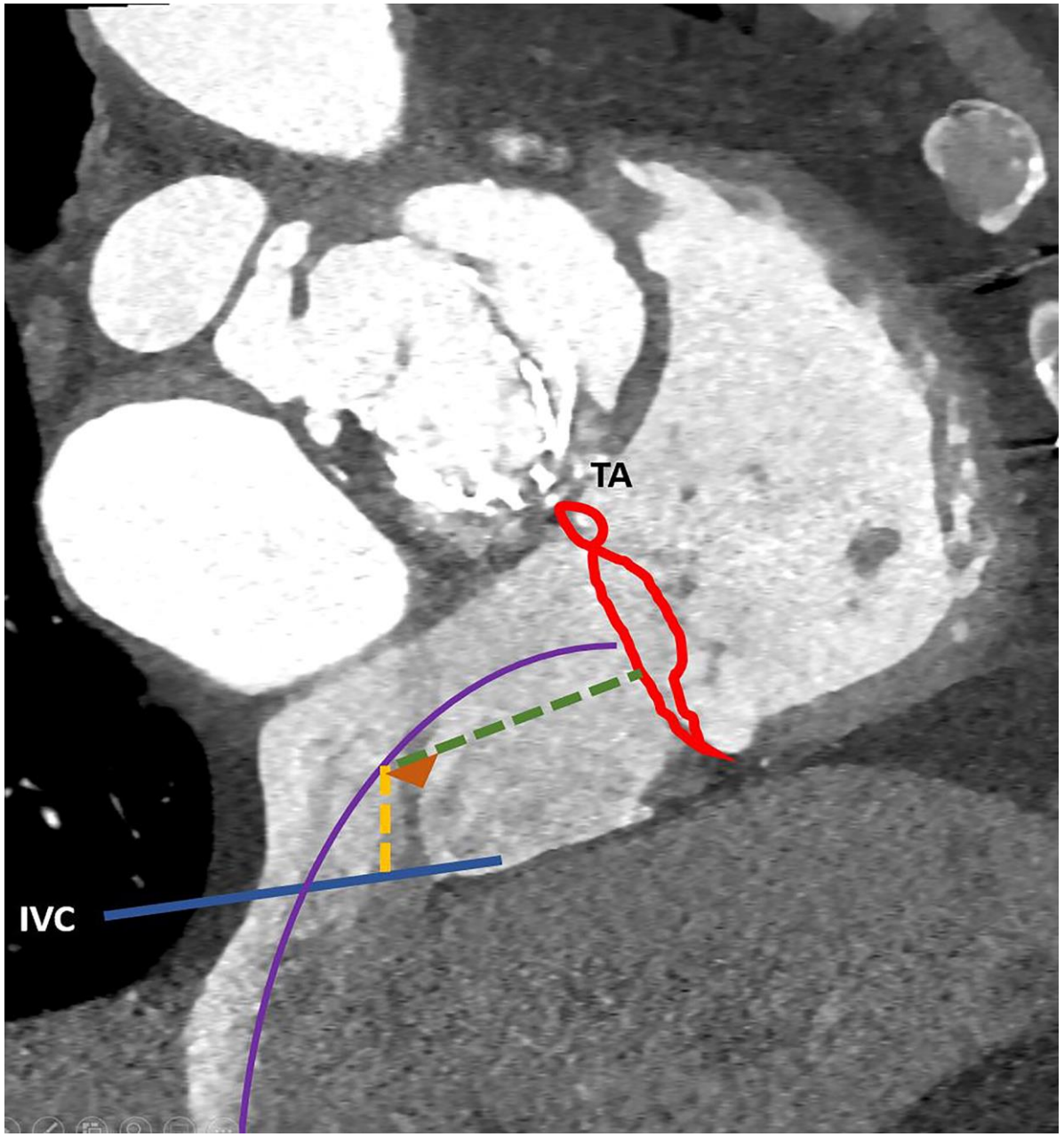
Valeria Cammalleri [1,*], Myriam Carpenito [1], Domenico De Stefano [2], Gian Paolo Ussia [3], Maria Caterina Bono [1], Simona Mega [1], Annunziata Nusca [1], Nino Cocco [1], Edoardo Nobile [1], Aurelio De Filippis [1], Luka Vitez [4], Carlo Cosimo Quattrocchi [3] and Francesco Grigioni [1]



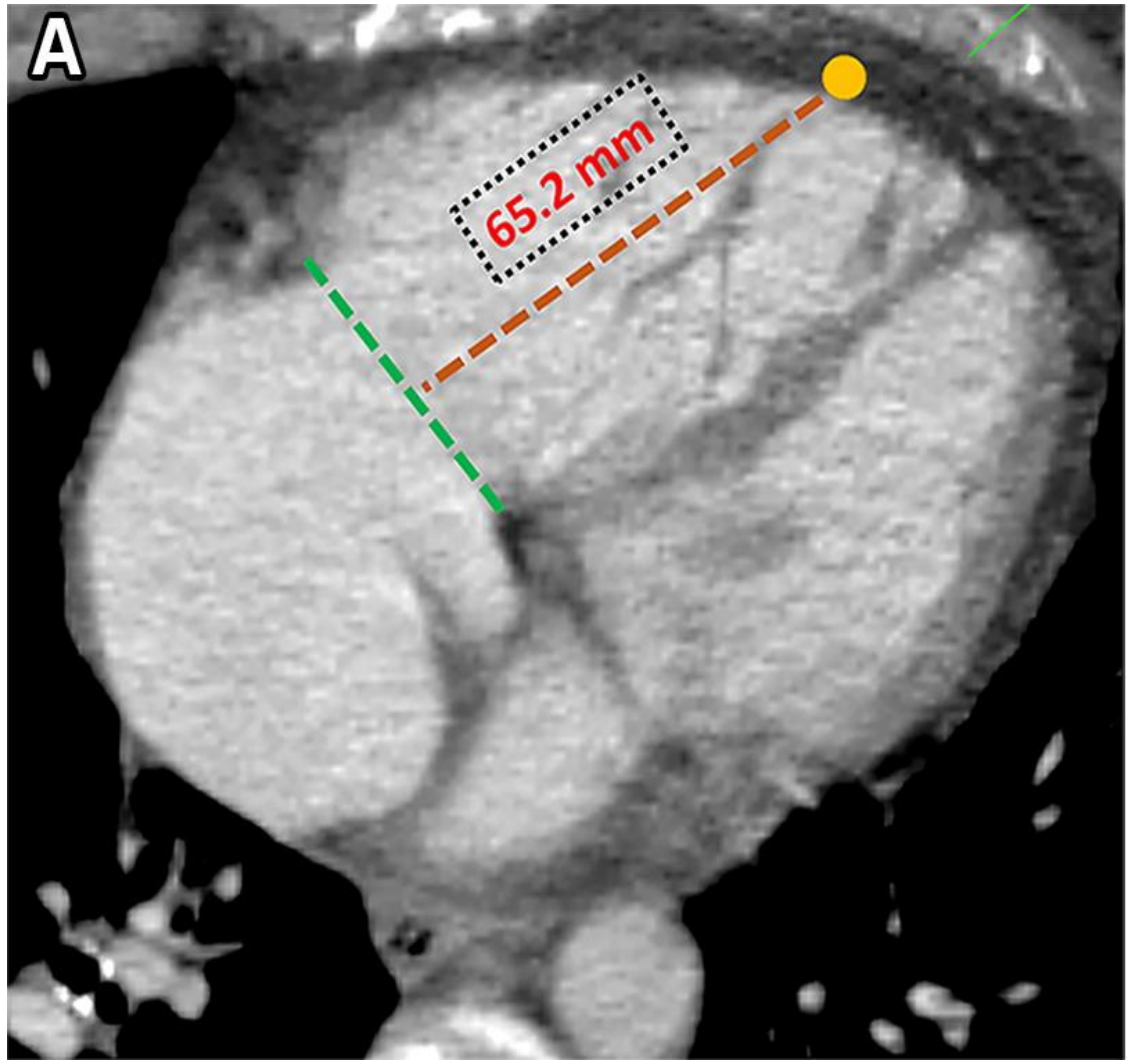
Predictors of recurrent TR in tricuspid annuloplasty
Tethering height > 7.2 mm

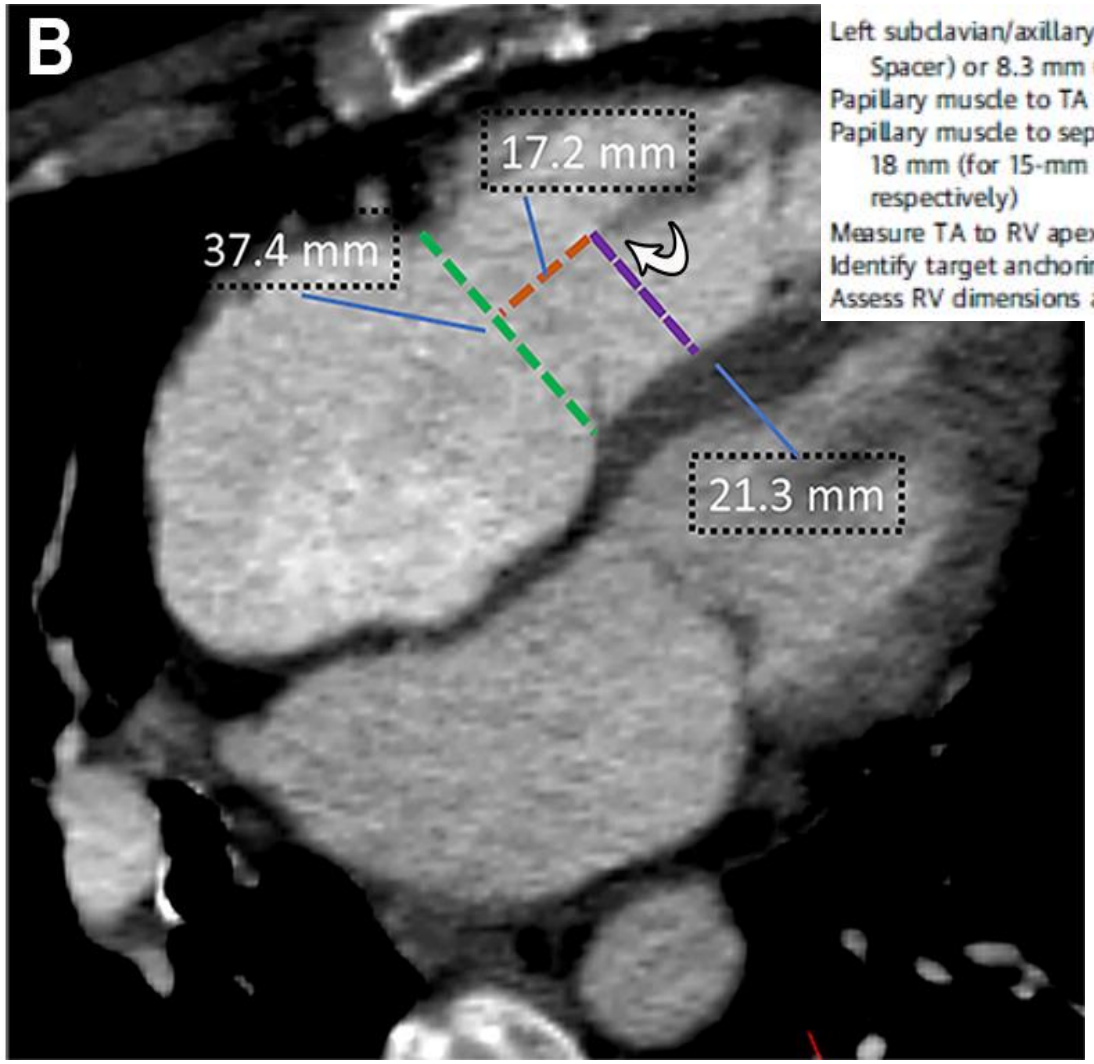
Masashi Kabasawa, MD, Hiroki Kohno, MD, PhD, Toru Ishizaka, MD, PhD, Keiichi Ishida, MD, PhD, Nobusada Funabashi, MD, PhD, Akihisa Kataoka, MD, PhD, Goro Matsumiya, MD, PhD

The Journal of Thoracic and Cardiovascular Surgery Volume 147 Issue 1 Pages 312-320 (January 2014)


TA
IVC

Spacer device (Forma)-RV sizing





Left subclavian/axillary vein ≥7.1 mm (12-mm Spacer) or 8.3 mm (15-, 18-mm Spacer)
Papillary muscle to TA distance >20 mm
Papillary muscle to septum distance >15 or 18 mm (for 15-mm and 18-mm devices, respectively)
Measure TA to RV apex distance
Identify target anchoring site
Assess RV dimensions and subvalvular structures

Rajiah PS. Published Online: June 29, 2023

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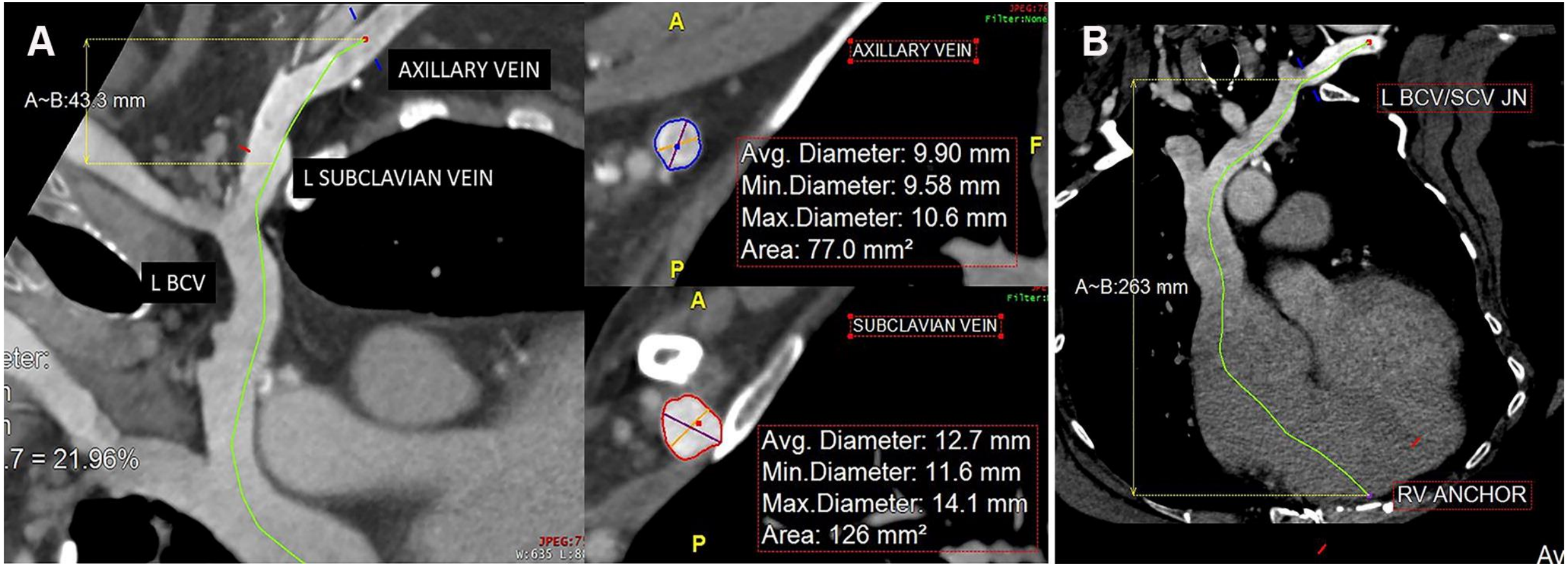

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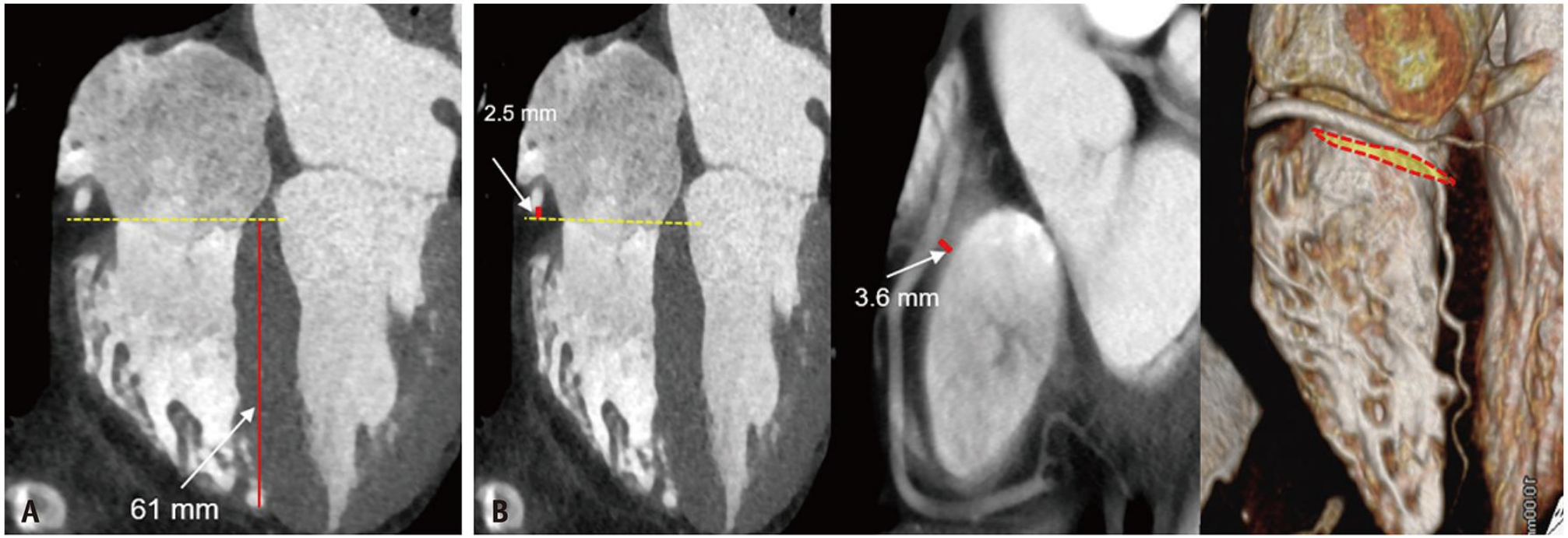
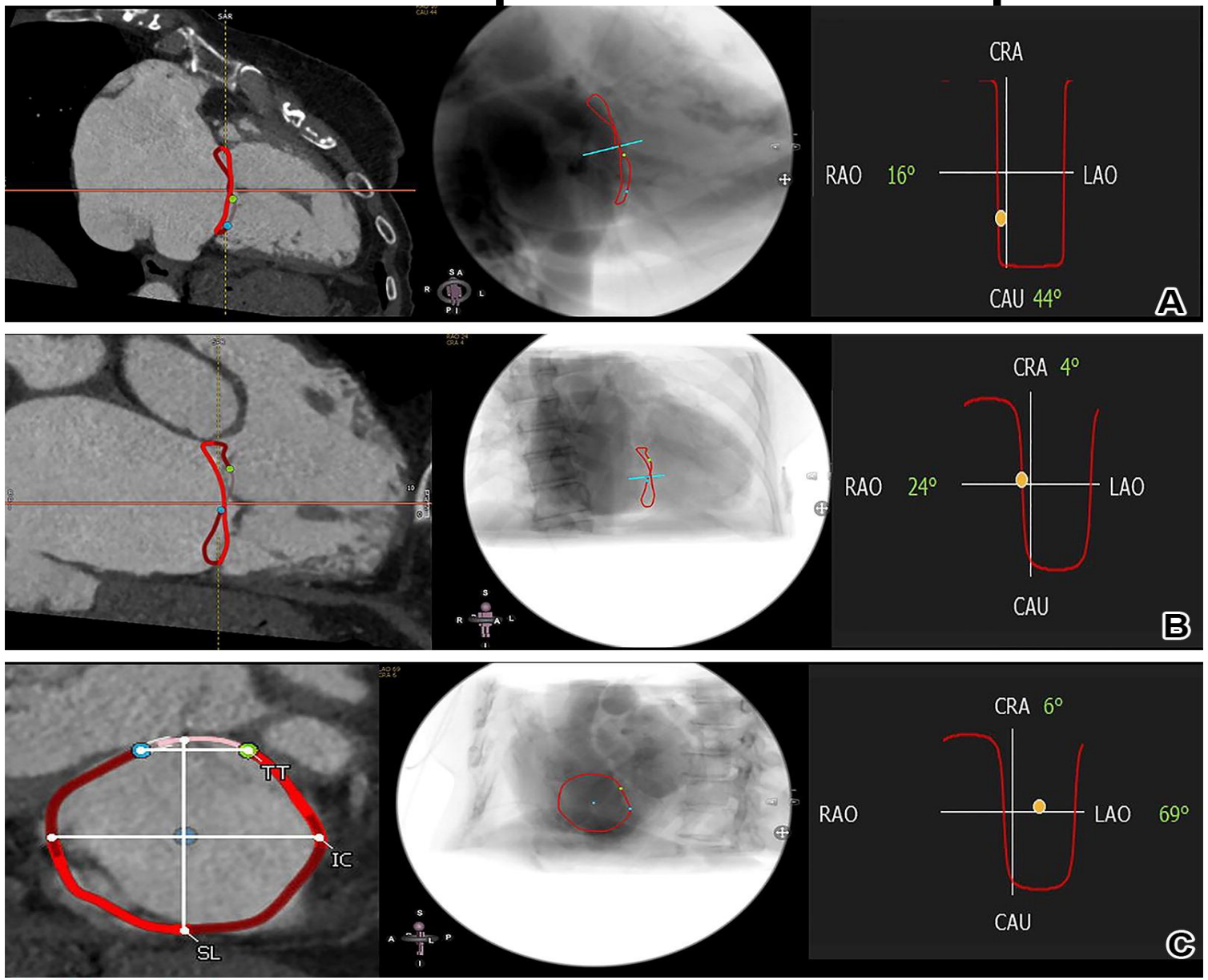
Transcatheter TV therapy



TA diameter: 36-52 mm with valve oversizing <10%
RA length ≥6 or 7 cm for transatrial or transjugular access
RIJV to SVC distance ≥14 mm
Assess RCA course and distance to TA
Assess Risk of RVOT obstruction
Co-axial deployment angle

Yura Ahn, et al. Korean J Radiol 2021 Dec; 22 (12)

Fluoroscopic views for procedural planning



Trajectory of the device through ICV+RCA

Coaxility of the delivery system

Coplanar deployment

RadioGraphics Rajiah PS et al. Published Online: June 29, 2023 https://doi.org/10.1148/rg.220153

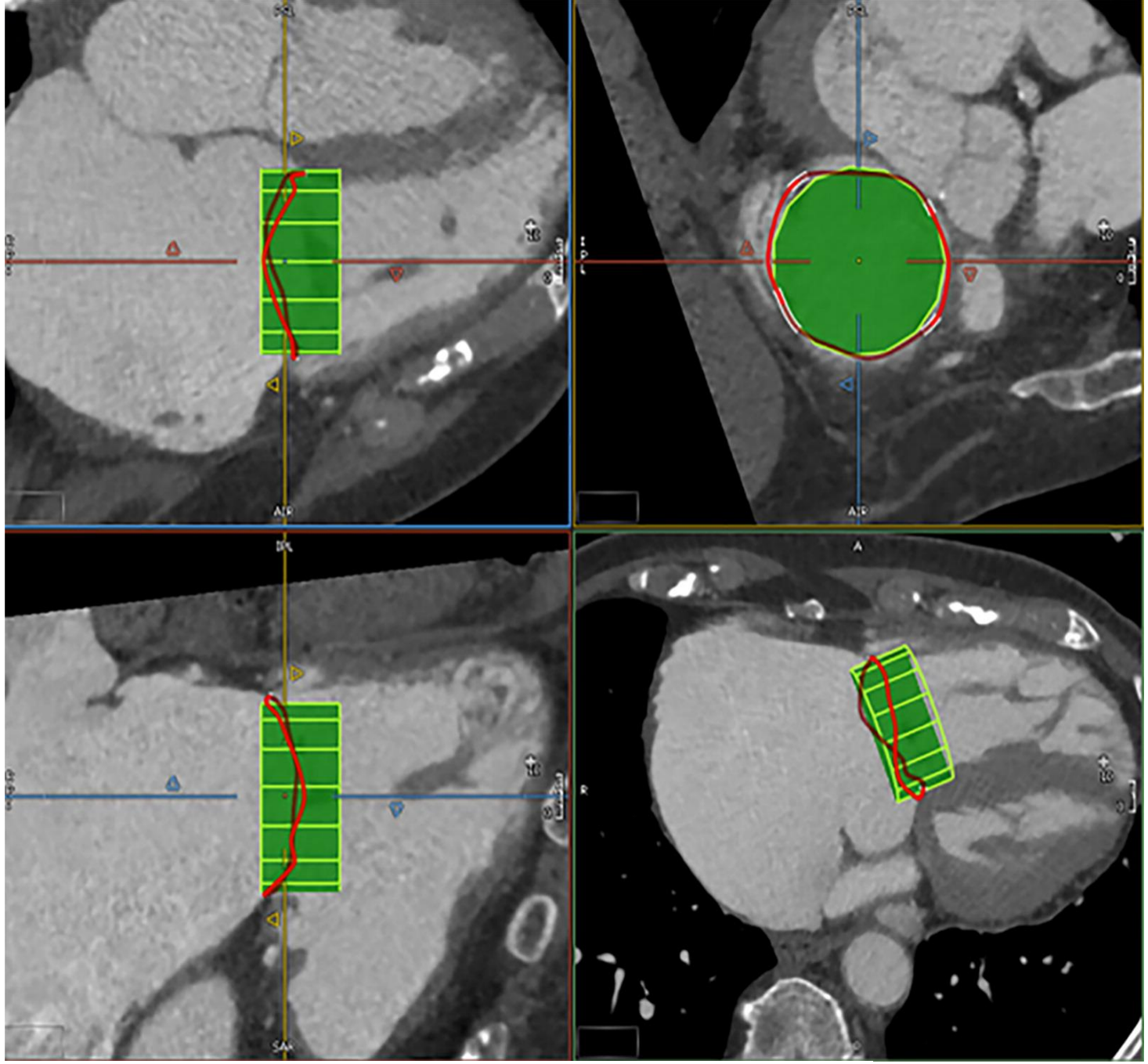
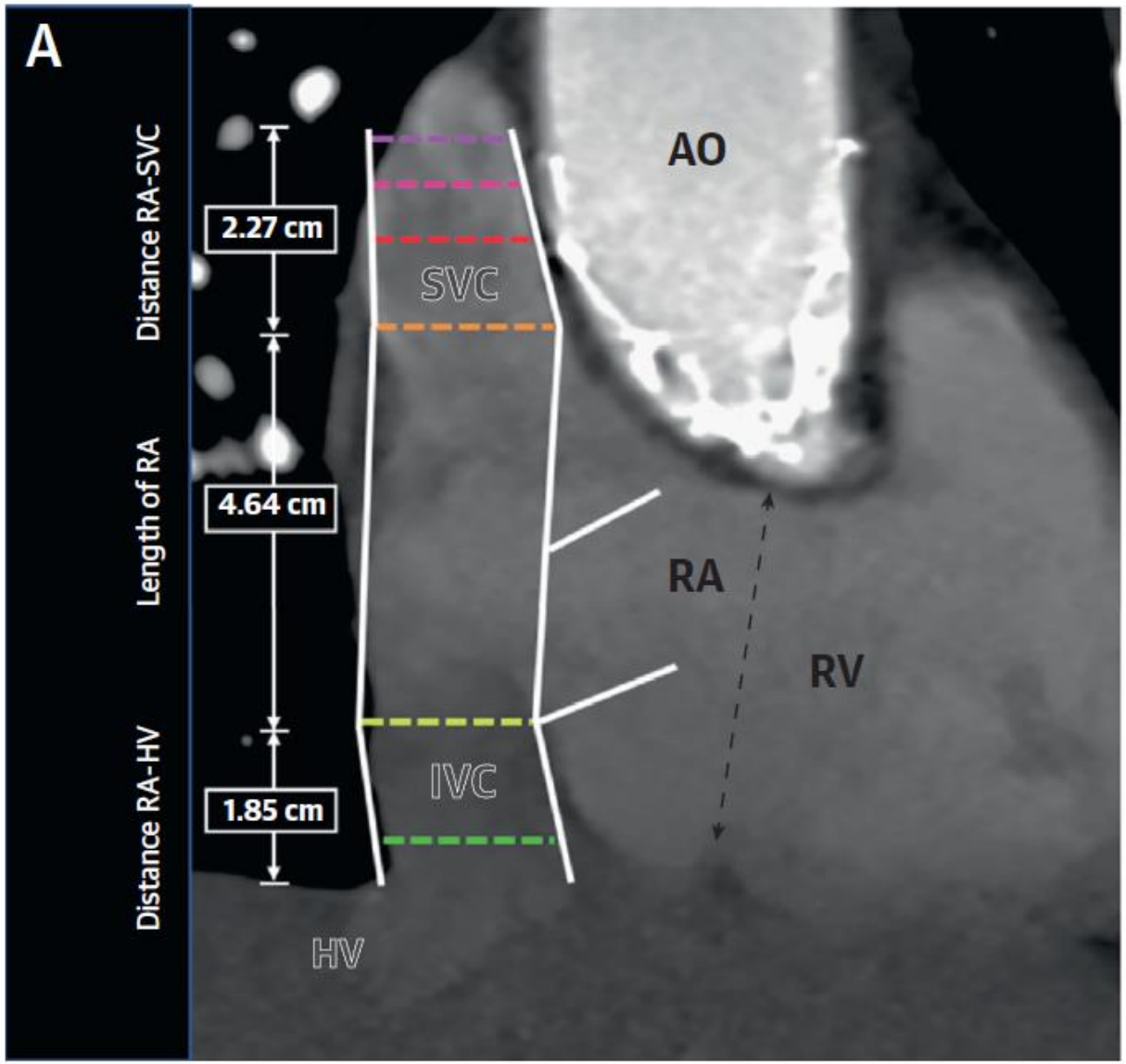
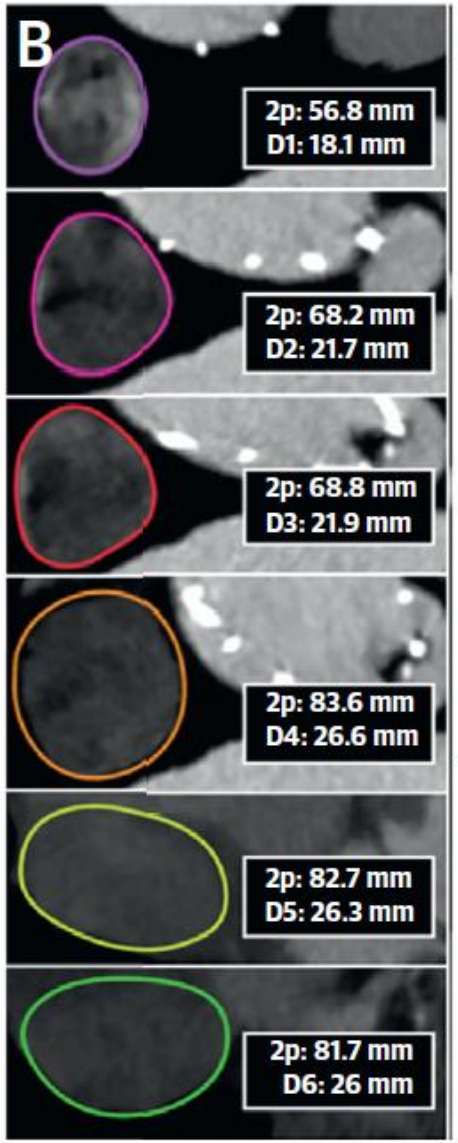


FIGURE 23 Pre-Procedural Planning for Heterotopic Valve Implantation by Computerized Tomographic Imaging





Measure SVC at the level of the innominate vein confluence, of the pulmonary artery and of SVC-RA junction; measure IVC at the level of IVC-RA junction, at top of hepatic veins and at 5 cm below IVC-RA transition

Landing zone ≤ 35 mm for TricValve and <42 mm for Tricento

Height between IVC-RA junction and hepatic veins >10 mm

SVC diameters and areas at different levels from RA

RA-IVC diameter

IVC diameter at level of HV

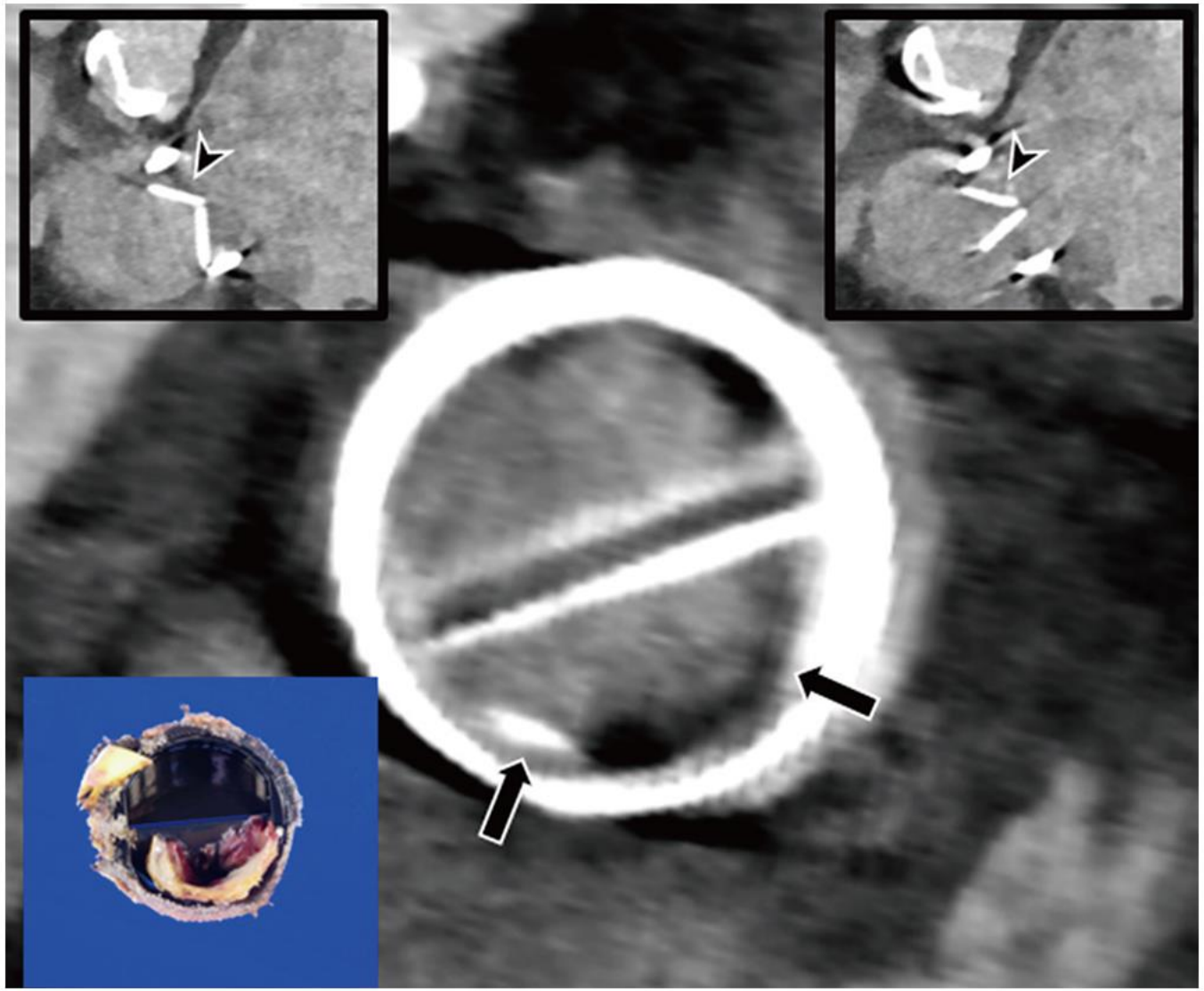
Agricola, E. et al. J Am Coll Cardiol Img. 2021;14(1):61-111.

CIED leads

- Is required to understand the interaction of CIED leads and the TV
- Leads may restrict, perforate or adhere to valve leaflets
- Can cause significant blooming artefacts that may render the analysis of TR mechanism and lead position challenging.

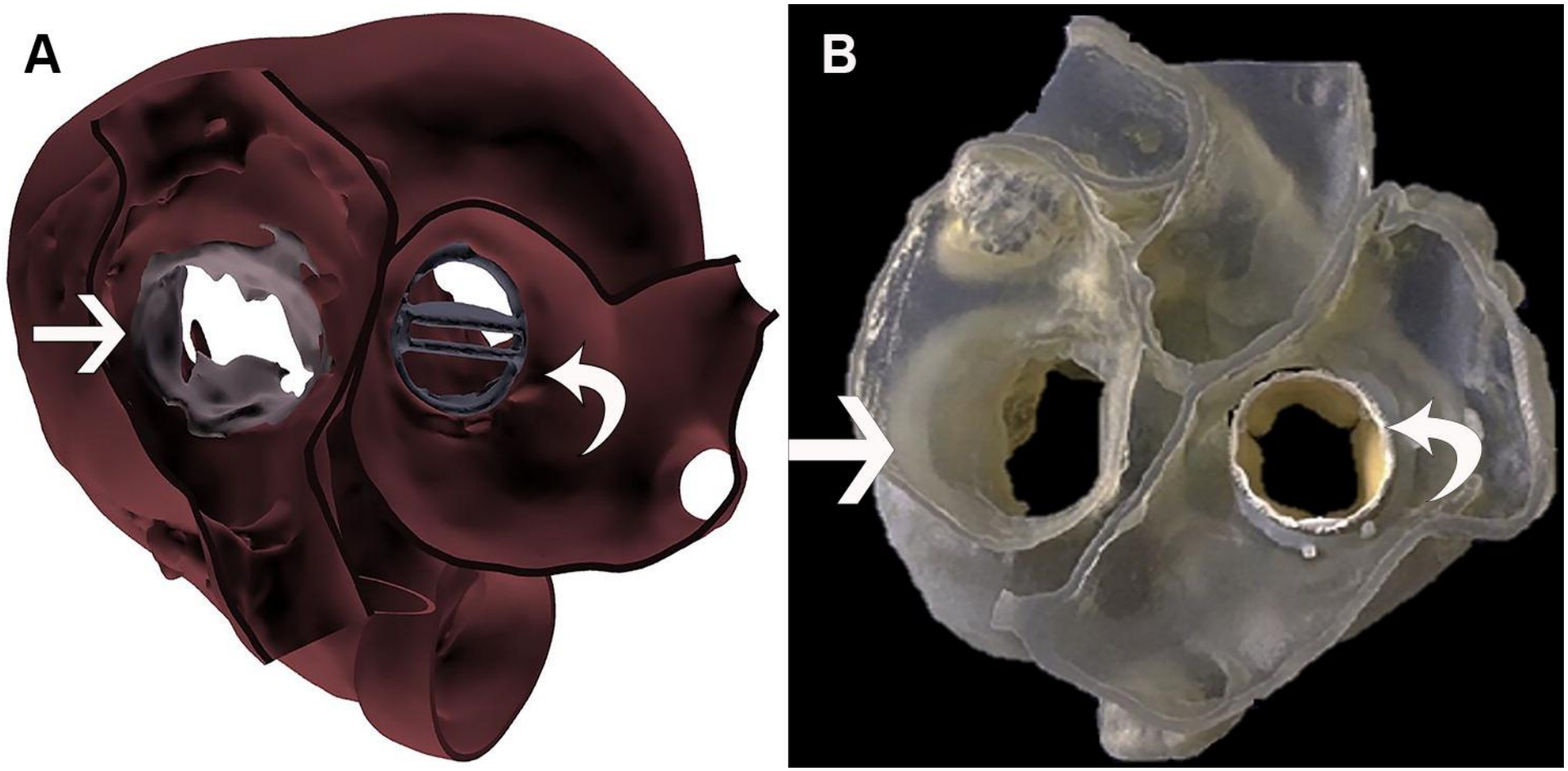
CT for follow-up

- Dubious findings
- Potential complications
- Prosthetic valve dysfunction by identifying thrombus formation and leaflet motion and distinguishing thrombus from pannus.



Yura Ahn, et al. Korean J Radiol 2021 Dec; 22 (12).

3D printing



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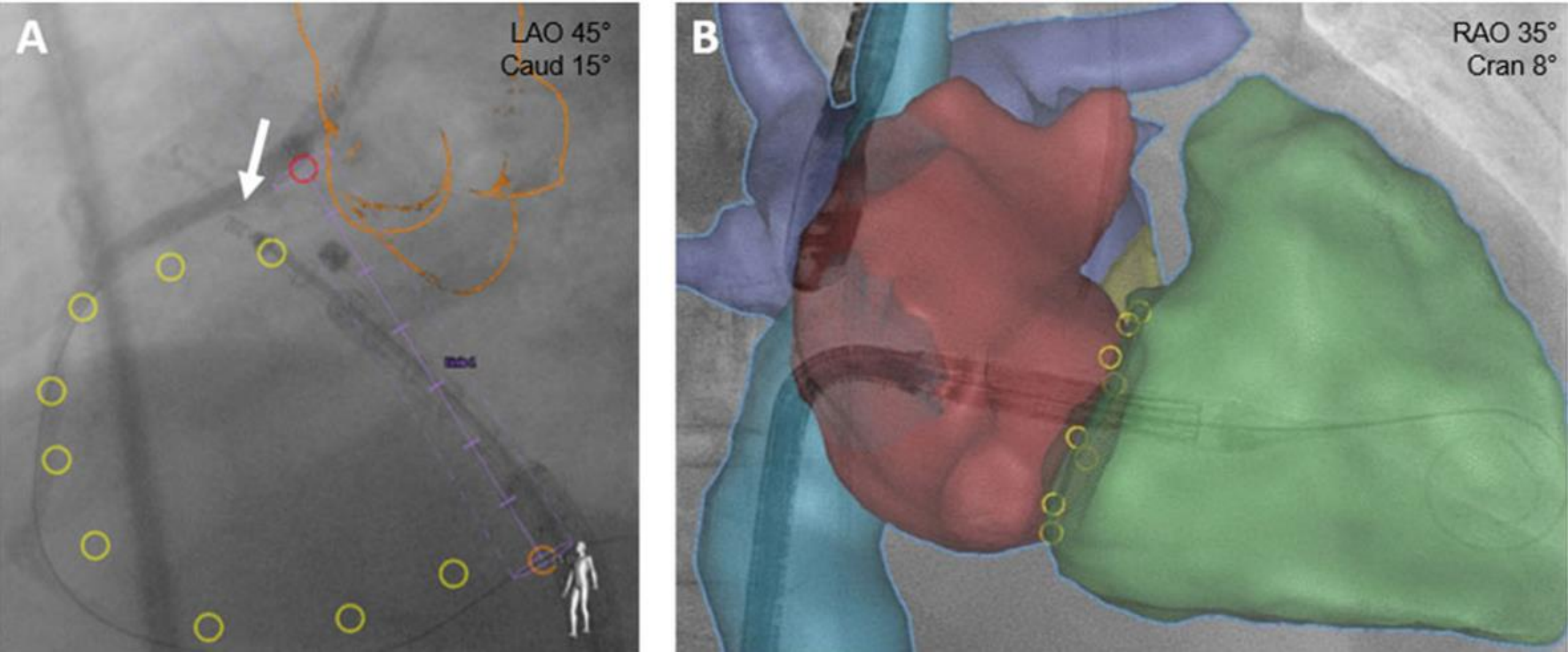
Fusion Imaging



Hell M et al. European Heart Journal - Cardiovascular Imaging (2021) 22, 601 - 610.

Conclusions

- Multimodality imaging is key
- CT important in tricuspid valve assessment
- Essential for patient selection and preprocedural planning
- Post-procedural investigation of the causes of valve dysfunction

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Thank you!

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