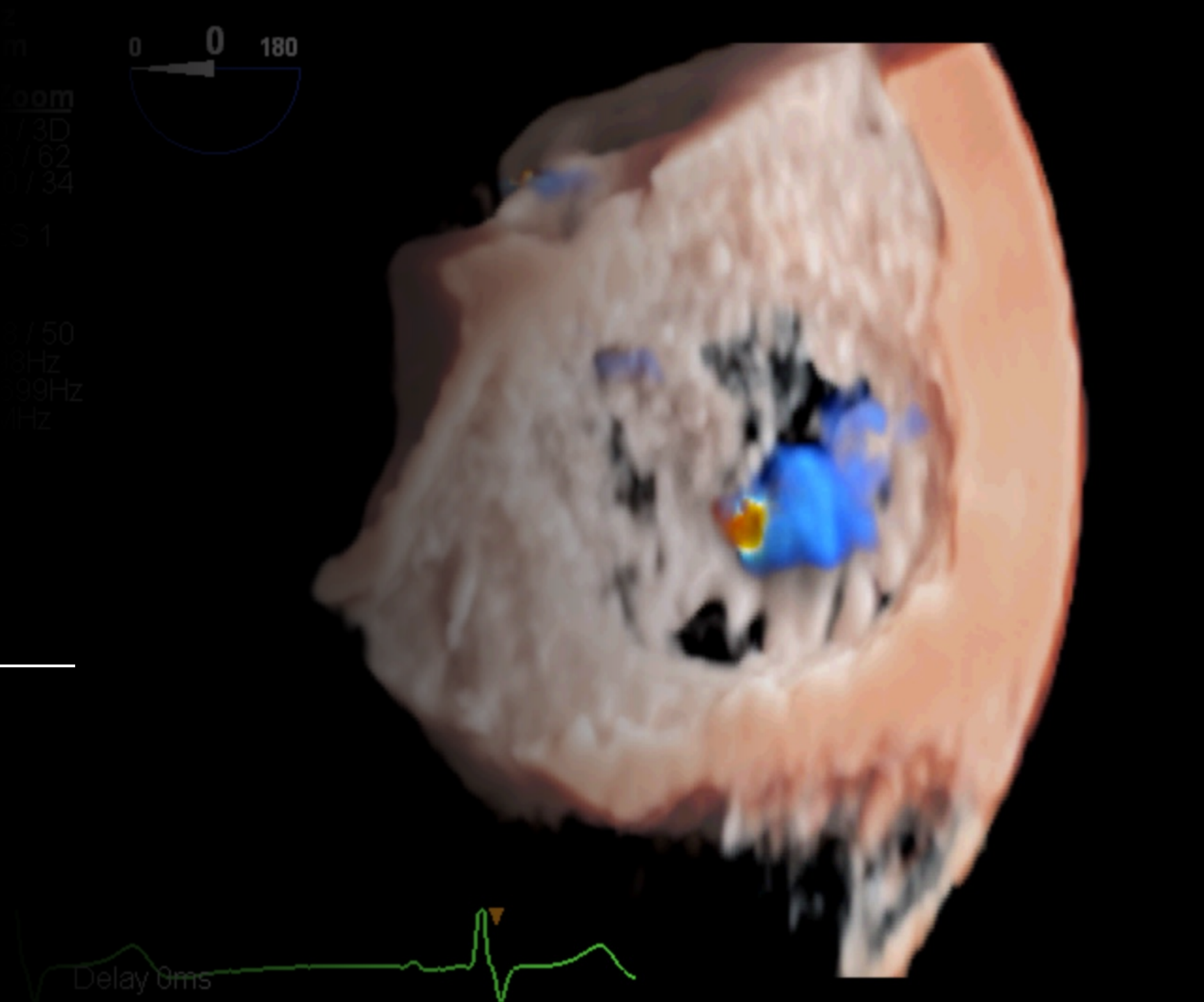
CENTRE HOSPITALIER
UNIVERSITAIRE DE NANTES

Valve tricuspide

DIU TUSAR 2023 - 2024

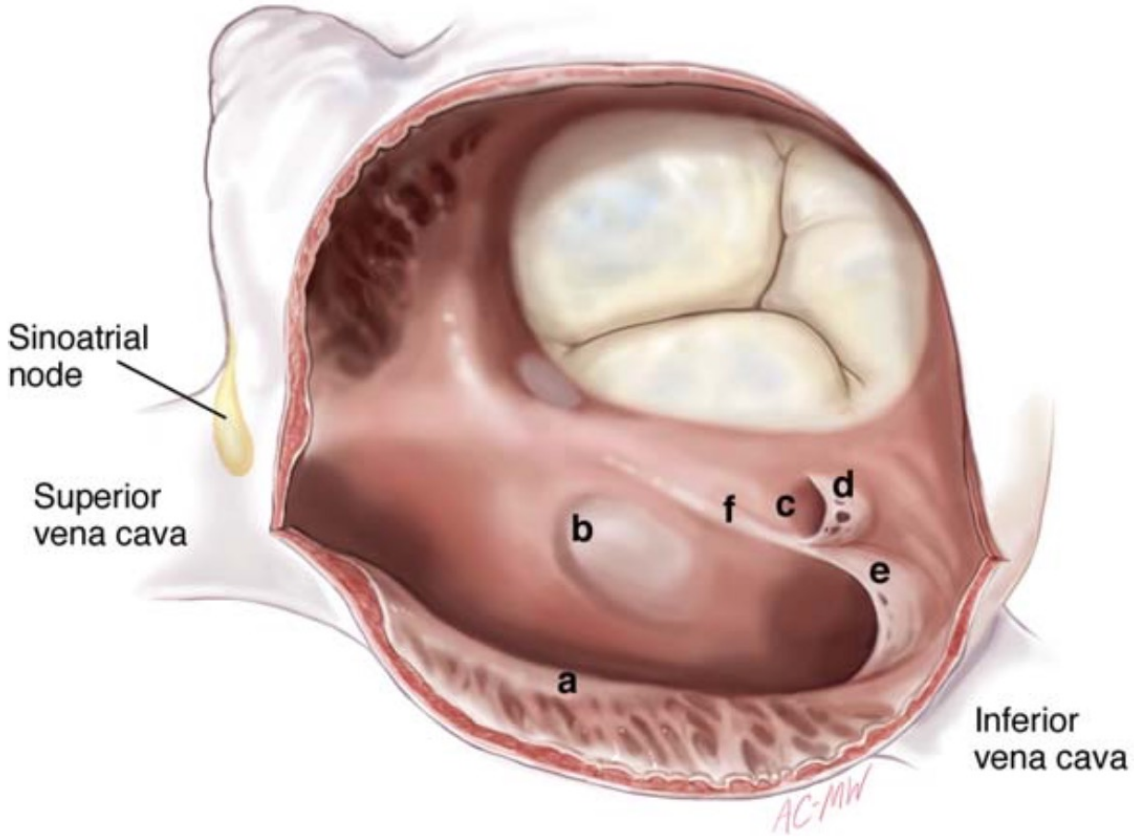
Dr Manon Canevet – Anesthésie
Réanimation CTCV Nantes



plan

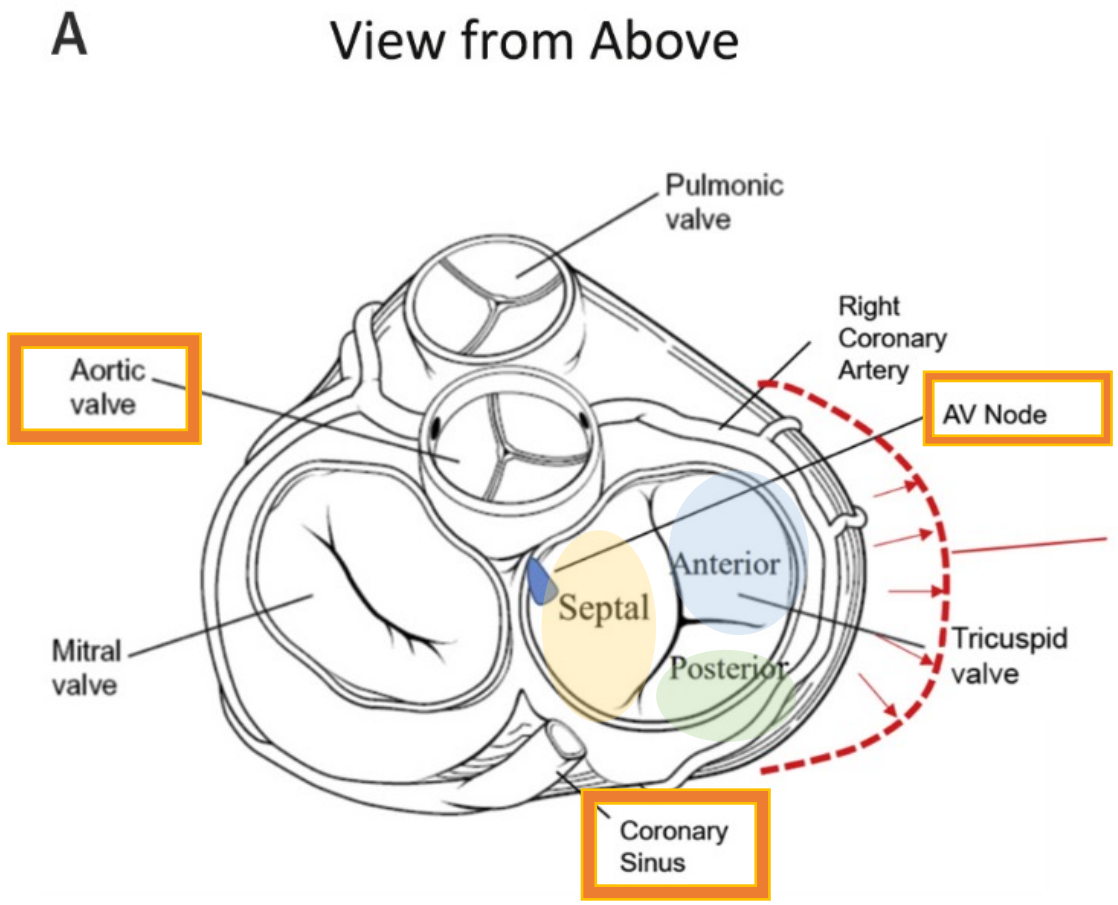
- Anatomie de la valve tricuspide
- Classification et étiologie de l’insuffisance tricuspidienne
- Sévérité de l’IT
- Sténose tricuspidienne étiologie et critères de sévérité

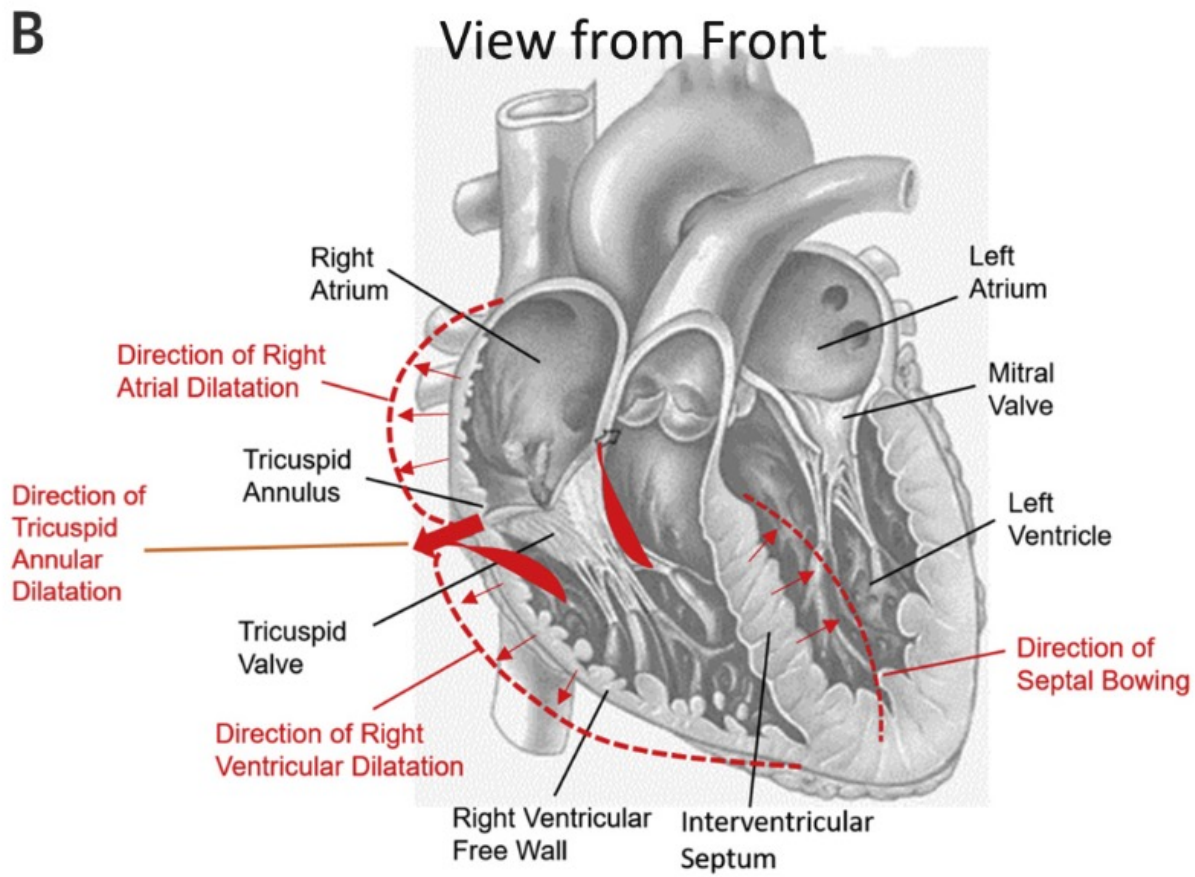
Anatomie valve tricuspide



- La + grande des valves : orifice 8 +/- 1 cm2
- La + apicale (en général moins de 1cm sous la VM)

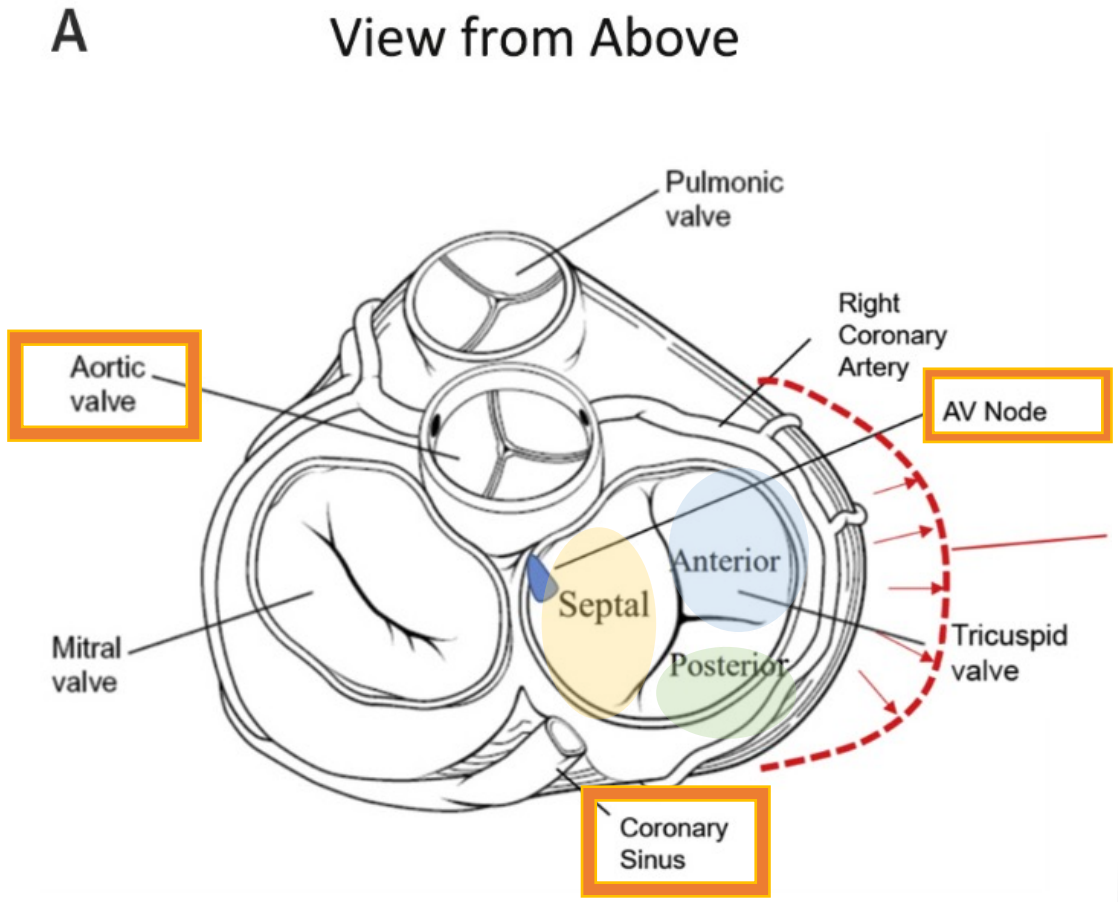
Anatomie valve tricuspide

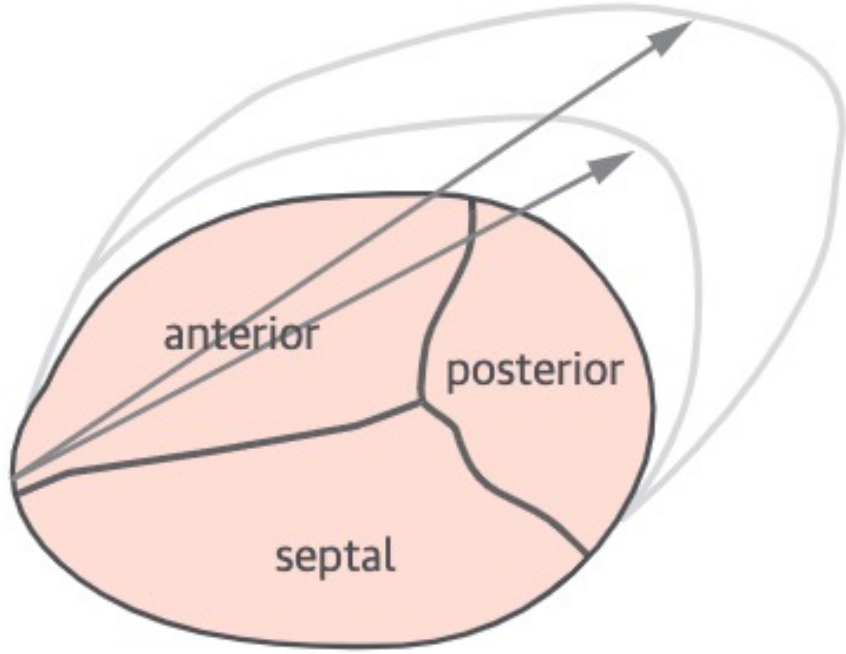


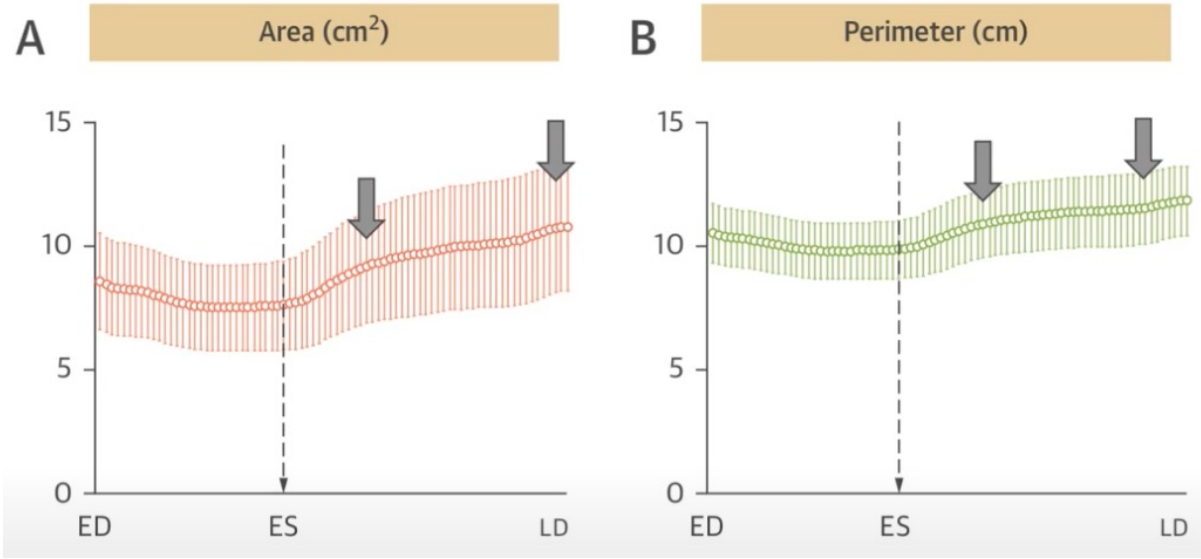


Dahou, A et al, J Am Coll Cardiol Img 2019

Anatomie valve tricuspide





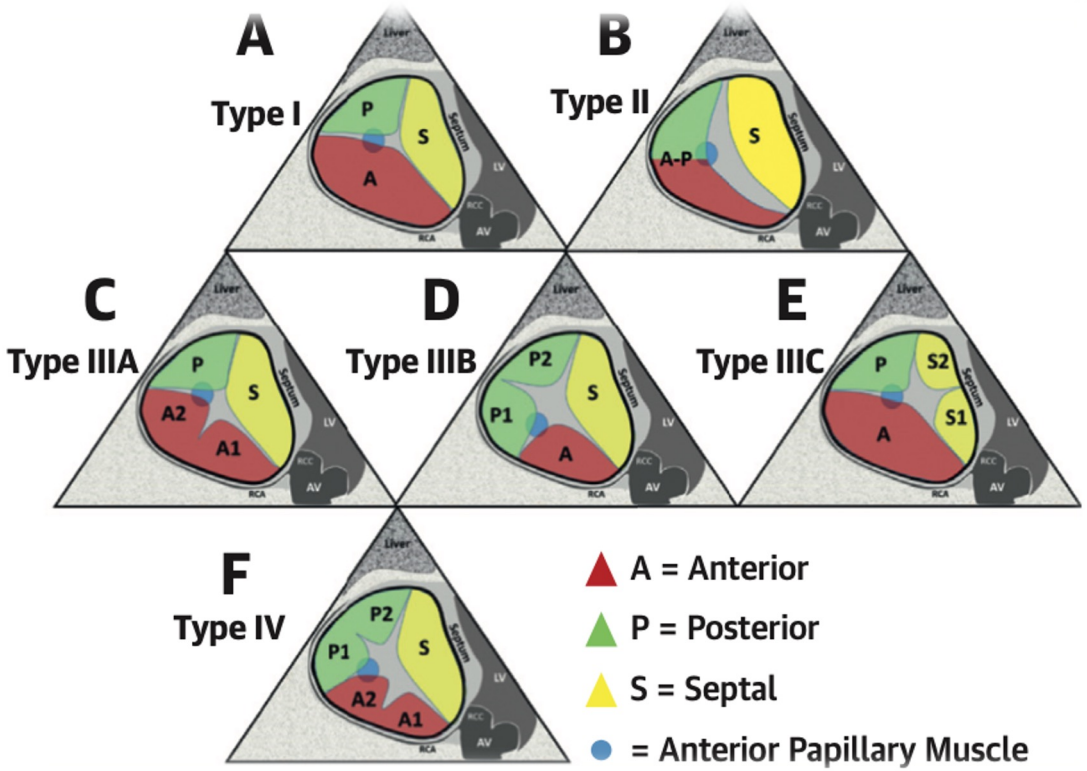


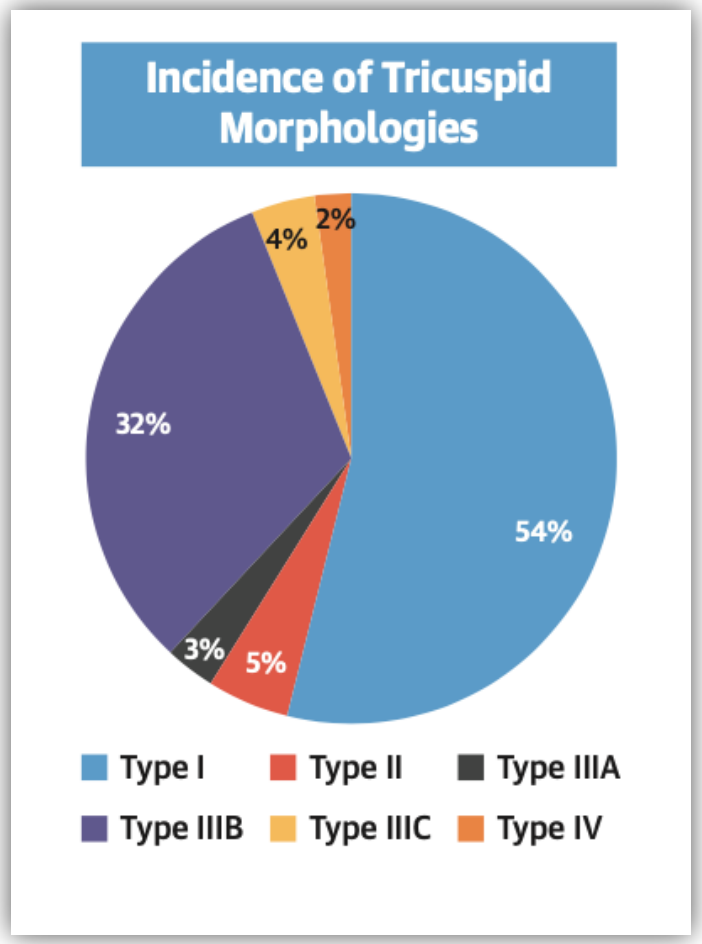
Addetia et al, J Am Coll Cardiol Img, 2019

Dahou, A et al, J Am Coll Cardiol Img 2019

Anatomie valve tricuspide

Proposal for a Standard Echocardiographic Tricuspid Valve Nomenclature, Hahn R, JACC 2021





Analyse en ETO

+/- difficile

- Position antérieure et inférieure de la valve tricuspide
- Finesse des feuillets
- Taille importante de l'orifice
- Impossibilité d'aligner anneau perpendiculaire aux US
- Nécessité de vues oesophagiennes profondes

Analyse en ETO et ETT

2019

GUIDELINES AND STANDARDS

Guidelines for Performing a Comprehensive Transthoracic Echocardiographic Examination in Adults: Recommendations from the American Society of Echocardiography

2013

GUIDELINES AND STANDARDS

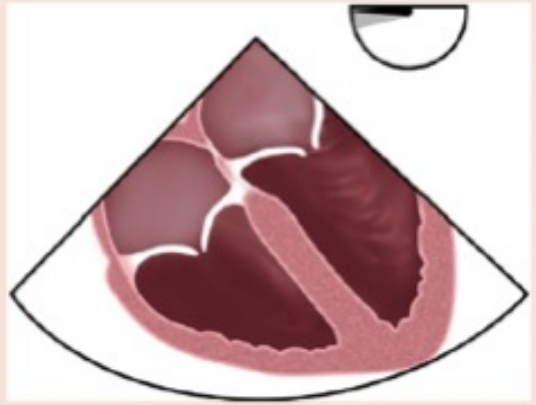
Recommended Standards for the Performance of Transesophageal Echocardiographic Screening for Structural Heart Intervention: From the American Society of Echocardiography

ETO valve tricuspide

Mid œsophage – 0°

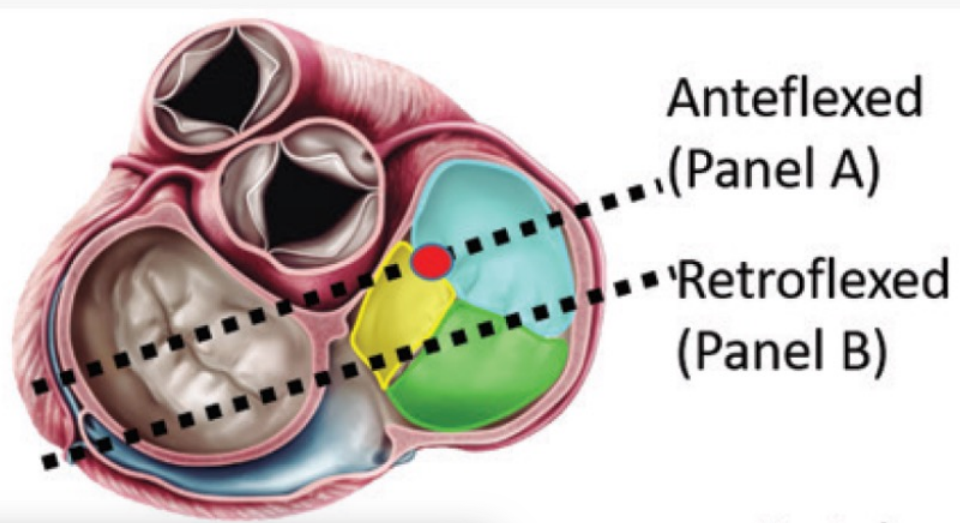
Acquisition protocol:

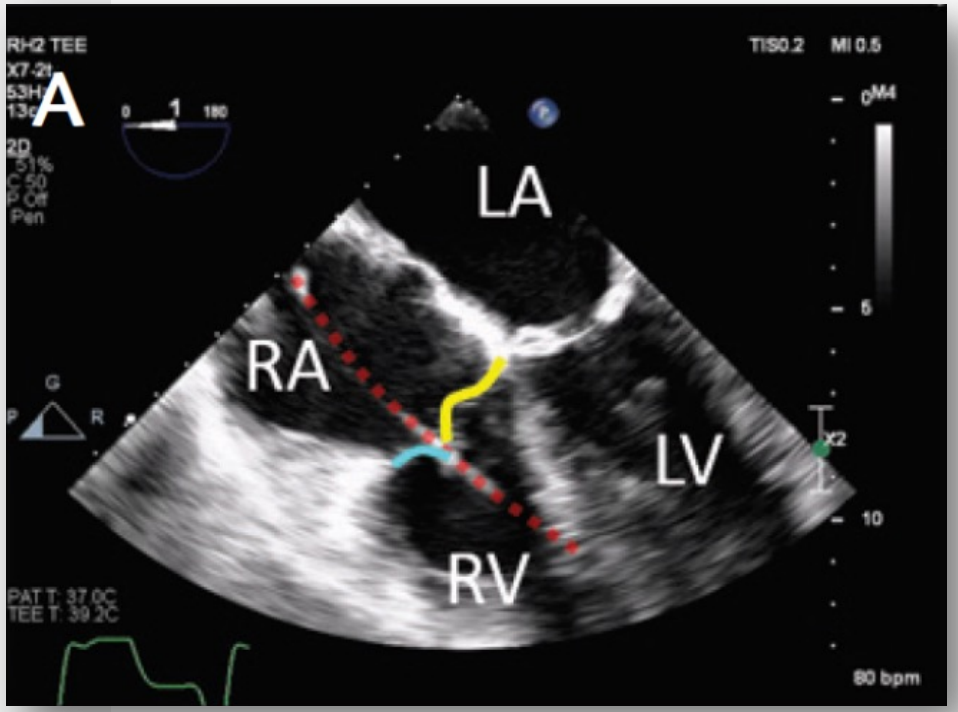
- From the ME four-chamber view focused on the MV (0° mechanical rotation), rotating the probe clockwise will center the TV in the imaging plane.
- Using right flexion may help center the TV and reduce interference from left heart structures.

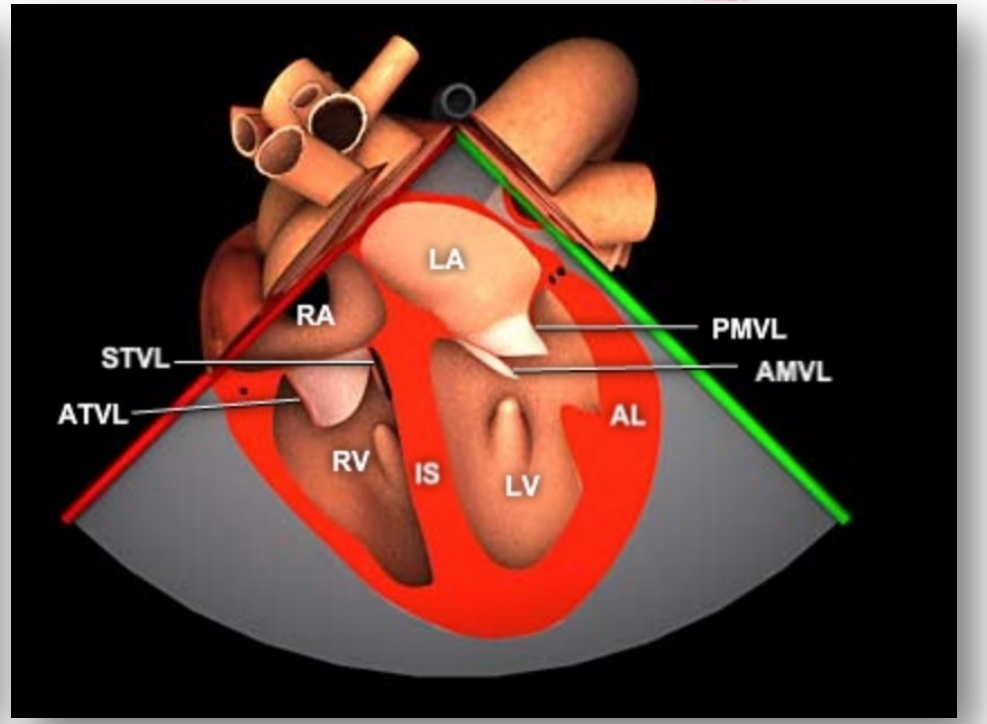


ETO valve tricuspide

Mid œsophage – 0°







Septal

Anterior

Posterior

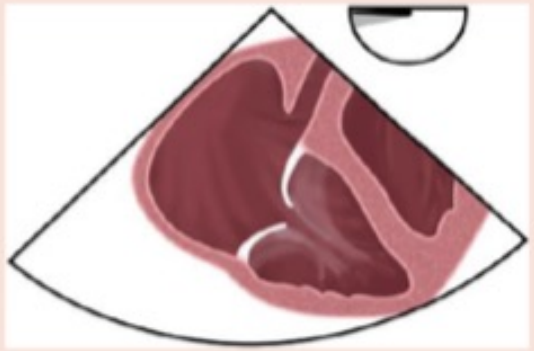
Pacing Wire

ETO valve tricuspide

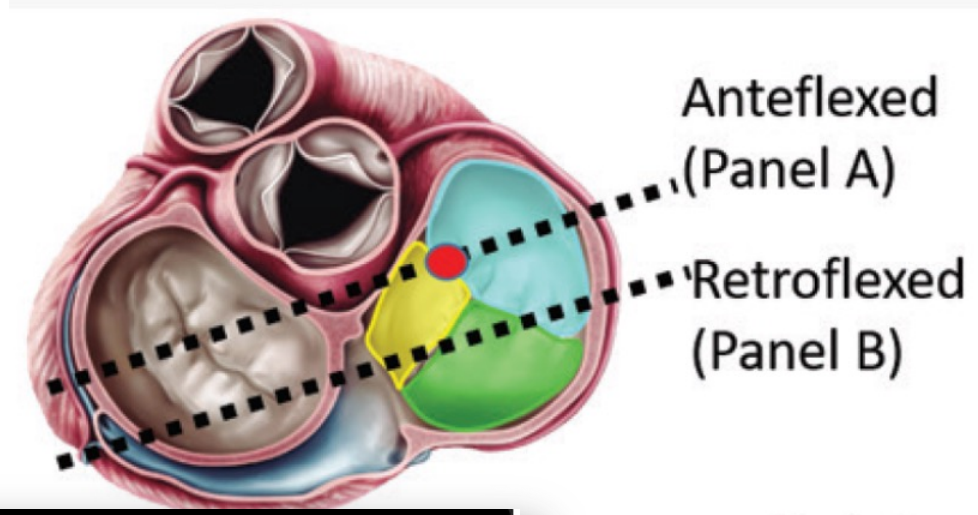
œsophage bas – 0°

Acquisition protocol:

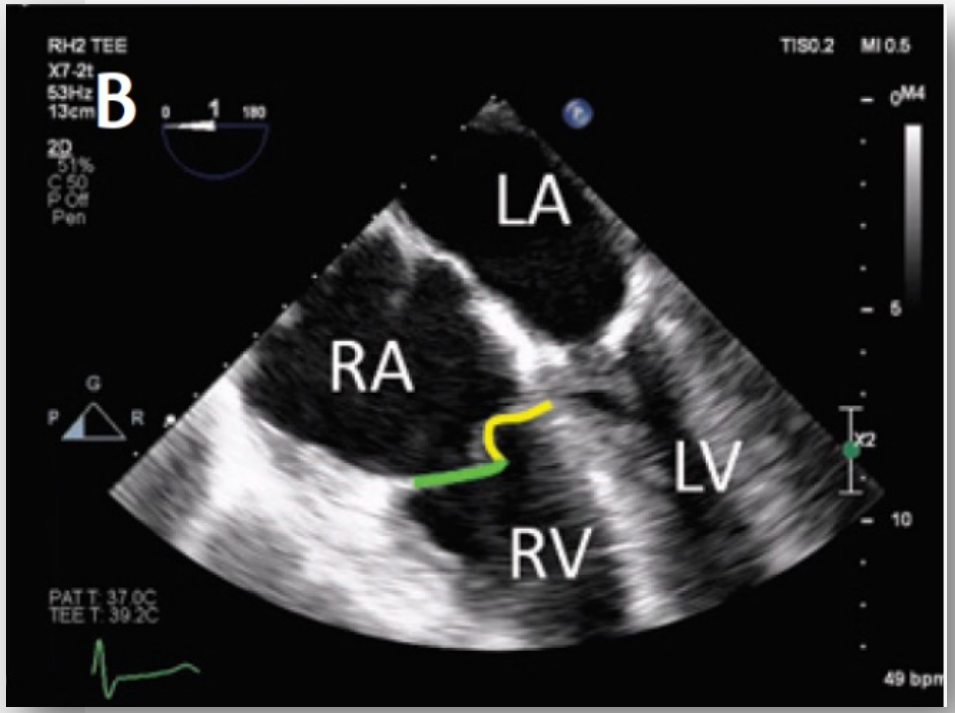
- Careful insertion of the TEE probe into the distal esophagus brings the probe closer to the tricuspid annulus; frequently there is no LA seen, and only the RA and coronary sinus with the orthogonal view imaging the RVOT.

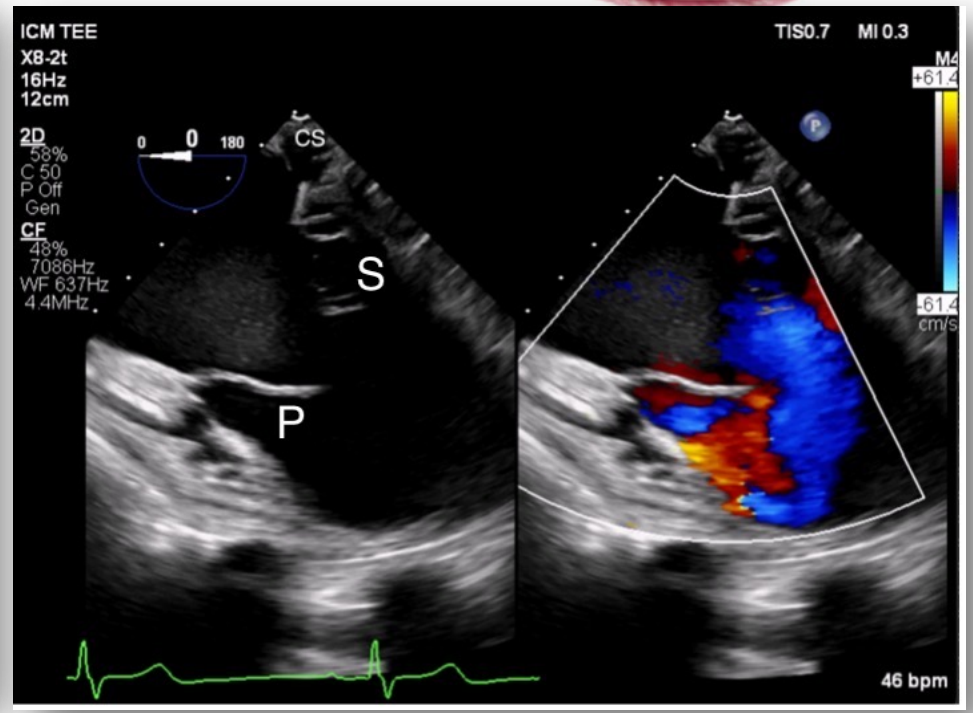


ETO valve tricuspide



Mid œsophage – 0°





Septal

Anterior

Posterior

Pacing Wire

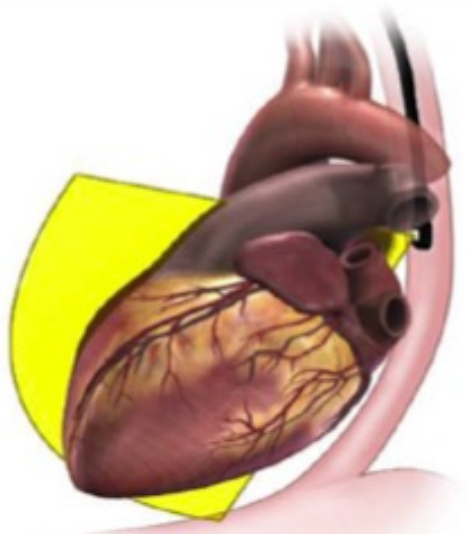
ETO valve tricuspide

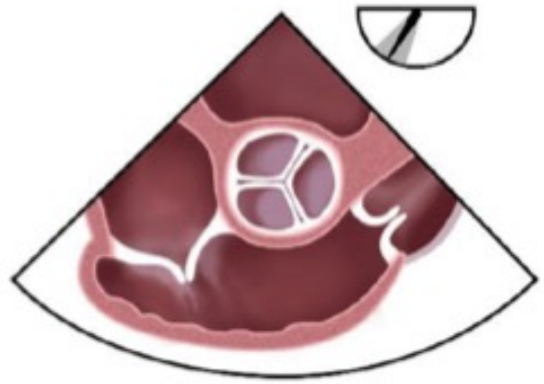
Mid œsophage 60° « RV inflow outflow »

Imaging level: right ventricular inflow-outflow view 60°

Acquisition protocol:

- Keeping the TV in the center of the imaging sector, forward mechanical rotation to ~60° results in the right ventricular inflow-outflow view, also known as the TV commissural view.

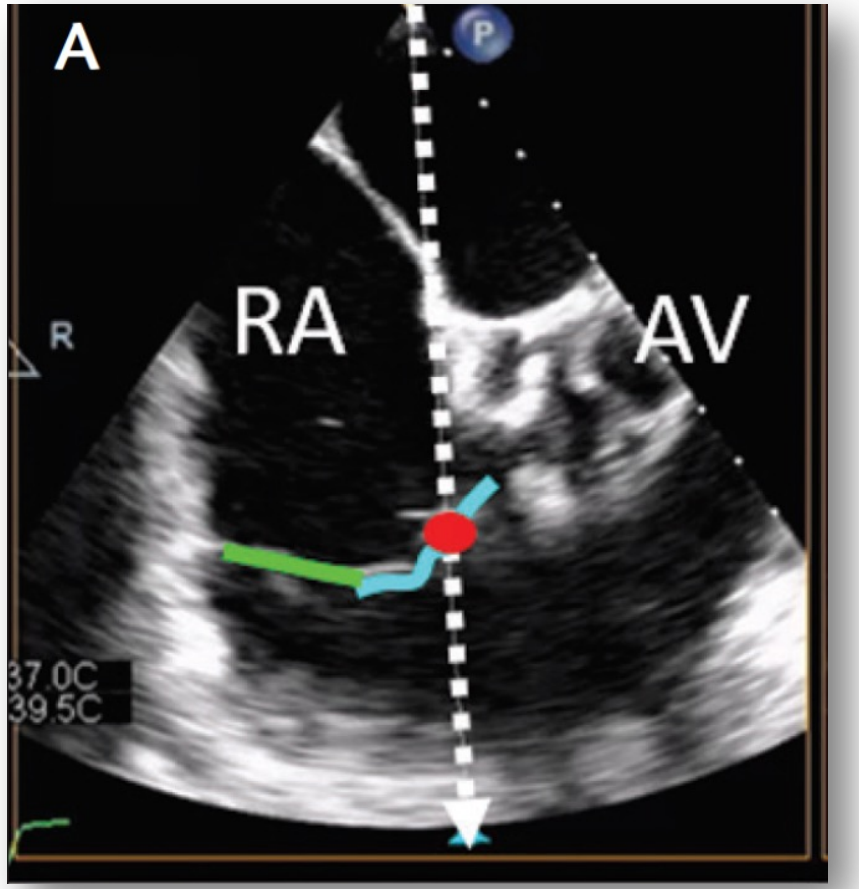


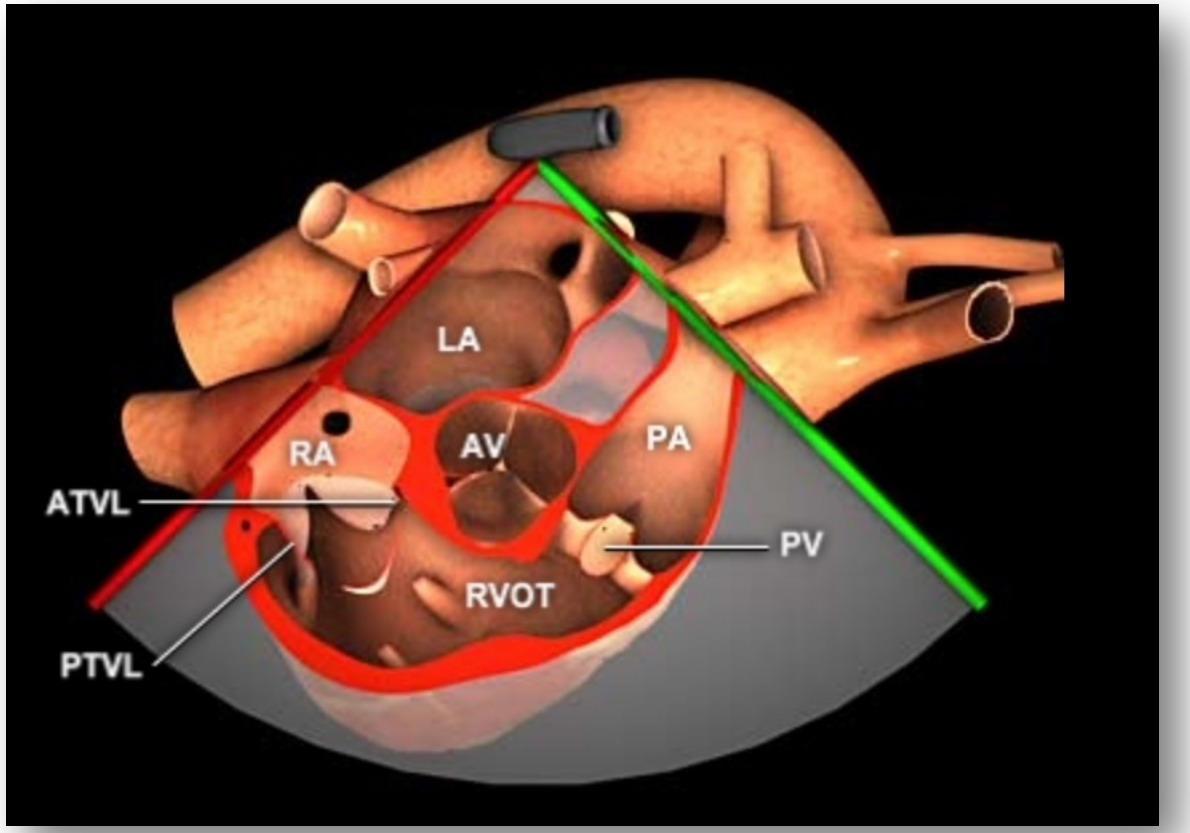


ETO valve tricuspide

Septal
Anterior
Posterior
Pacing Wire

Mid oesophage 60° « RV inflow outflow »

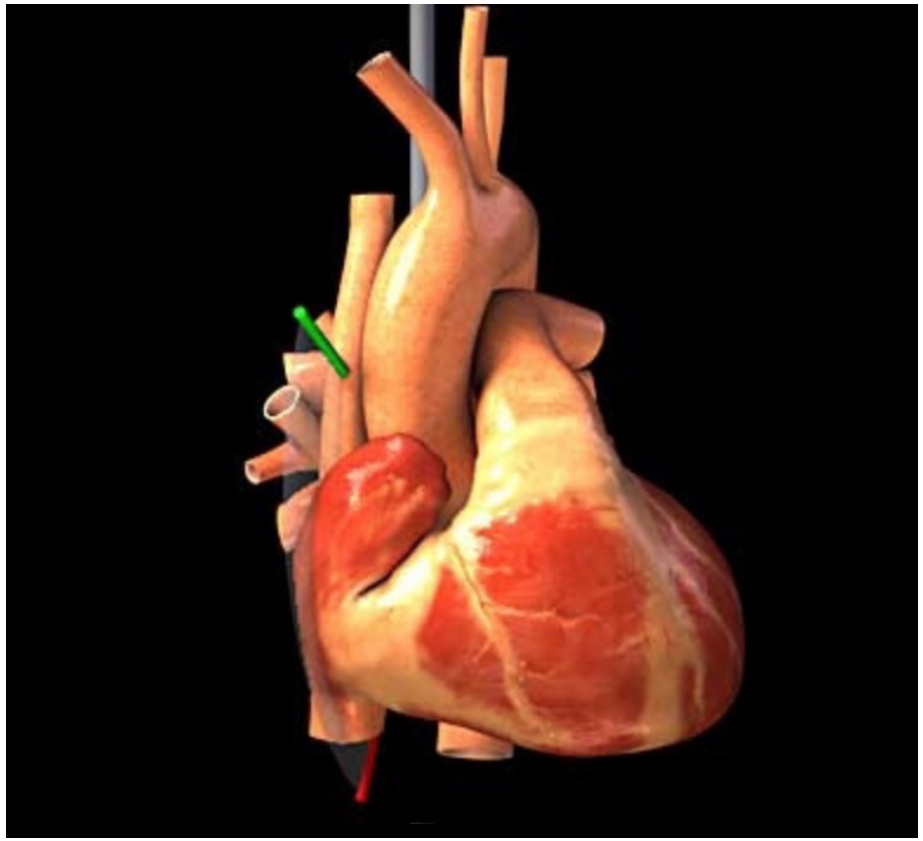


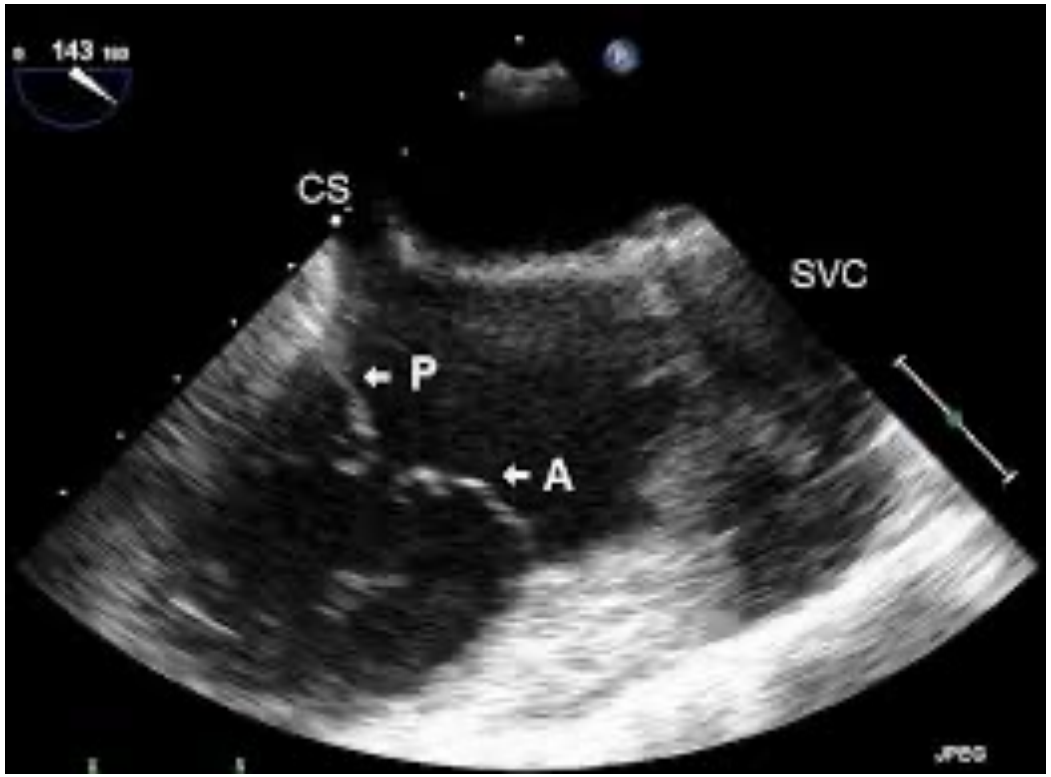


ETO valve tricuspide

Vue pour CWD PWD

Vue bicavale modifiée Mid œsophage – 120/140°



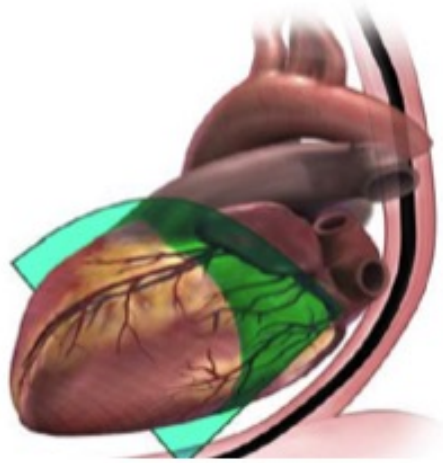


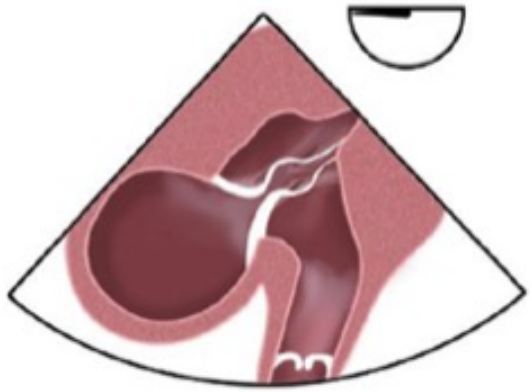
ETO valve tricuspide

Imaging level: TG

Acquisition protocol:

- With both right and anteflexion and rotating the probe clockwise to center the TV in the imaging plane, a two-chamber inflow-outflow view of the right heart is obtained.



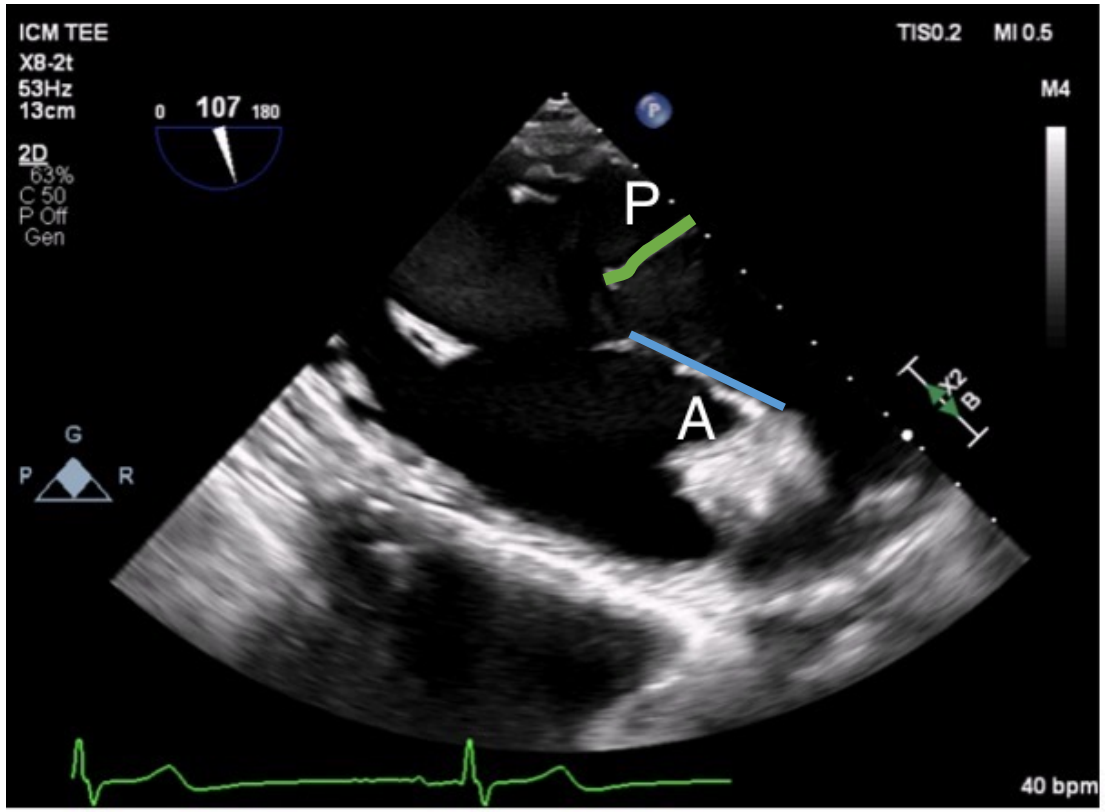


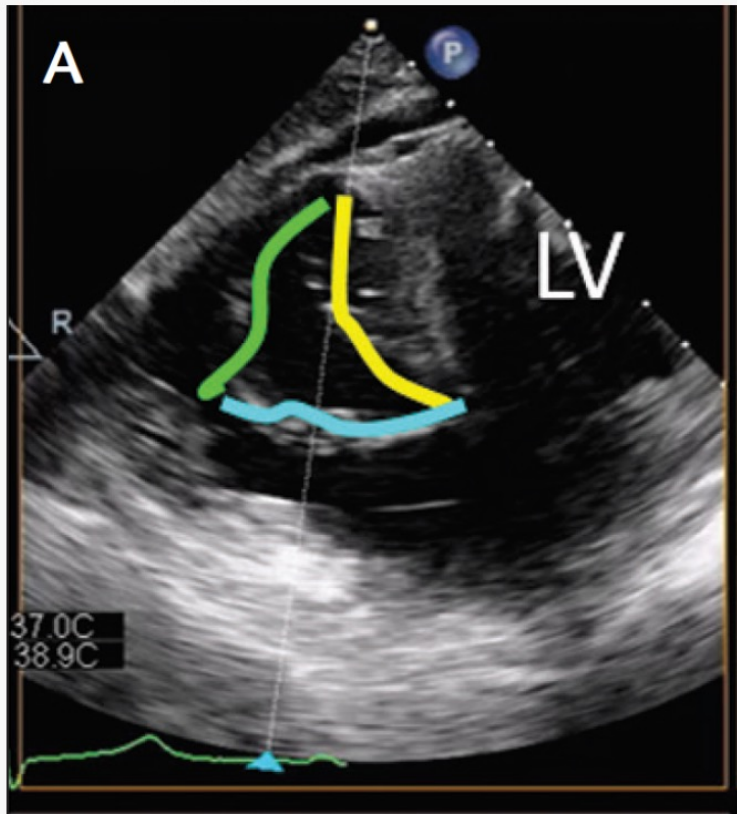
ETO valve tricuspide

Transgastric 0°

100-110° « RV inflow »

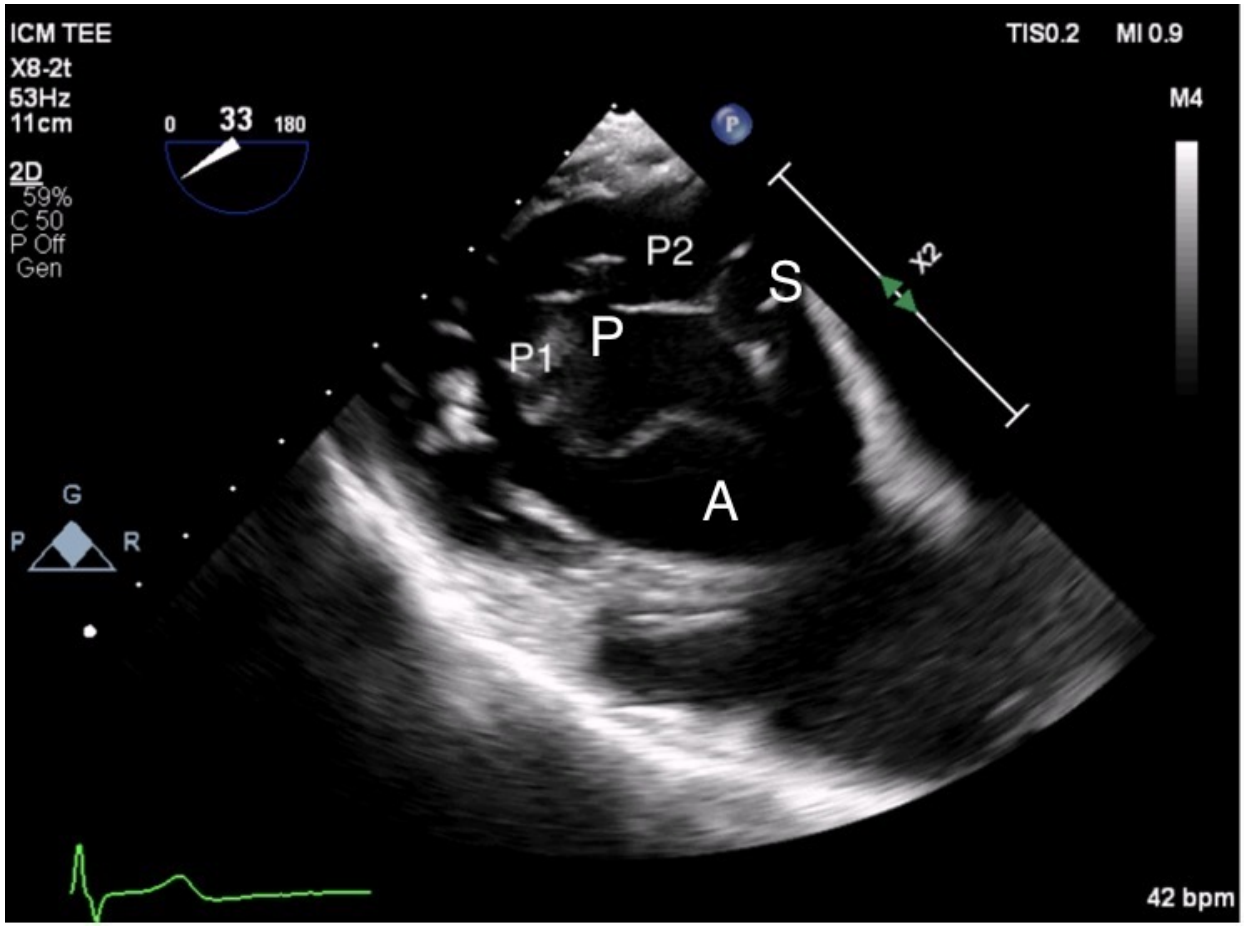
anteflex « Short axis »





ETO valve tricuspide

TG short axis



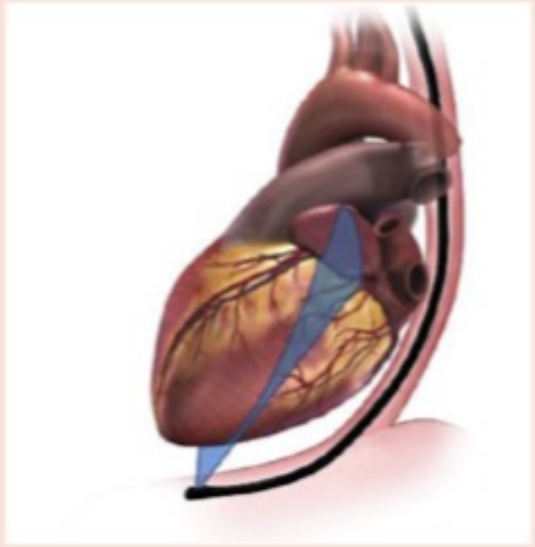
ETO valve tricuspide

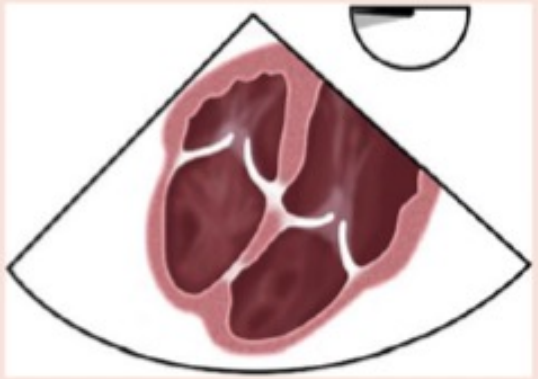
Deep transgastric 0°

Imaging level: DT

Acquisition protocol:

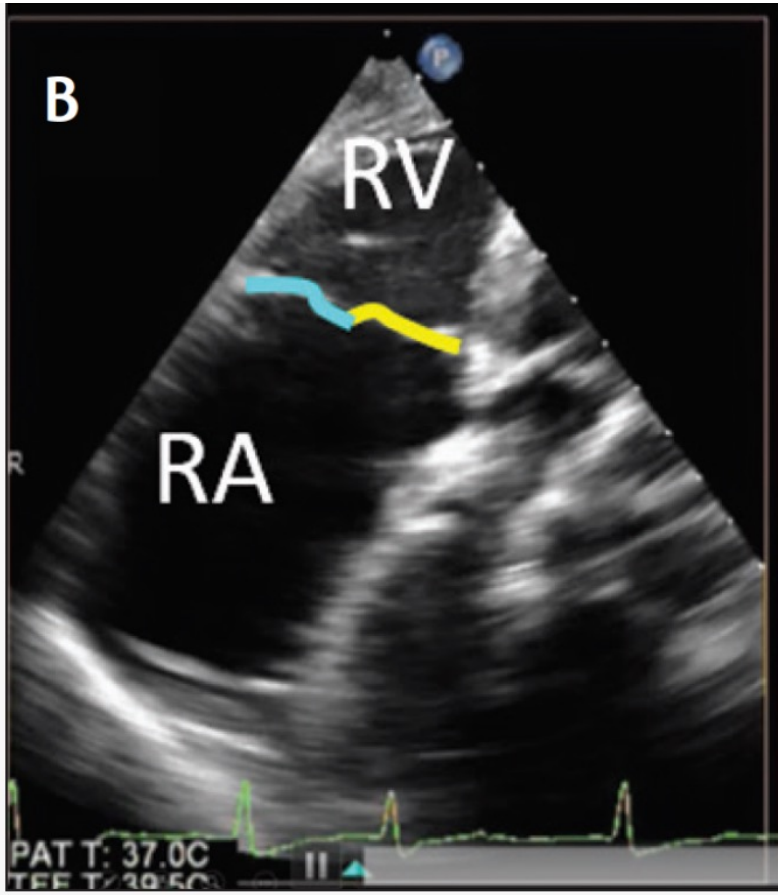
- Advancing the TEE probe further into the stomach along with rightward anterior flexion produces a DT view of the TV, which frequently can be used to assess TV function using Doppler parameters.





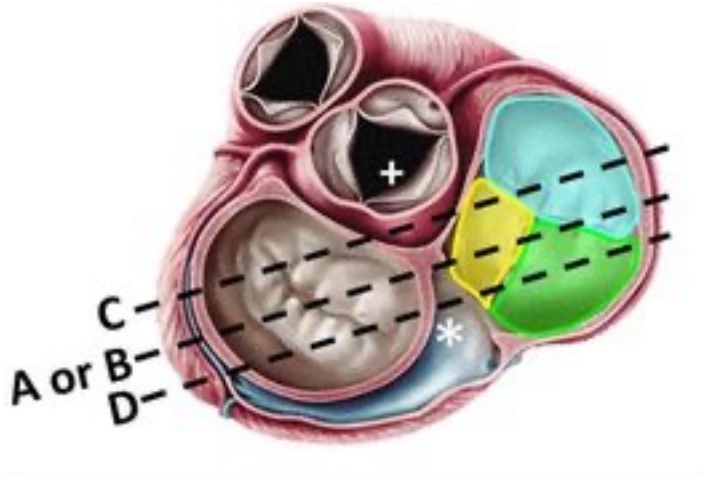
ETO valve tricuspide

Deep transgastric

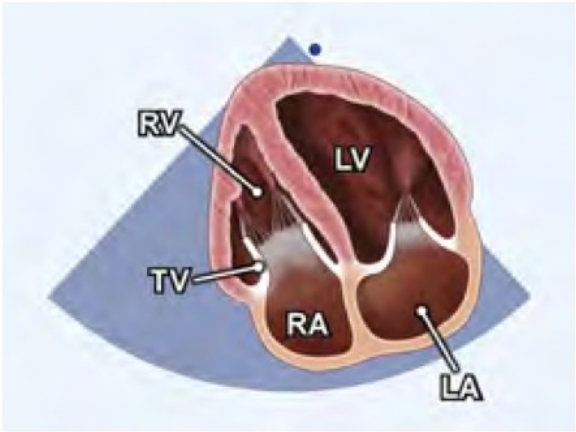


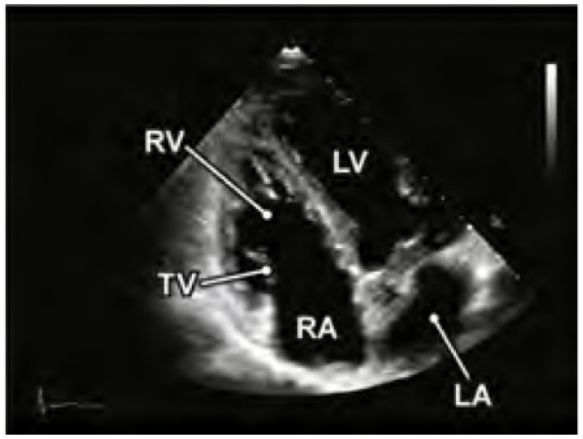
ETT valve tricuspide

4 cavités



2.16. A4C RV-focused (see Video 55)

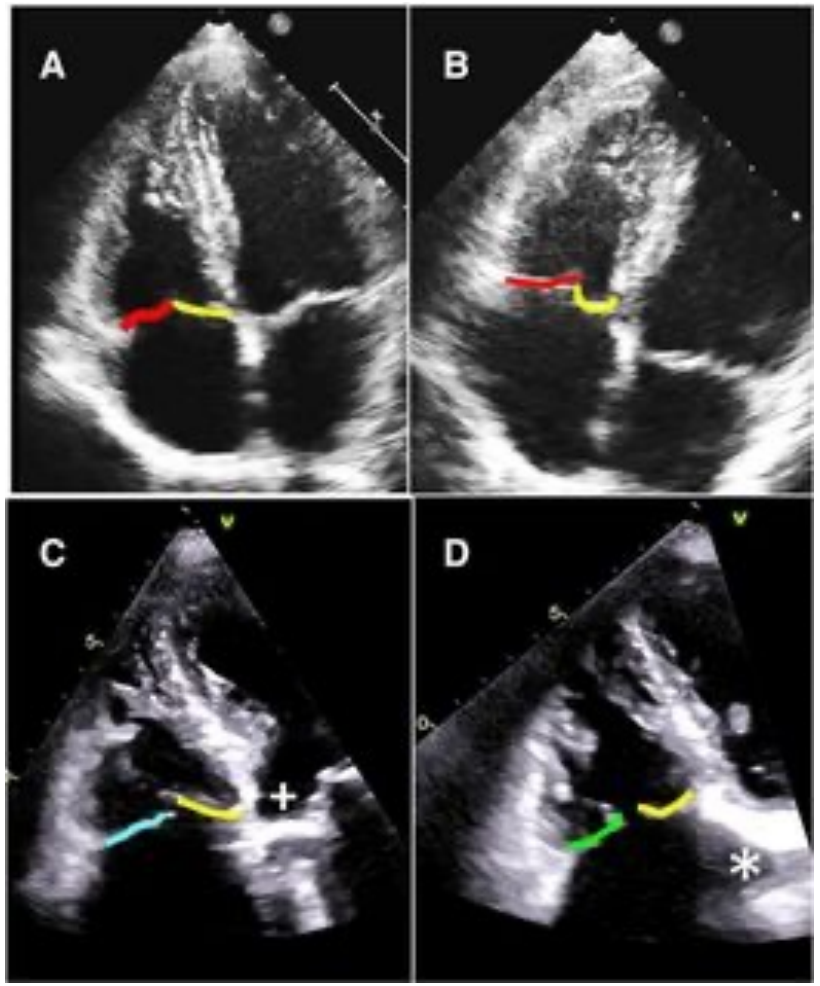


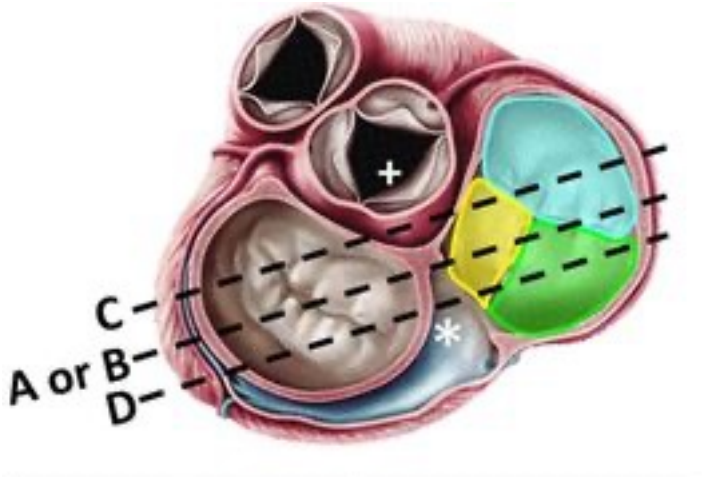


Apical window	RA
RV-focused A4C view	TV
Rotate the transducer	RV
to maximize the RV area	LA
and lateral dimensions	LV

ETT valve tricuspide

4 cavités





Septal or posterior

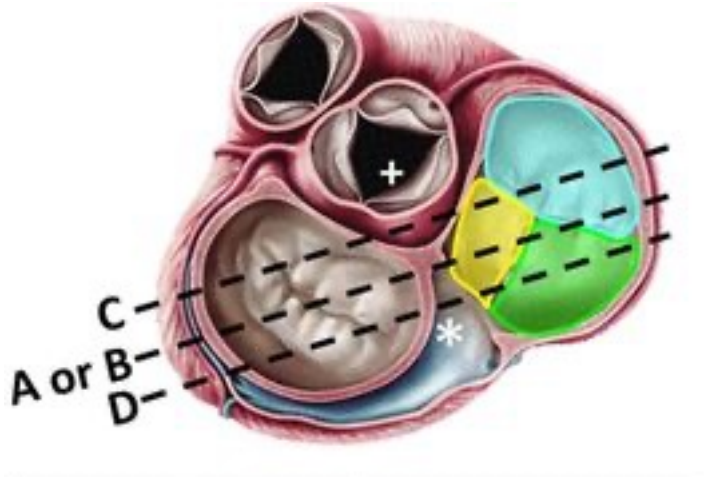
Septal

Anterior

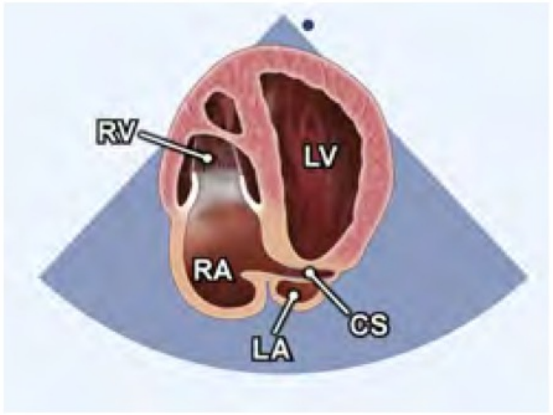
Posterior

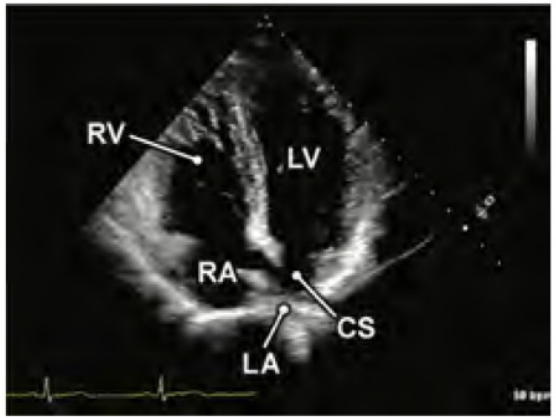
ETT valve tricuspide

4 cavités



.18. A4C posterior angulation (see Video 58)

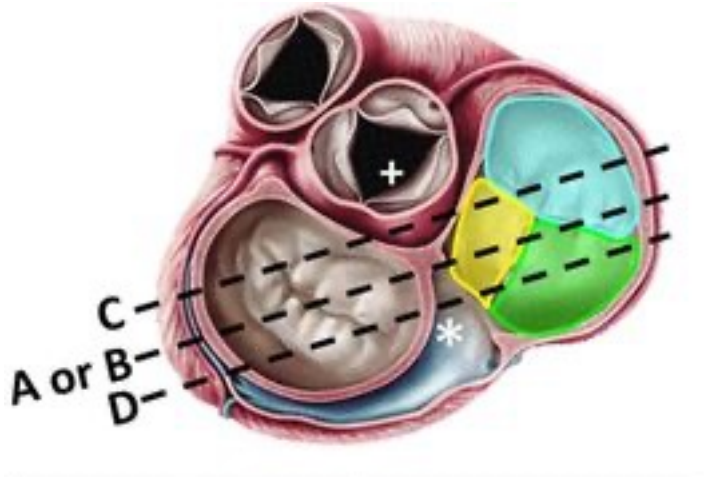


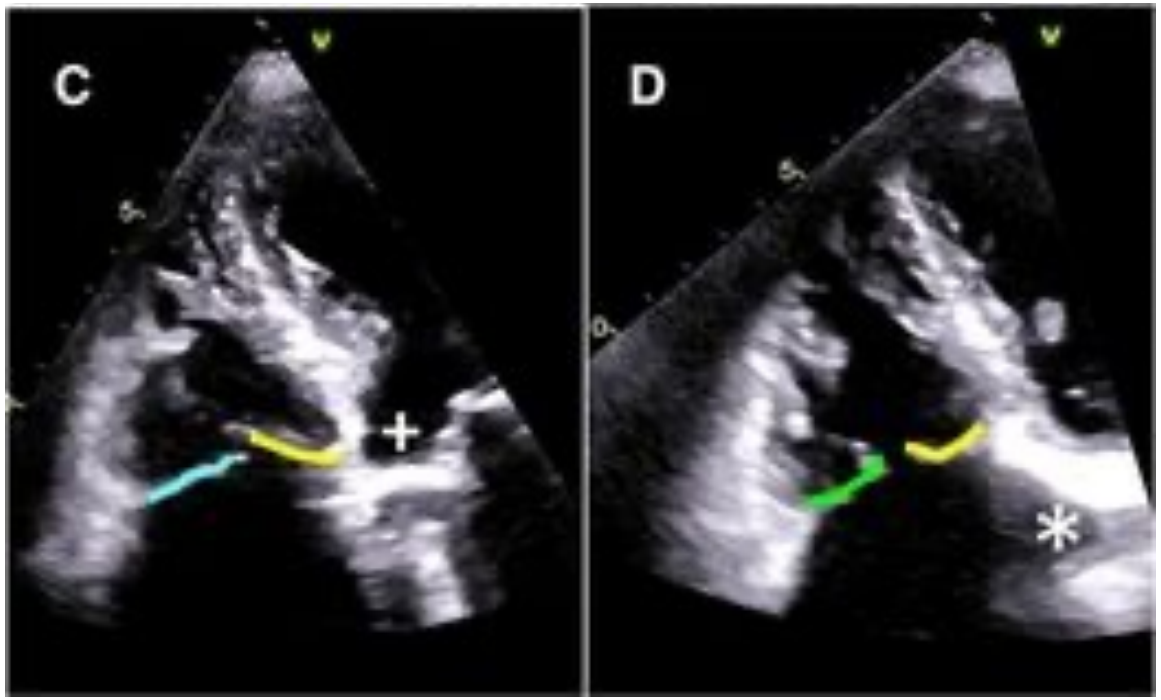


Apical window	CS
4C view	RA
From the A4C view tilt	RV
the beam posteriorly to	LV
show the CS	LA

ETT valve tricuspide

4 cavités





Septal

Anterior

Posterior

ETT valve tricuspide

Parasternal long axe

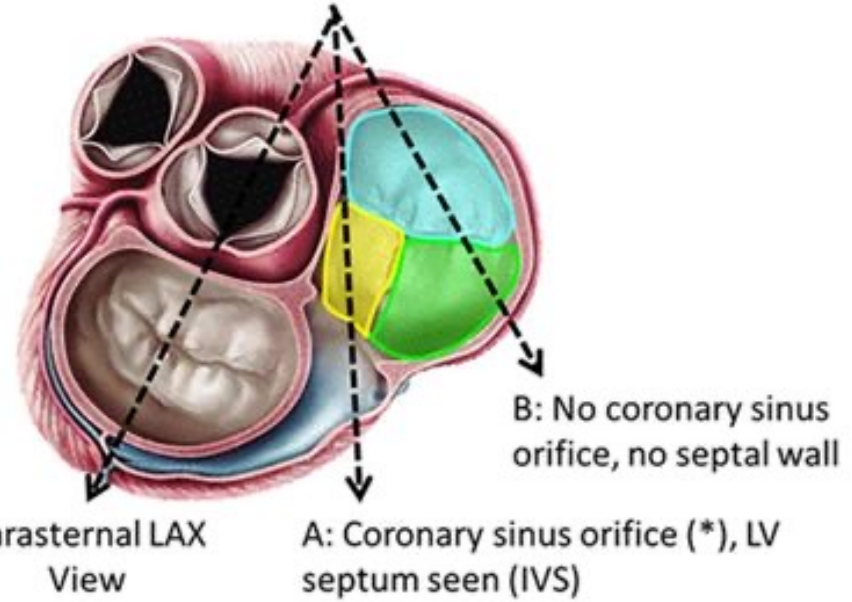
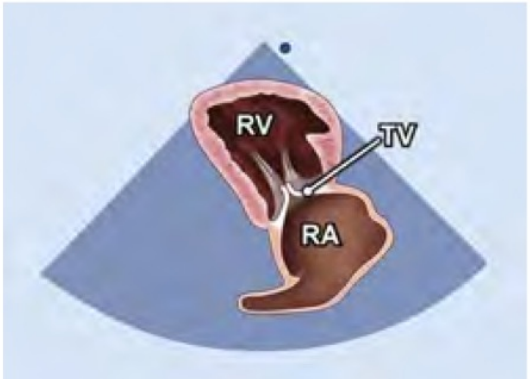
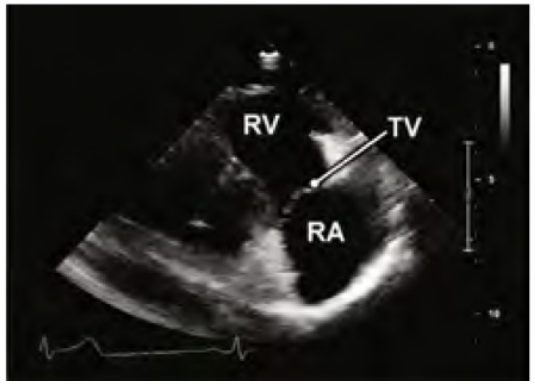
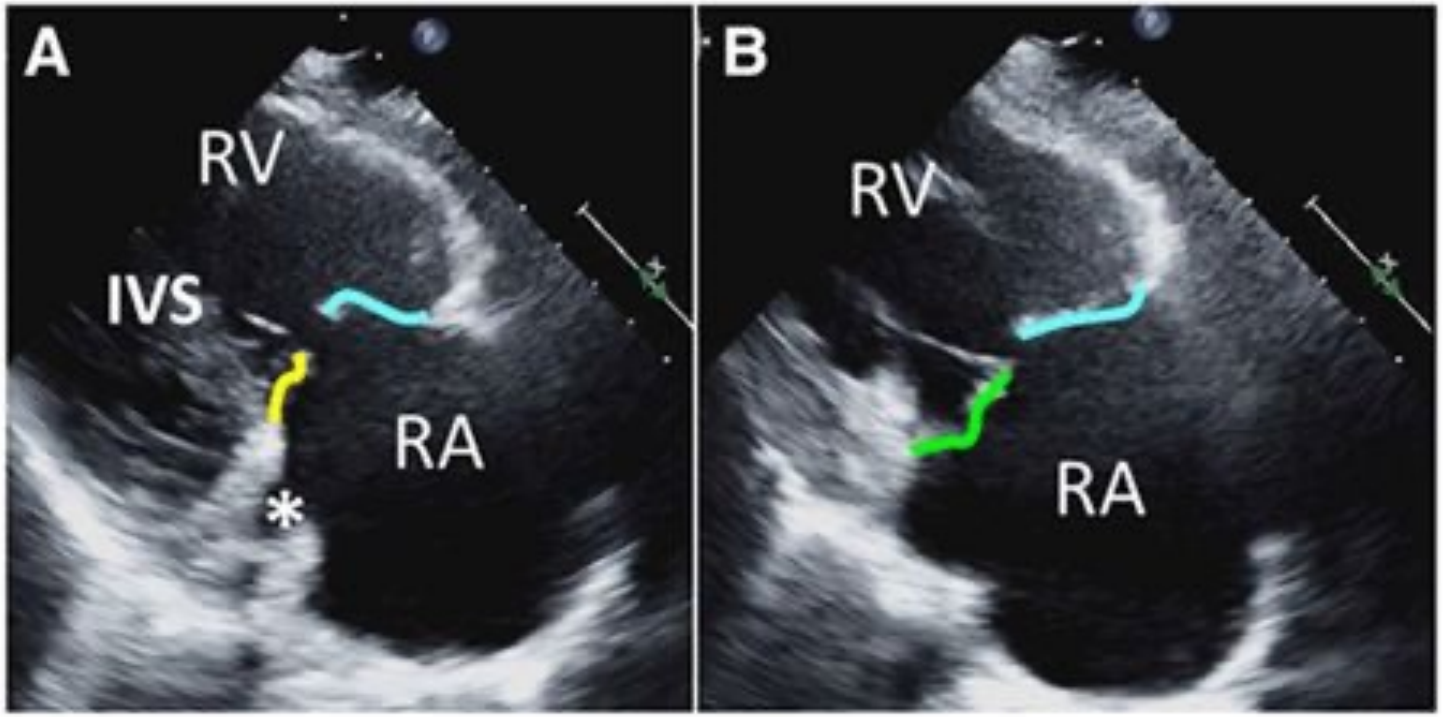


Table 2 (*Continued*)

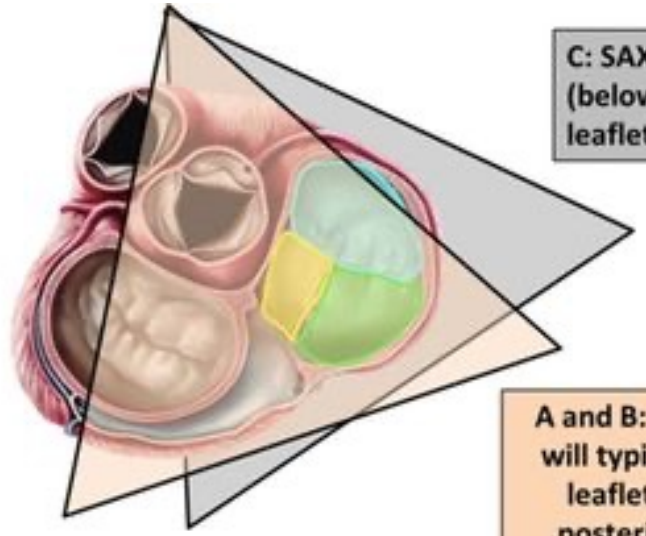
Anatomic image	2D TTE image	Acquisition image	Structures to demonstrate
2.6. PLAX RV inflow (see Video 44)			
		Parasternal window PLAX view Tilt the face of the transducer inferiorly toward the right hip	RA TV RV

ETT valve tricuspide



ETT valve tricuspide

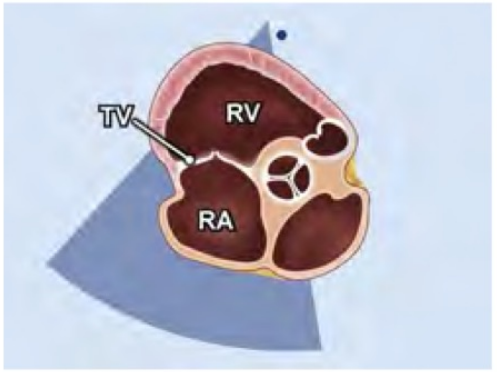
Parasternal court axe

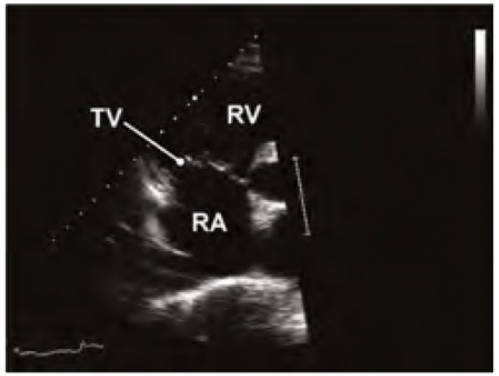


C: SAX at level of LV outflow tract (below AV) with imaging of the septal leaflet

A and B: SAX view at the level of AV will typically image just the anterior leaflet (A) however anterior and posterior leaflets may be seen (B)

2.10a. PSAX (level great vessels) focus on TV (see Video 48)

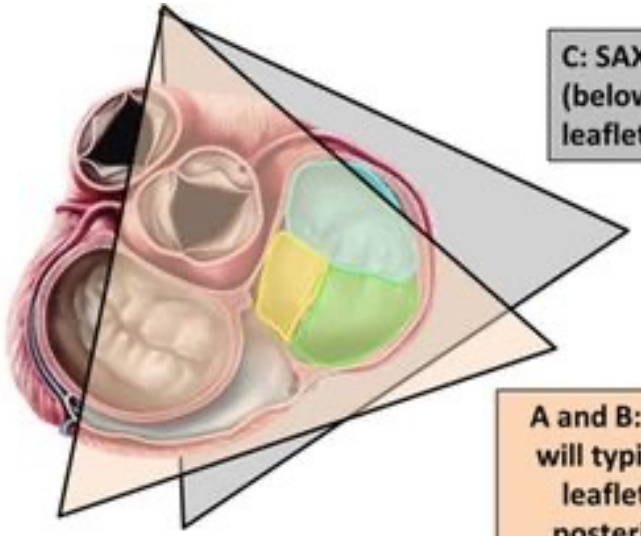




Parasternal window	RA
PSAX view	TV
Zoomed to focus on TV	RV

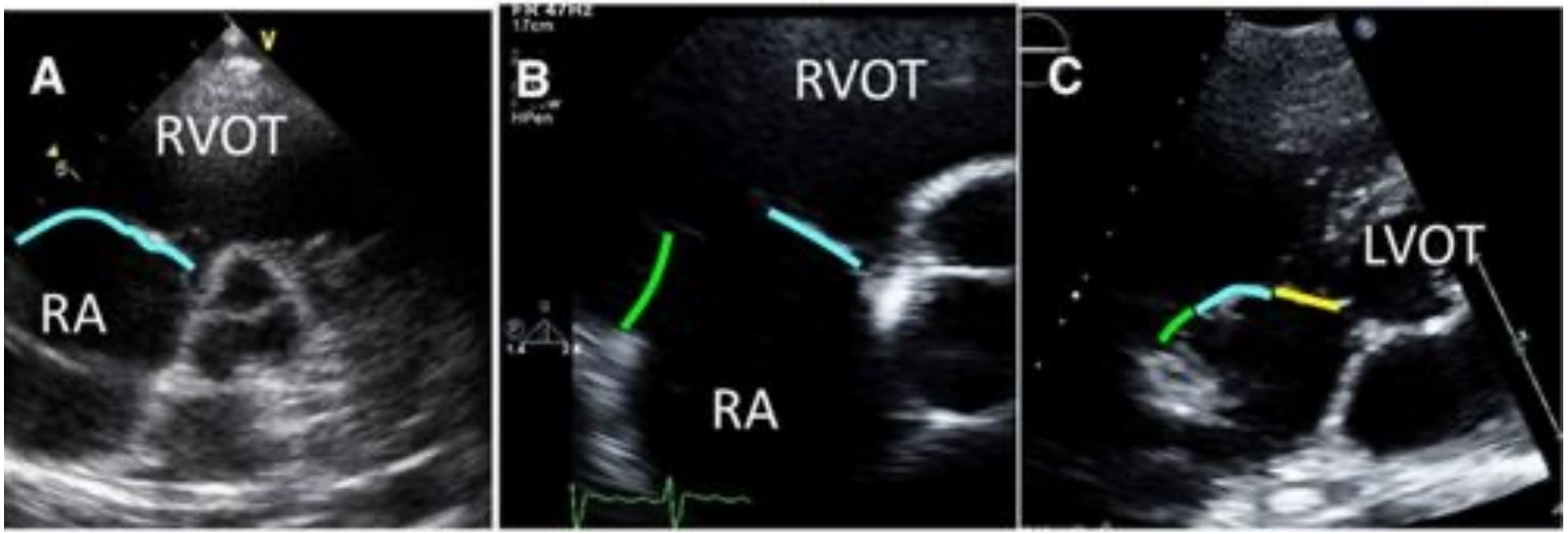
ETT valve tricuspide

Parasternal court axe

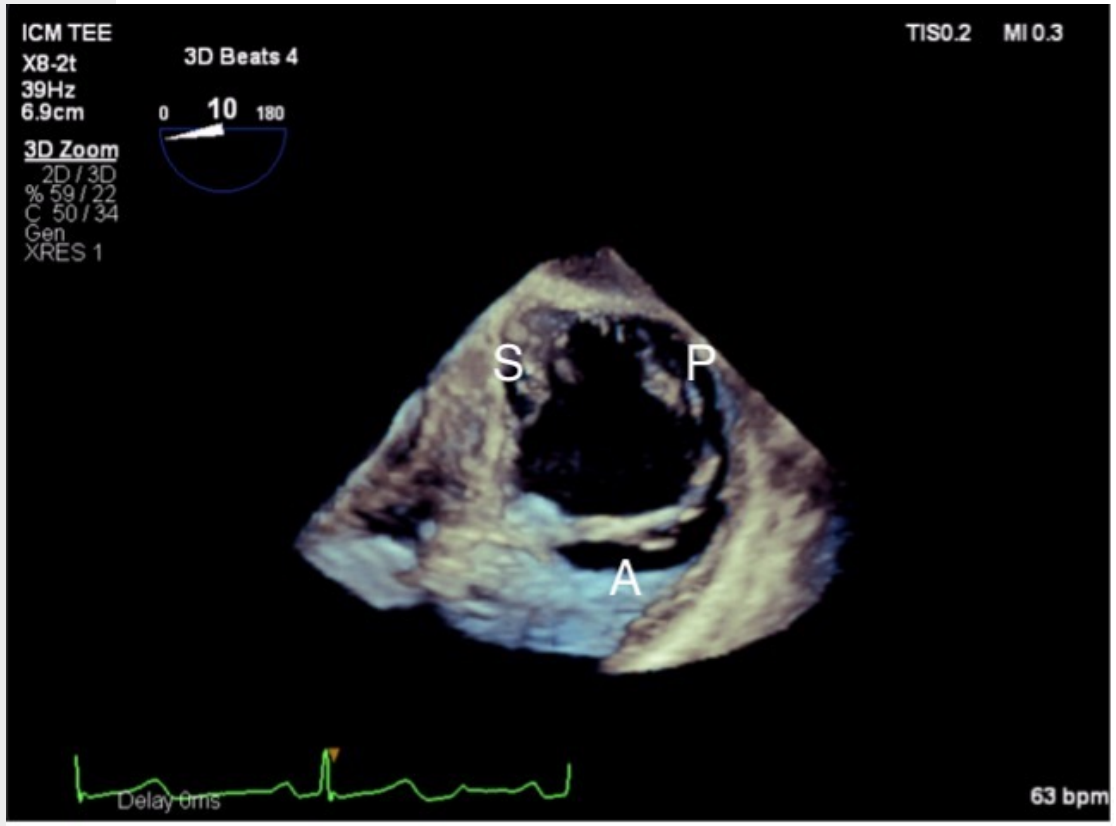


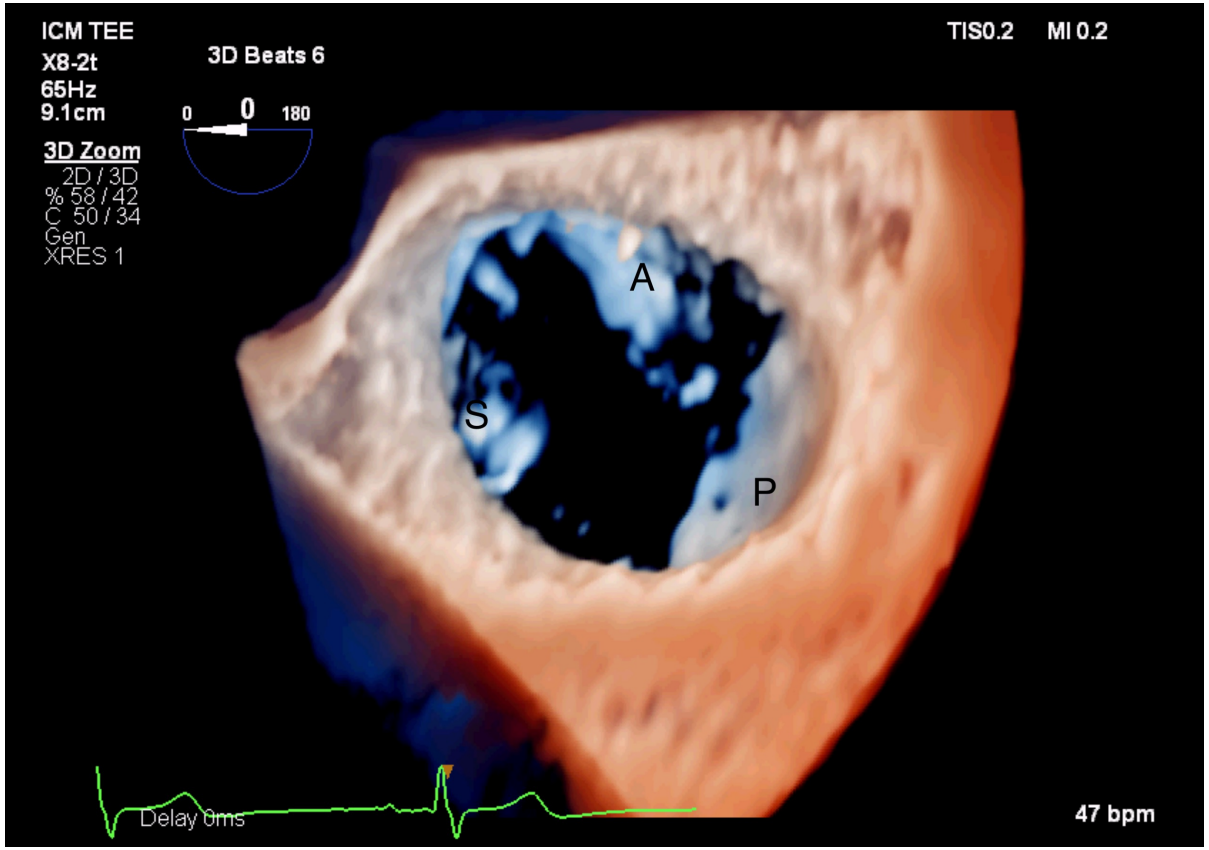
C: SAX at level of LV outflow tract (below AV) with imaging of the septal leaflet

A and B: SAX view at the level of AV will typically image just the anterior leaflet (A) however anterior and posterior leaflets may be seen (B)



Vue 3D ETO


ICM TEE
X8-2t
39Hz
6.9cm
3D Zoom
2D / 3D
% 59 / 22
C 50 / 34
Gen
XRES 1
3D Beats 4
0 10 180
TIS0.2 MI 0.3
S
P
A
Delay 0ms
63 bpm

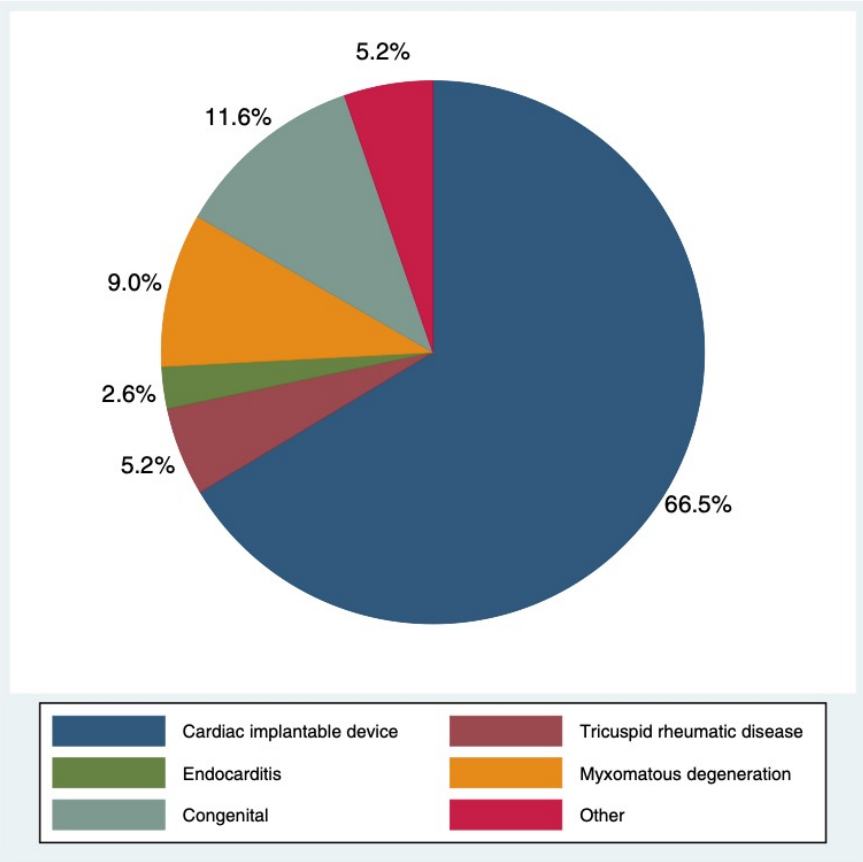

ICM TEE
X8-2t
65Hz
9.1cm
3D Zoom
2D / 3D
% 58 / 42
C 50 / 34
Gen
XRES 1
3D Beats 6
0 0 180
TIS0.2 MI 0.2
A
S
P
Delay 0ms
47 bpm

Insuffisance tricuspidienne

Classification IT

Primaire ≅ 10%

secondaire ≅ 90%

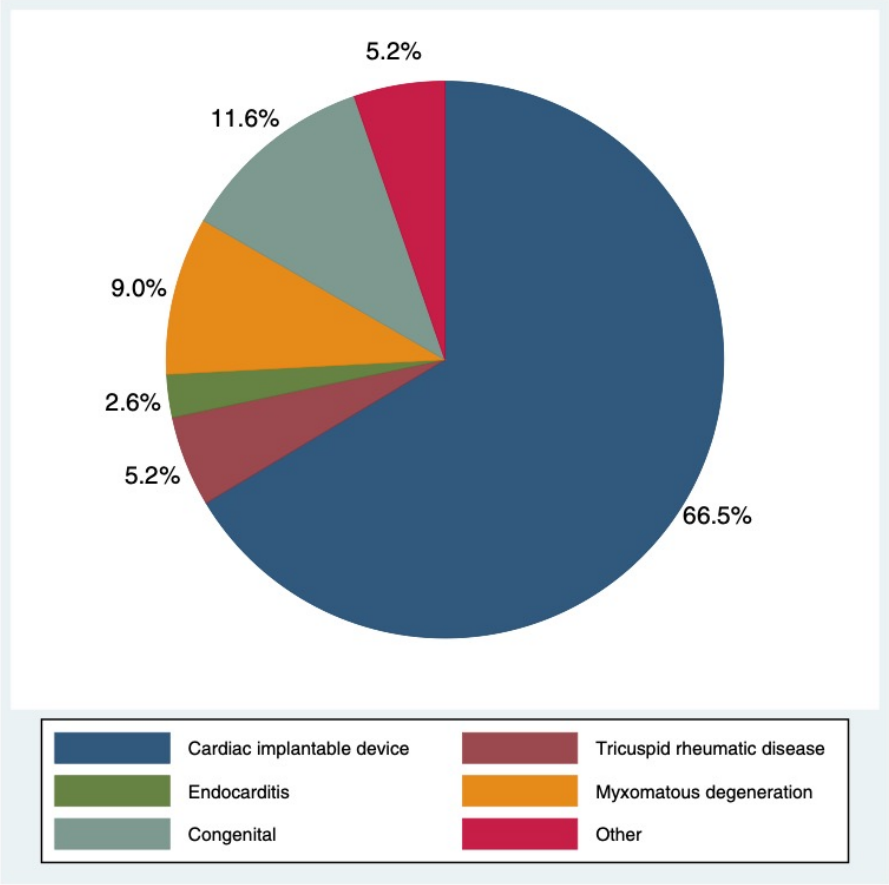


Vieitez JM et al, New insights of tricuspid regurgitation : a large-scale prospective cohort study, European Heart Journal Cardio Imaging, 2021

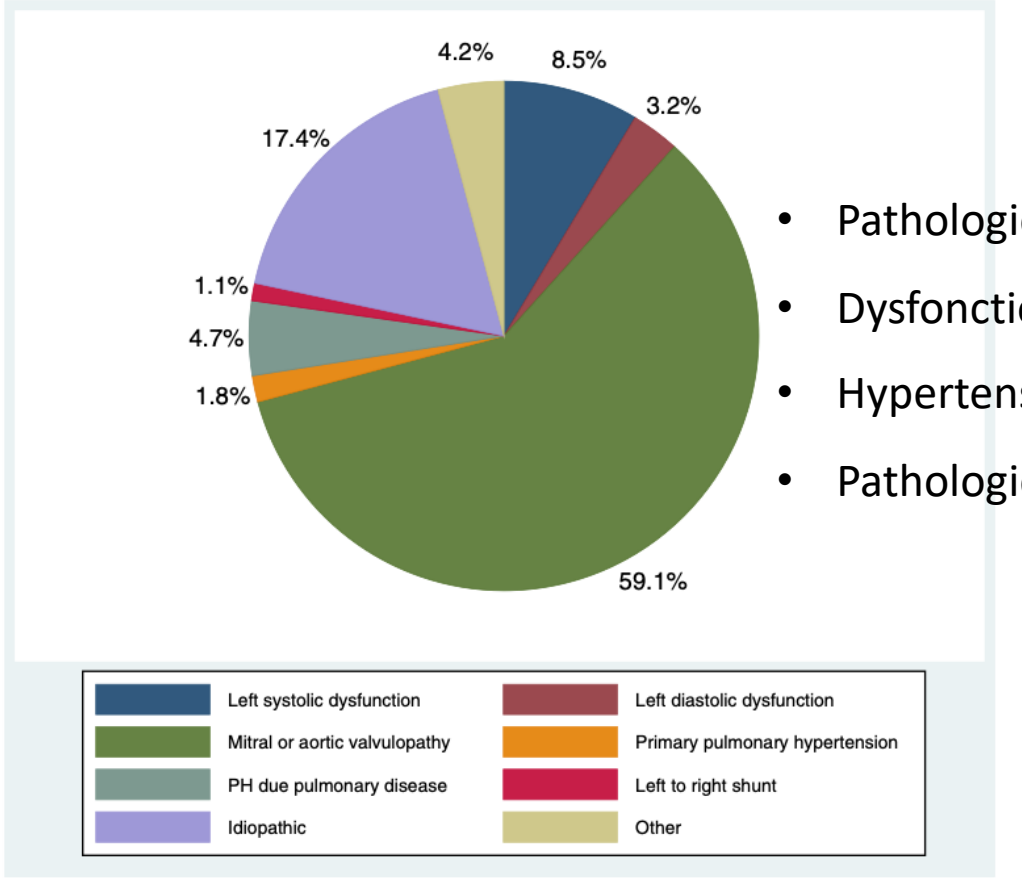
Classification IT

ESC European Society of Cardiology

Primaire ≅ 10%



secondaire ≅ 90%



- Pathologies cœur gauche
- Dysfonction VD
- Hypertension pulmonaire
- Pathologies OD

Vieitez JM et al, New insights of tricuspid regurgitation : a large-scale prospective cohort study, European Heart Journal Cardio Imaging, 2021

Classification IT

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Tricuspid regurgitation: recent advances in understanding pathophysiology, severity grading and outcome

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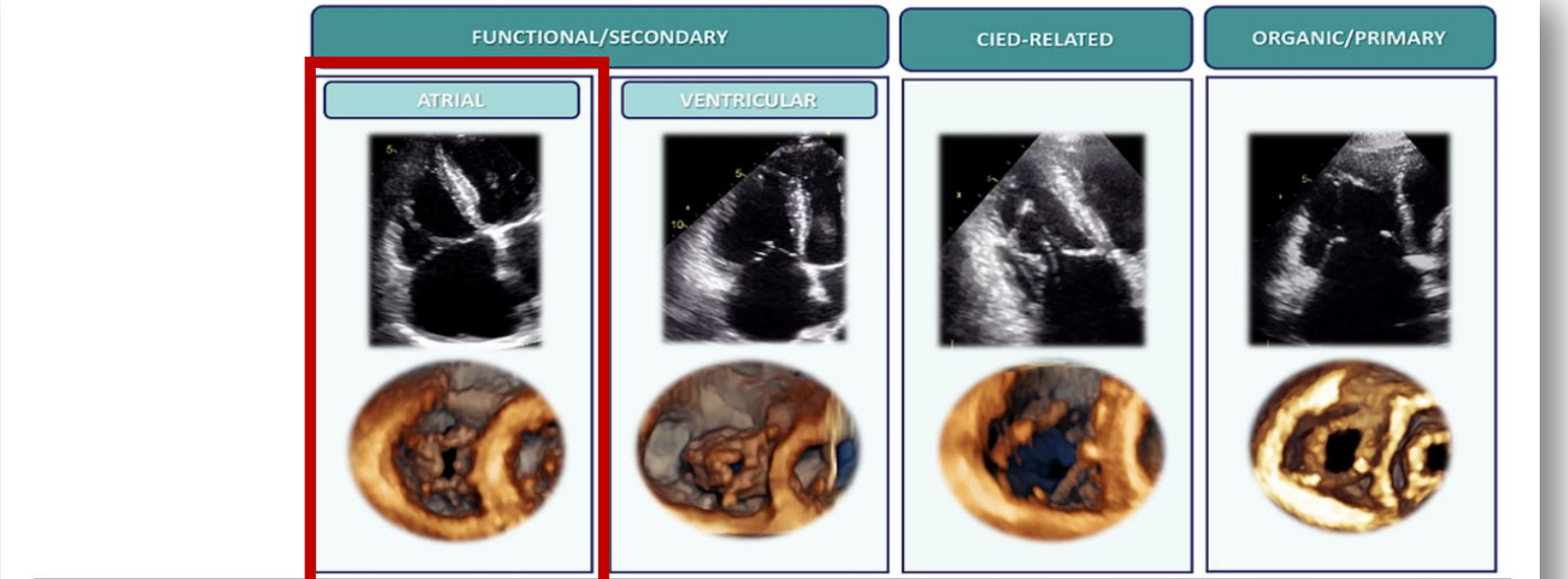
2021



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	+/-	+++	+/-	+/-	+/-

Classification IT

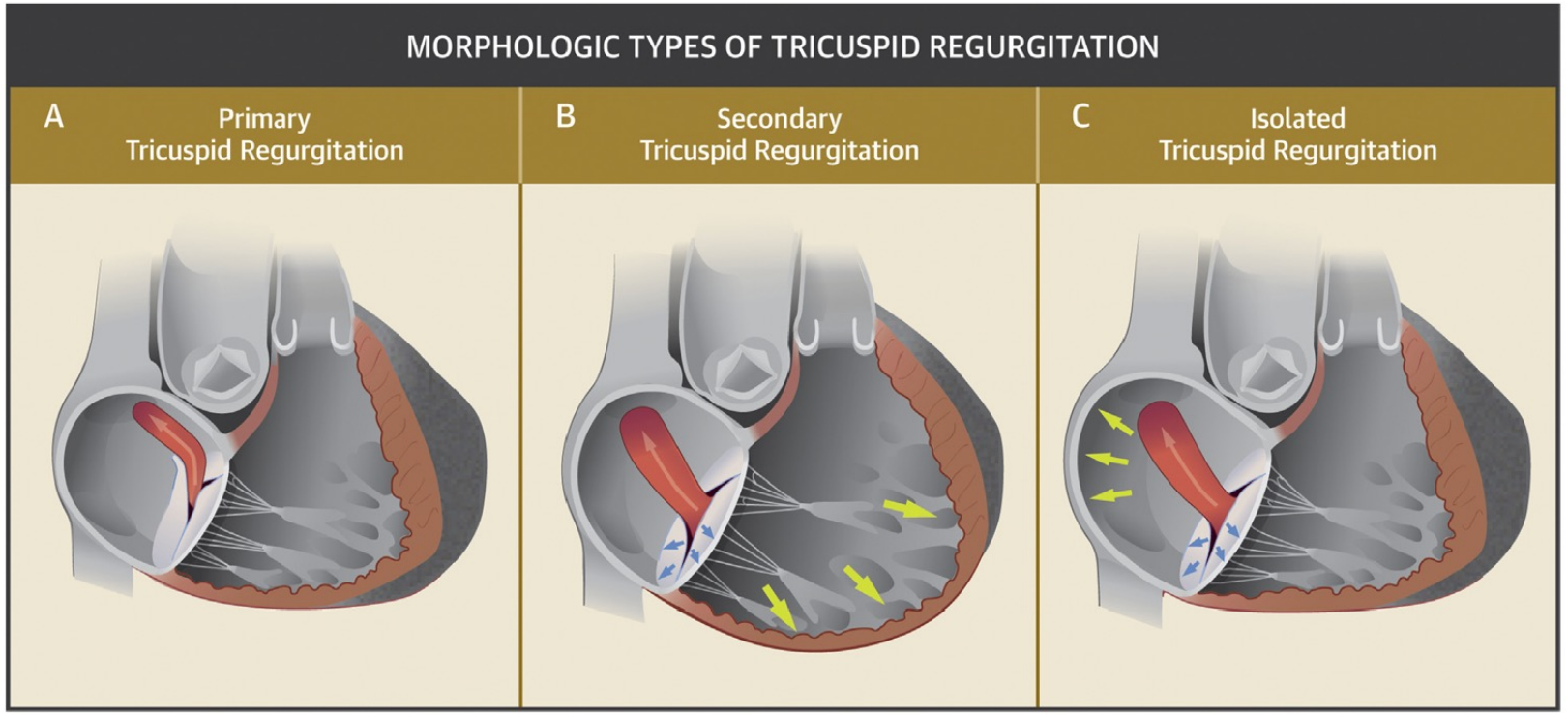
STATE-OF-THE-ART PAPER

Morphologic Types of Tricuspid Regurgitation

Characteristics and Prognostic Implications

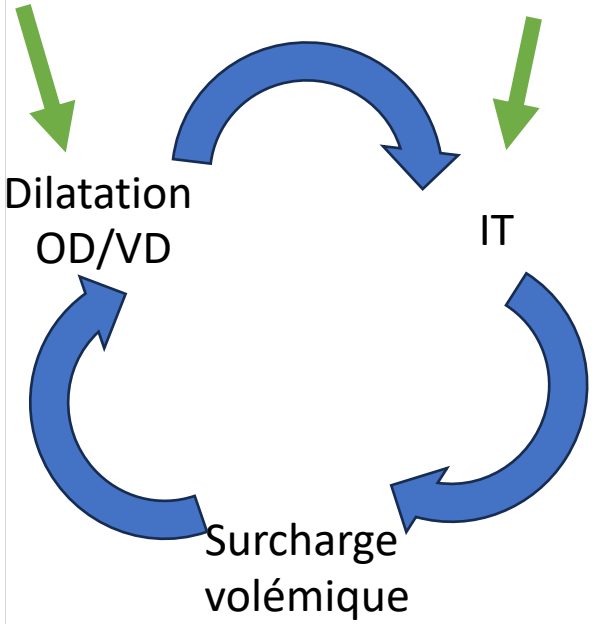
Edgard A. Prihadi, MD,[a,b] Victoria Delgado, MD, PhD,[a] Martin B. Leon, MD, PhD,[c] Maurice Enriquez-Sarano, MD, PhD,[d] Yan Topilsky, MD, PhD,[e] Jeroen J. Bax, MD, PhD[a]

CENTRAL ILLUSTRATION Schematic Drawing of the Different Morphologic Types of Tricuspid Regurgitation



Prihadi, E.A. et al. J Am Coll Cardiol Img. 2019;12(3):491-9.

Primary tricuspid regurgitation **(A),** where there is primary damage of the tricuspid valve apparatus (prolapse of the posterior leaflet in this example). Secondary tricuspid regurgitation **(B),** due to significant dilation of the right ventricle **(arrows)** and tethering of the tricuspid valve leaflets and coaptation gap. Isolated tricuspid regurgitation **(C)** with dilation of the tricuspid annulus due to dilation of the right atrium **(arrows)** in the presence of atrial fibrillation.



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2021

IT secondaire ou « fonctionnelle »

Ventriculaire

- dilatation VD (+sphérique) +/- dysfonction VD
- tethering des feuillets
- dilatation légère de l'anneau (+/- dilatation OD)

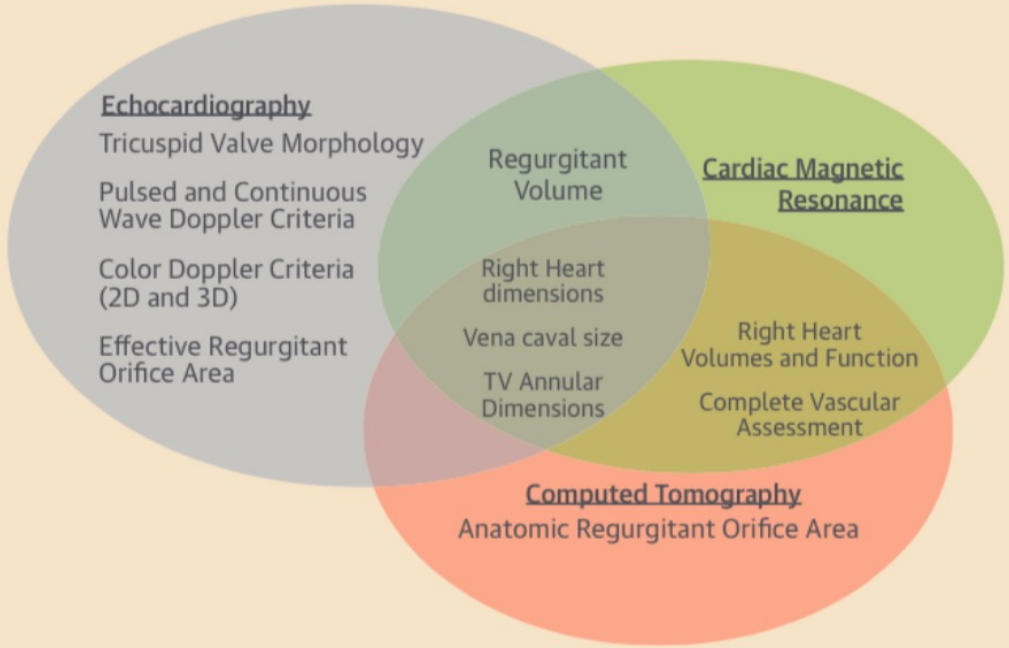
Atriale

- dilatation sévère de l'anneau tricuspidien et de l'OD
- mouvement normal des feuillets
- dilatation de la base du VD mais forme conique préservée

Sévérité IT

!! Variations respiratoires

Multi-modality Imaging for Assessment of Tricuspid Regurgitation Severity



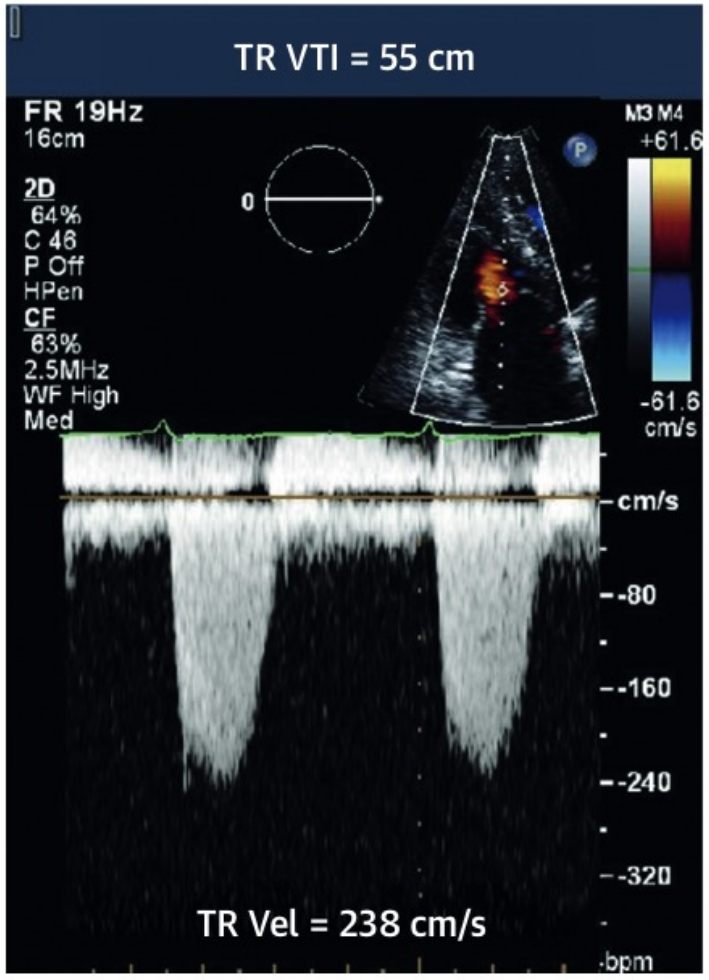
Relative Utility of Each Imaging Modality

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.

Sévérité IT

CWD



Avantages

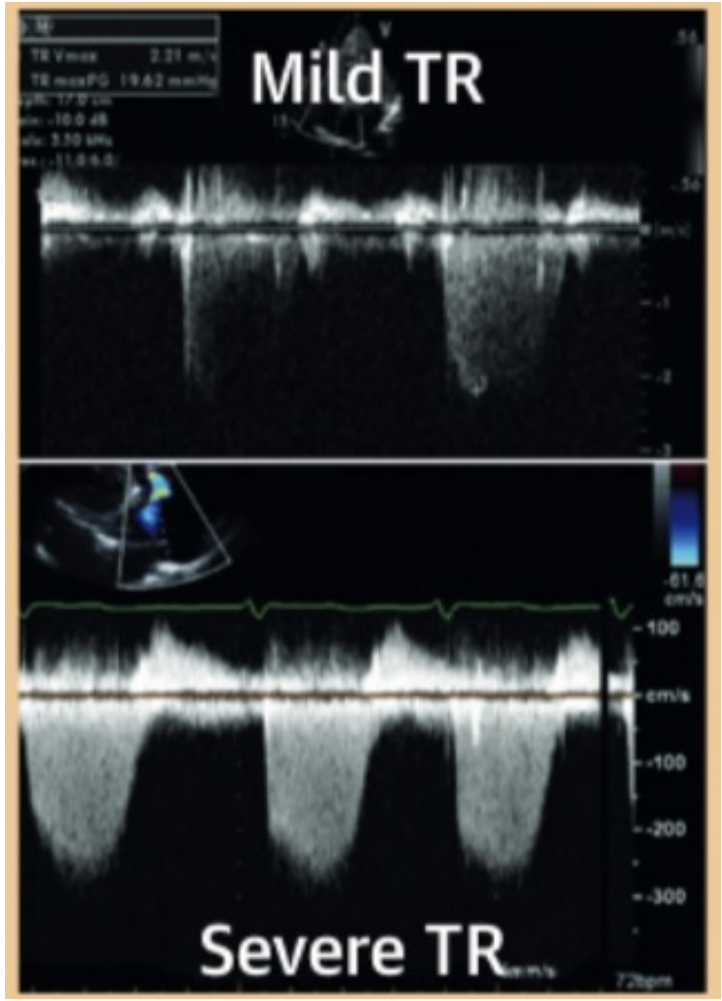
- simple
-densité proportionnelle
-jet faible ou incomplet ➔ compatible avec léger

Inconvénients

- qualitatifs
-jets très centraux + dense que les jets excentriques même si plus grave
-difficile de distinguer IT modérée/sévère

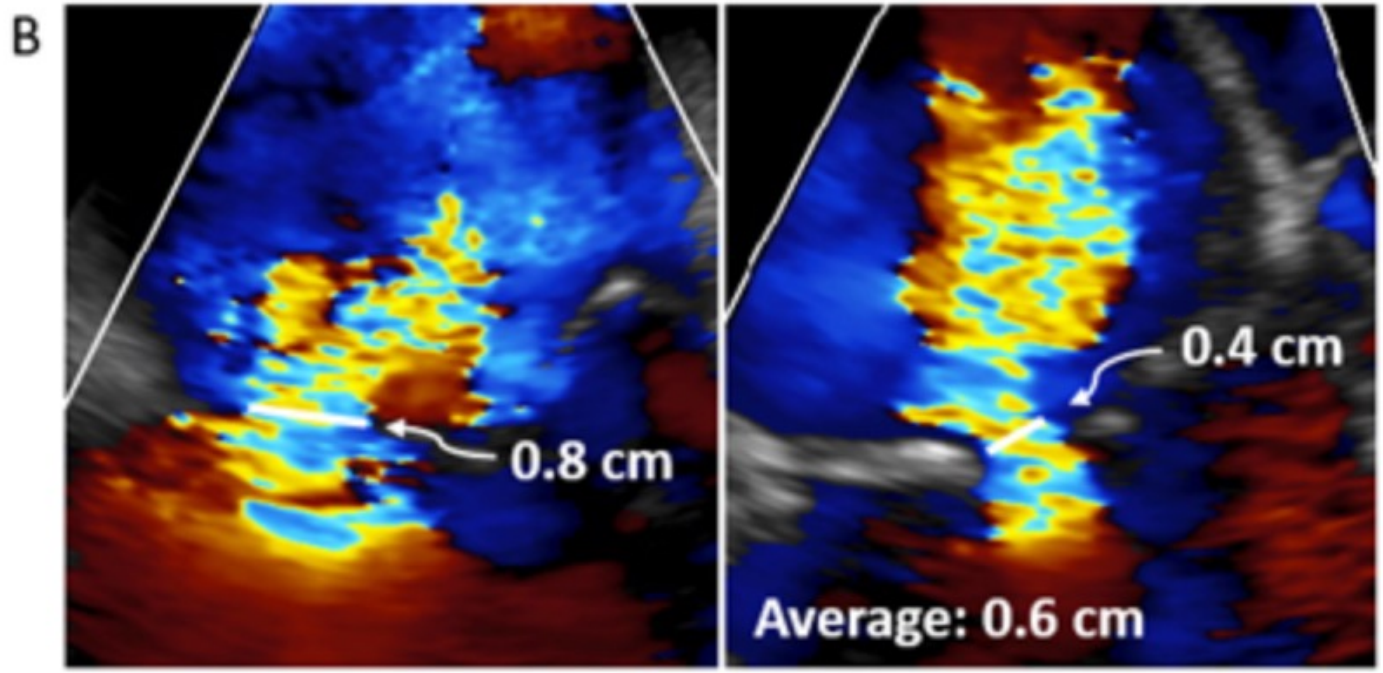
DENSE

TRIANGULAIRE



Sévérité IT

Vena contracta



$\geq 0,7cm$

Avantages

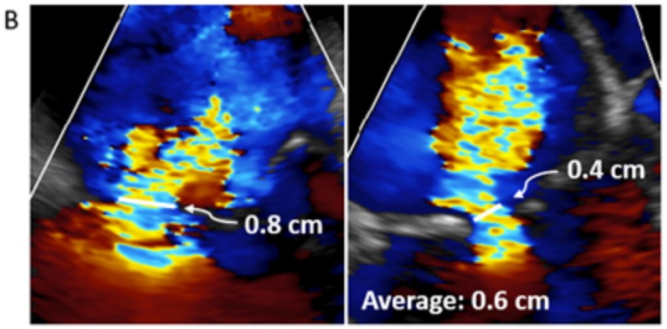
- estimation taille orifice régurgitant (semi quantitatif)
-indépendant du débit et pression
-permet d'identifier les IT sévères

Inconvénients

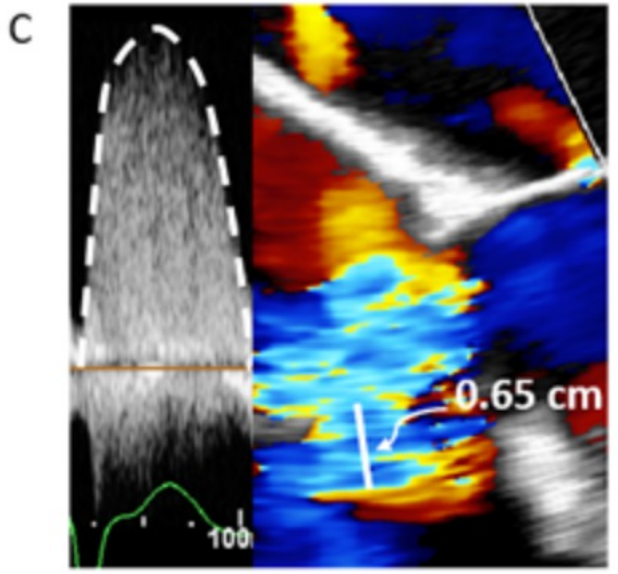
- sous-estime la gravité en cas de multiples jets
-surestime quand l'IT n'est pas holosystolique

Sévérité IT

Vena contracta $\geq 0,7cm$



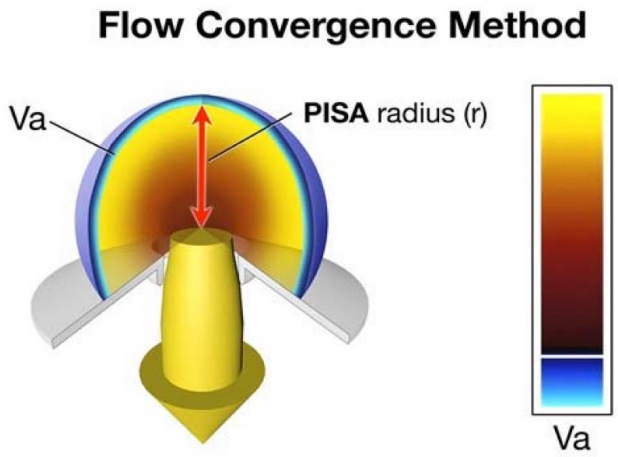
PISA



ERO: 0.32 cm2 RVol 27 mL/beat

Avantages

- paramètre quantitatif



$ERO A \geq 0,40cm2$
$VR \geq 45ml$

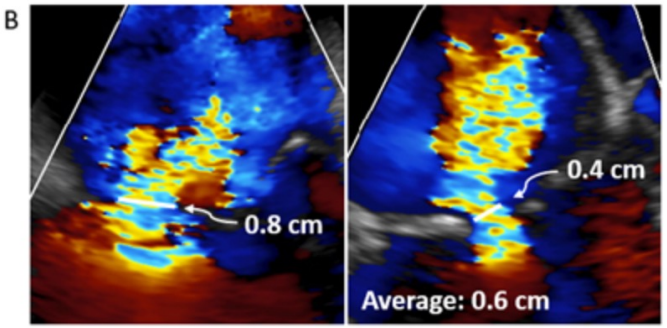
Nquist 28cm/s

Inconvénients

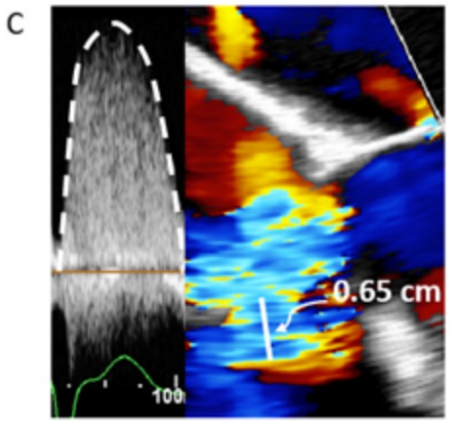
- jets multiples
- aspect non hémisphériques pour certaines IT sévère surtout fonctionnelle
- surestimation quand IT non holosystolique

Sévérité IT

Vena contracta $\geq 0,7cm$

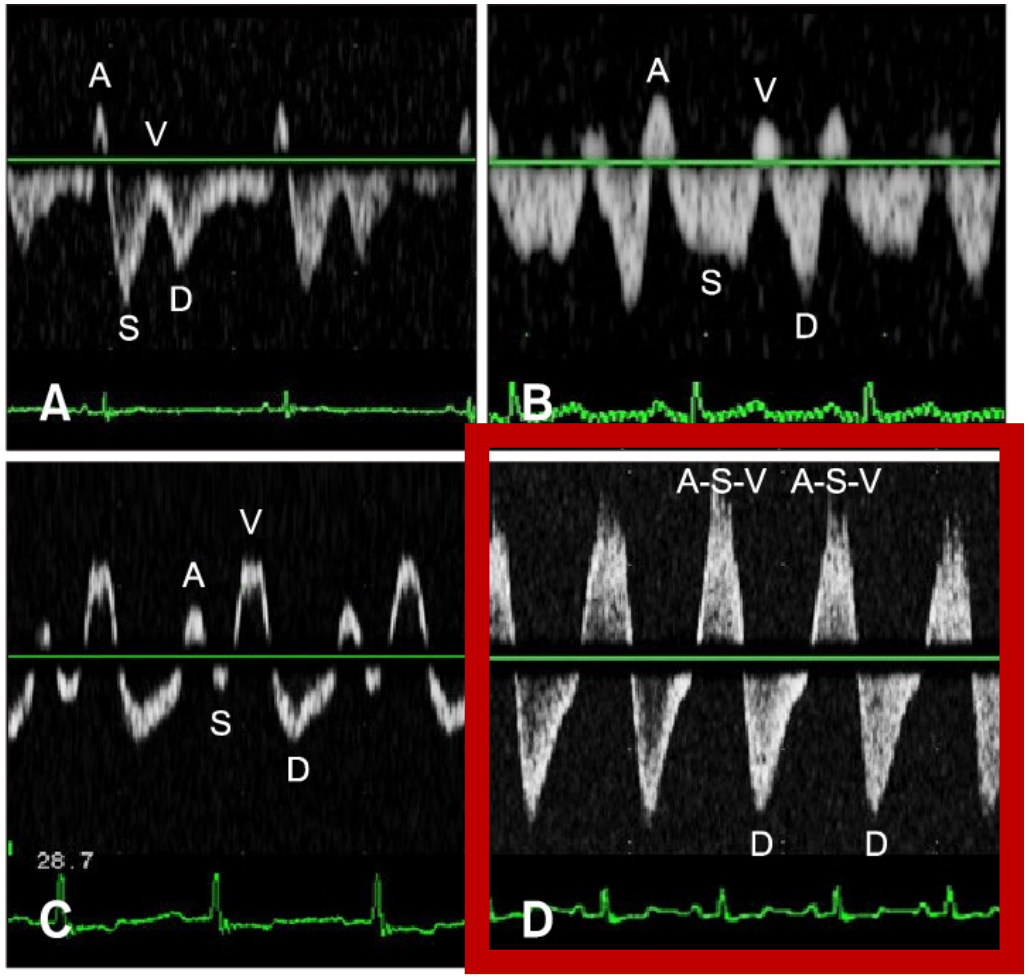


PISA $EROA \geq 0,40cm2$



ERO: 0.32 cm2 RVol 27 mL/beat

Flux veineux VSH



Avantages

- simple signe d'IT sévère +++
-ETT et ETO

Inconvénients

- dépend de la compliance de l'OD
-non valable quand FA/ pacemaker

Sévérité IT

Avantages

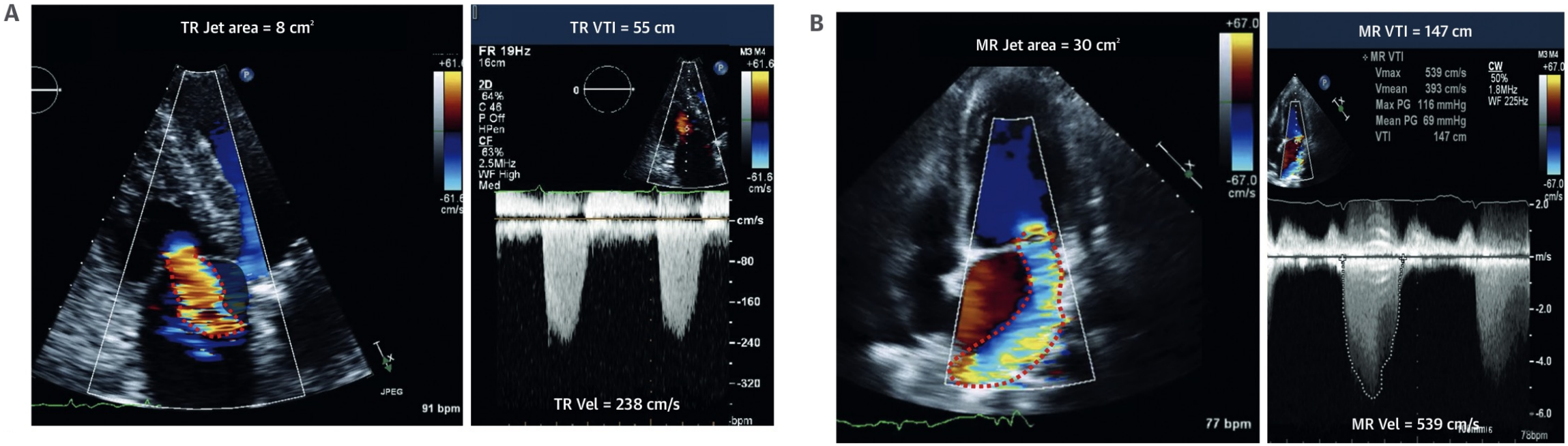
- simple à mesurer

Inconvénients

- dépend de la différence de P° et direction jet
- jets centraux surestimés/ jets excentriques sousestimés
-surestimation quand non holosystolique

Jet area

!!! Jet dépend du Q et EROA



IT

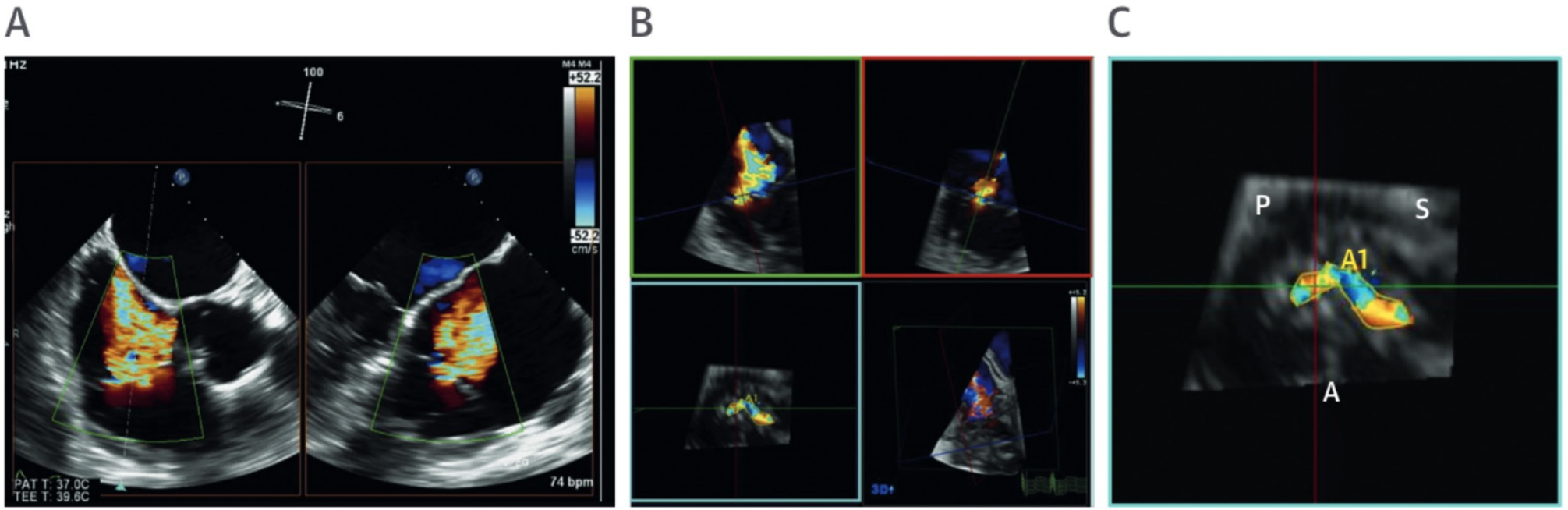
IM

Même surface d'orifice régurgitant !

Sévérité IT

Quantitatif

3D Vena contracta $\geq 75mm2$



Sévérité IT

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY

PUBLISHED BY ELSEVIER

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TABLE 20 Stages of TR

Stage	Definition	Valve Hemodynamics	Hemodynamic Consequences	Clinical Symptoms and Presentation
B	Progressive TR	■ Central jet <50% RA ■ Vena contracta width <0.7 cm ■ ERO <0.40 cm^2 ■ Regurgitant volume <45 mL	■ None	■ None
C	Asymptomatic severe TR	■ Central jet ≥50% RA ■ Vena contracta width ≥0.7 cm ■ ERO ≥0.40 cm^2 ■ Regurgitant volume ≥45 mL ■ Dense continuous wave signal with triangular shape ■ Hepatic vein systolic flow reversal	■ Dilated RV and RA ■ Elevated RA with "c-V" wave	■ Elevated venous pressure ■ No symptoms
D	Symptomatic severe TR	■ Central jet ≥50% RA ■ Vena contracta width ≥0.7 cm ■ ERO ≥0.40 cm^2 ■ Regurgitant volume ≥45 mL ■ Dense continuous wave signal with triangular shape ■ Hepatic vein systolic flow reversal	■ Dilated RV and RA ■ Elevated RA with "c-V" wave	■ Elevated venous pressure ■ Dyspnea on exertion, fatigue, ascites, edema

c-V wave indicates systolic positive wave; ERO, effective regurgitant orifice; RA, right atrial; RV, right ventricular; and TR, tricuspid regurgitation.

Sévérité IT

ESC European Society of Cardiology

Tricuspid regurgitation: recent advances in understanding pathophysiology, severity grading and outcome

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2022

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	Significant/ moderate-severe	Severe	Massive	Torrential
Vena contracta width	<3 mm	3–6.9 mm	6–6.9 mm	7–13 mm	14–20 mm	≥21 mm
EROA	20 mm^2	20–29 mm^2	30–39 mm^2	40–59 mm^2	60–79 mm^2	≥80 mm^2
Regurgitant volume	<15 mL	15–29 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]

+ retentissement hémodynamique

+ symptomatologie ?

Sévérité IT

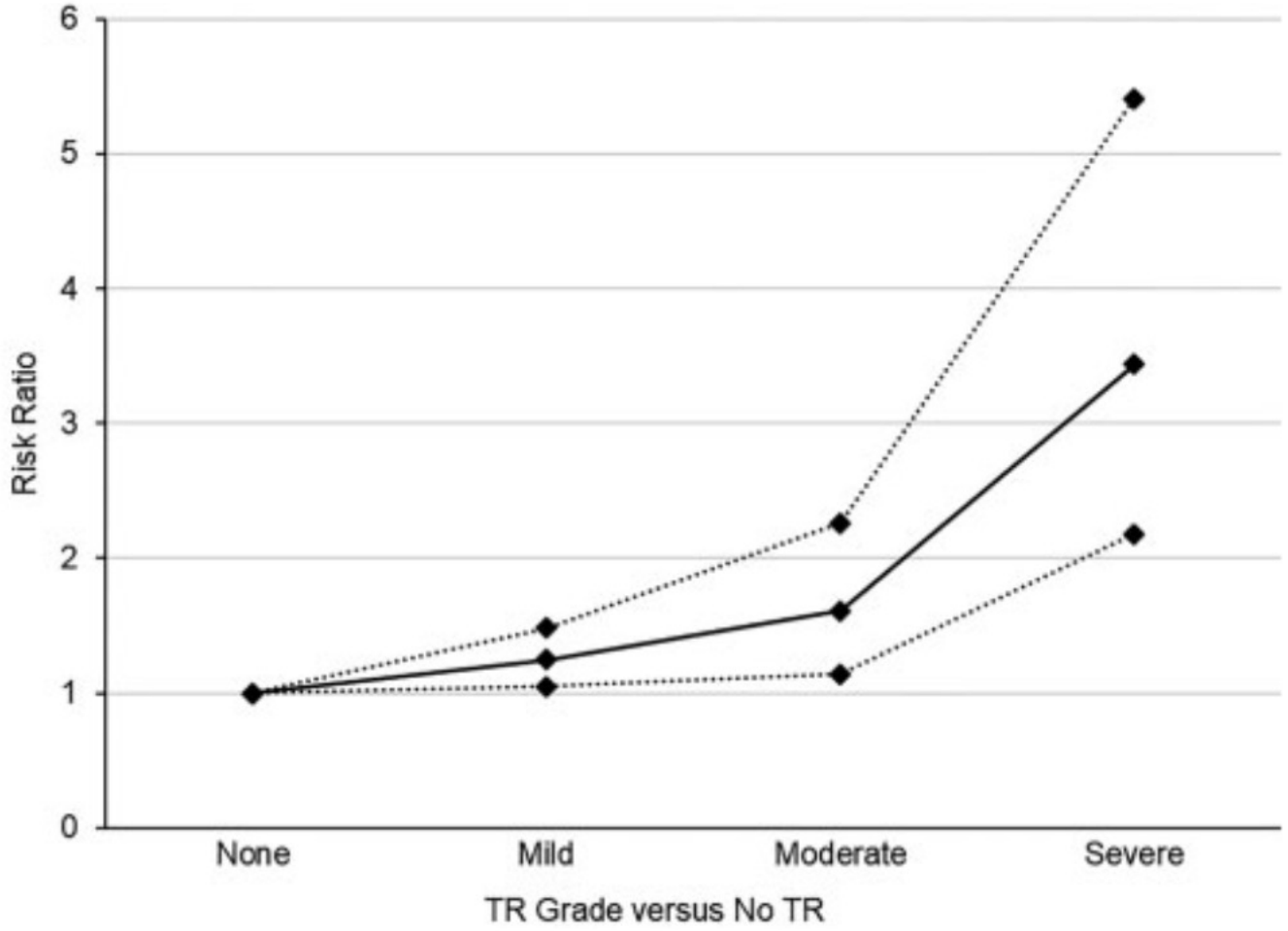
ASE GUIDELINES AND STANDARDS

Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation

A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Magnetic Resonance

Parameters	Mild	Moderate	Severe
Structural			
TV morphology	**Normal or mildly abnormal leaflets**	Moderately abnormal leaflets	**Severe valve lesions** (e.g., flail leaflet, severe retraction, large perforation)
RV and RA size	Usually normal	Normal or mild dilatation	Usually dilated*
Inferior vena cava diameter	Normal < 2 cm	Normal or mildly dilated 2.1- 2.5 cm	Dilated > 2.5 cm
Qualitative Doppler			
Color flow jet area†	**Small, narrow, central**	Moderate central	**Large central jet** or eccentric wall-impinging jet of variable size
Flow convergence zone	**Not visible, transient or small**	Intermediate in size and duration	**Large throughout systole**
CWD jet	**Faint/partial**/parabolic	Dense, parabolic or triangular	Dense, often triangular
Semiquantitative			
Color flow jet area (cm^2)†	Not defined	Not defined	**>10**
VCW (cm)†	<0.3	0.3-0.69	≥**0.7**
PISA radius (cm)‡	≤0.5	0.6-0.9	**>0.9**
Hepatic vein flow§	Systolic dominance	Systolic blunting	**Systolic flow reversal**
Tricuspid inflow§	**A-wave dominant**	Variable	E-wave >1.0 m/sec
Quantitative			
EROA (cm^2)	<0.20	0.20-0.39‖	≥**0.40**
RVol (2D PISA) (mL)	<30	30-44‖	≥45

Devenir des patients



N Wang and al, Tricuspid regurgitation is associated with increased mortality independent of pulmonary pressures and right heart failure: a systematic review and meta-analysis, European Heart Journal, 2019

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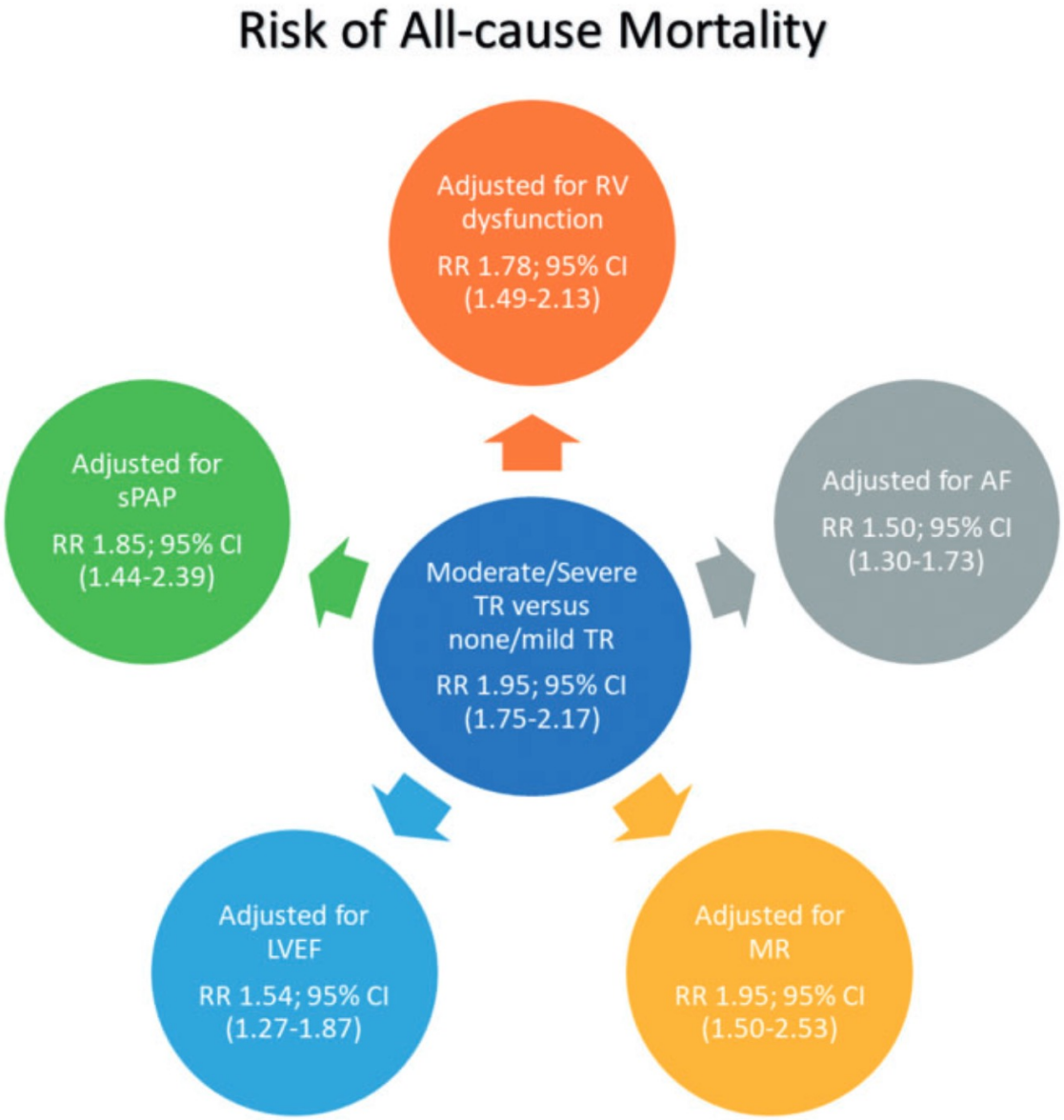

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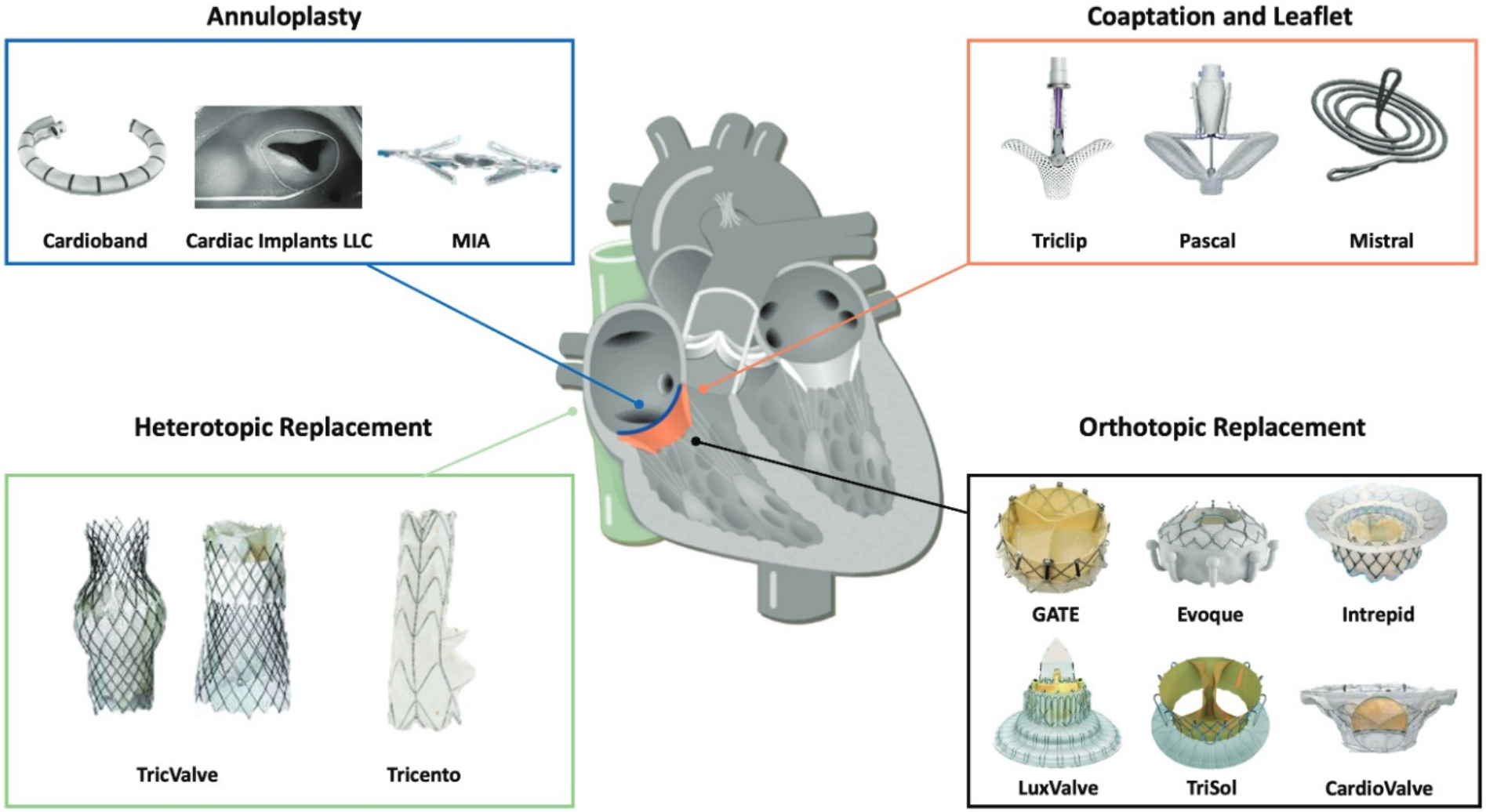

Russo and al, Challenges and future perspectives of transcatheter tricuspid valve interventions: adopt old strategies or adapt to new opportunities? European journal of heart failure 2022

Sténose tricuspidienne

Etiologies

Sténose tricuspidienne = moins fréquente !

- Rhumatismale +++ (associé à sténose mitrale)
- Congénitale
- Endocardite infectieuse
- Anomalie métabolique ou enzymatique (syndrome carcinoïde)
- Lésion sur PM : développement de fibrose en réponse à une inflammation

En général = traitement chirurgical (même si cas dilatation percutanée décrit)

Critères échographiques

GUIDELINES AND STANDARDS

Echocardiographic Assessment of Valve Stenosis: EAE/ASE Recommendations for Clinical Practice

Helmut Baumgartner, MD,† Judy Hung, MD,‡ Javier Bermejo, MD, PhD,†
John B. Chambers, MD,† Arturo Evangelista, MD,† Brian P. Griffin, MD,‡ Bernard Iung, MD,†
Catherine M. Otto, MD,‡ Patricia A. Pellikka, MD,‡ and Miguel Quiñones, MD‡

Rechercher

- Un épaississement et/ou une calcification de la valve
- Une mobilité restreinte (surtout en diastole)
- Une séparation réduite des feuillets à l'ouverture maximale
- Un élargissement de l'oreillette droite

Souvent associé à une IT +++

Critères échographiques

GUIDELINES AND STANDARDS 2009

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Multiplier les mesures +++ (variation en fonction du cycle respiratoire)

Table 10 Findings indicative of haemodynamically significant tricuspid stenosis

Specific findings	
Mean pressure gradient	≥5 mmHg
Inflow time–velocity integral	>60 cm
$T_{1/2}$	≥190 ms
Valve area by continuity equation[a]	≤1 cm^{2a}
Supportive findings	
Enlarged right atrium ≥moderate	
Dilated inferior vena cava	

Critères échographiques

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ESC European Society of Cardiology
European Heart Journal (2022) **43**, 561–632
https://doi.org/10.1093/eurheartj/ehab395

ESC/EACTS GUIDELINES

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

Developed by the Task Force for the management of valvular heart disease of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS)

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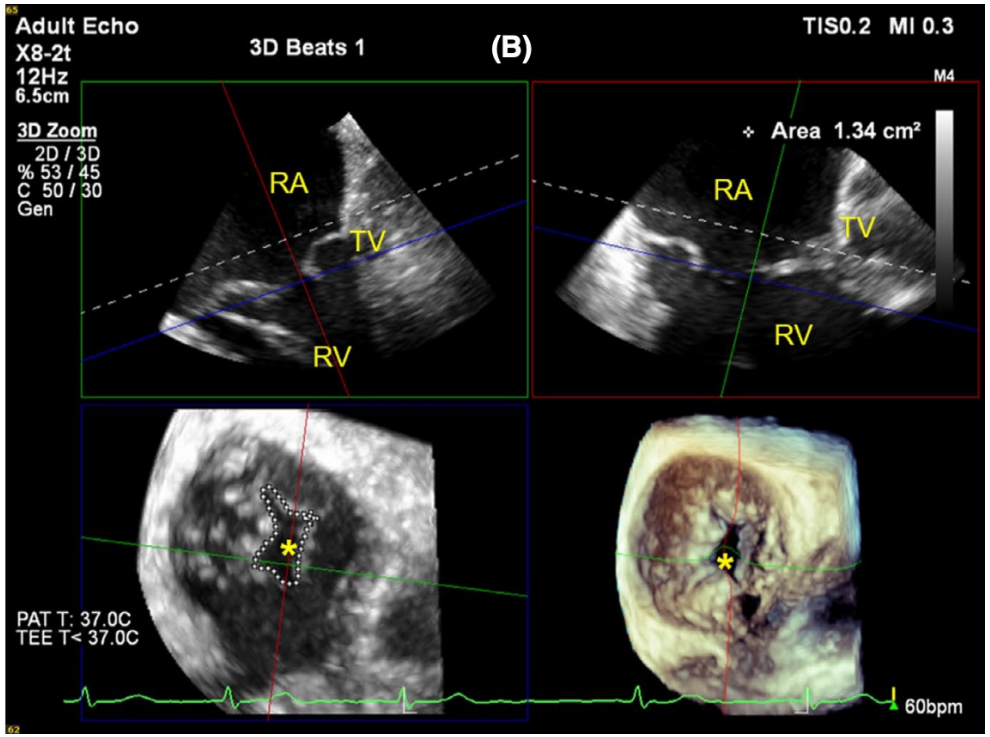


Planimétrie 3D ? Futur ?

En bref

- Grande valve, à basse pression, anatomie variable
- Principale étiologie de l'IT est fonctionnelle
- Sévérité de l'IT … pas toujours facile ! Variation en fonction des conditions de charge
- Attention à l'interprétation du doppler couleur ➔ privilégier les mesures qualitatives et les répéter
- Plein essor des procédures percutanées
- Sténose tricuspidienne plus rare, rhumatismale la plus fréquente et souvent associée à l'IT

- State-of-the-Art Review of Echocardiographic Imaging in the Evaluation and Treatment of Functional Tricuspid Regurgitation, rebecca Hahn
- Imaging Considerations for Percutaneous Tricuspid Intervention. A review of imaging options relevant to treating functional tricuspid regurgitation with transcatheter techniques. Rebecca Hahn, August 2017, cardiac interventions
- Guidelines

Sévérité IT

Vena contracta

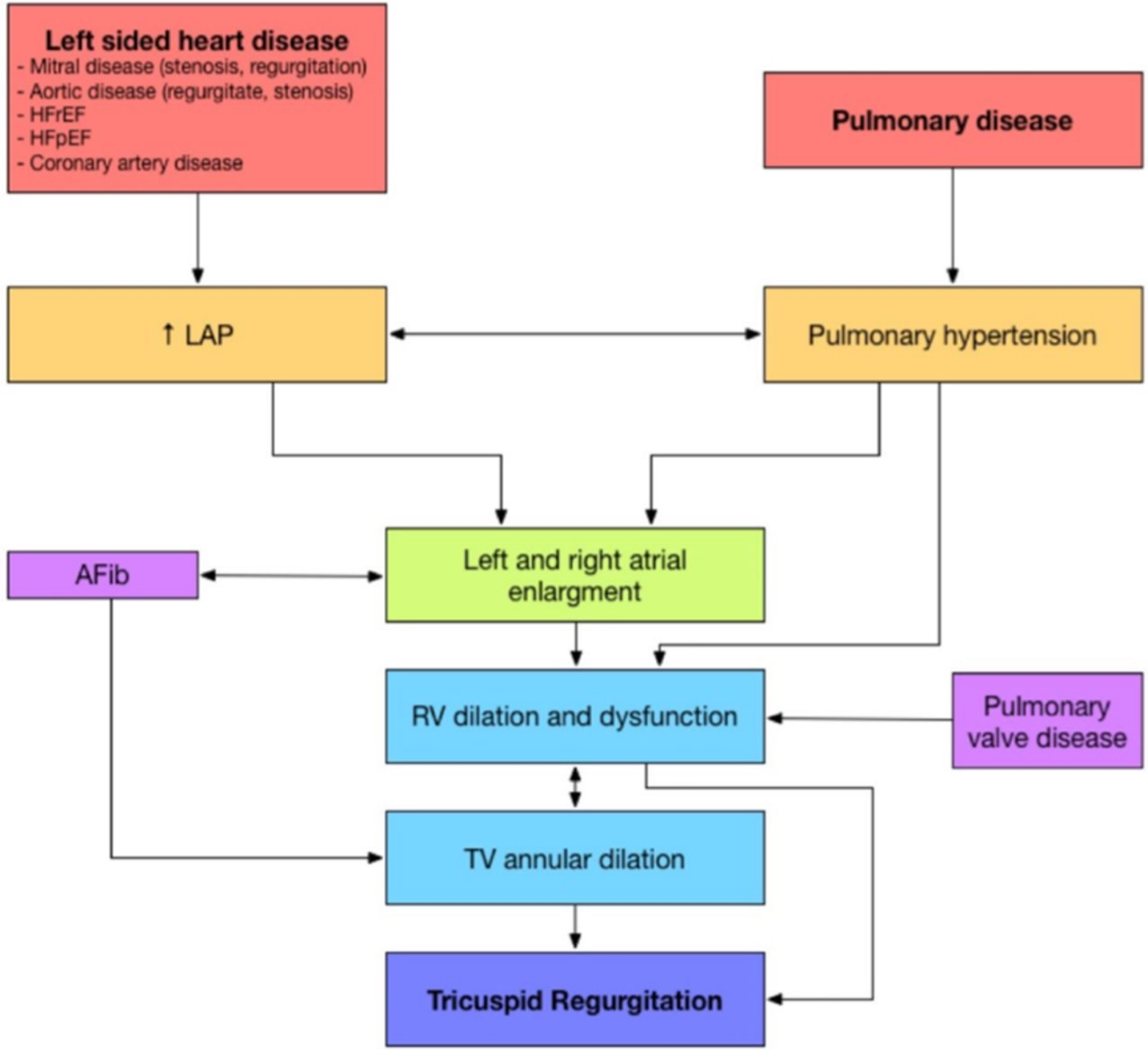
PISA

PISA radius >9 mm at a Nyquist limit of 28 m/s

ACC guidelines,

Smallest high velocity on hte atrial side of the tricuspid

Also, there are no quantitative
criteria for grading mild and moderate TR, and it is
not possible to distinguish between the 2 grades of TR
using quantitative grading


Left sided heart disease
- Mitral disease (stenosis, regurgitation)
- Aortic disease (regurgitate, stenosis)
- HFrEF
- HFpEF
- Coronary artery disease
Pulmonary disease
↑ LAP
Pulmonary hypertension
AFib
Left and right atrial enlargment
RV dilation and dysfunction
Pulmonary valve disease
TV annular dilation
Tricuspid Regurgitation