

# **Updates in Transcatheter Tricuspid Transcatheter Interventions: Focus on Prehab and Post-hab**

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**OACNS Medicine Virtual Ground Rounds**

**April 10<sup>th</sup>, 2026**

# Conflict of Interest

- Speakers' bureau - Abbott Structural Heart
- Receipt of research support: Enrollment in TRILUMINATE Pivotal and CAS

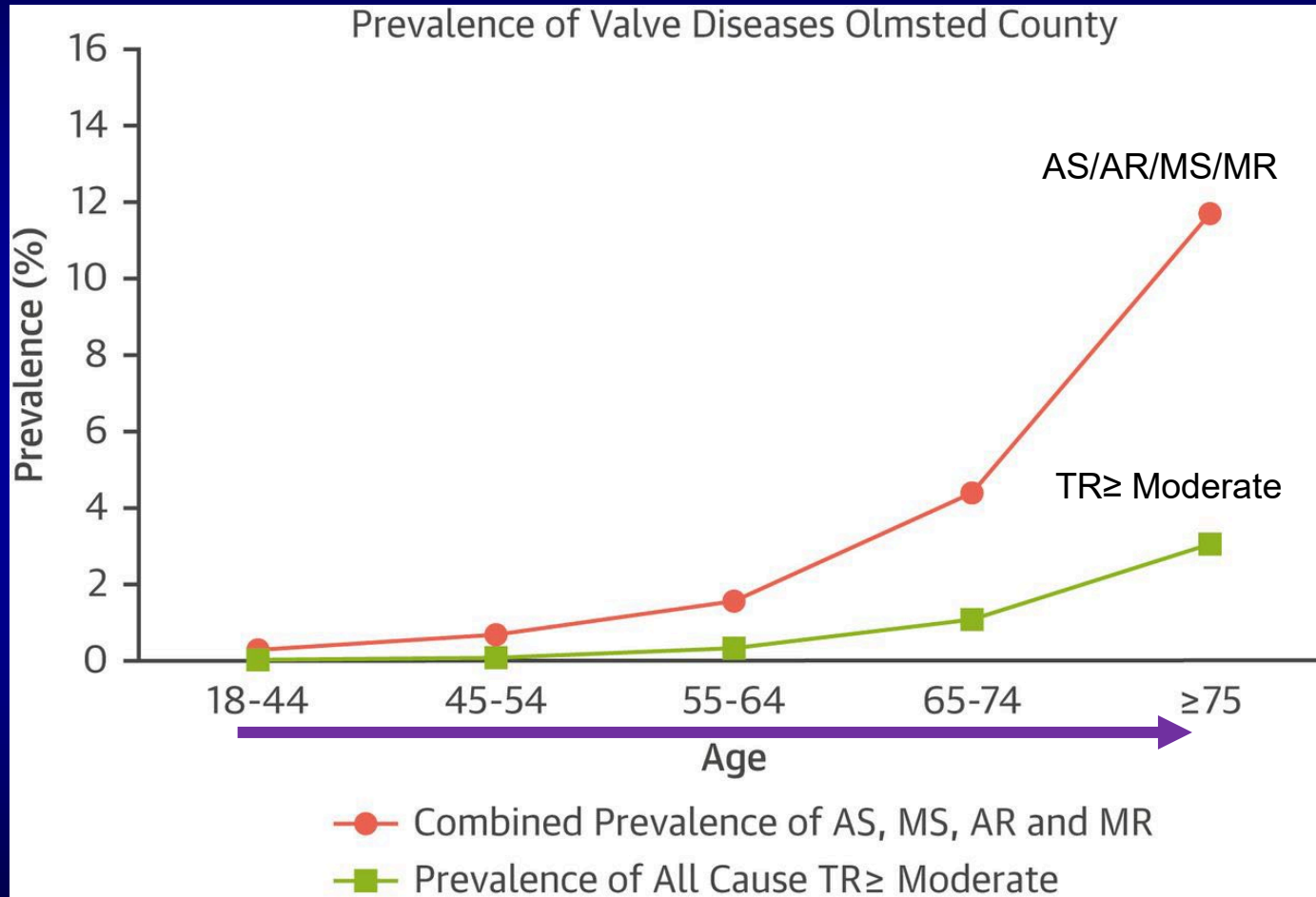
# OUTLINE

- Burden of Severe TR
- Challenges with Managing TR
- Transcatheter Tricuspid Landscape
- Patient Screening and Selection
- Case examples
- TTVR

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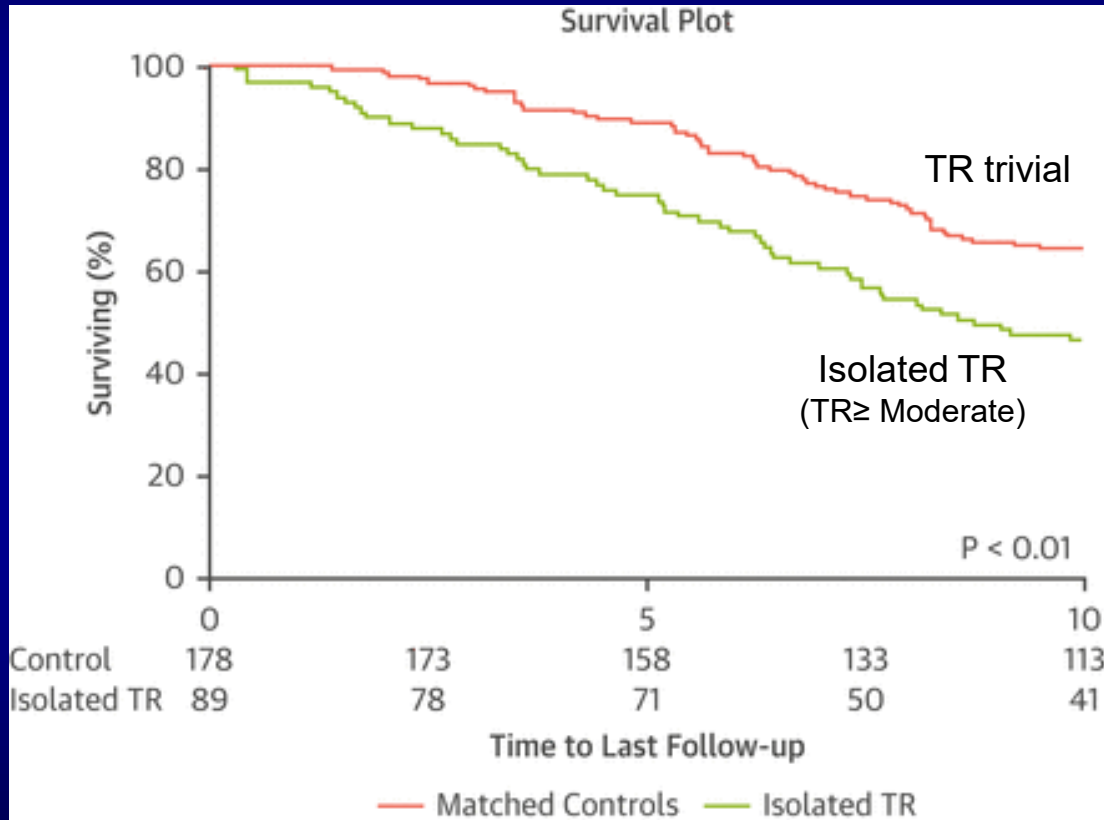
# Tricuspid Regurgitation (TR) is highly prevalent



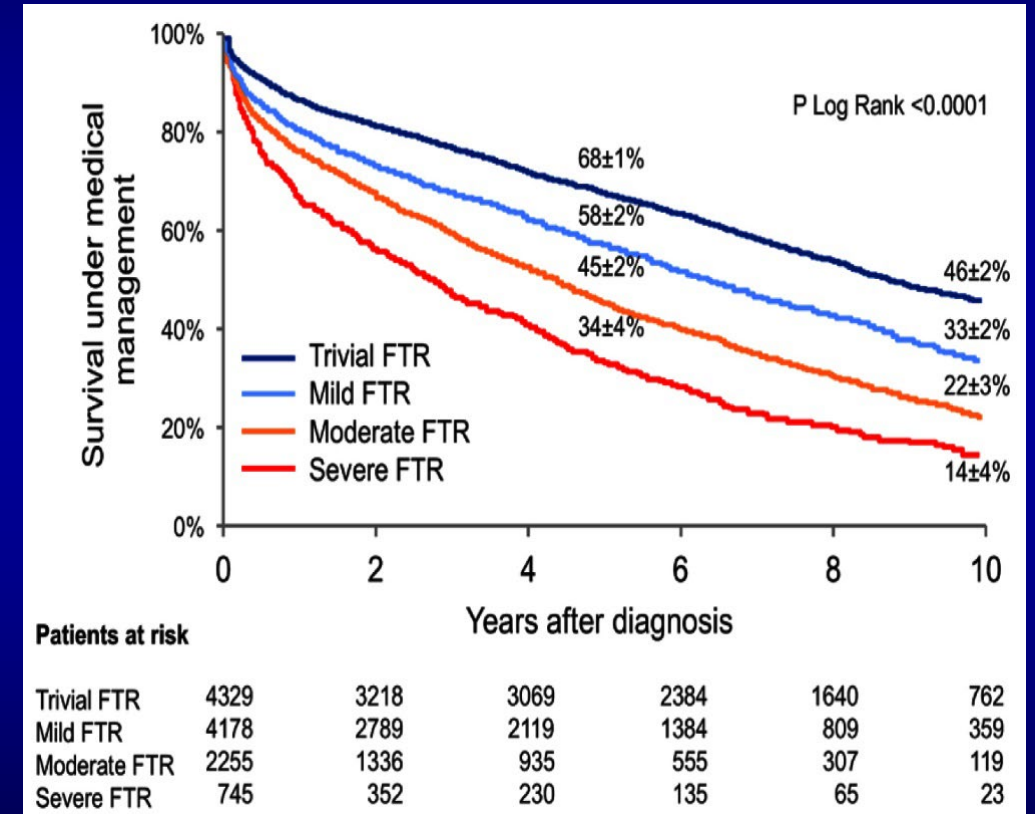
- TR is **more common with age**.
- TR is approximately **one-fourth** of all left-sided valve disease, similar to the **prevalence of AS**.

# TR is associated with adverse outcomes

## Associated with higher mortality



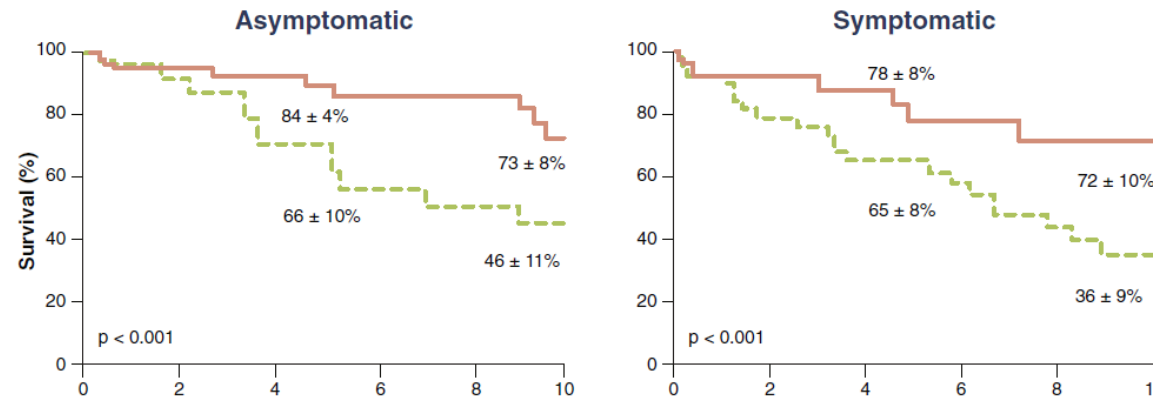
## Risk of mortality increases with severity



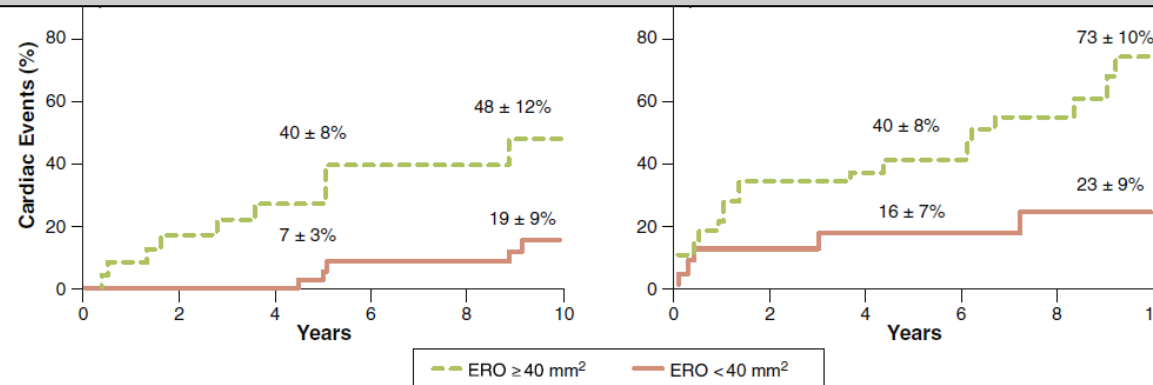
# Clinical Outcome of Isolated Tricuspid Regurgitation



Yan Topilsky, MD,\* Vuyisile T. Nkomo, MD,† Ori Vatury, MD,† Hector I. Michelena, MD,† Thierry Letourneau, MD,† Rakesh M. Suri, MD, DPHIL,‡ Sorin Pislaru, MD,† Soon Park, MD,‡ Douglas W. Mahoney, MSc,§ Simon Biner, MD,\* Maurice Enriquez-Sarano, MD†



**Severe TR = worse survival, more cardiac events**



# Only 0.4% of TR patients treated today

Etiology: Secondary or Functional (>75%)

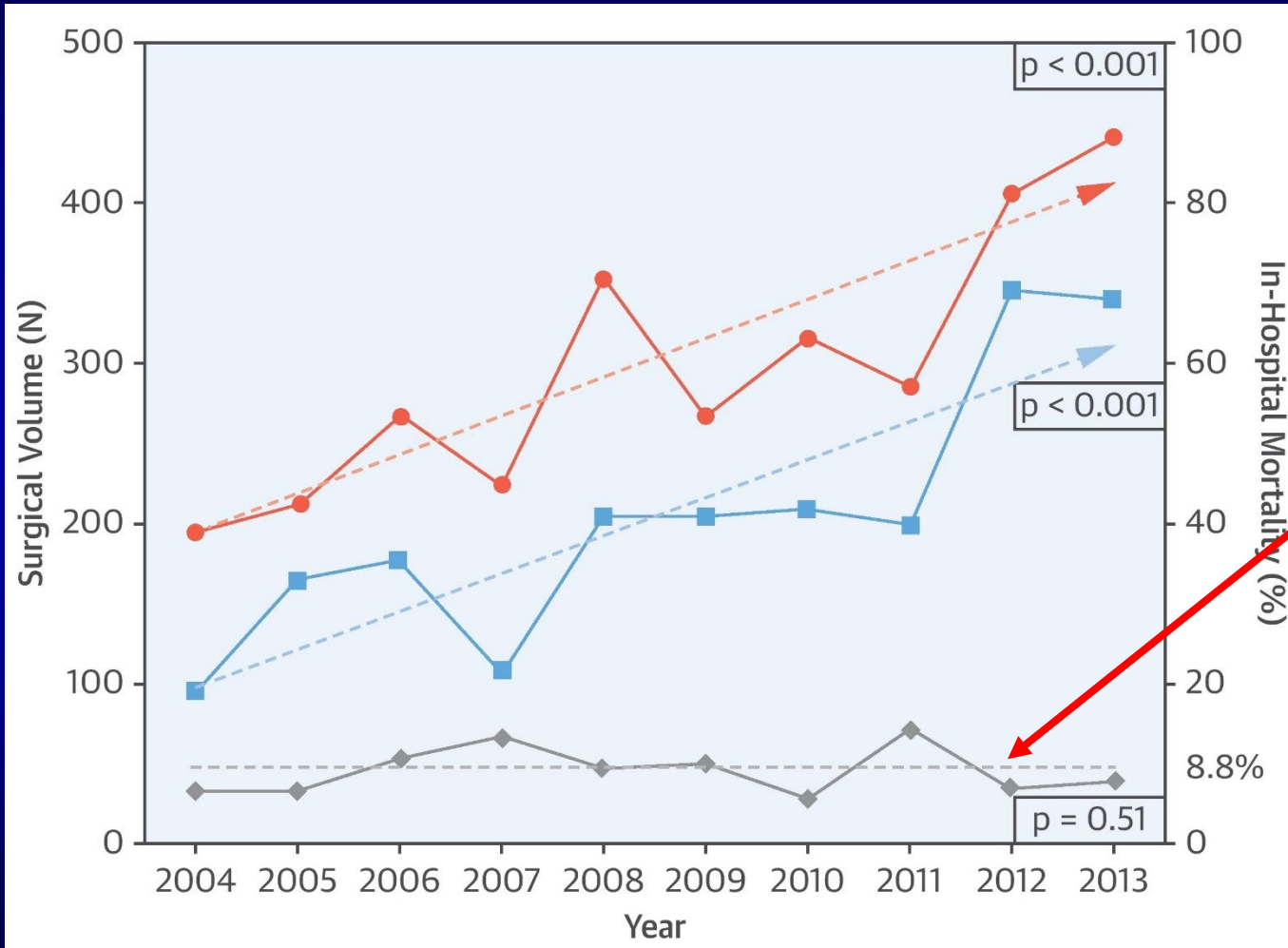


2.4 M  
≥3+ TR Prevalence



12,324  
Surgical Procedures

# Mortality for isolated TV surgery remains high



Tricuspid Valve Replacement  
Tricuspid Valve Repair (N)  
In-Hospital Mortality After Tricuspid Valve Surgery

In-hospital mortality post **isolated tricuspid surgery** was **8.8%** and unchanged despite increasing surgical volumes

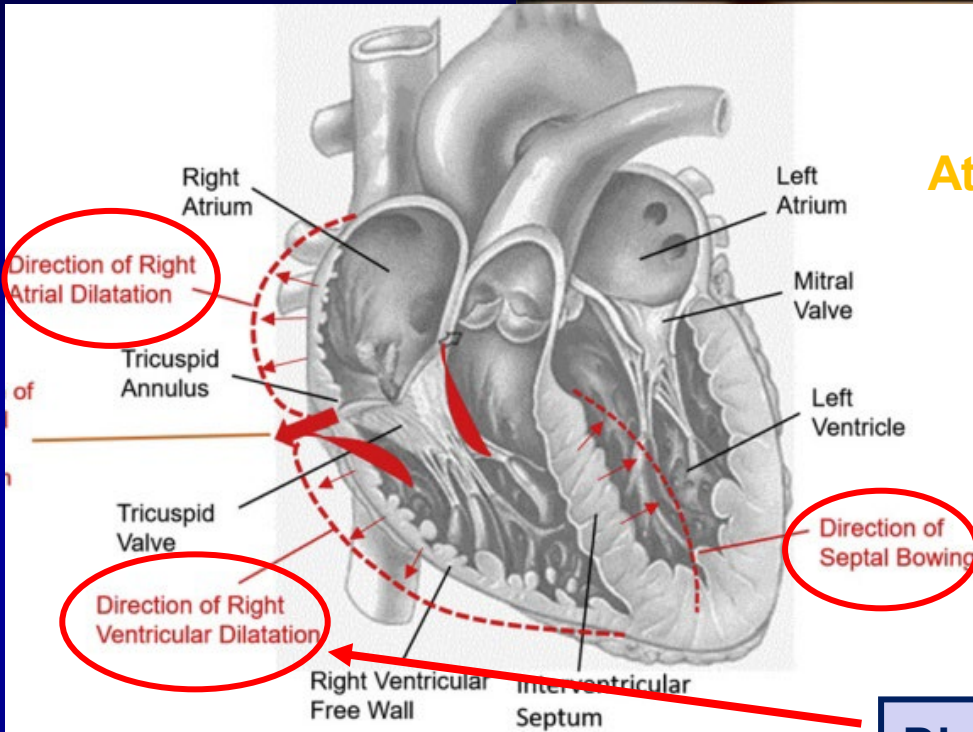
# Why don't Surgeons like to Operate Isolated TR?

- Referred late => +++ comorbidities
- Bad RV: high risk of acute RV failure off CPB => ↑ mortality
- End-organ dysfunction: kidney, liver
- High risk of acute liver failure => ↑ mortality
- Significant % are reops: prior MV surgery

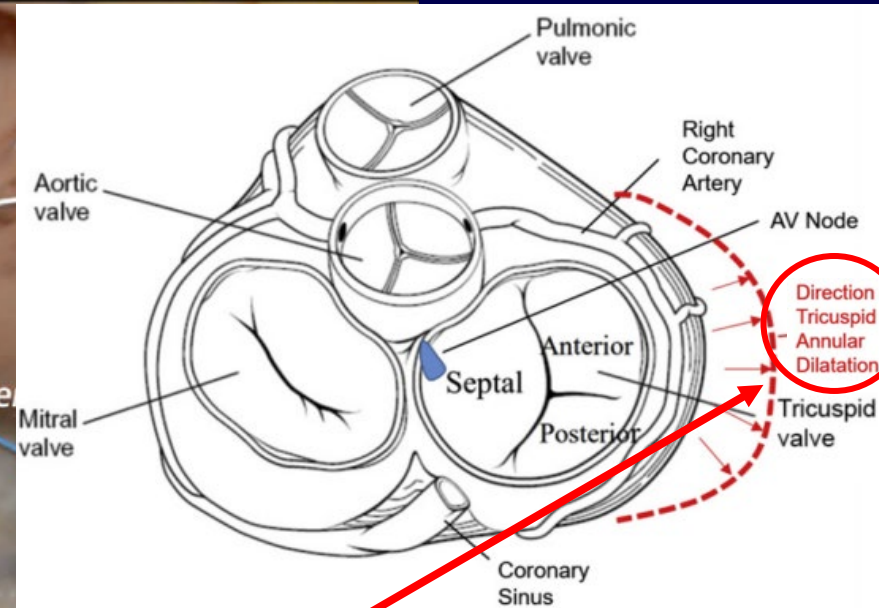
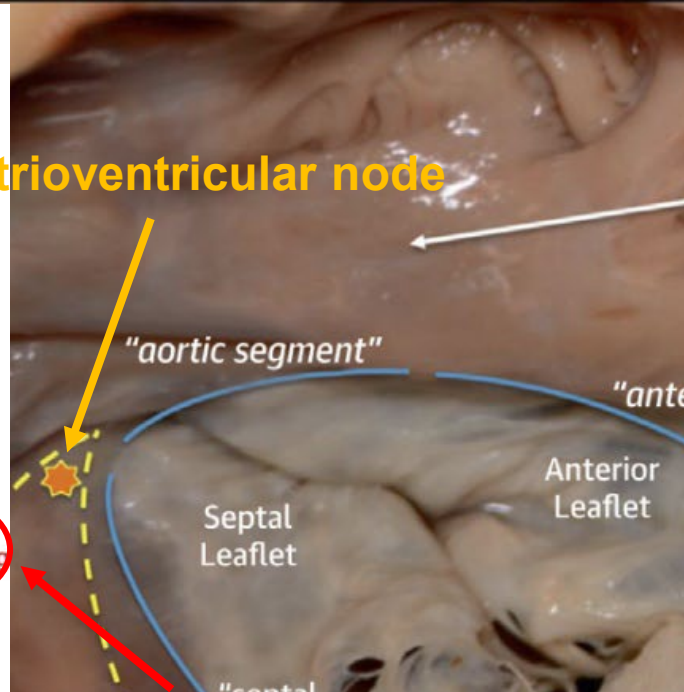
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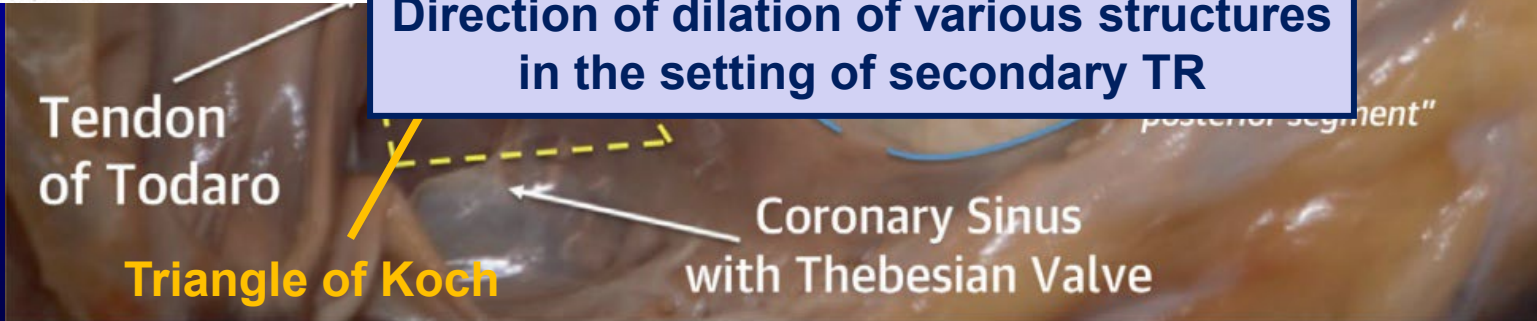
# Complex Tricuspid Valve Anatomy



Atrioventricular node



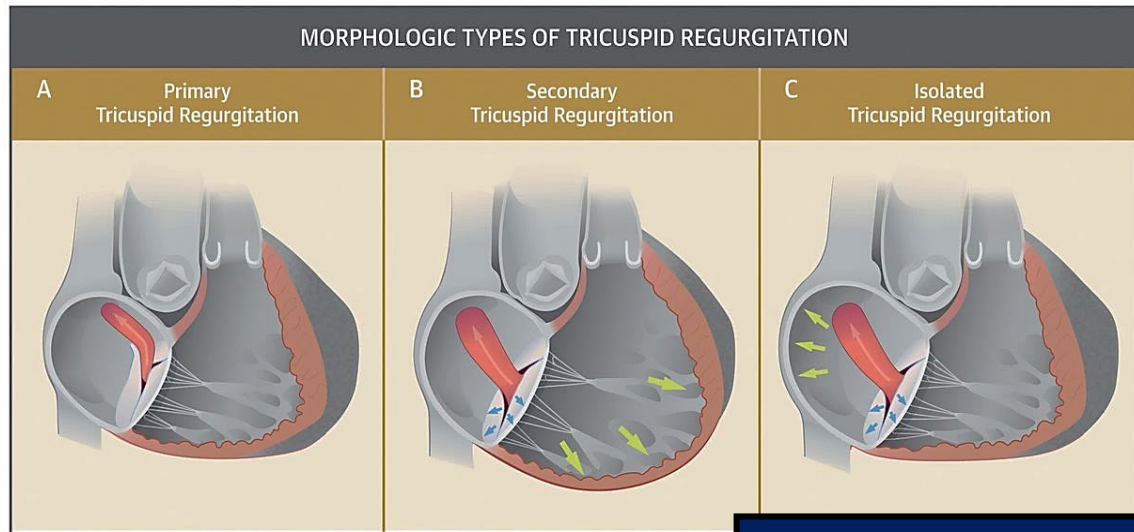
Direction of dilation of various structures in the setting of secondary TR



# 2020 ACC/AHA Valve Guidelines

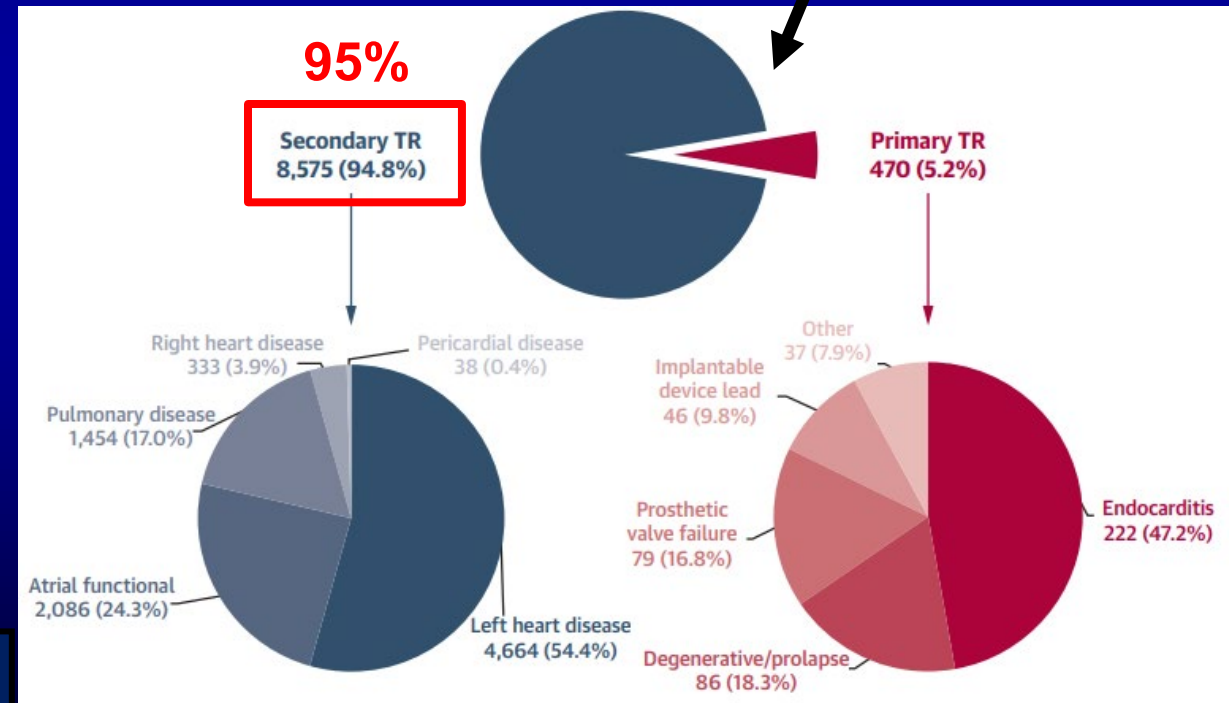
COR	LOE	RECOMMENDATIONS
1	C-LD	1. In patients with TR, <b>TTE</b> is indicated to evaluate the presence and severity of TR, determine the <b>etiology</b> , measure the sizes of the <b>right-sided chambers</b> and inferior vena cava, assess <b>RV systolic function</b> , estimate <b>pulmonary artery systolic pressure</b> , and characterize any associated left-sided heart disease (1,2).
2a	C-LD	2. In patients with TR, invasive measurement of the cardiac index, right-sided diastolic pressures, pulmonary artery pressures, and pulmonary vascular resistance, as well as right ventriculography, can be useful when clinical and noninvasive data are discordant or inadequate (3-5).

## 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.

\*Isolated TR is associated with AF and has LVEF >60%, pulmonary artery systolic pressure <50mmHg, and no left-sided valve disease, with normal-appearing tricuspid valve leaflets.



Otto et al., J Am Coll Cardiol 2021;77:e25

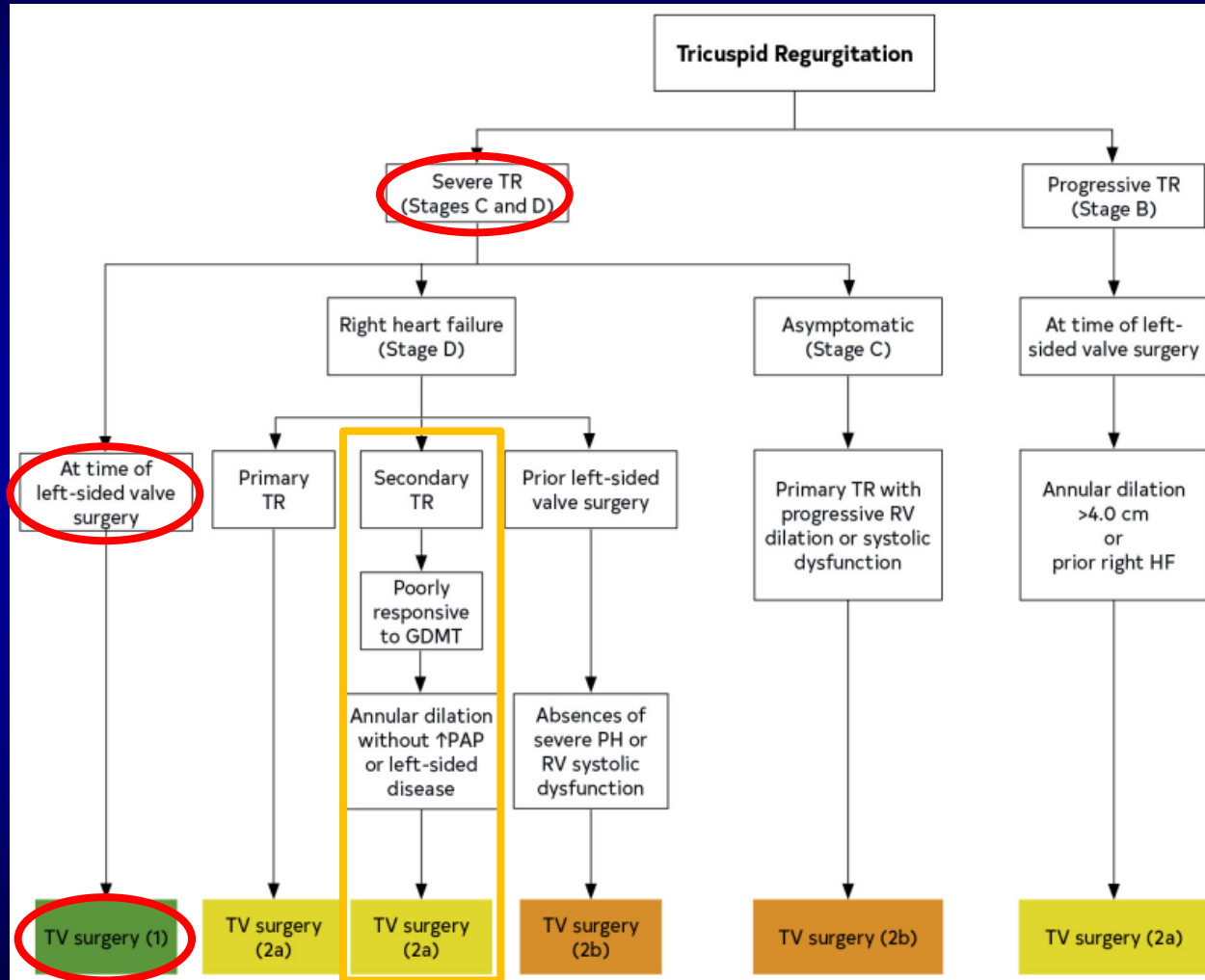
Ming Wang et al., JACC Cardiovasc Imaging 2022;15:731

# Limited Help from Guidelines

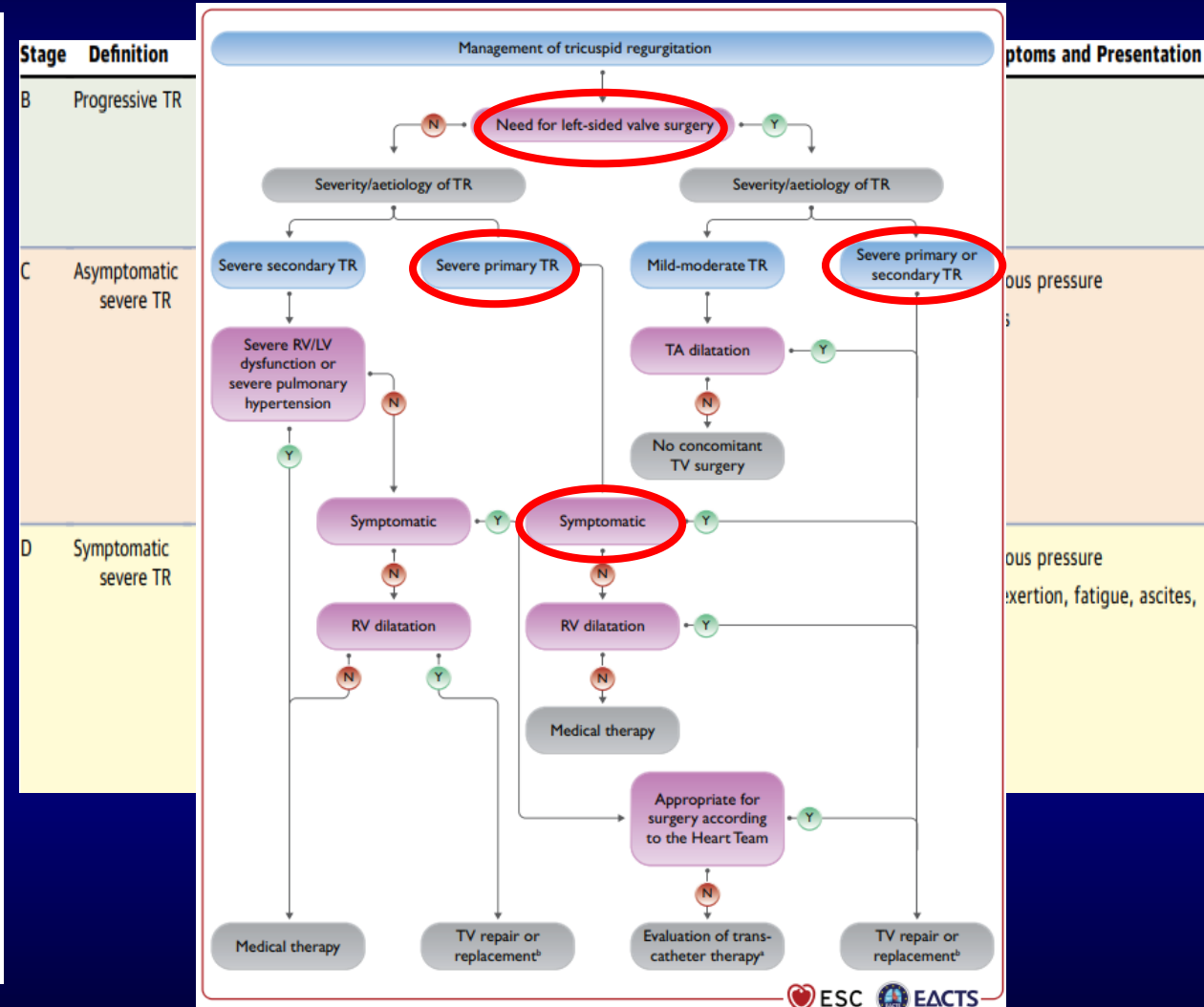
2020 ACC/AHA Guideline for Valvular Heart Disease

COR	LOE	RECOMMENDATIONS
2a	C-EO	1. In patients with signs and symptoms of right-sided HF attributable to severe TR (Stages C and D), <u>diuretics</u> can be useful.
2a	C-EO	2. In patients with signs and symptoms of right-sided HF attributable to <u>severe secondary TR</u> (Stages C and D), therapies to treat <u>the primary cause of HF</u> (eg, pulmonary vasodilators to reduce elevated pulmonary artery pressures, <u>GDMT for HF with reduced LVEF</u> , or <u>rhythm control of AF</u> ) can be useful (1,2)

# 2020 ACC/AHA Guideline for the Management of Patients With Valvular Heart Disease



# 2021 ESC/EACTS Guidelines for the management of Valvular heart disease



# 2025 ESC GUIDELINES

## Patients with tricuspid regurgitation and left-sided valvular heart disease requiring surgery

Concomitant TV surgery<sup>c</sup> is recommended in patients with severe primary or secondary TR.<sup>725,731,743,744</sup>

**I**

**B**

Concomitant TV repair should be considered in patients with moderate primary or secondary TR, to avoid progression of TR and RV remodelling.<sup>723,724,726,731</sup>

**IIa**

**B**

Concomitant TV repair may be considered in selected patients with mild secondary TR and tricuspid annulus dilatation ( $\geq 40$  mm or  $> 21$  mm/m<sup>2</sup>), to avoid progression of TR and RV remodelling.<sup>723–726,731,743</sup>

**IIb**

**B**

## Patients with severe tricuspid regurgitation without left-sided valvular heart disease requiring surgery

TV surgery<sup>c</sup> is recommended in symptomatic patients with severe primary TR without severe RV dysfunction or severe PH.

**I**

**C**

TV surgery<sup>c</sup> should be considered in asymptomatic patients with severe primary TR who have RV dilatation/RV function deterioration, but without severe LV/RV dysfunction or severe PH.

**IIa**

**C**

TV surgery<sup>c</sup> should be considered in patients with severe secondary TR who are symptomatic or have RV dilatation/RV function deterioration, but without severe LV/RV dysfunction or PH.<sup>685,720,745–747</sup>

**IIa**

**B**

Transcatheter TV treatment should be considered to improve quality of life and RV remodelling in high-risk patients with symptomatic severe TR despite optimal medical therapy in the absence of severe RV dysfunction or pre-capillary PH.<sup>713,733,735,738,748–751</sup>

**IIa**

**A**

# Practical approach for assessing severe TR by TTE

Classification	Primary	CIED-related	Ventricular	Secondary	Atrial
	 Flail leaflet	 Transgastric view lead impinging septal leaflet	 tenting		
Valve morphology	Any organic abnorm.	Lead impingement	Tenting	Minor or no tenting	
Annular remodeling	+	+/-	+	+++	
RA dilation	+ / ++	+ / ++	+ / ++	+++	
RV dysfunction	+	-	+++	+	
RV remodeling	++ (global)	+ (depending on TR severity)	+++ (mid cavity > annular + RV elongation)	+ (mid/base ratio preserved, conical remodeling)	
LV dysfunction, left-sided valve diseases	May co-exist	-	Frequent	May be present	
High LA pressure	-	-	+++ if group 2 PH, normal in others	+ Afib mostly frequent	
LV dilatation	No	+ (mostly related to underlying pathology)	++	+	

TEE guideline for TV assessment for percutaneous procedures were published in 2022

**Imaging level: ME view**

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.

**Imaging level: DE Views**

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.

**Planar imaging**

**Volumetric imaging**

**Functional imaging**

**Planar imaging**

**Volumetric imaging**

**Functional imaging**

### Assessment of Severity

**Qualitative**

- Any abnormal valve structure
- IVC dilatation
- Triangular dense CWD TR signal
- Flow convergence
- RV, RA dilatation

**Semi-quantitative**

- Hepatic vein systolic flow reversal
- E wave dominance
- Biplane VC width > 7 mm at Nyquist limit: 50 - 60 cm/s
- PISA r > 9 mm with baseline Nyquist shift of  $\approx 30$  cm/s
- VC area (a) and anatomic regurgitant orifice area (b) (by MPR from 3D data set)

**Quantitative**

by Continuity eq:  $Regurg\ Vol = (Area_{annulus} \cdot VTI_{annulus}) - (Area_{LVOT} \cdot VTI_{LVOT})$

$EROA = Regurg\ Vol / VTI_{TR}$

by VC Area (Assuming 3D VC area approximates EROA):  $Regurg\ Vol = 3D\ VC\ area \cdot VTI_{TR}$

by PISA:  $v_{alias} \cdot 2\pi r^2 = EROA \cdot vel_{TR}$  &  $Regurg\ Vol = EROA \cdot VTI_{TR}$

### Stepwise Approach for Patient Management

Assess TV morphology and leaflet coaptation

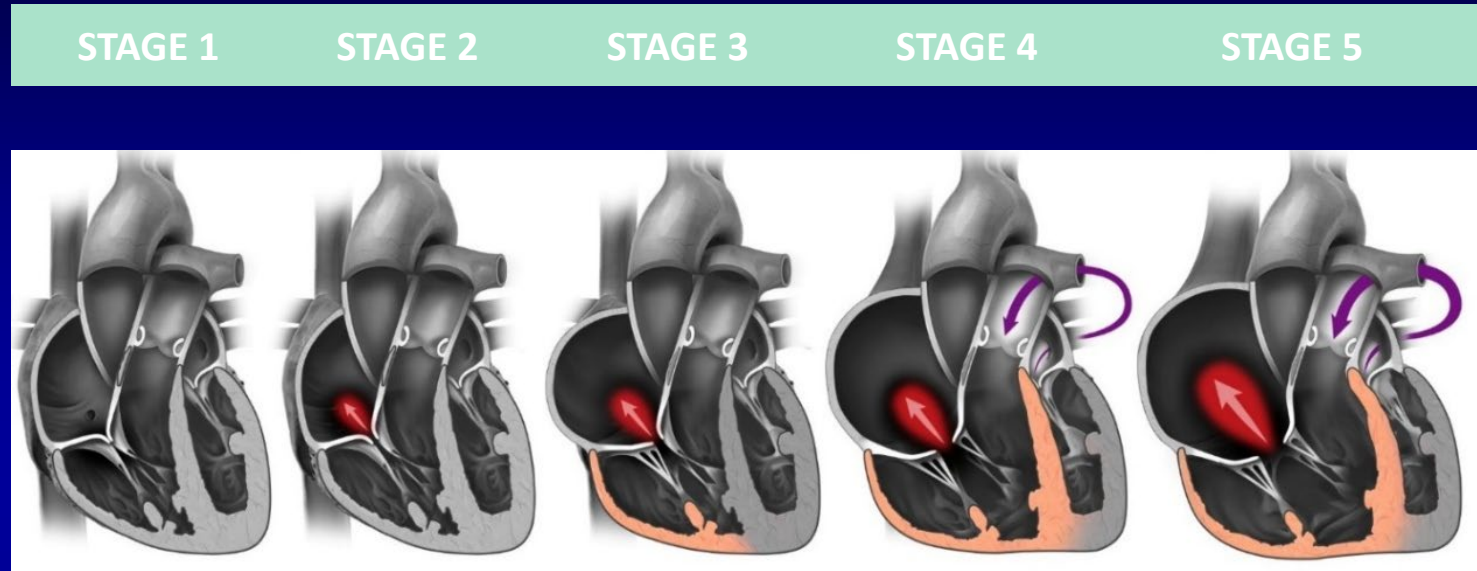
- Normal or minimally abnormal → Treatment oriented multiparametric assessment
- Significantly abnormal → Qualitative findings of significant TR (see above)
  - No → No need for quantification → Follow up
  - Yes → Quantification of TR severity (see above)
    - No → Follow up
    - Severe → Re-assess with 3D echo or CMR → Treatment oriented multiparametric assessment

**Treatment oriented multiparametric assessment:**

- Annular dilatation
- Tenting height
- Tenting volume
- Leaflet coaptation gap
- RV remodeling
- RA remodeling
- Pulmonary artery pressure
- Left sided valve disease
- LV function

# New Stages of TR

- To better characterize the severity of TR currently being treated, a new grading scale is proposed, increasing the grade to include very severe (or massive), as well as torrential.<sup>1</sup>
- Traditional proximal isovelocity surface area (PISA) method underestimates the quantitative method for assessing effective regurgitant orifice area (EROA) and different cut offs should be considered.<sup>1</sup>



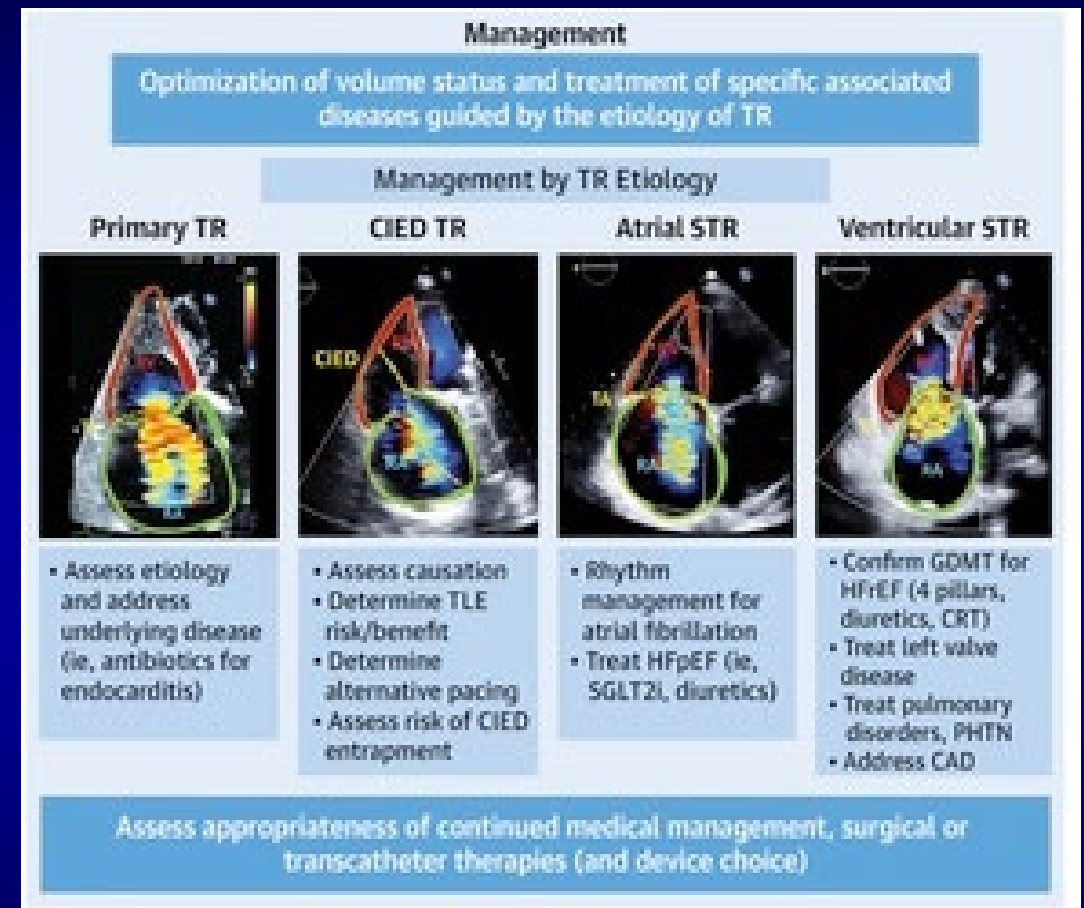
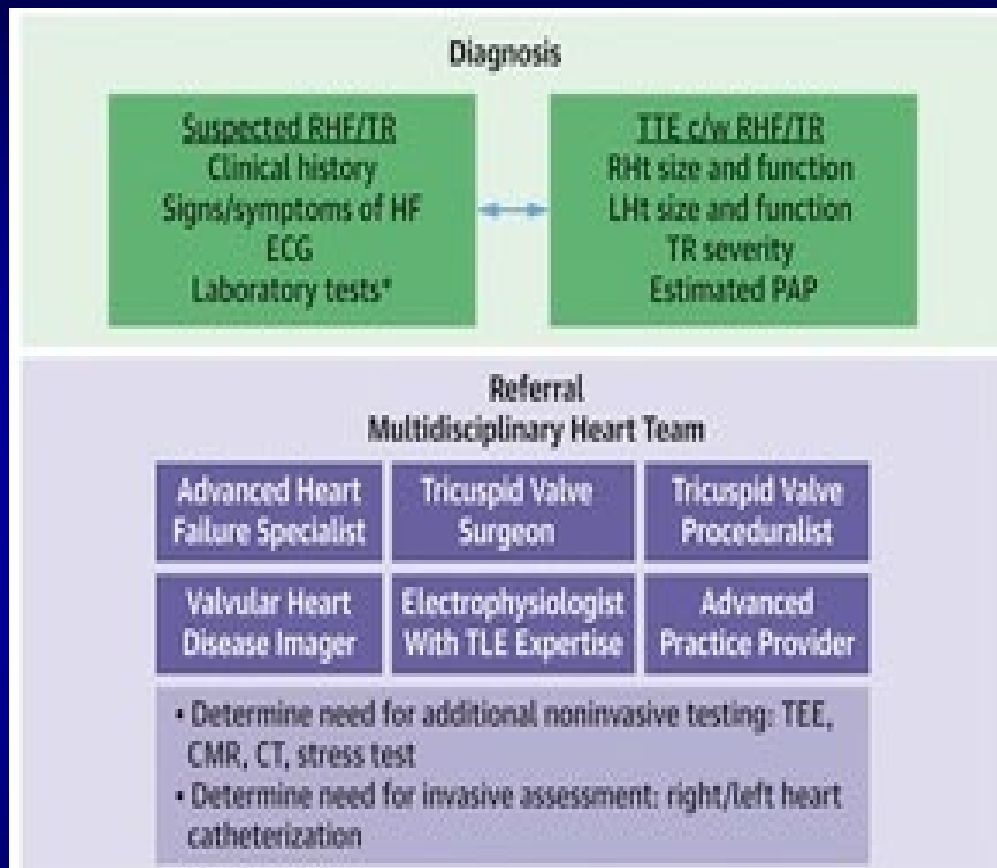
**Table 1** Proposed expansion of the 'Severe' grade

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

VC, vena contracta; EROA, effective regurgitant orifice area; 3D VCA, three-dimensional vena contracta area.

<sup>a</sup>3D VCA and quantitative Doppler EROA cut-offs may be larger than PISA EROA.

# It Takes a Village – MDHT!



# Challenges with TR

- Limitations with Medical therapy
- Complex anatomy and nomenclature
- Screening and intraprocedural Imaging
- Lack of Guidelines
- Presence of CIED

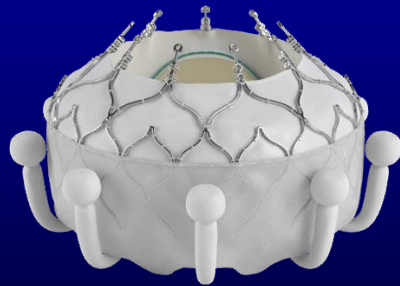
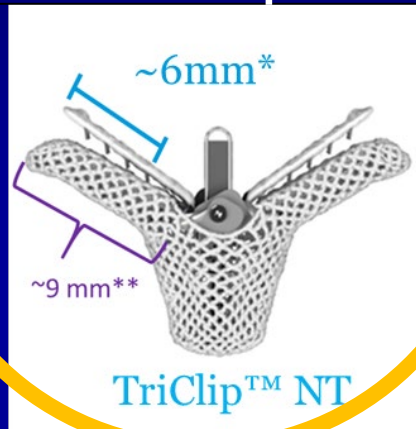
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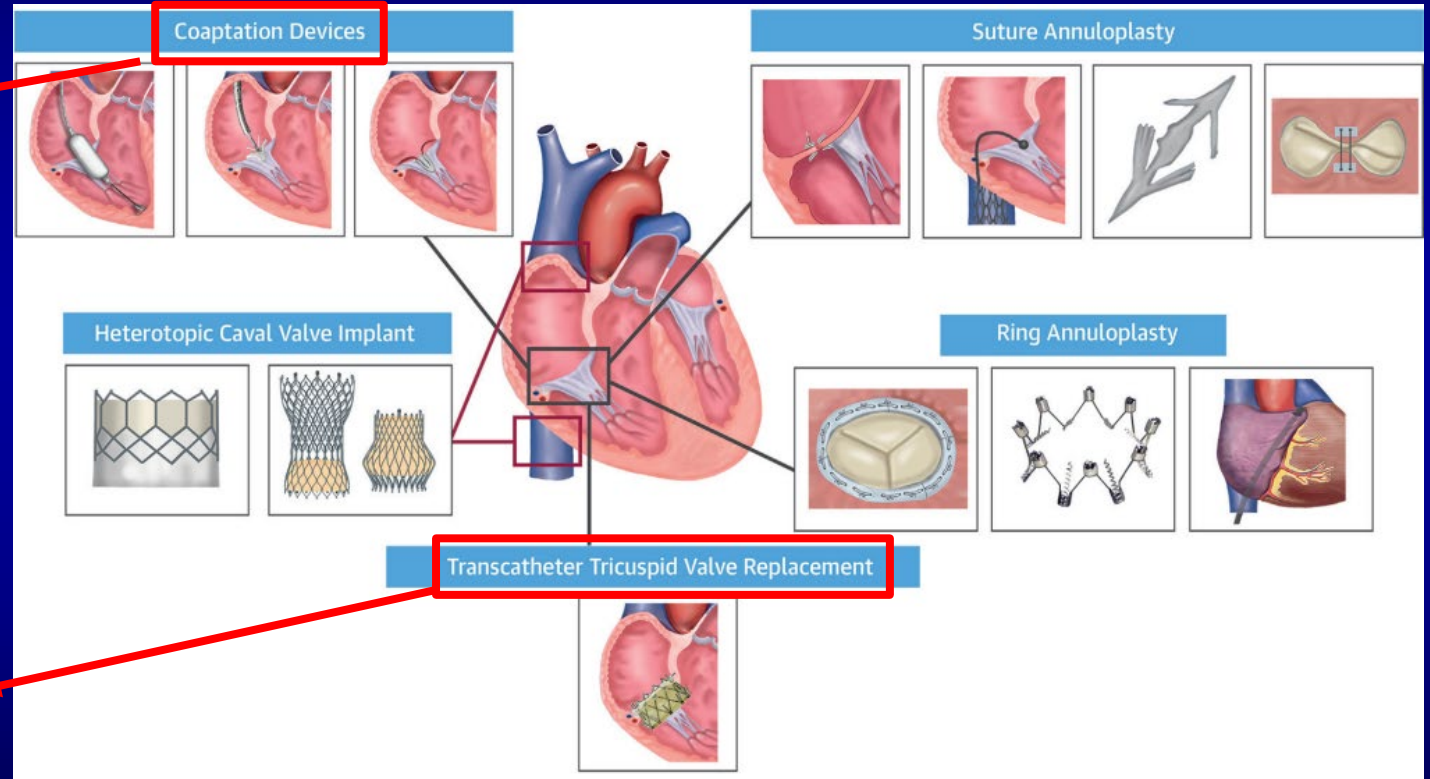
# Transcatheter Tricuspid Landscape

**T-TEER** : Tricuspid Transcatheter Edge-to-Edge Repair

TriClip



Evoque



**TTVR** : Transcatheter Tricuspid Valve Replacement

# FDA Approved

## TTVR

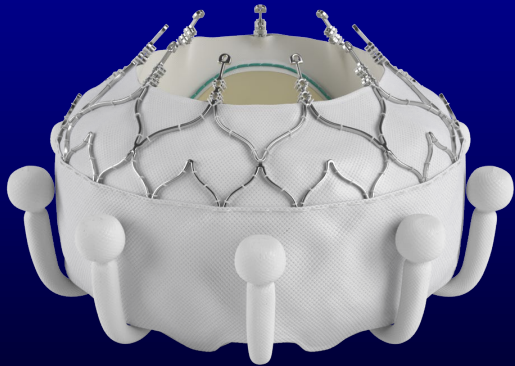
NEWS > Daily News

### FDA Approves First Transcatheter Tricuspid Valve Replacement Device

(UPDATED) Edwards Lifesciences says there are “favorable trends” in hard outcomes among patients who have completed 1-year follow-up.

by [L.A. McKeown](#) | FEBRUARY 02, 2024

**Feb 2024**



## T-TEER

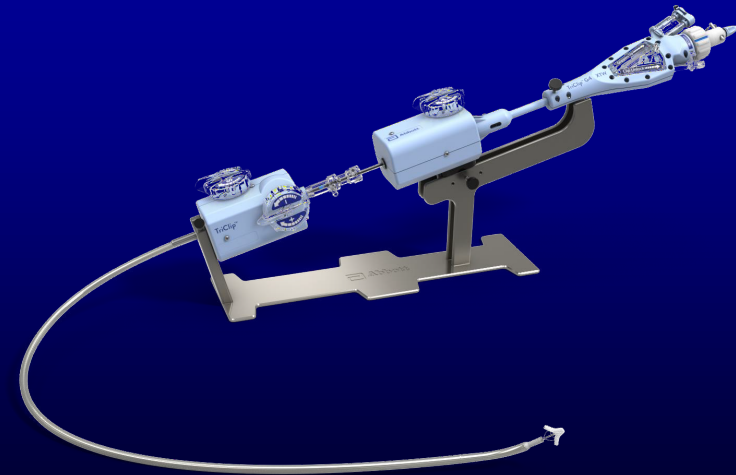
NEWS > Daily News

### FDA Approves TriClip TEER Device for Tricuspid Repair

(UPDATED) The approval was based on positive data from the TRILUMINATE pivotal trial, which included a highly symptomatic population.

by [L.A. McKeown](#) | APRIL 02, 2024

**Apr 2024**

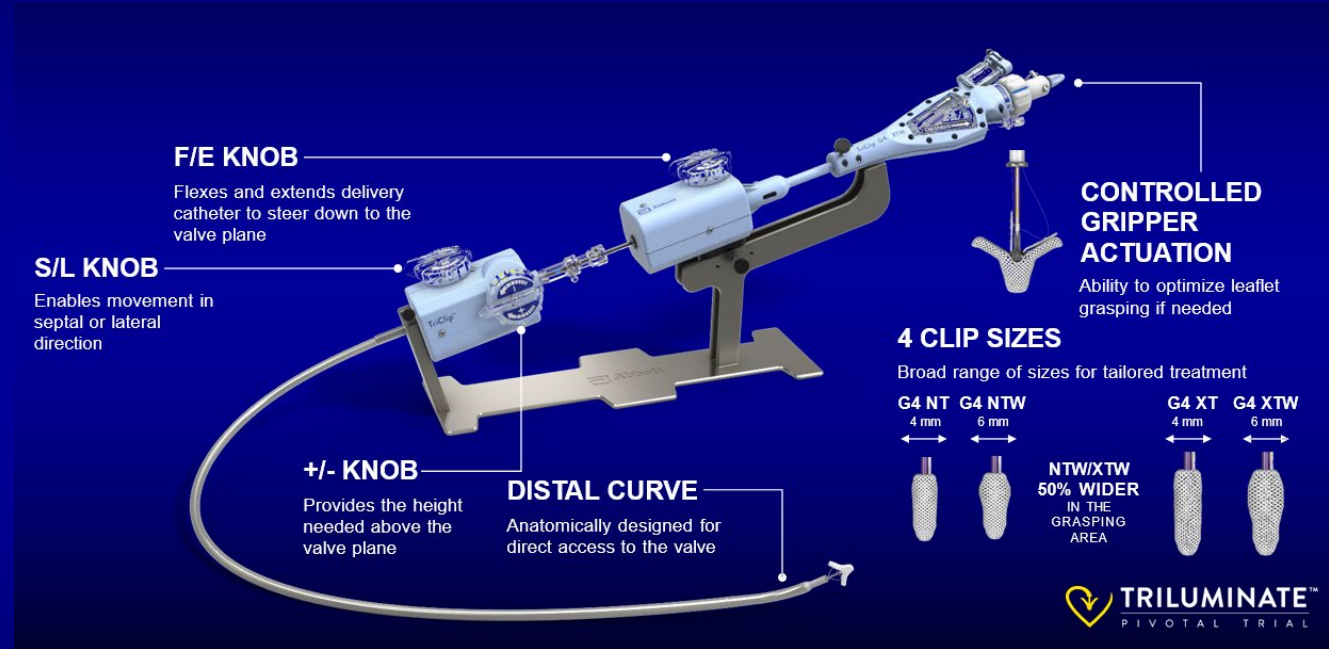


# TRILUMINATE Pivotal trial

ORIGINAL ARTICLE

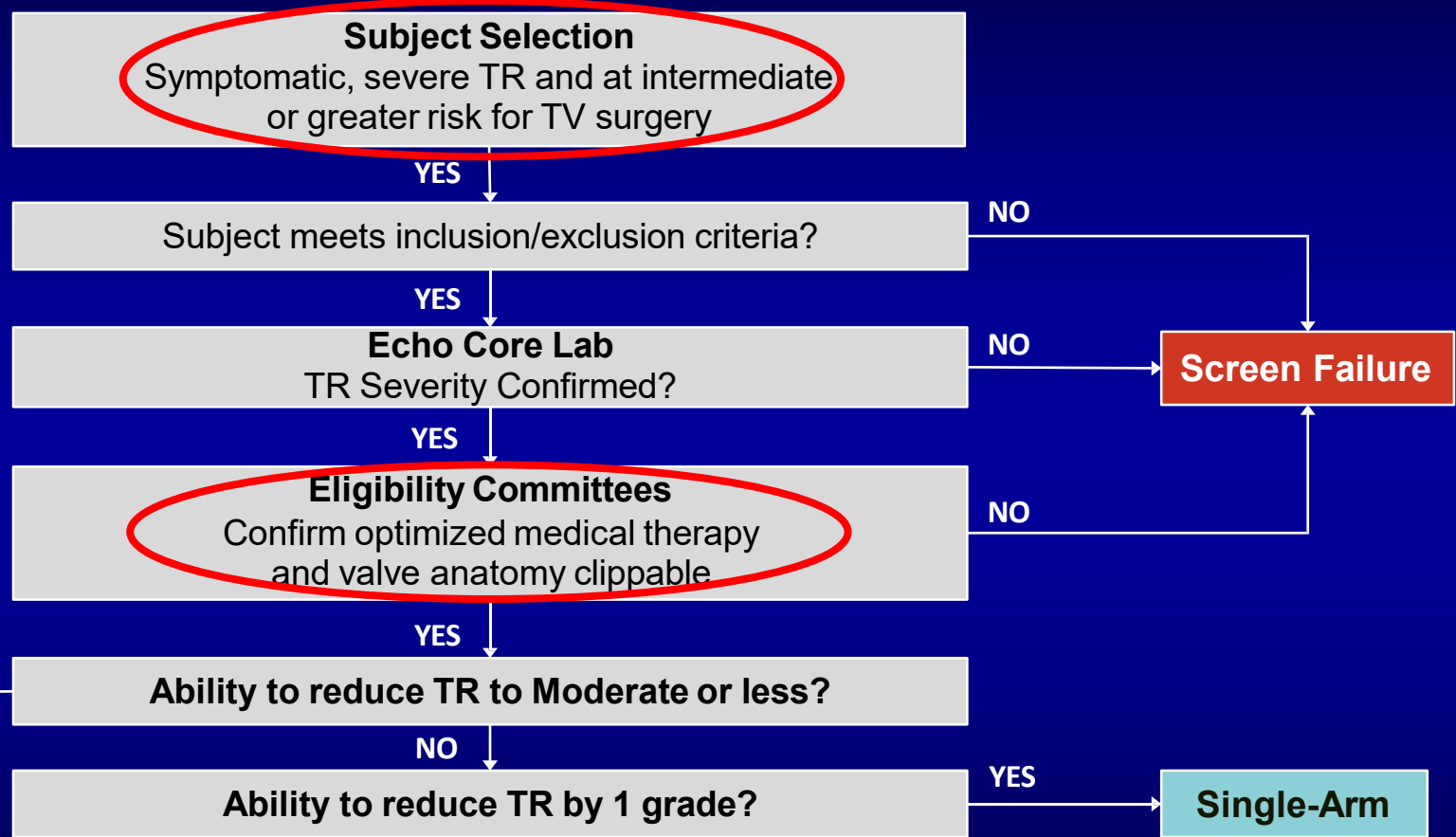
## Transcatheter Repair for Patients with Tricuspid Regurgitation

Paul Sorajja, M.D., Brian Whisenant, M.D., Nadira Hamid, M.D., Hursh Naik, M.D., Raj Makkar, M.D., Peter Tadros, M.D., Matthew J. Price, M.D., Gagan Singh, M.D., Neil Fam, M.D., Saibal Kar, M.D., Jonathan G. Schwartz, M.D., Shamir Mehta, M.D., Richard Bae, M.D., Nishant Sekaran, M.D., Travis Warner, M.D., Moody Makar, M.D., George Zorn, M.D., Erin M. Spinner, Ph.D., Phillip M. Trusty, Ph.D., Raymond Benza, M.D., Ulrich Jorde, M.D., Patrick McCarthy, M.D., Vinod Thourani, M.D., Gilbert H.L. Tang, M.D., Rebecca T. Hahn, M.D., and David H. Adams, M.D., for the TRILUMINATE Pivotal Investigators\*

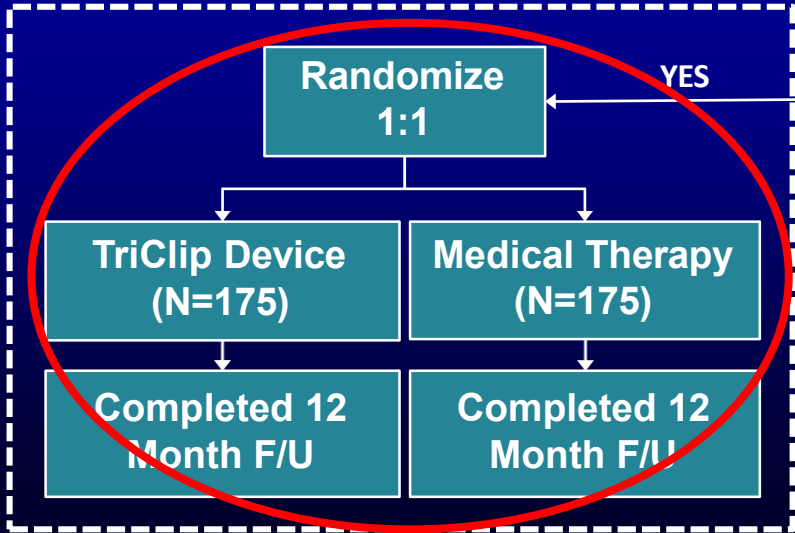


# Enrollment and Treatment Pathway

Primary endpoint:  
A composite of mortality, TV surgery,  
HFH, and KCCQ improvement  $\geq 15$



350 patients



12 M follow up

# Key Inclusion & Exclusion Criteria

## Inclusion:

- Symptomatic severe TR on TTE
- On optimal GDMT and stable for at least 30 days (e.g. SBP <140)
  - On GDMT for Afib, MR, CAD, HF if present
- Intermediate or greater surgical risk deemed by Heart Team

## Exclusion:

- Systolic PAP >70 mmHg or fixed pulmonary Htn by RHC
- LVEF ≤ 20%
- Leaflet gap >1 cm

If MV intervention needed, need to wait at least 60 days after procedure

If cardiac procedure performed, need to wait at least 30 days

## TRILUMINATE PIVOTAL TRIAL


# Baseline Characteristics

	Device N=175 # (%)	Control N=175 # (%)
Age, Mean (years)	78.0±7.4	77.8±7.2
Sex (Female)	98 (56.0)	94 (53.7)
NYHA class III or IV	104 (59.4)	97 (55.4)
KCCQ-OS Score, Mean	56.0 ± 23.4	54.1 ± 24.2
Hypertension	142 (81.1)	141 (80.6)
Renal disease	62 (35.4)	62 (35.4)
Liver disease	11 (6.3)	16 (9.1)
Atrial fibrillation	153 (87.4)	162 (92.6)
Diabetes	28 (16.0)	27 (15.4)
Chronic obstructive pulmonary disease	19 (10.9)	24 (13.7)
CRT, CRT-D, ICD, or permanent pacemaker — no. (%)	28 (16.0)	24 (13.7)
Prior aortic intervention	27 (15.4)	27 (15.4)
Prior mitral intervention	45 (25.7)	42 (24.0)
Prior tricuspid intervention	1 (0.6)	0 (0.0)

	Device N=175 # (%)	Control N=175 # (%)
<b>TR Severity</b>		
Moderate	4 (2.3)	2 (1.2)
Severe	44 (25.4)	49 (29.7)
Massive	37 (21.4)	30 (18.2)
Torrential	88 (50.9)	84 (50.9)
Etiology (functional)	165 (94.8)	158 (92.9)
Coaptation gap, Mean (mm)	5.5 ± 1.8	5.2 ± 1.7
<b>Heart size /function, Mean</b>		
RVEDD (base, mm)	5.0 ± 0.8	5.2 ± 0.8
TV annulus diameter (cm)	4.3 ± 0.7	4.5 ± 0.8
RV TAPSE (cm)	1.7 ± 0.4	1.6 ± 0.4
LVEF (%)	59.3 ± 9.3	58.7 ± 10.65
CO (L/min)	4.1 ± 1.2	4.2 ± 1.1

 **71%**

OF PATIENTS HAD  
MASSIVE OR  
TORRENTIAL TR

 **4.4±0.7cm**

TRICUSPID VALVE  
ANNULUS DIAMETER

 **>35%**

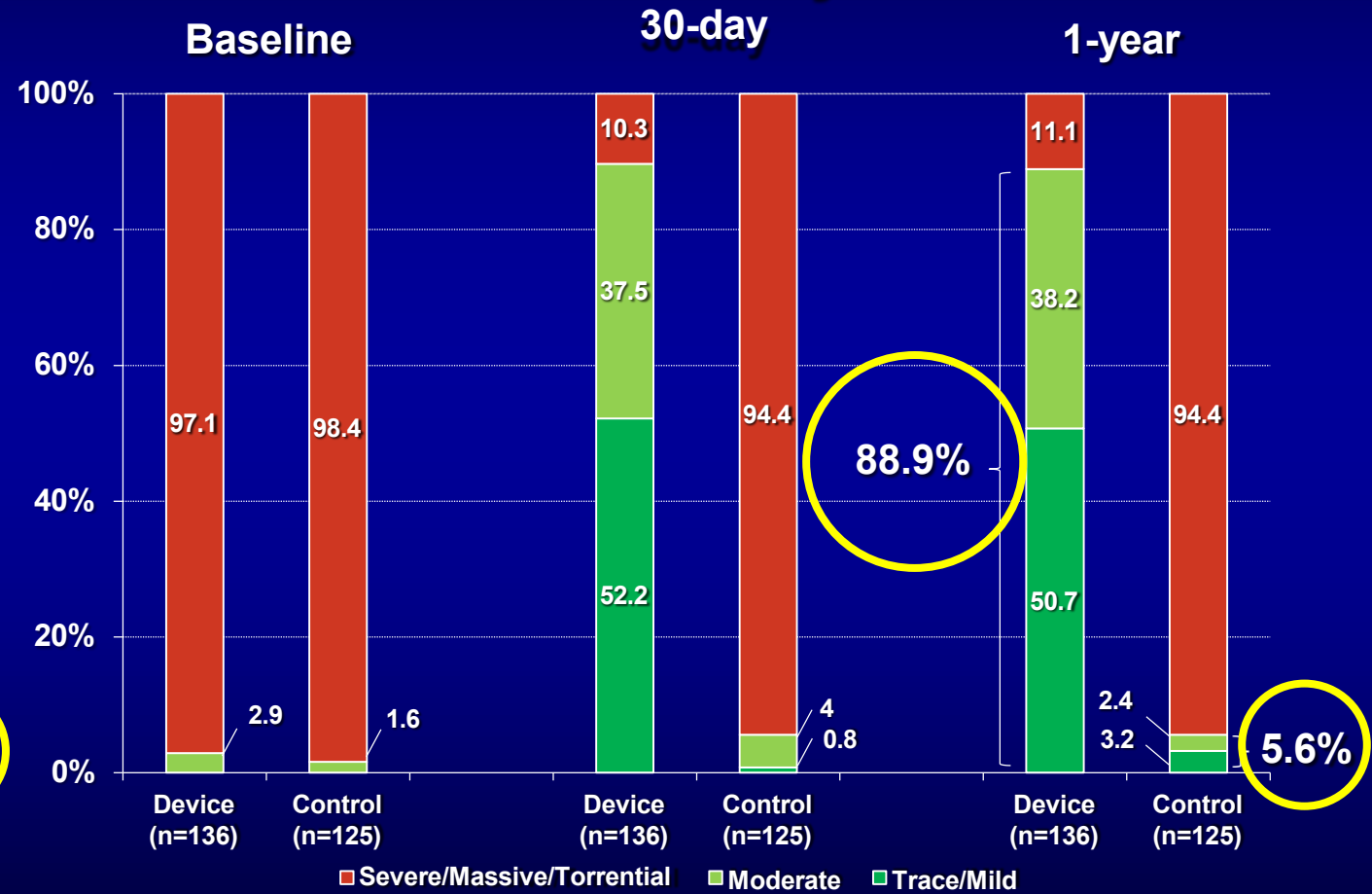
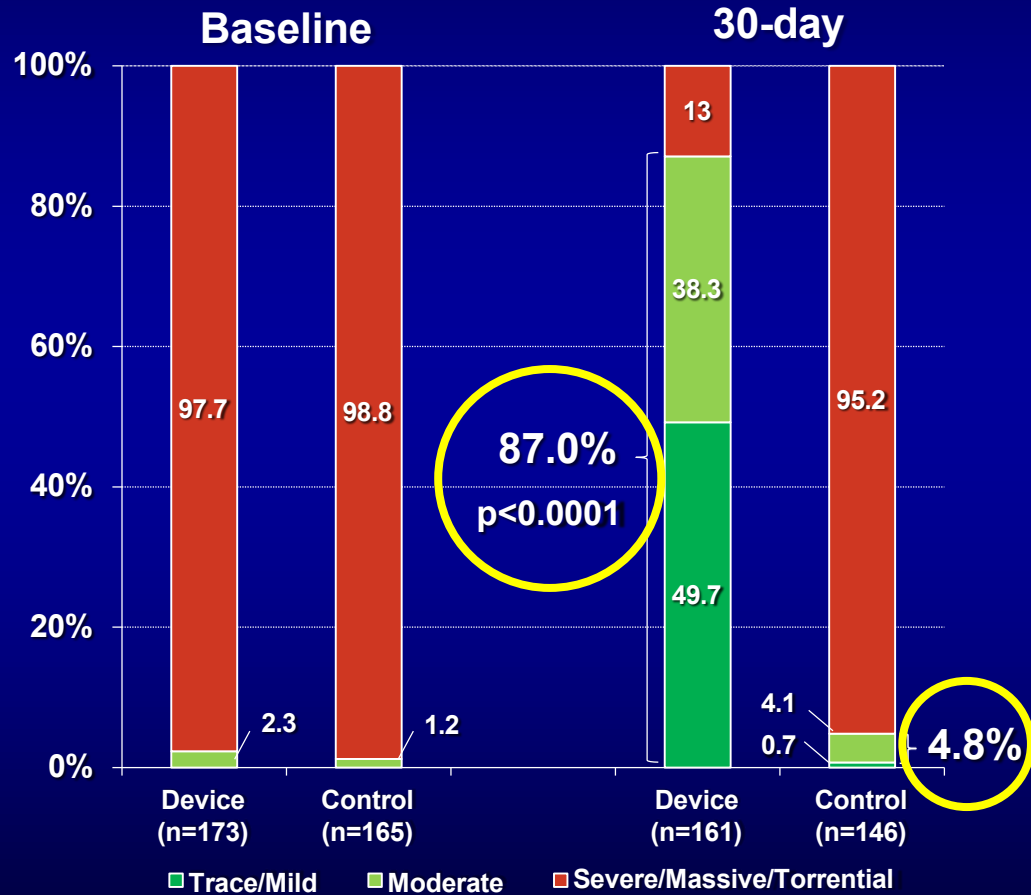
OF PATIENTS WITH  
PRIOR VALVULAR  
INTERVENTION

 **15%**

OF PATIENTS HAD A  
CRT, CRT-D, ICD, OR  
PERMANENT PACEMAKER

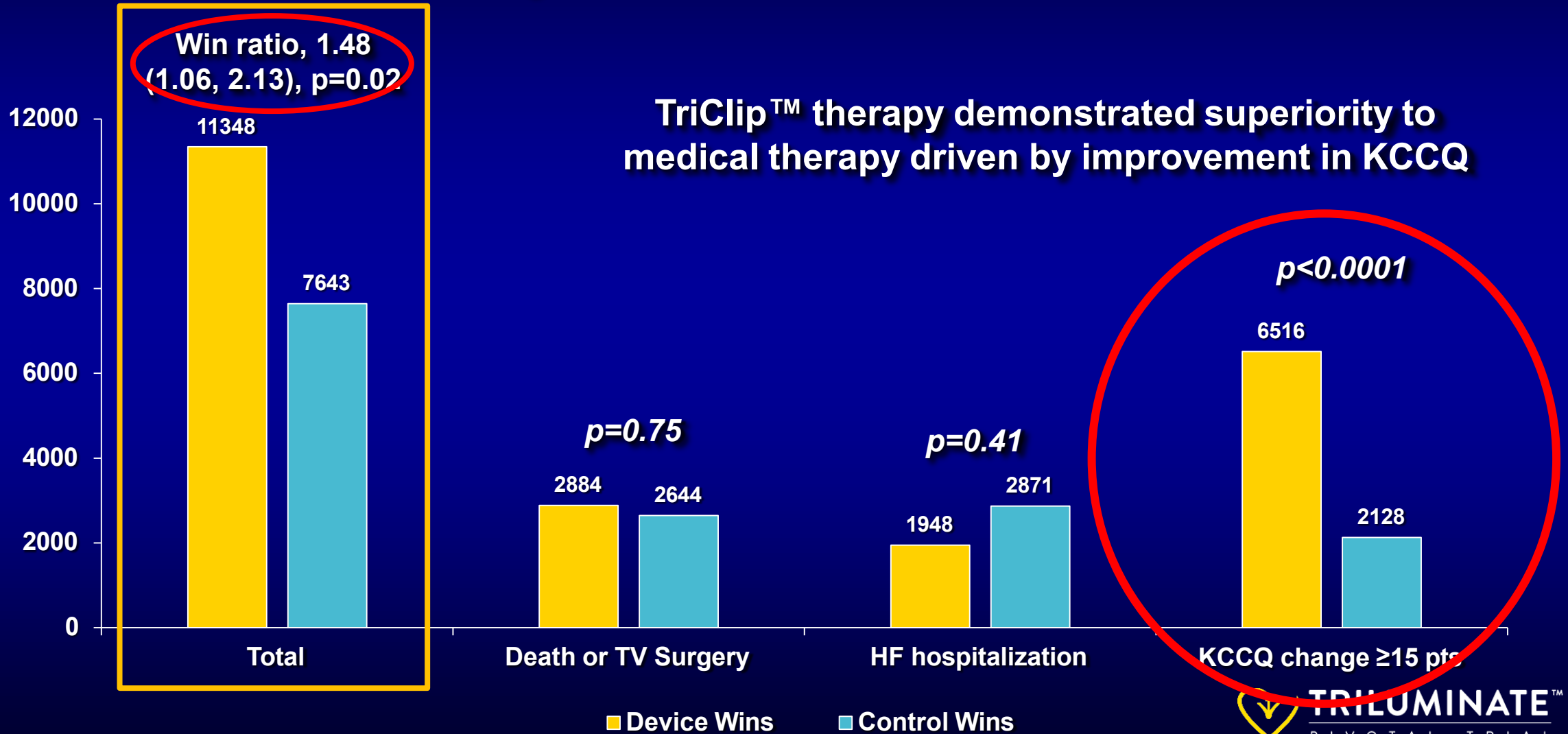
# Reduction in TR Severity

## Paired Analyses

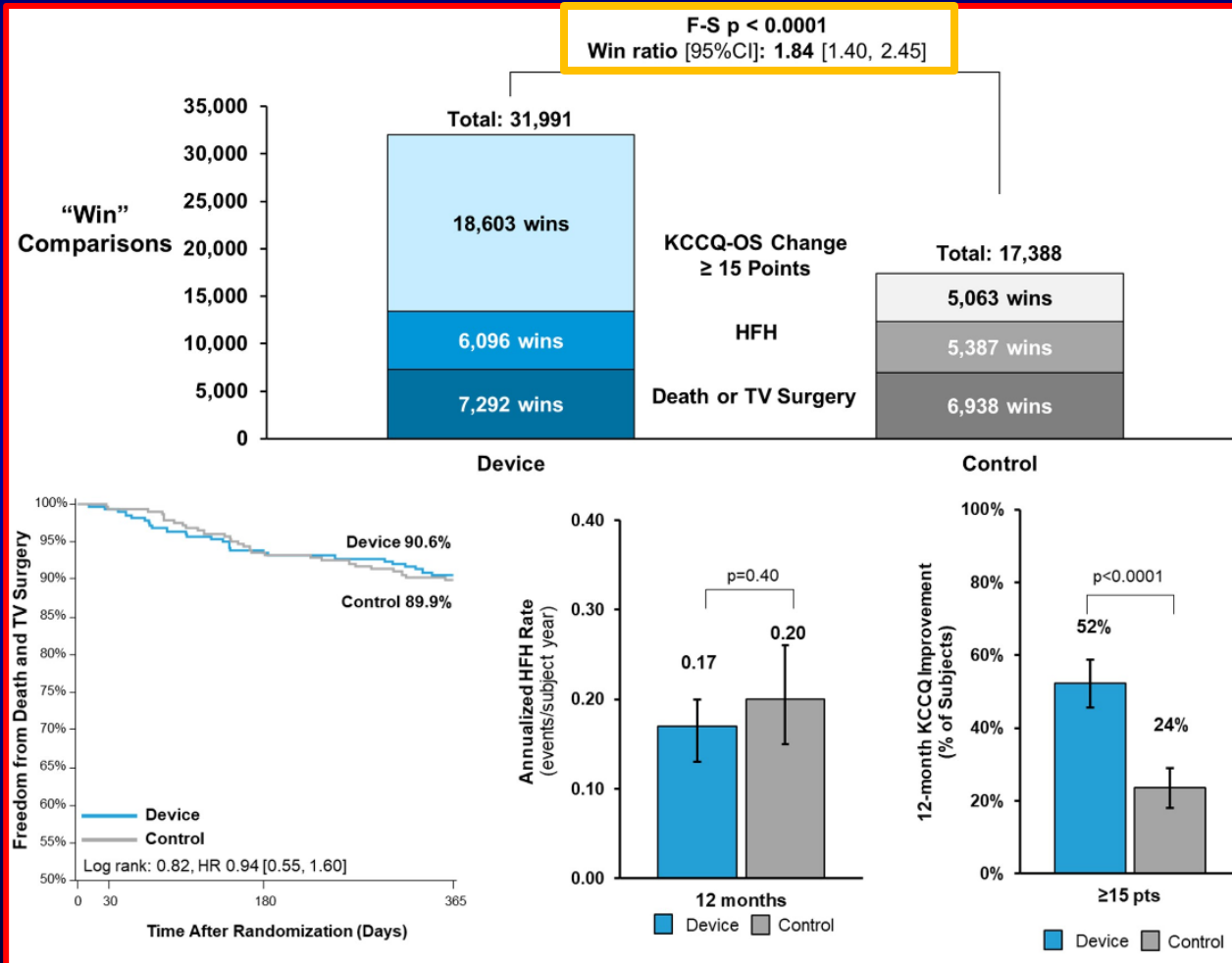


# Primary Endpoint

## Finkelstein-Schoenfeld Analysis



# TRILUMINATE Pivotal (full randomized cohort)



- 572 patients with symptomatic, severe TR
- T-TEER vs medical therapy
- **Primary endpoint met for T-TEER**
- All-cause mortality, TV surgery, HFH →
- Less TR at 30 days
- **Improvement on KCCQ change** at 1 year, 6-min walk distance change
- Freedom from major adverse events was 98.9% for T-TEER

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OCTOBER 27–30, 2024  
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WASHINGTON, DC

#TCT2024

# TRILUMINATE 2 Year Outcomes

**ACC.25**

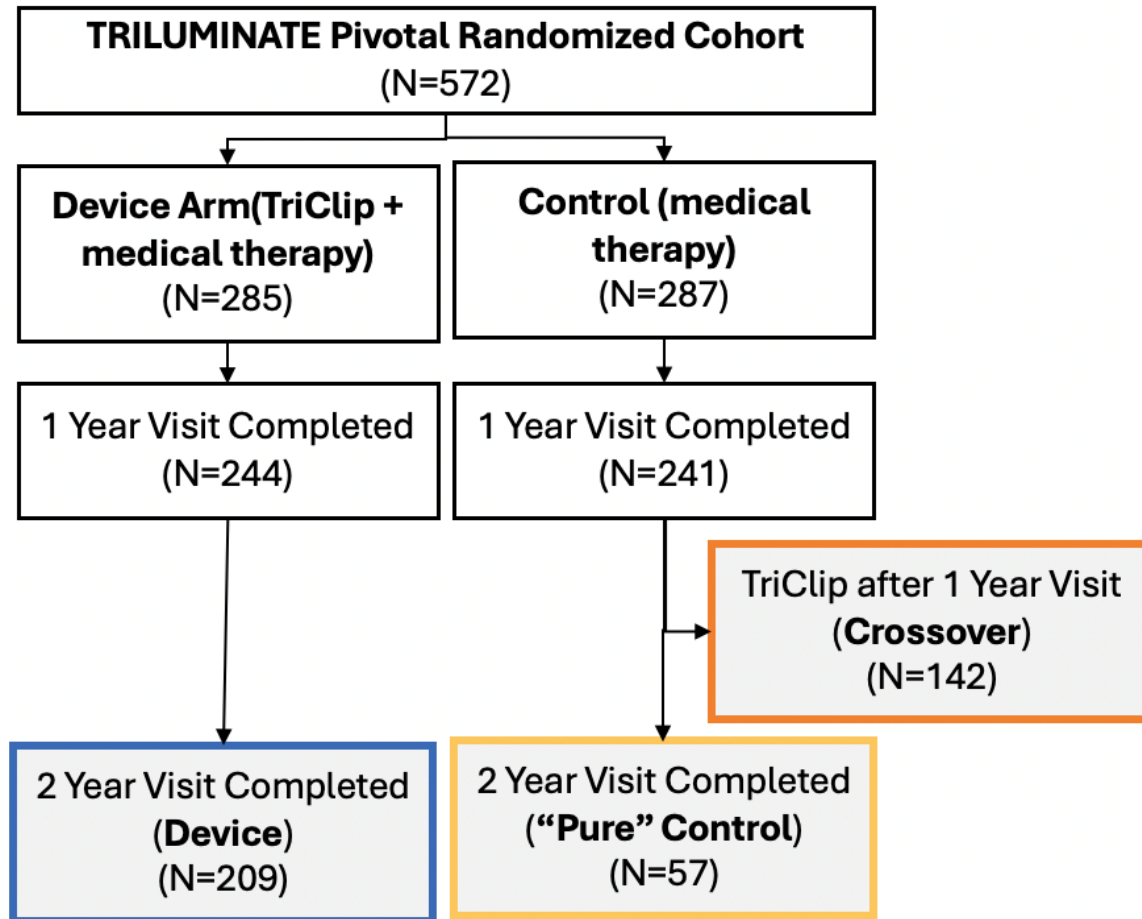


**Two-year Outcomes Of  
Transcatheter Tricuspid Valve  
Edge-to-Edge Repair For  
Tricuspid Regurgitation:  
The TRILUMINATE Pivotal Trial**



**Saibal Kar, MD, on behalf of the  
TRILUMINATE Pivotal Trial investigators**

# TRILUMINATE 2 Year Outcomes



## Prespecified 2-year Endpoints (ITT)

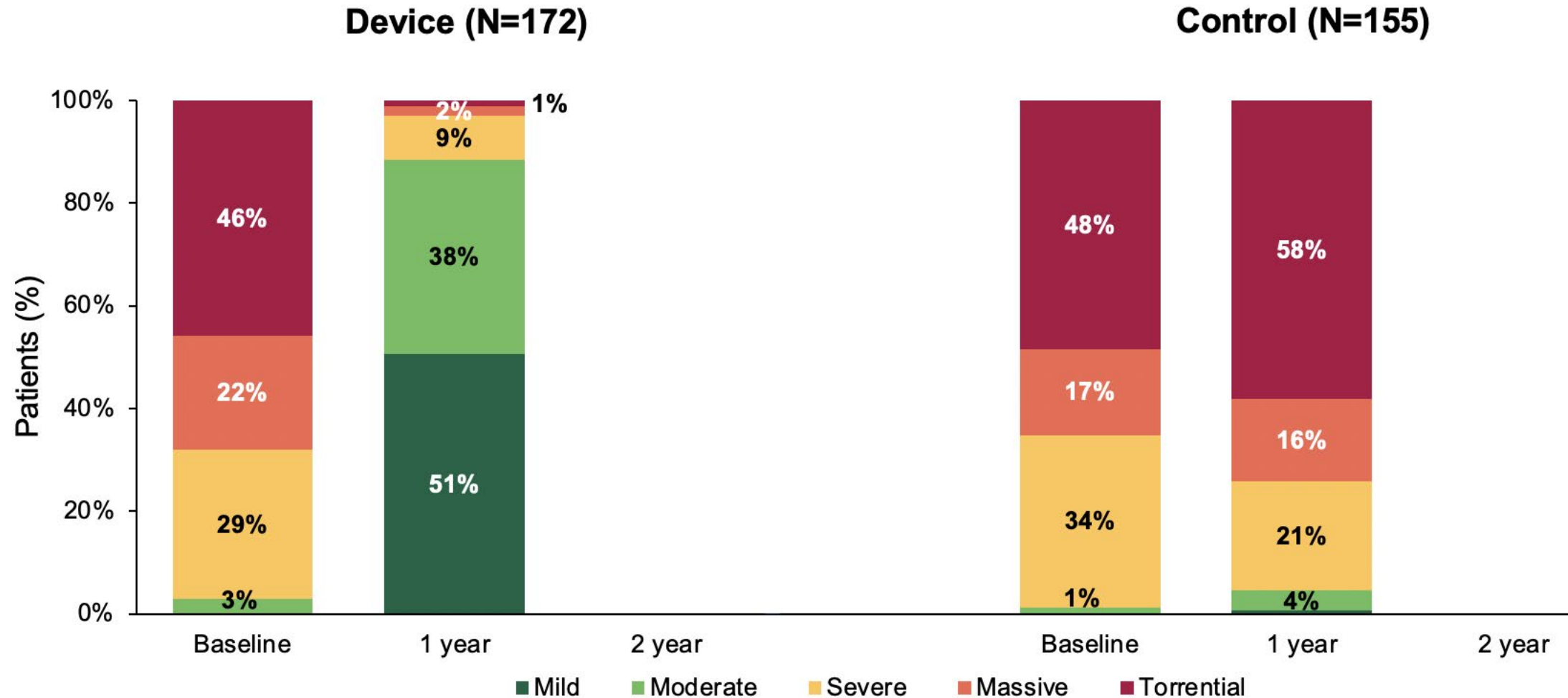
1. Recurrent Heart Failure Hospitalizations (HFH) at 24 months
2. Freedom from all-cause mortality, tricuspid valve surgery, and tricuspid valve intervention at 24 months

## Additional 2-year Outcomes

Adverse events, tricuspid regurgitation grade, health status

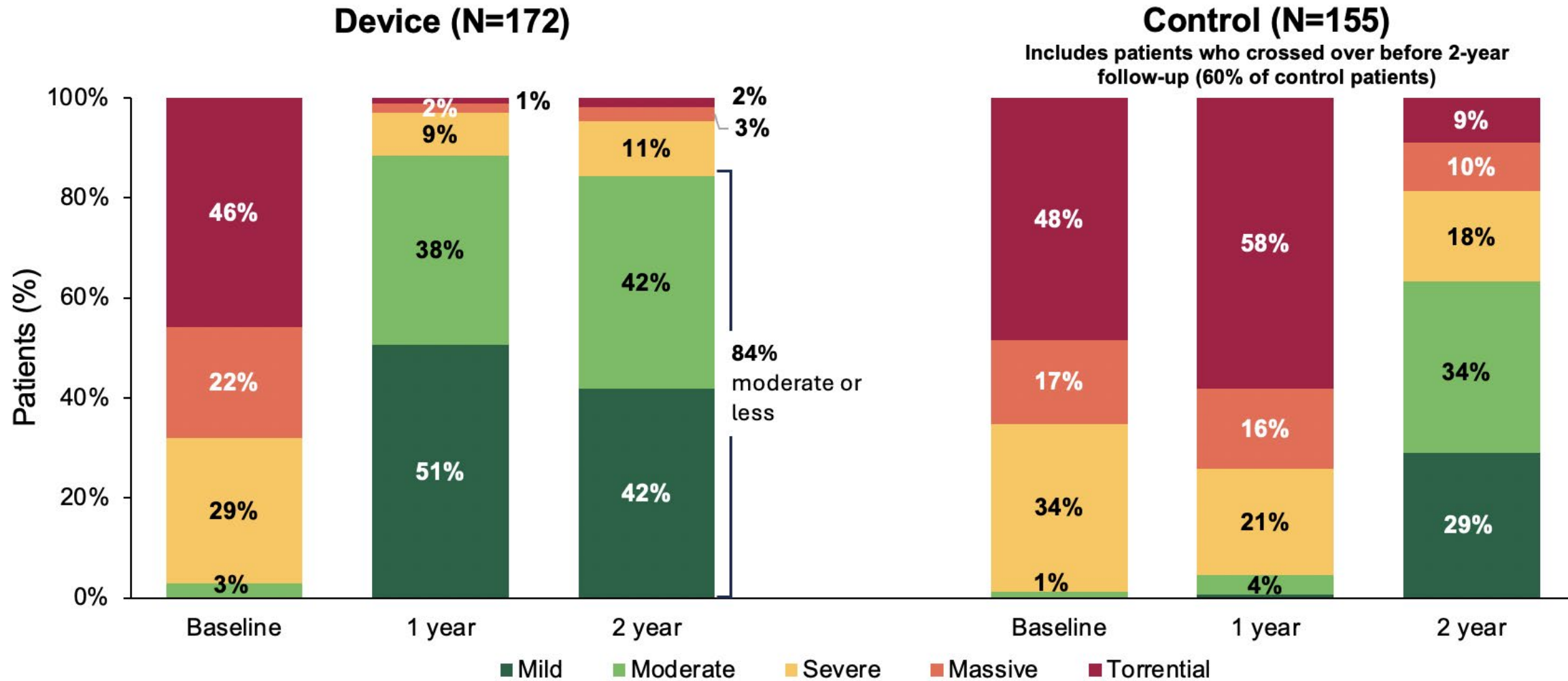
INTENTION-TO-TREAT

# Tricuspid Regurgitation Severity (Paired)

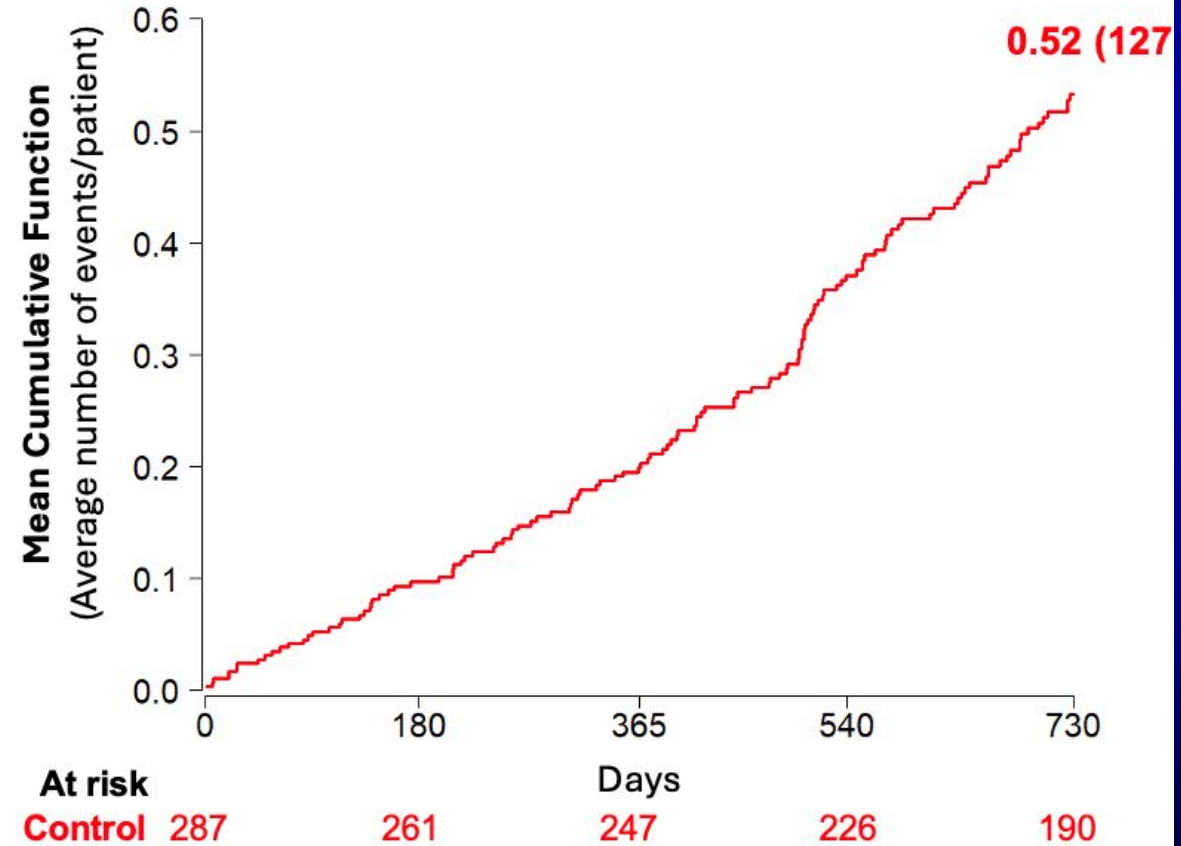
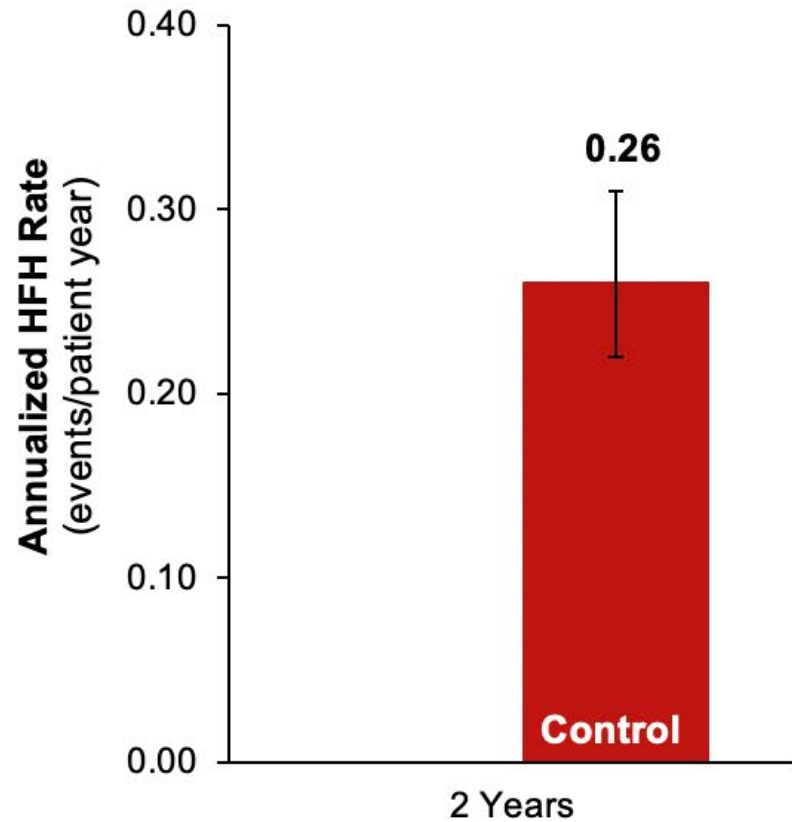


Paired data shown. Patients with tricuspid valve surgery are excluded.

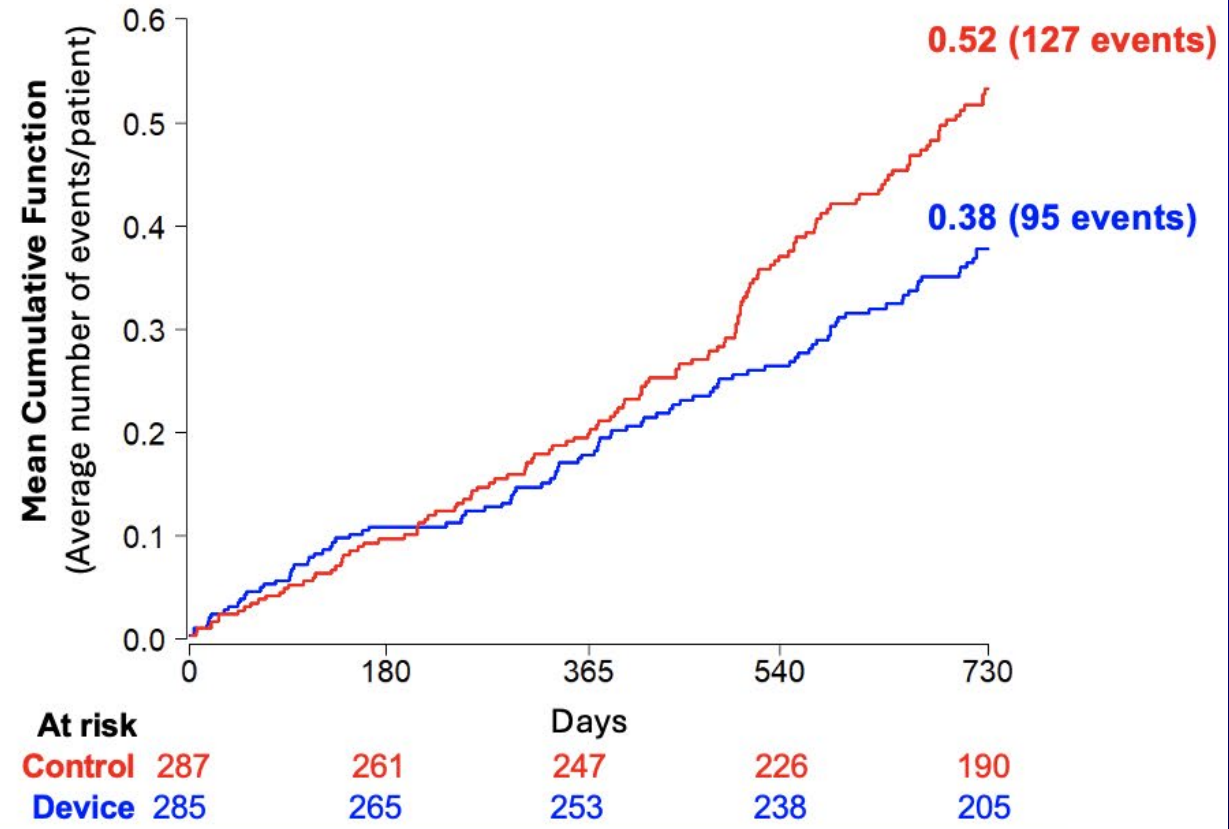
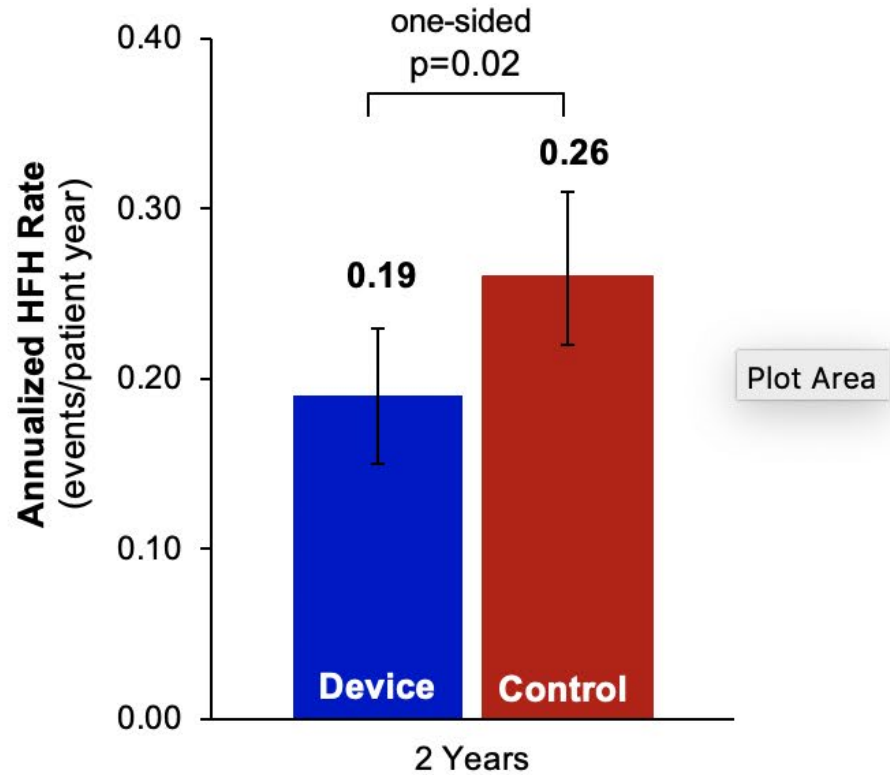
# Tricuspid Regurgitation Severity (Paired)



# Prespecified Endpoint: Heart Failure Hospitalizations

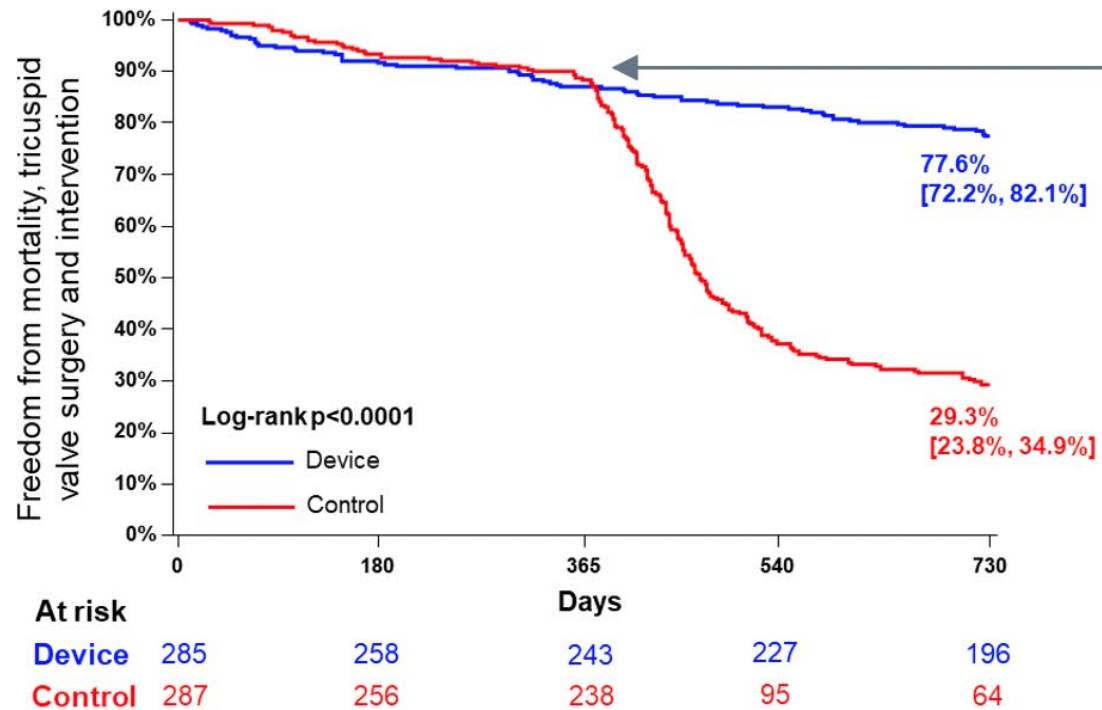


# Prespecified Endpoint: Heart Failure Hospitalizations



**28% relative risk reduction in HFH with TriClip device treatment, HR 0.72 (two-sided 95%CI [0.53, 0.98])**

# Prespecified Endpoint: Freedom from all cause mortality, TV surgery and TV intervention



Difference driven by transcatheter intervention in Control group (crossover procedure) after 1 year. Rates of all-cause mortality and tricuspid valve (TV) surgery not statistically different between groups.

Component	Device N=285	Control N=287	p-value
<b>Composite</b>	<b>22.4% (62)</b>	<b>70.7% (185)</b>	<b>&lt;0.0001</b>
All-cause mortality	17.9% (49)	17.1% (45)	
Tricuspid valve surgery	2.3% (6)	4.3% (11)	
Transcatheter intervention	3.8% (10)	61.5% (142)	

# TRILUMINATE 2 Year Outcomes

INTENTION-TO-TREAT

## Both 2-year Prespecified Endpoints Met



Reduction in annualized HFH at 24 months in Device group ( $p=0.02$ ).



Higher freedom from all-cause mortality, tricuspid valve surgery, and transcatheter intervention at 24 months in Device group, driven by transcatheter interventions in the Control group ( $p<0.0001$ ).

# TRILUMINATE 2 Year Outcomes

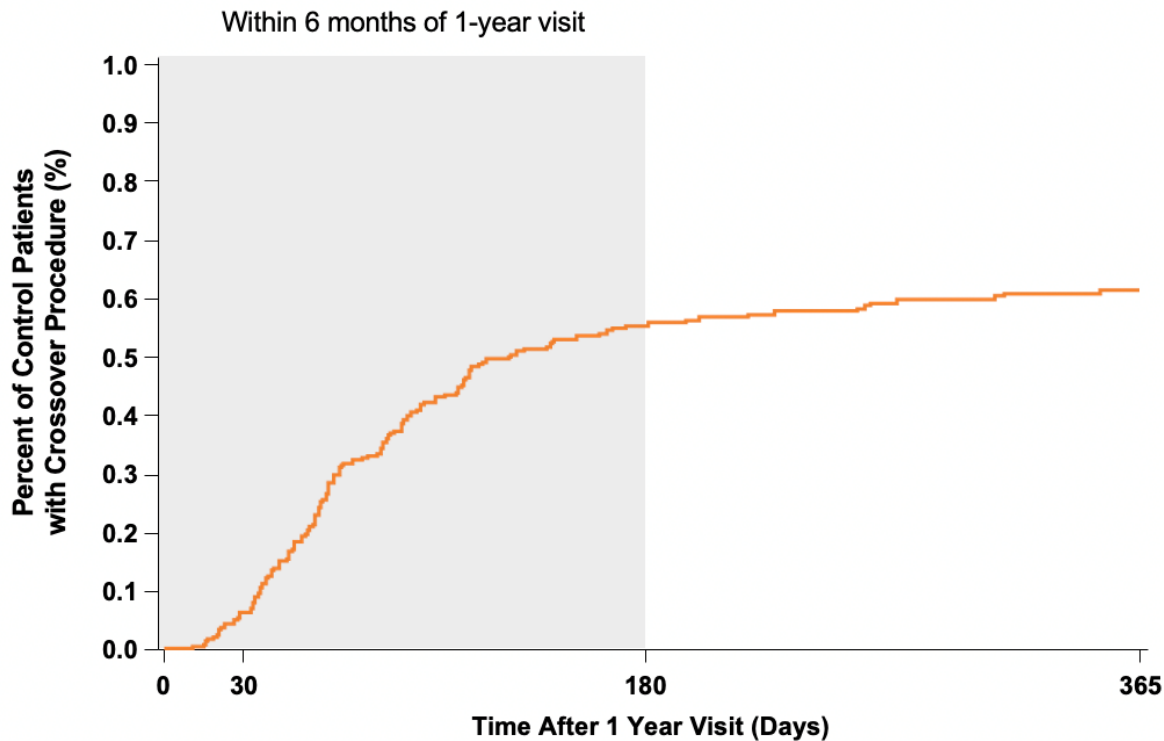
INTENTION-TO-TREAT

## Safety Through Two Years

	<b>Device</b>	<b>Control</b>
<b>Adverse Event through 2 Years</b>	<b>N=285</b>	<b>N=287</b>
Stroke	1.9%	2.5%
Transient ischemic attack	1.7%	1.0%
Cardiogenic shock	0.4%	1.3%
New conduction disturbance requiring permanent pacemaker	5.5%	4.2%
Device embolization	0%	0%
Device thrombosis	0%	0%

# Crossover Analysis

## Timing of Crossover Procedure



Of the 241 Control patients eligible for crossover after 1-year follow-up, **142 (59%) patients crossed over prior to 2-year follow-up**

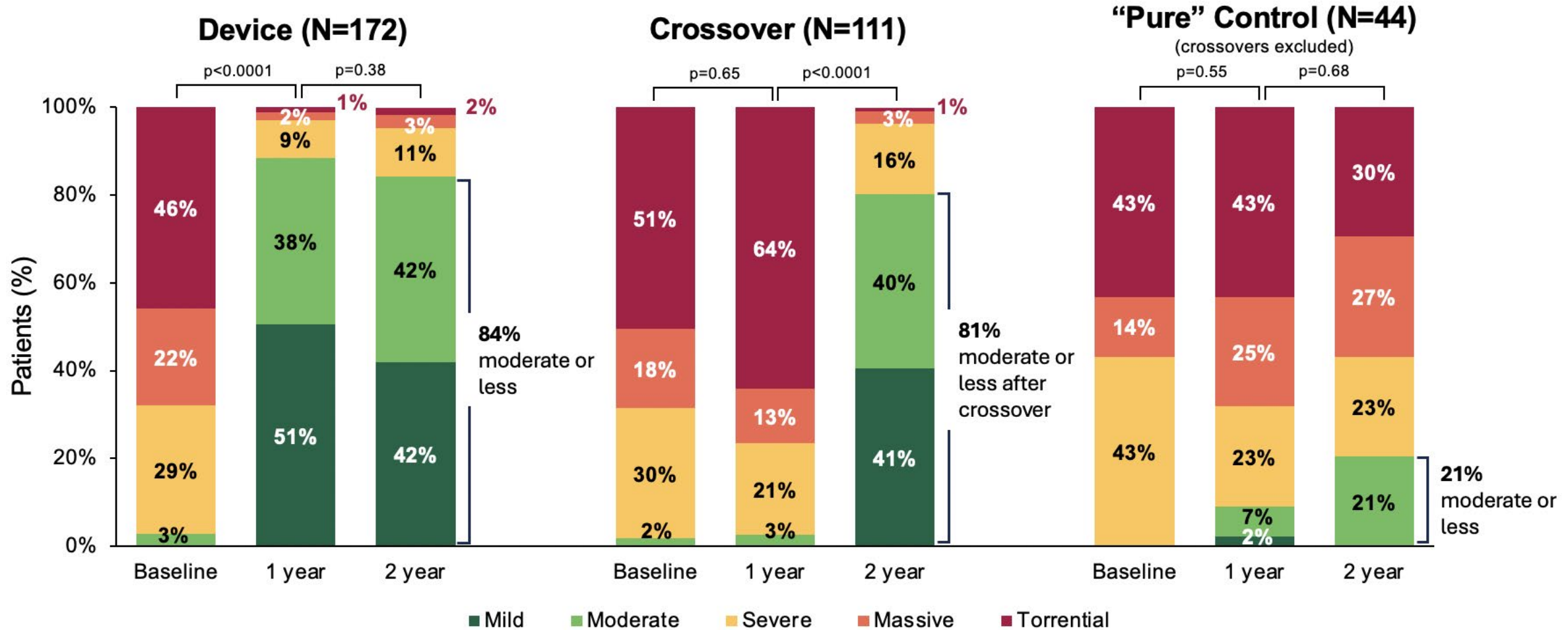
**92% (130/142) of crossover procedures occurred within 6 months of the 1-year visit**

# Characteristics Prior to Crossover

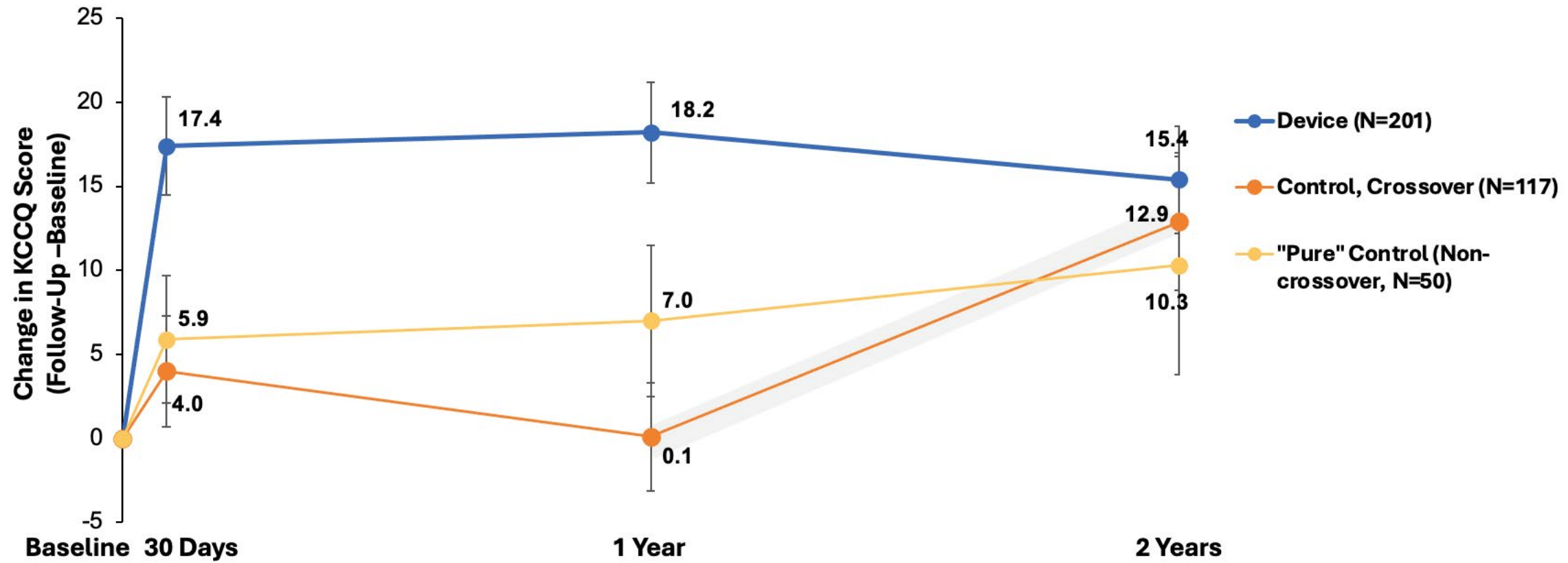
Variable at 1 Year (Prior to Crossover)	Patients who Crossed Over N=142	Patients who did not Crossover N=94
Torrential TR	65.2%	41.5%
NYHA III/IV	47.5%	30.4%
KCCQ Change (baseline to 1YR)	0 ± 18	7 ± 18
6MWD Change (baseline to 1YR)	-22 ± 103	-1 ± 90
HFH (events/patient-year)	0.17	0.07
Diuretic Dose Change (baseline to 1YR)	+22 mg	+5 mg

Patients who crossed over were **more symptomatic with a higher prevalence of torrential TR and more HFH prior to crossover.**

# Tricuspid Regurgitation Grade After Crossover



# KCCQ Score



*Control eligible for crossover after 1-year follow-up visit*

# TRILUMINATE 2 Year Outcomes

- At 2 years, **treatment with the TriClip device reduced HFH compared with medical therapy** (despite crossovers in the Control group).
- Improvements in TR severity and quality of life were sustained in Device patients through 2 years.
- TriClip therapy is safe through 2 years and upon crossover.
- Control patients, whose symptoms and health status had worsened prior to crossover, benefited from TriClip device with improvements in TR severity and quality of life.

# OUTLINE

- Burden of Severe TR
- Challenges with Managing TR
- Transcatheter Tricuspid Landscape
- ***Patient Screening and Selection***
- Case examples
- TTVR



Patient history and symptoms

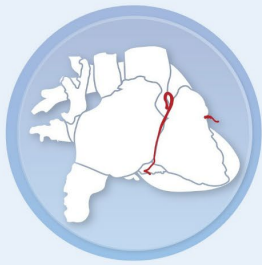


Confirmation of disease severity



TRI-SCORE<sup>a</sup>

Comorbidities  
Risk assessment



Anatomical suitability



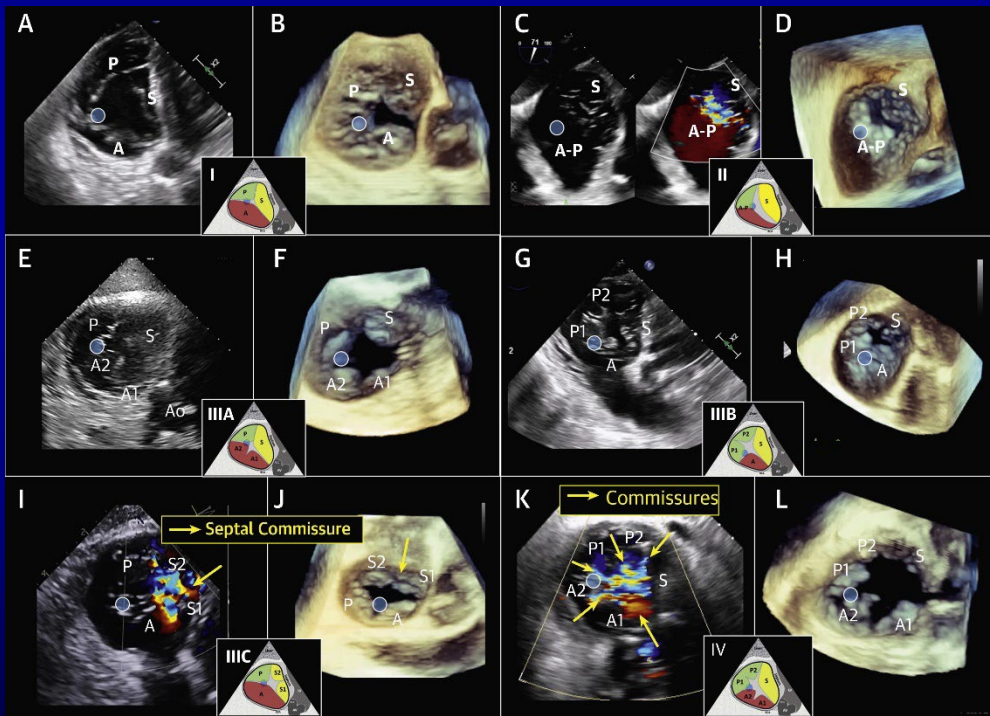
Heart Team treatment

(C)

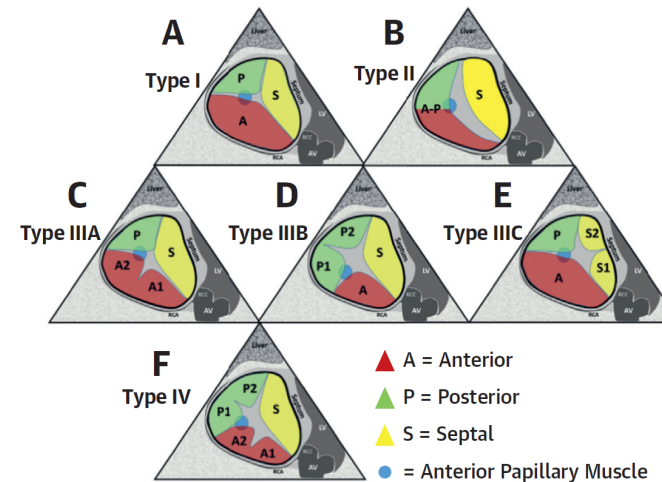
- Age  $\geq$  70 years
  - Female
  - NYHA functional class III or IV
  - Right-sided heart failure signs <sup>(1)</sup>
  - Prior left-sided heart valve intervention
  - Permanent pacemaker / defibrillator
  - Atrial fibrillation / flutter
  - Daily dose of furosemide  $\geq$  125 mg
  - Glomerular filtration rate  $<$  30 ml/min <sup>(2)</sup>
  - Elevated total bilirubin <sup>(3)</sup>
  - Left ventricular ejection fraction  $<$  60% <sup>(4)</sup>
  - Moderate/severe right ventricular dysfunction <sup>(5)</sup>
- Mechanism of tricuspid regurgitation

# Proposal for a Standard Echocardiographic Tricuspid Valve Nomenclature

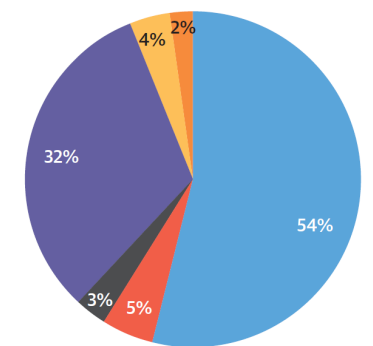
Rebecca T. Hahn, MD,<sup>a</sup> Ludwig T. Weckbach, MD,<sup>b</sup> Thilo Noack, MD, PhD,<sup>c</sup> Nadira Hamid, MD,<sup>b</sup> Mitsunobu Kitamura, MD,<sup>b</sup> Richard Bae, MD,<sup>d</sup> Philipp Lurz, MD, PhD,<sup>c</sup> Susheel K. Kodali, MD,<sup>a</sup> Jörg Hausleiter, MD,<sup>b</sup> Michael Nabauer, MD<sup>b</sup>



## CENTRAL ILLUSTRATION Tricuspid Valve Nomenclature Classification Scheme



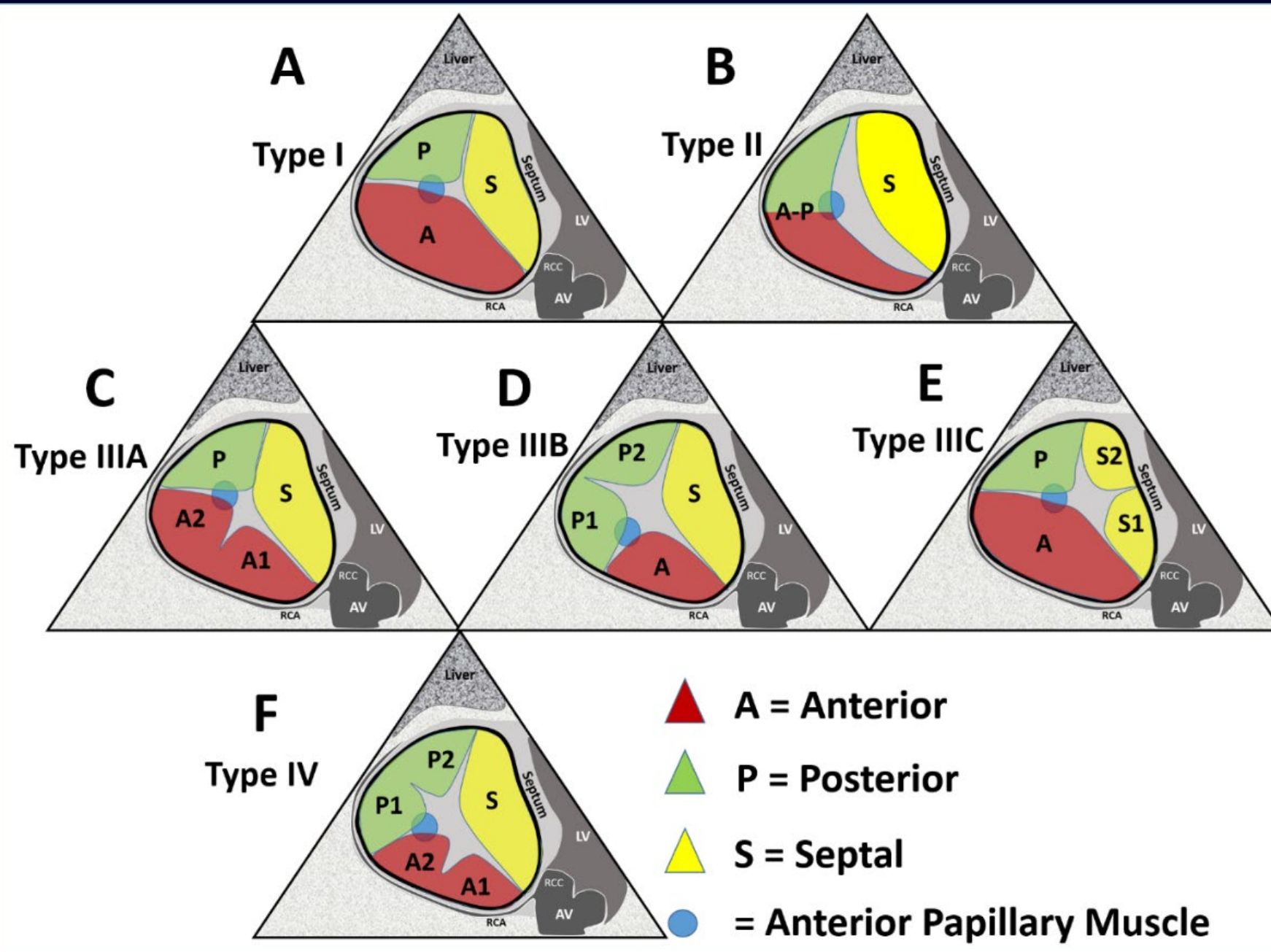
### Incidence of Tricuspid Morphologies



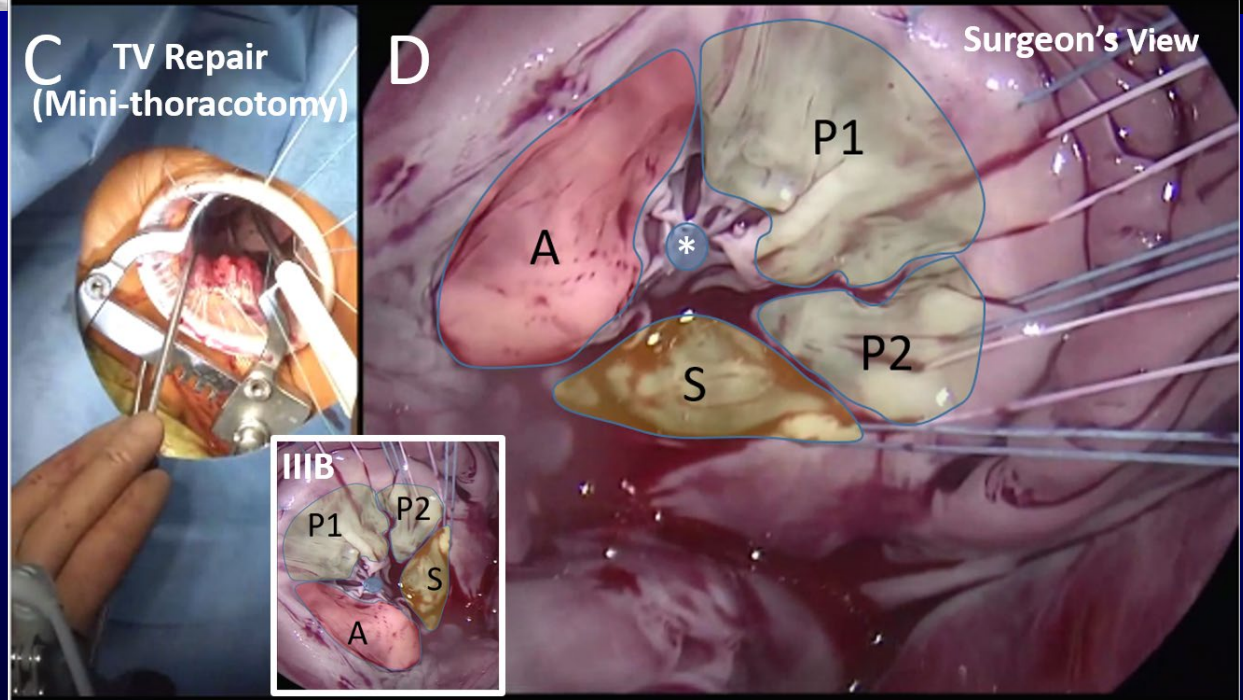
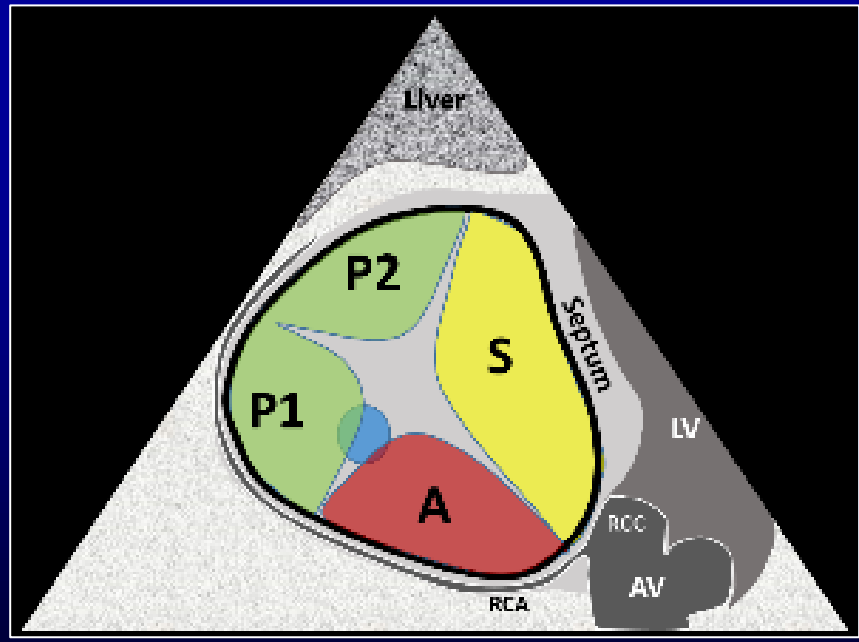
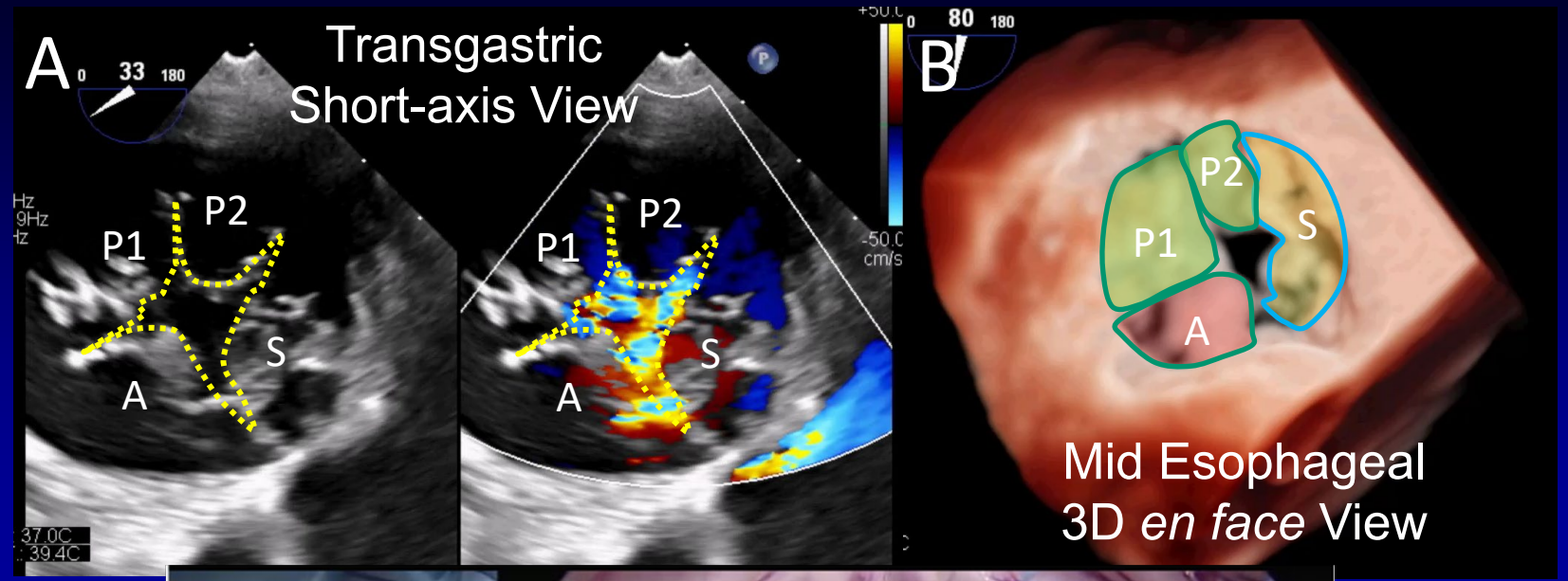
■ Type I ■ Type II ■ Type IIIA  
■ Type IIIB ■ Type IIIC ■ Type IV

Hahn, R.T. et al. J Am Coll Cardiol Img. 2021; ■(■):■-■.

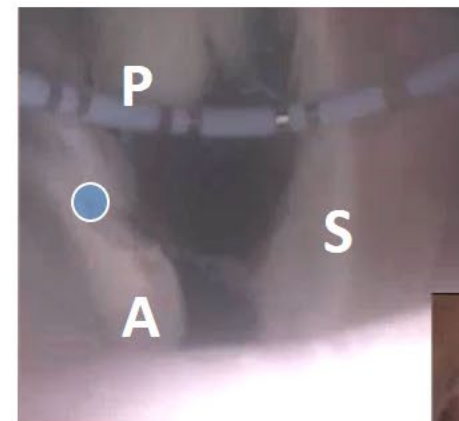
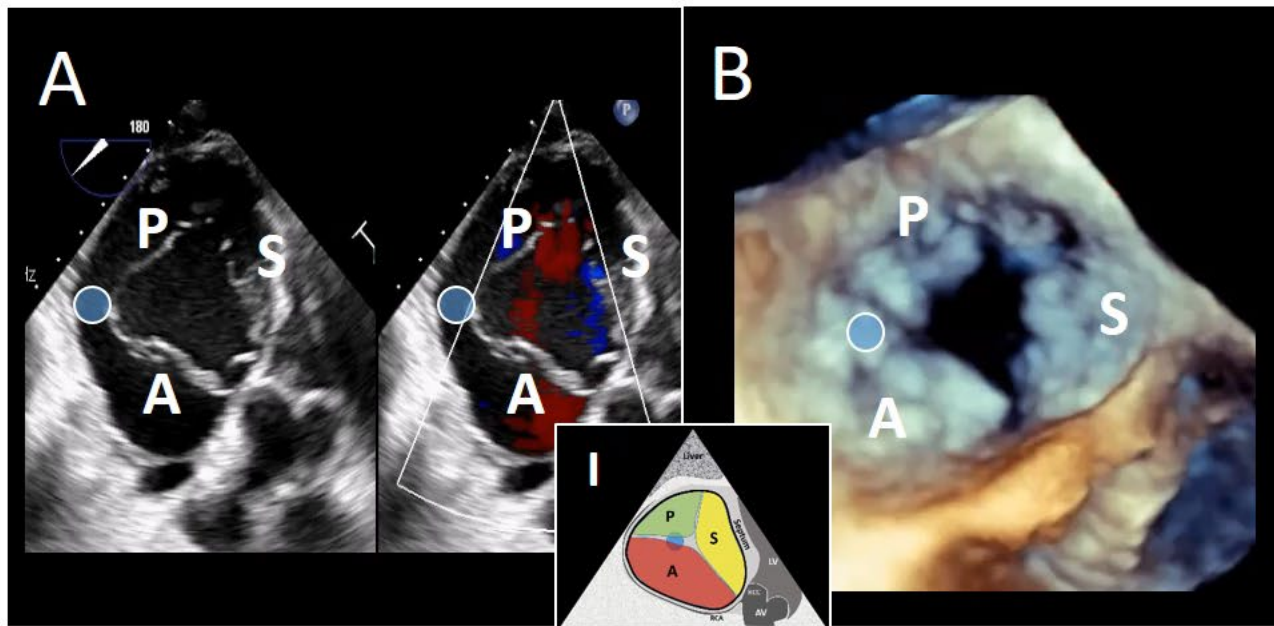
(Left) A proposed tricuspid valve nomenclature classification scheme is shown in the left panel. The anterior papillary muscle is indicated as a blue circle and defines the separation of the anterior from the posterior leaflets. (A) Type I: 3-leaflet configuration. (B) Type II: 2-leaflet configuration. (C to E) Type III: 4-leaflet configurations. (F) Type IV: 5-leaflet configuration. (Right) Incidence of each morphology in the present study of 579 patients. A = anterior leaflet; AV = aortic valve; LV = left ventricle; NCC = noncoronary cusp; P = posterior leaflet; RCC = right coronary cusp; S = septal leaflet.



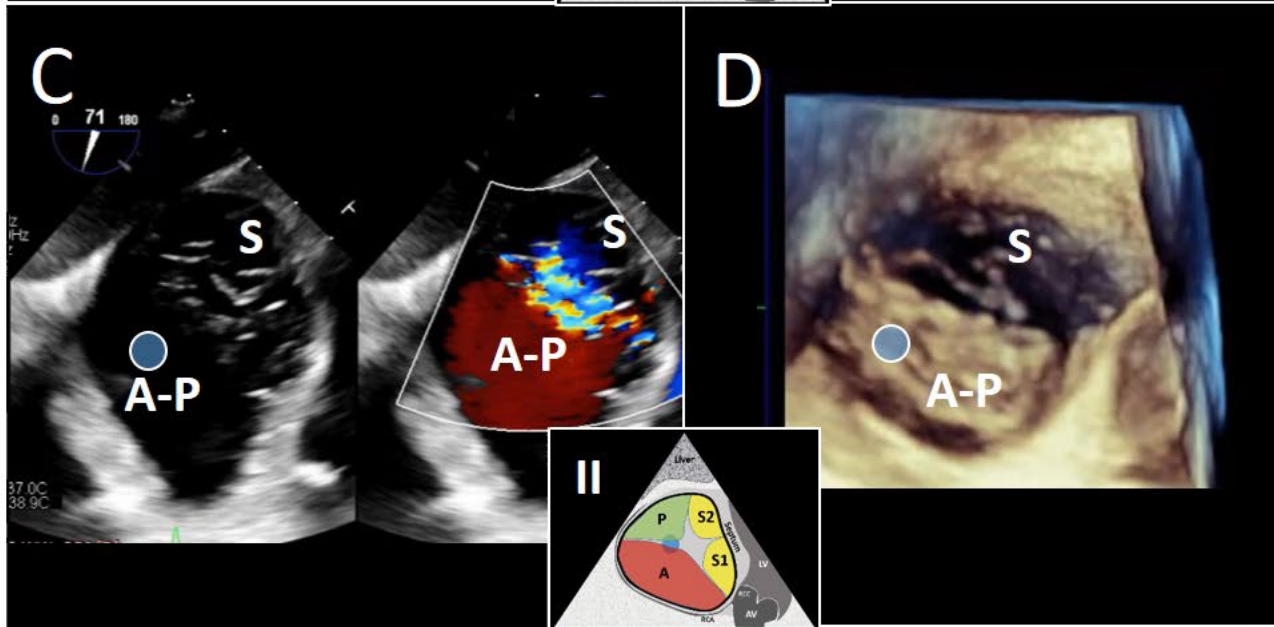
# Example from Leipsic: Type IIIB



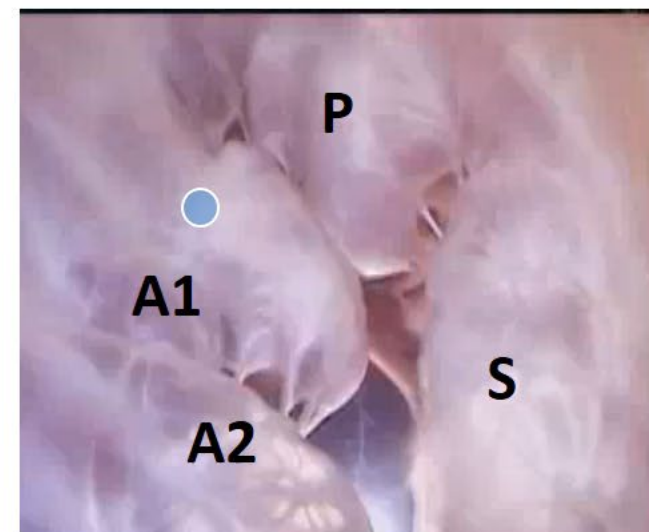
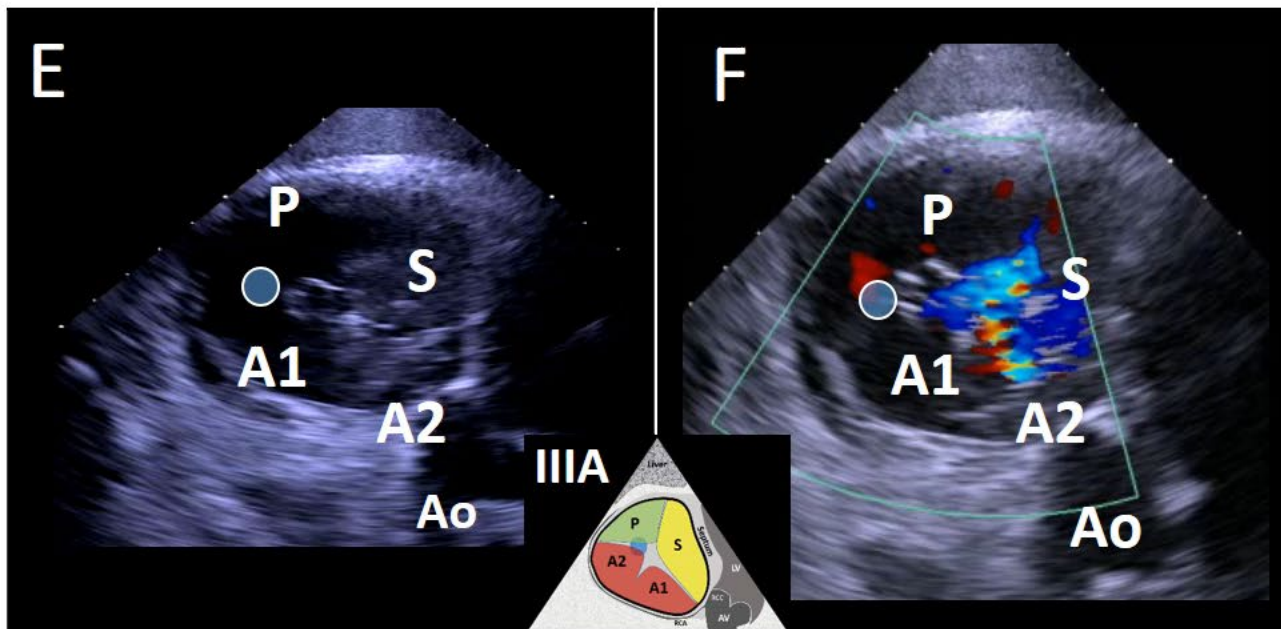
# Type I



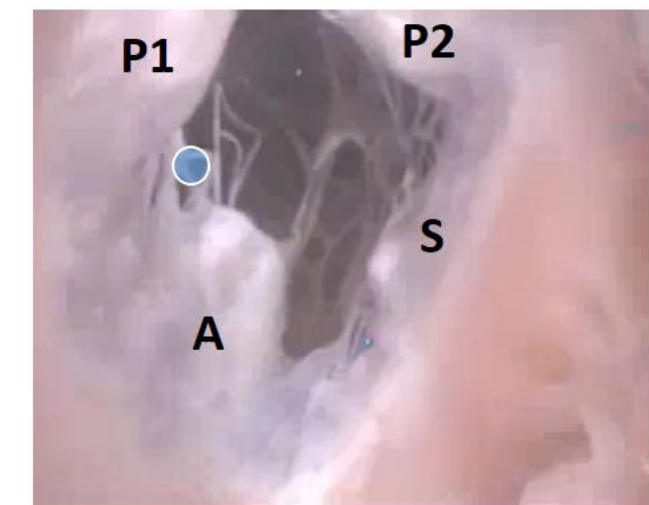
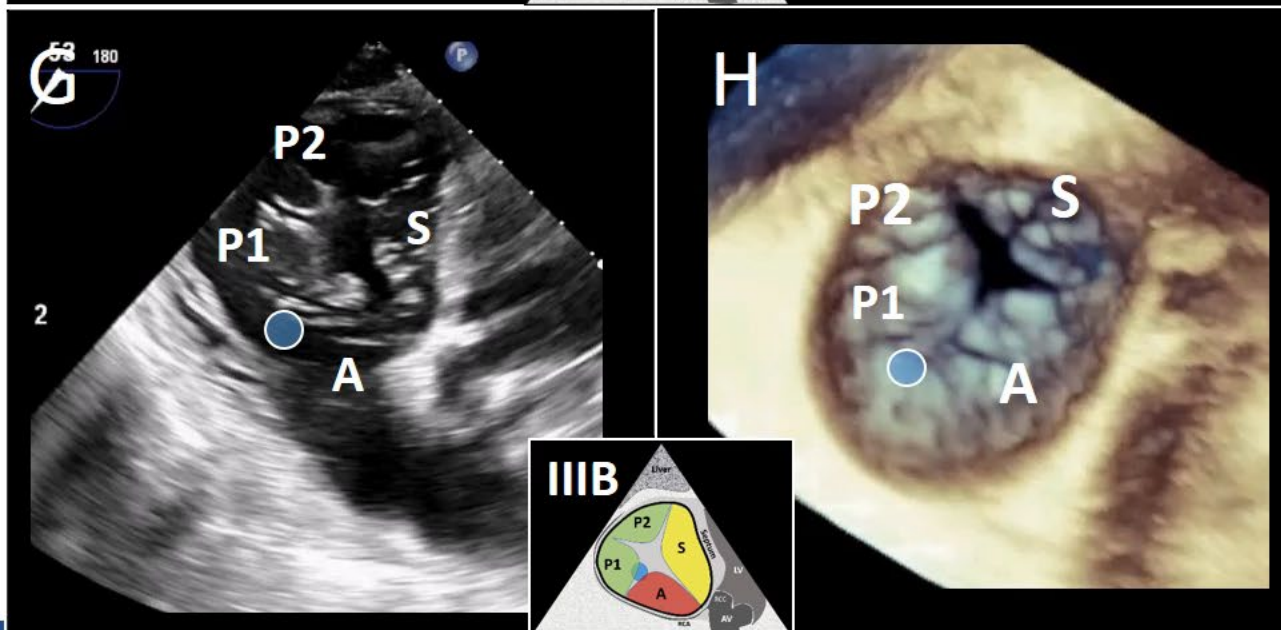
# Type II



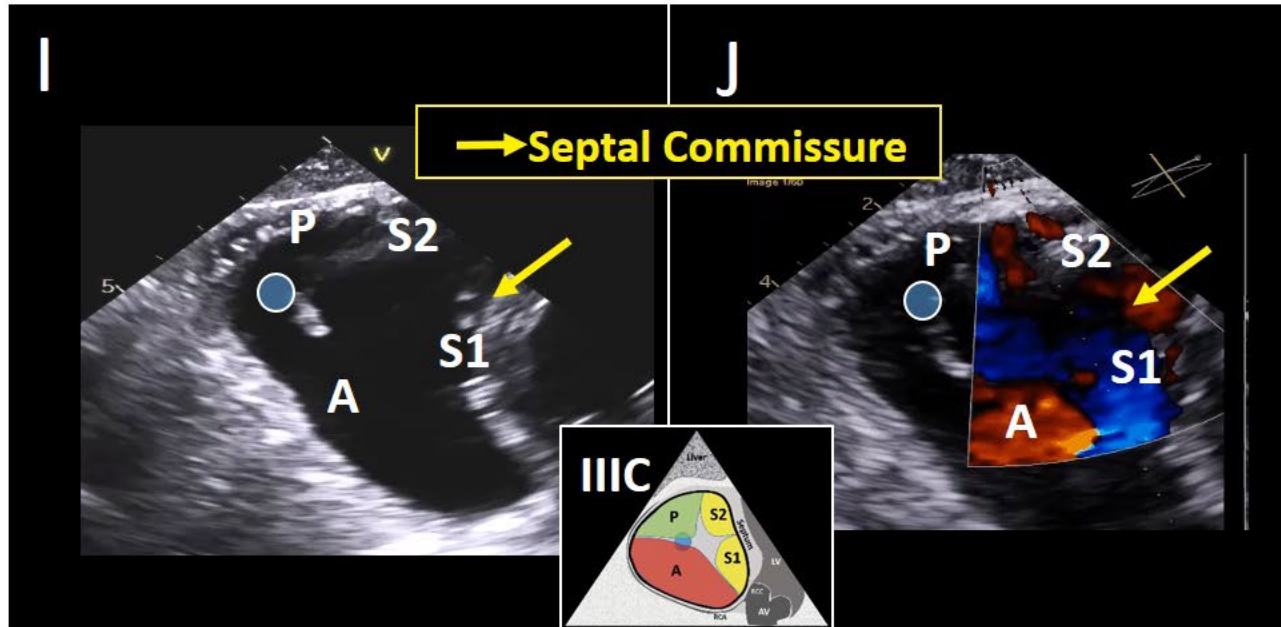
# Type IIIA



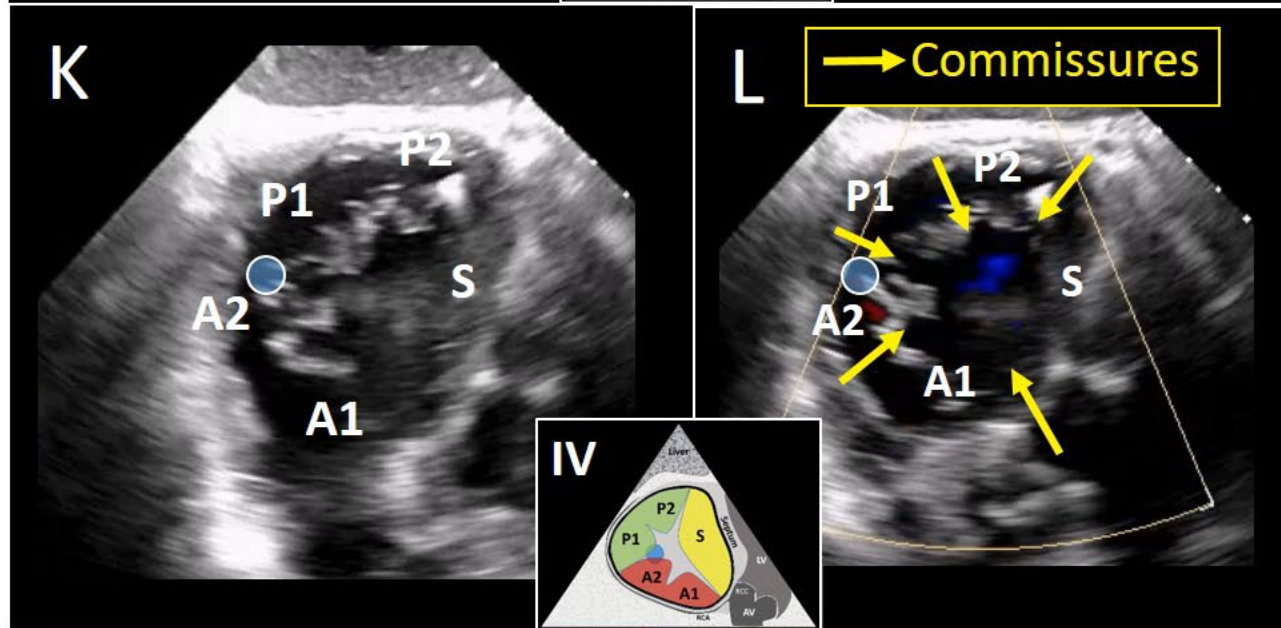
# Type IIIB



Type IIIC



Type IV

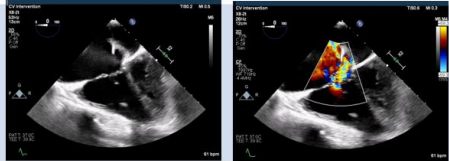
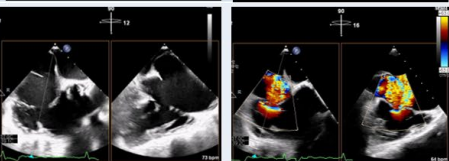
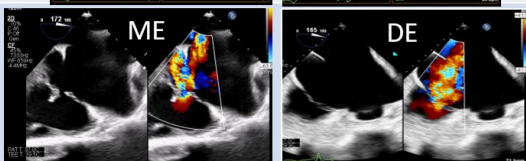
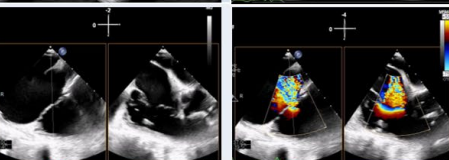
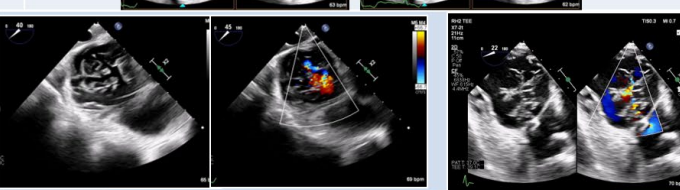
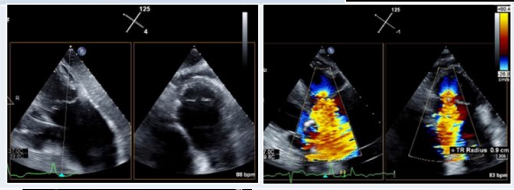
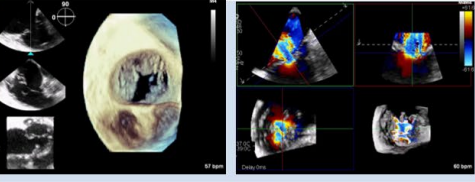


Type IV

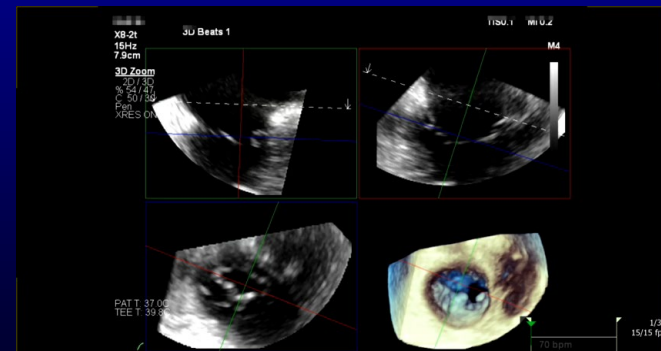
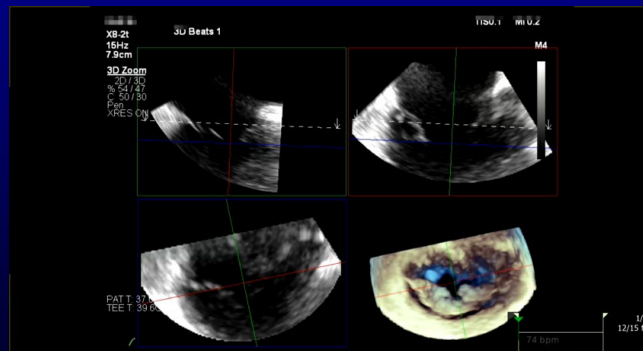
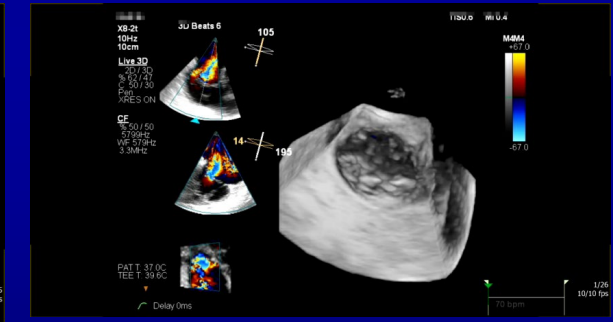
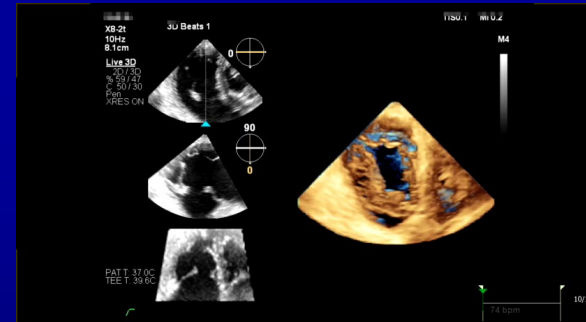
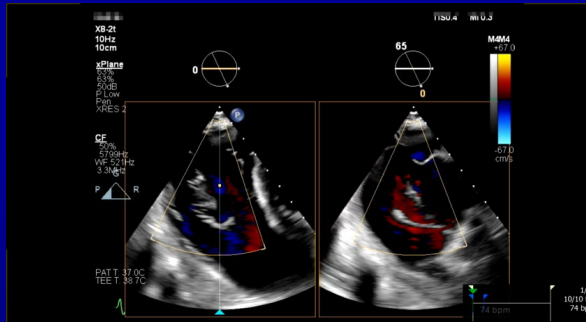
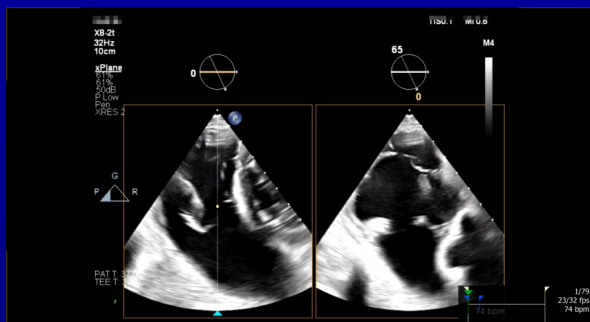
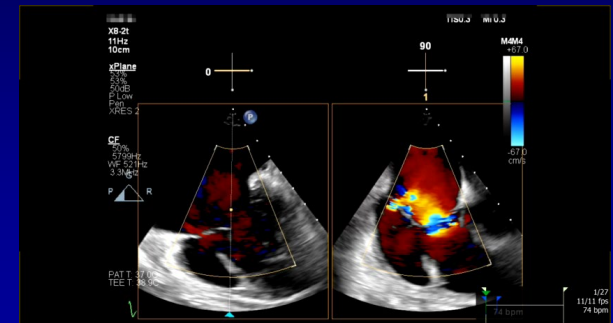
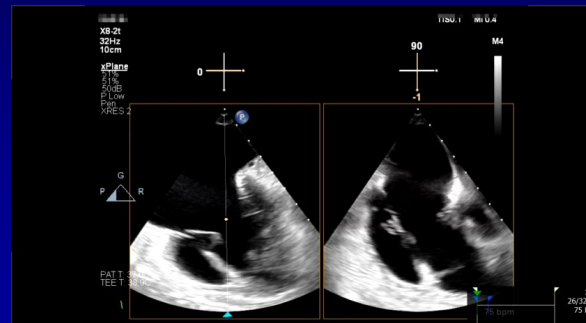
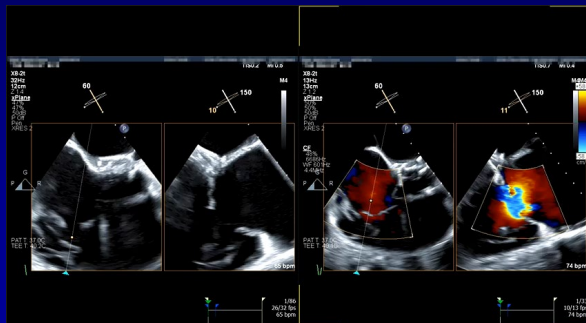
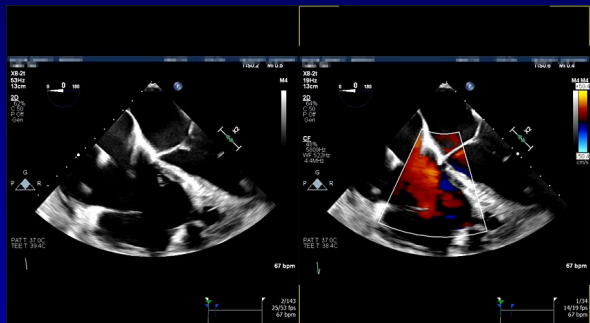


# TEER Screening

- Which leaflets are involved? How many leaflets?
- Is the leaflet length adequate for grasping?
- Are the leaflets severely thickened? Severely tethered?
- Is the TR lead-induced?
- Location of the TR jet, eccentric and/or antero-posterior gaps
- RV orientation: horizontal?
- Acoustic shadowing from other structures: AV, MV, RV lead
- Eustachian valve

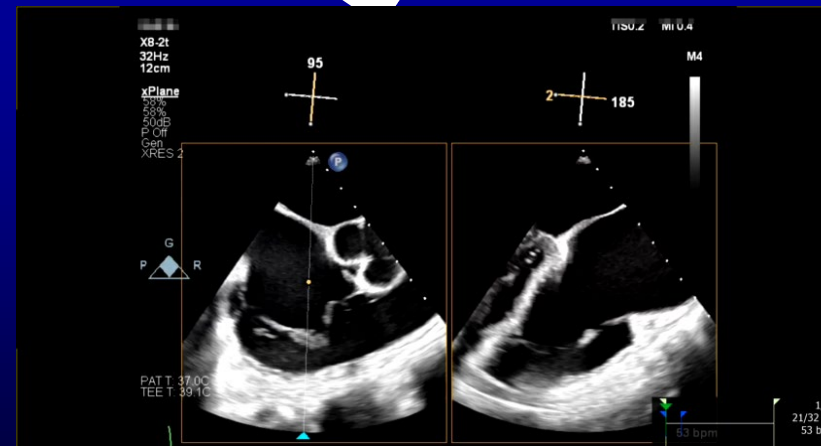
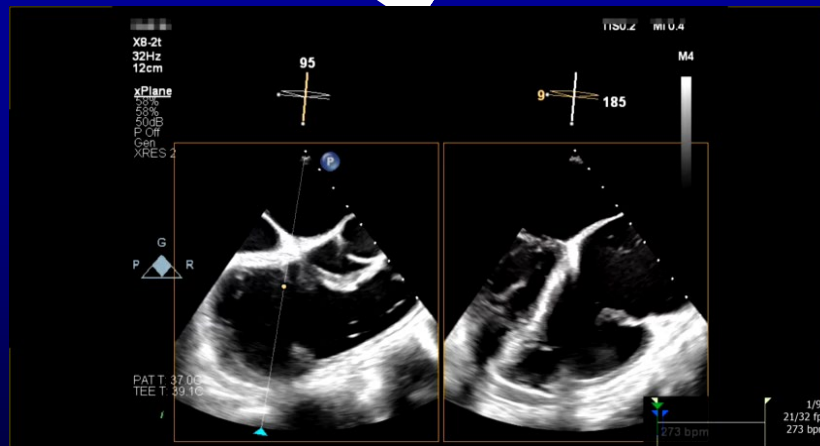
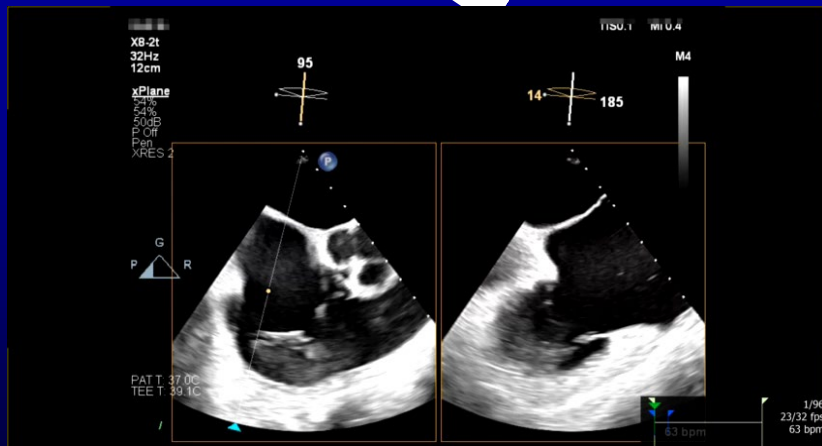
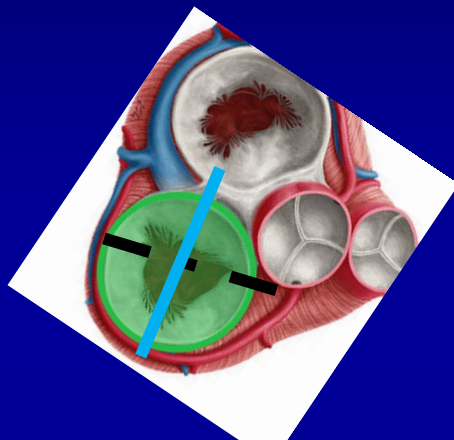
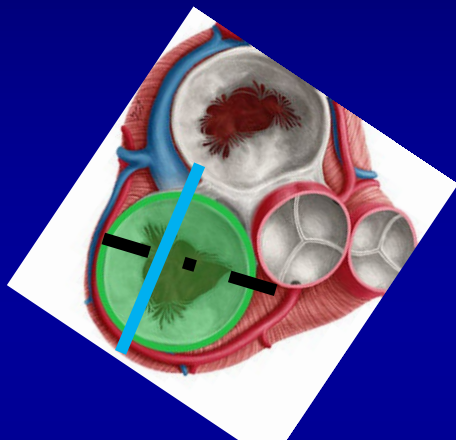
View	Example
4 Chamber TV Mid esophageal (ME)	
RV Inflow/Outflow View ME (SWEEP) <b>X-Plane</b>	
Alternate Grasping View ME and Deep esophageal (DE) <b>140-180°</b>	
4 Chamber TV DE	
Transgastric SAX	
Deep Transgastric	
3D Volumes	

# Pre-procedural TEE Screening Checklist



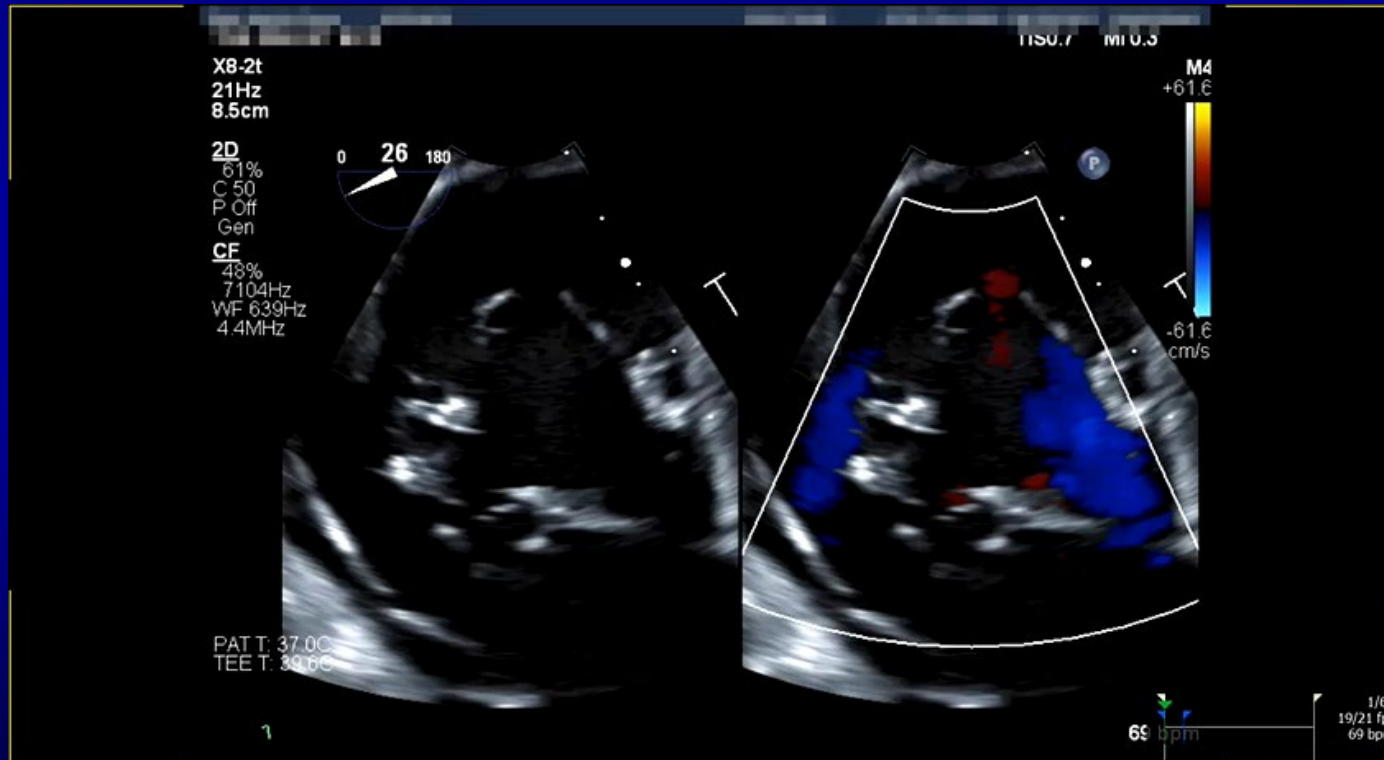
# TEER Intra-op KEY VIEWS

## 1. ME RV Inflow- Biplane

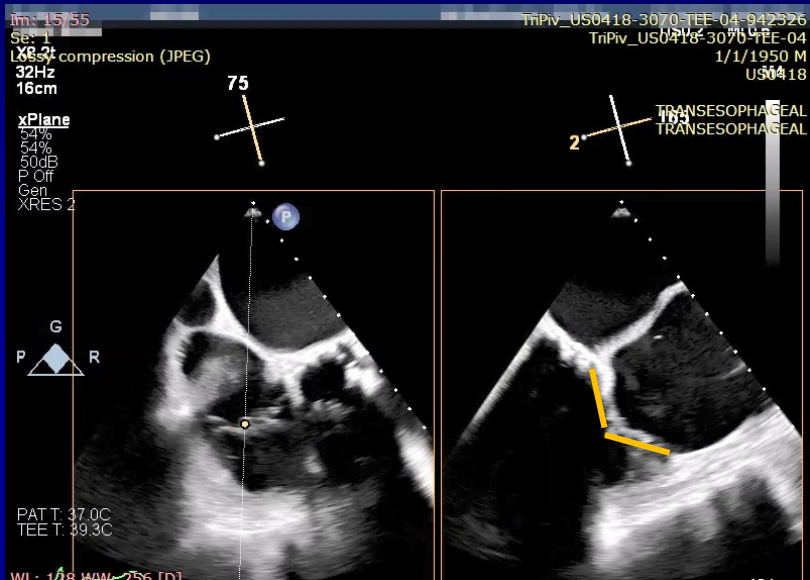


# TEER Intra-op KEY VIEWS

## 2. TG Short-axis



# Assessing TEER Difficulty: Leaflet Coaptation Reserve

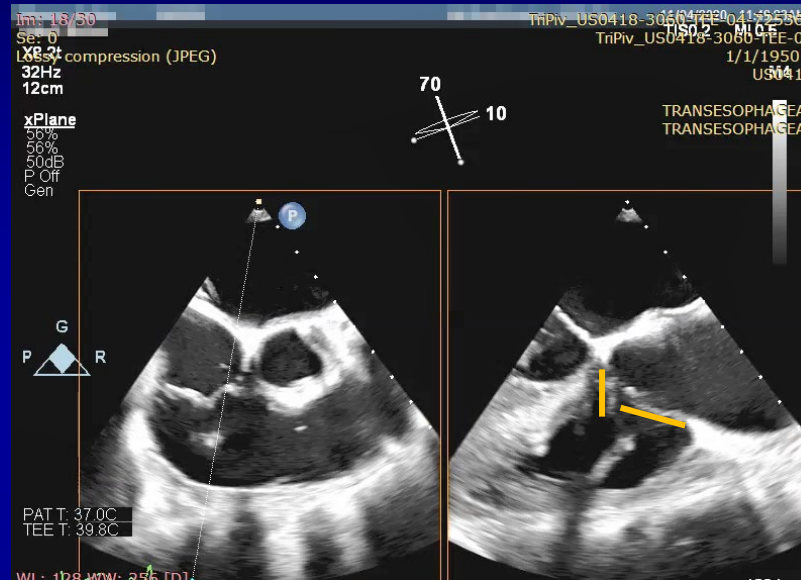


Symmetric "V"

*Good Reserve*

Smaller gap: Easier

Larger gap: Harder



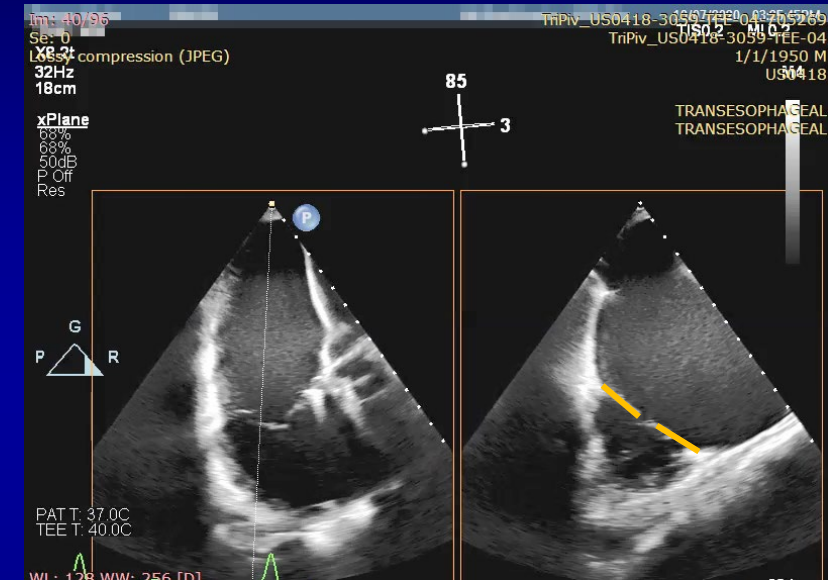
Asymmetric "V"

*Fair Reserve*

Smaller gap: Easier

Larger gap: Harder

Septal leaflet tethered: Harder



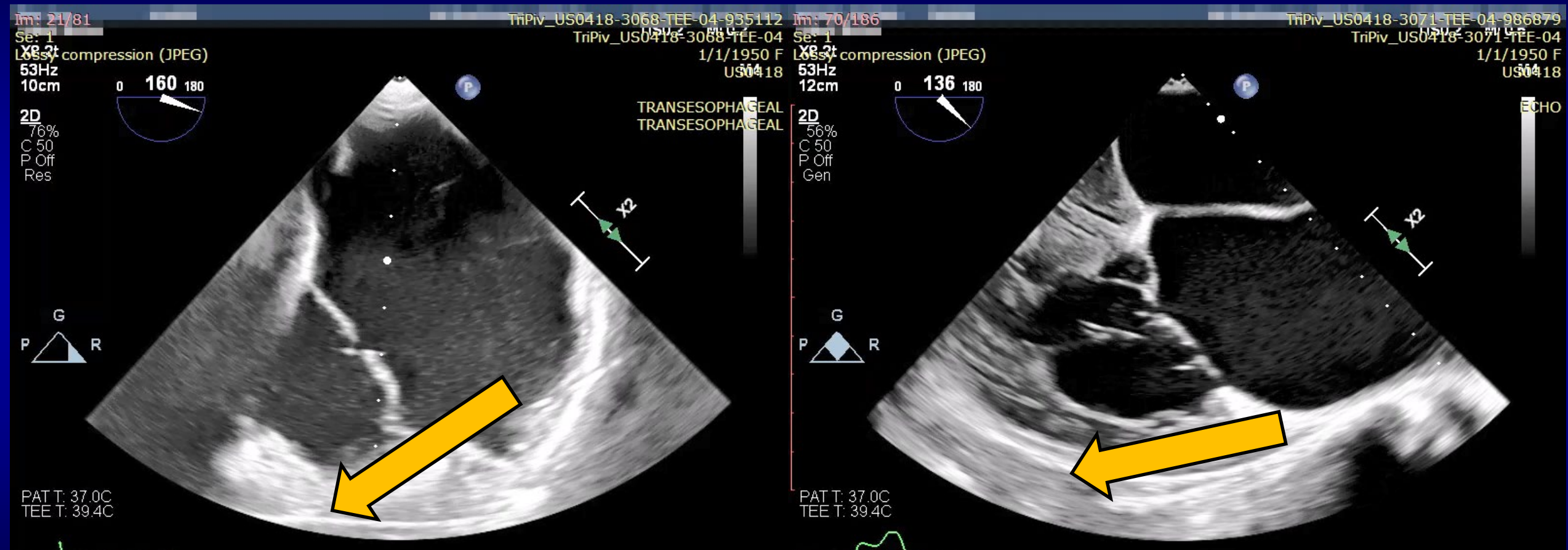
Flattened V

*Poor Reserve*

Smaller gap: Hard

Larger gap: Harder

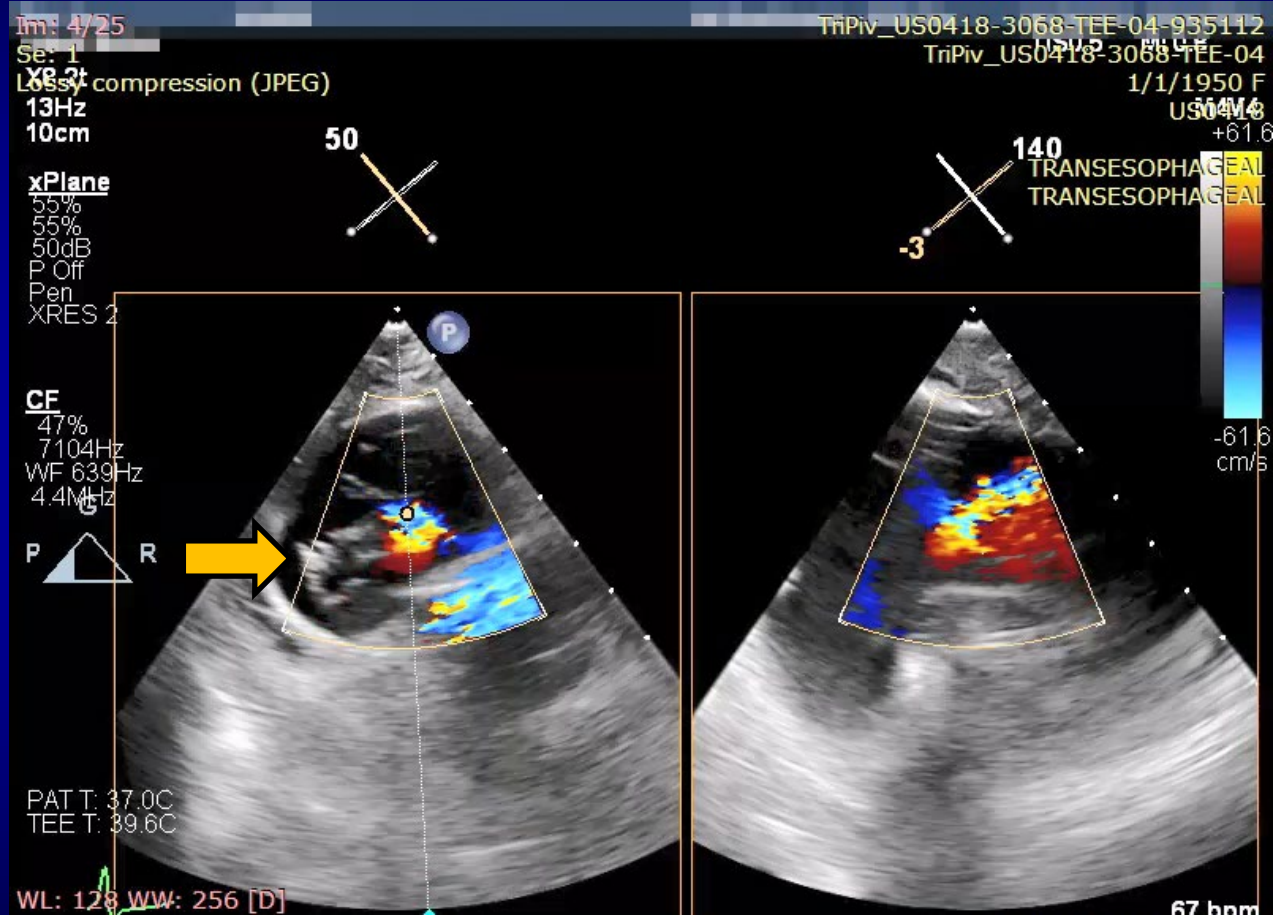
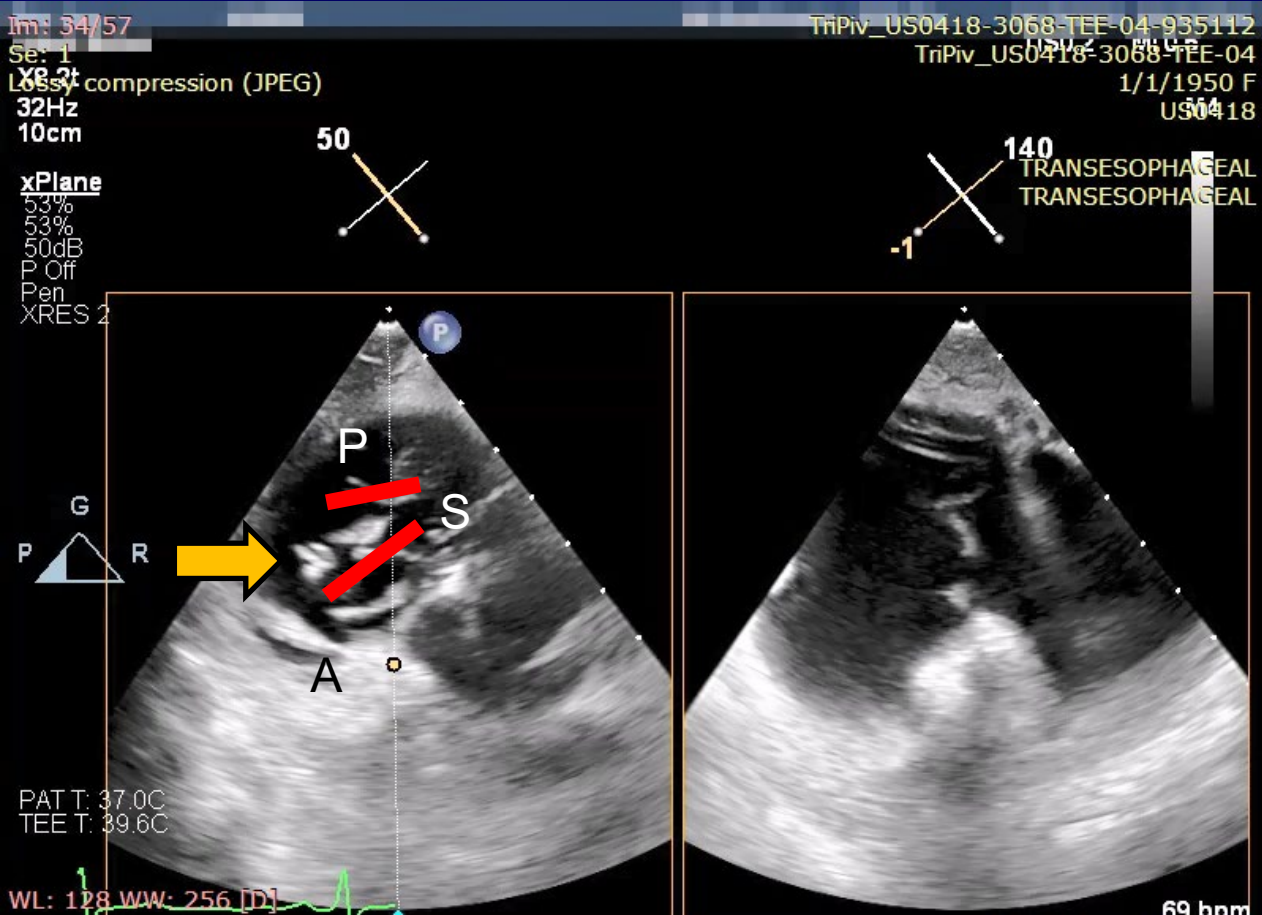
# Assessing TEER Difficulty: RV Orientation



More Vertical: Easier

More Horizontal: Harder

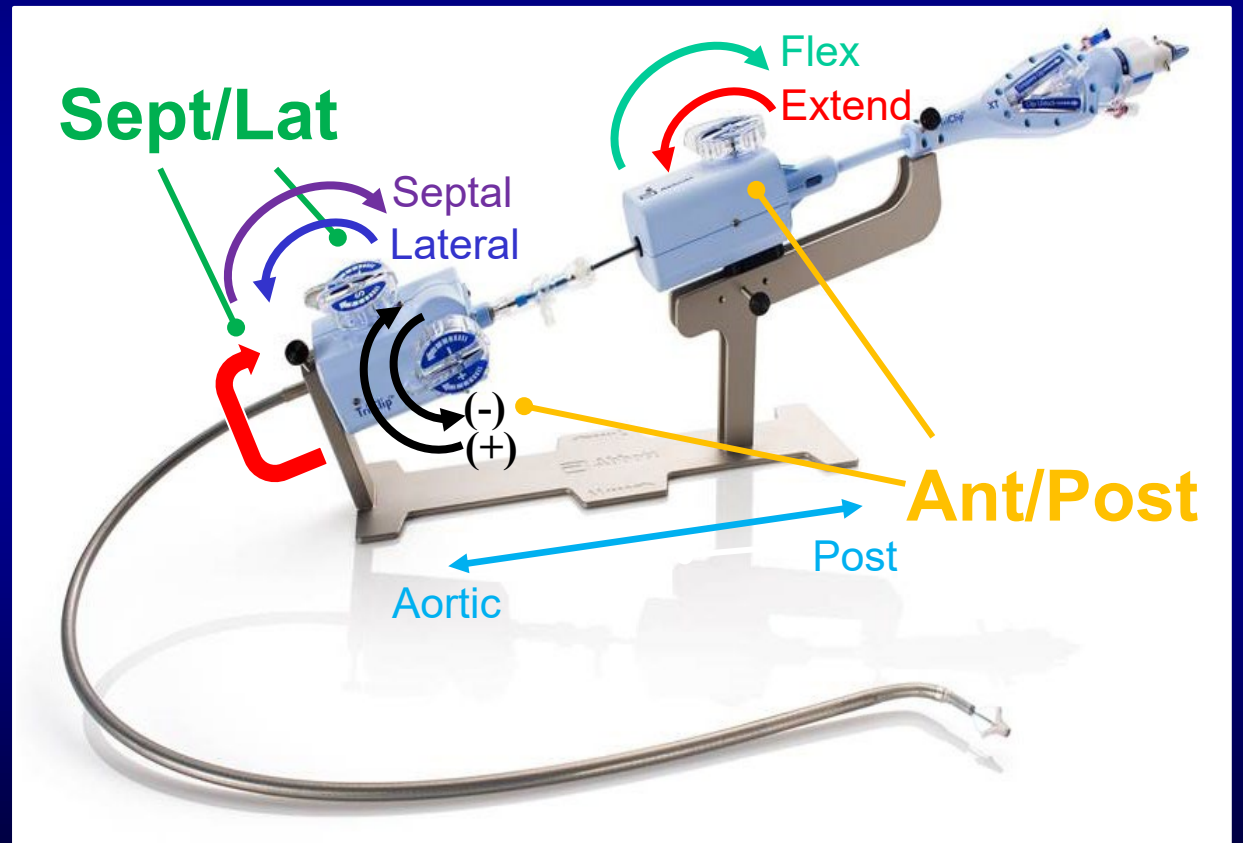
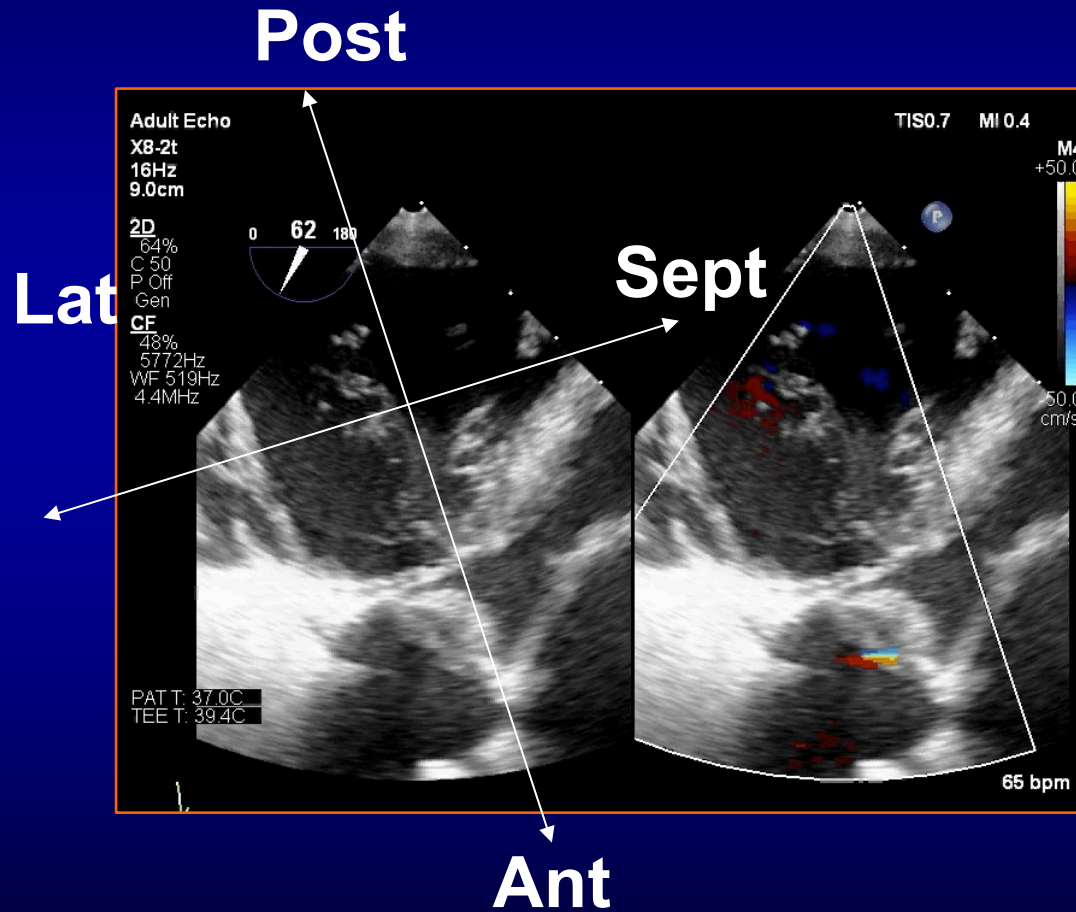
# Watch for the AP Canyon



# Clip Selection Criteria

	<b>XTW</b>	<b>XT</b>	<b>NTW</b>	<b>NT</b>
Septal Leaflet $\geq 9$ mm	+	+		
Septal Leaflet $< 9$ mm			+	+
First Clip	+		+	
Narrow Grasping Zone		+		+
Broad Jet	+		+	
Near Commissure			+	+
Dense Chordae at Grasping Site				+

# Key Maneuvers



# TriClip System Steering and Positioning

Device Maneuver	Movement	Leaflet Target	Height Effect
Advance Stabilizer	Aortic	Aortic direction	May gain height
Retract Stabilizer	Posterior	Posterior direction	May lose height
SGC in "S" or CW	Septal	Septal leaflet	May gain height
SGC in "L" or CCW	Lateral	Lateral direction	May lose height
SGC (+)	Posterior/Septal	Posterior/Septal	Lose height
SGC (-)	Anterior/Septal	Anterior/Septal	Gain height
CDS (F)	Posterior/Septal	Posterior/Septal	Lose height
CDS (E)	Aortic/Septal	Anterior/Septal	Gain height

Modified from: Abbott

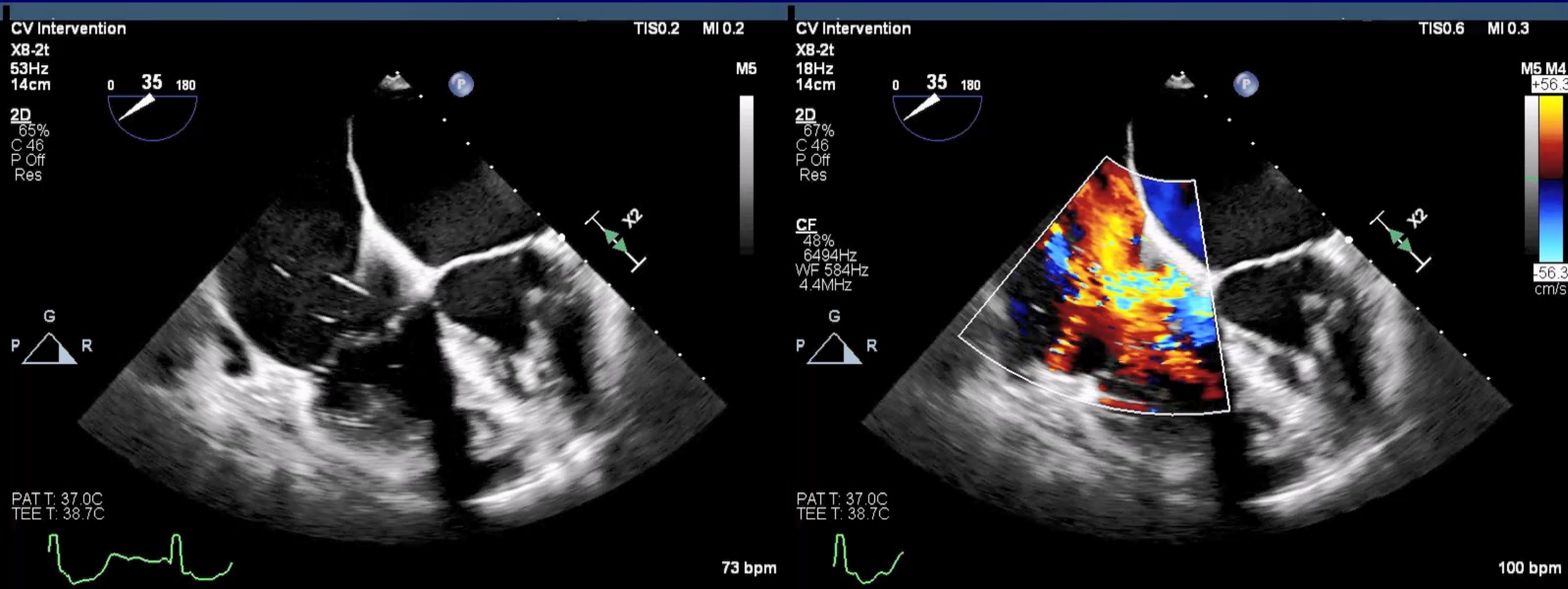
# OUTLINE

- Burden of Severe TR
- Challenges with Managing TR
- Transcatheter Tricuspid Landscape
- Patient Screening and Selection
- ***Case examples***
- TTVR

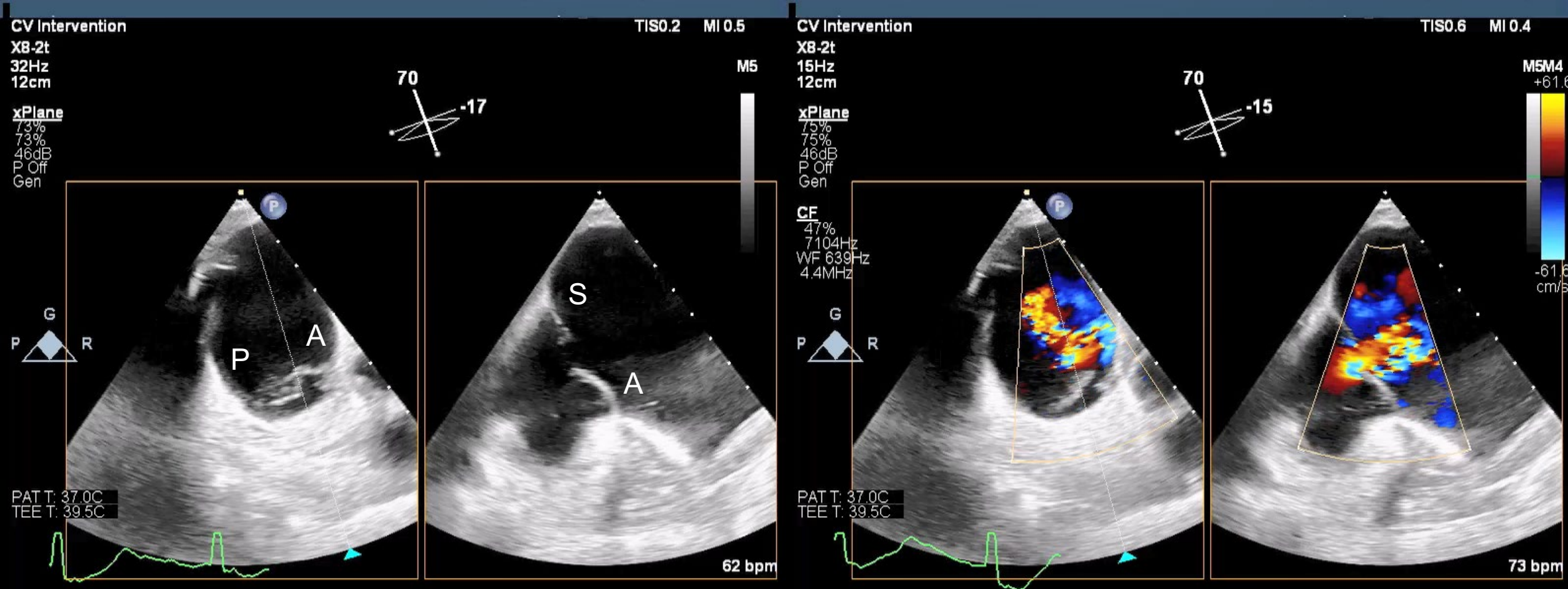
# Case #1

- 87 year-old female; severe TR, LVEF 65%, NYHA-III
- Afib s/p multiple ablations, skin cancer, DM2, endometrial cancer, frail
- Deemed high risk for tricuspid surgery
- Symptomatic despite maximally optimal GDMT
- TEE: Severe TR due to anterior leaflet prolapse, annular dilatation

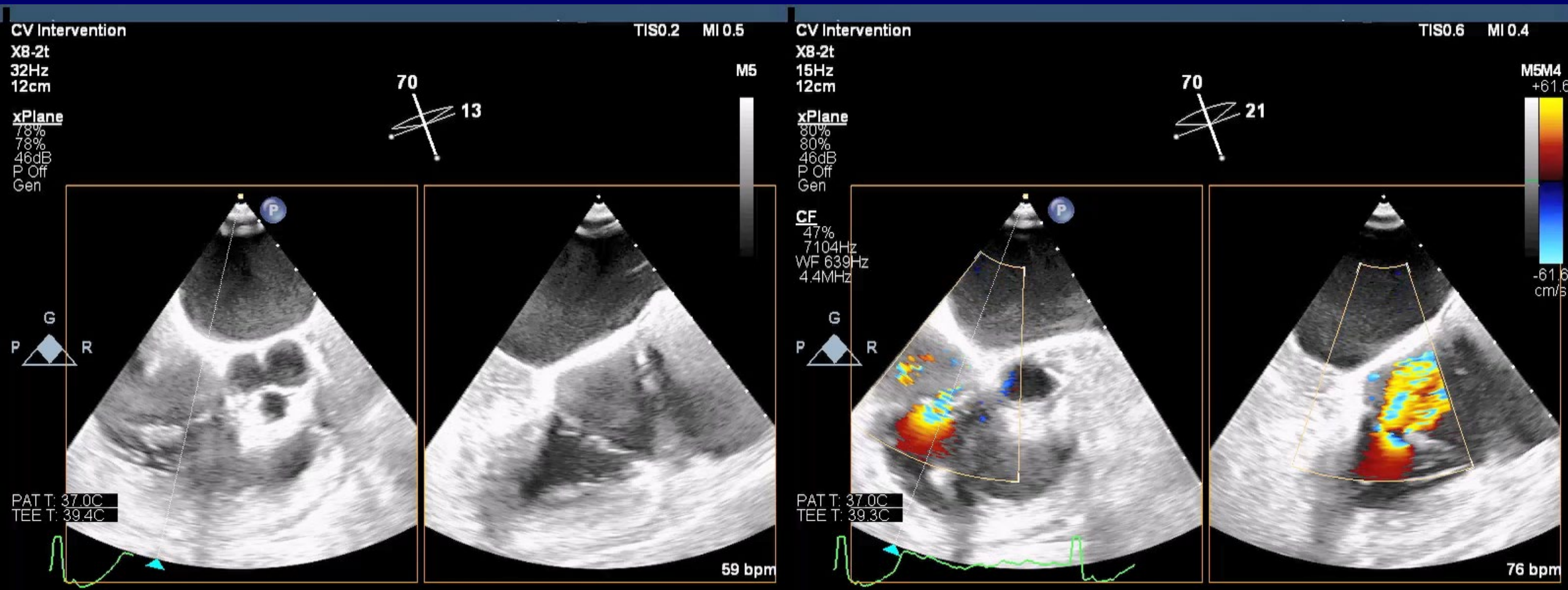
# TEE: 4 Chamber



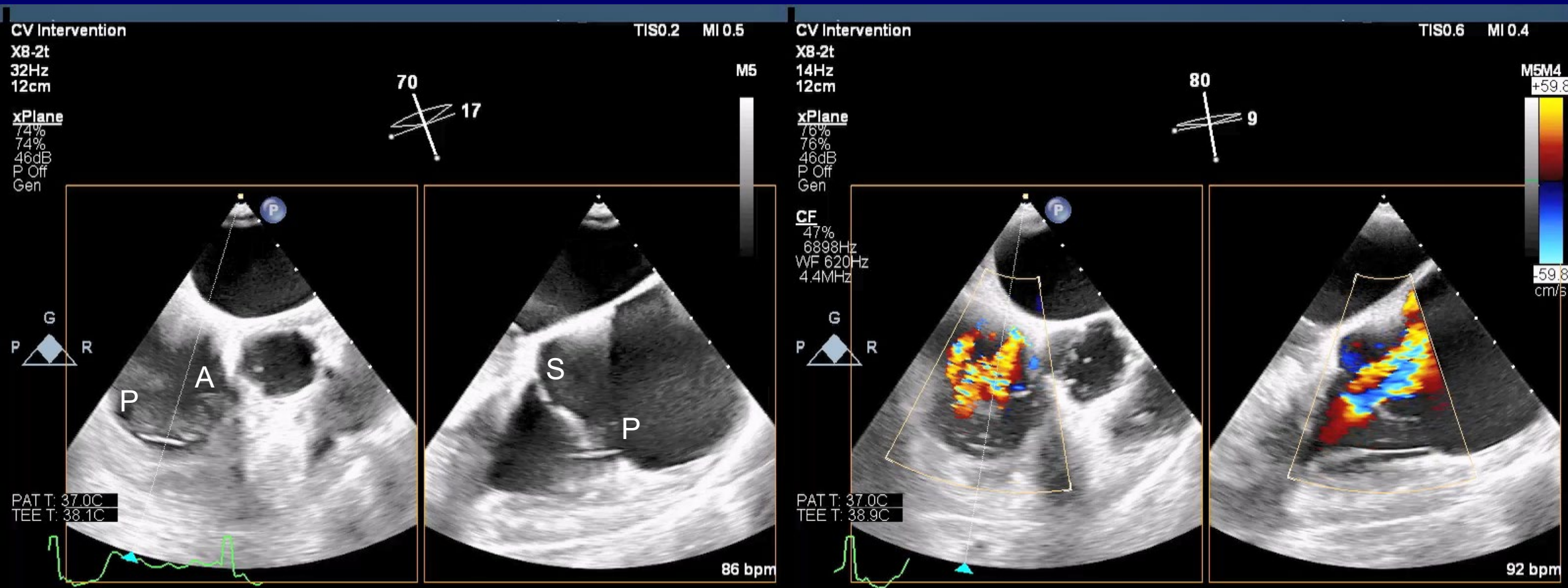
# RV Inflow-Xplane to Grasping View – Anterior-Septal



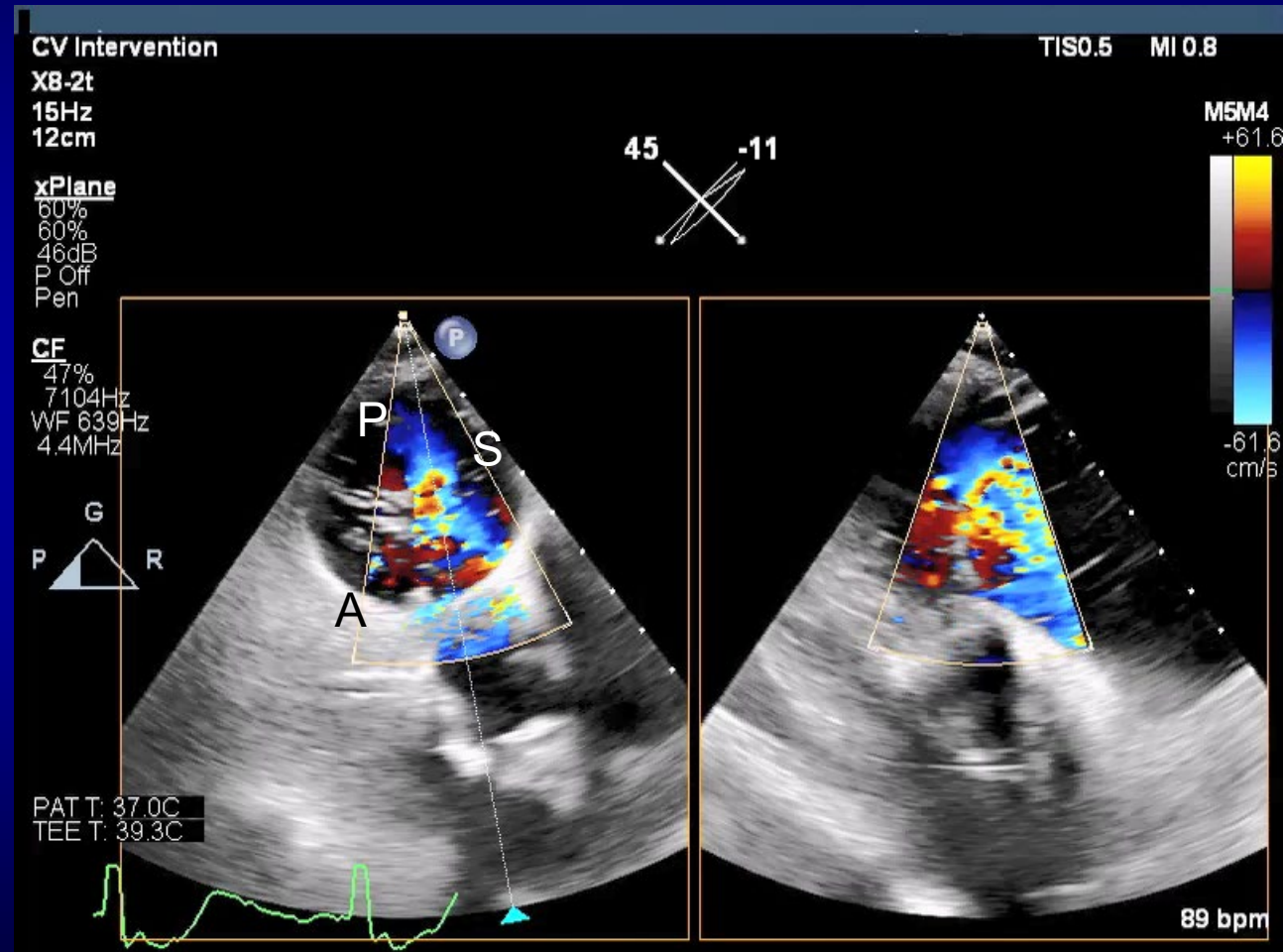
# RV Inflow-Xplane to Grasping View – Anterior-Septal



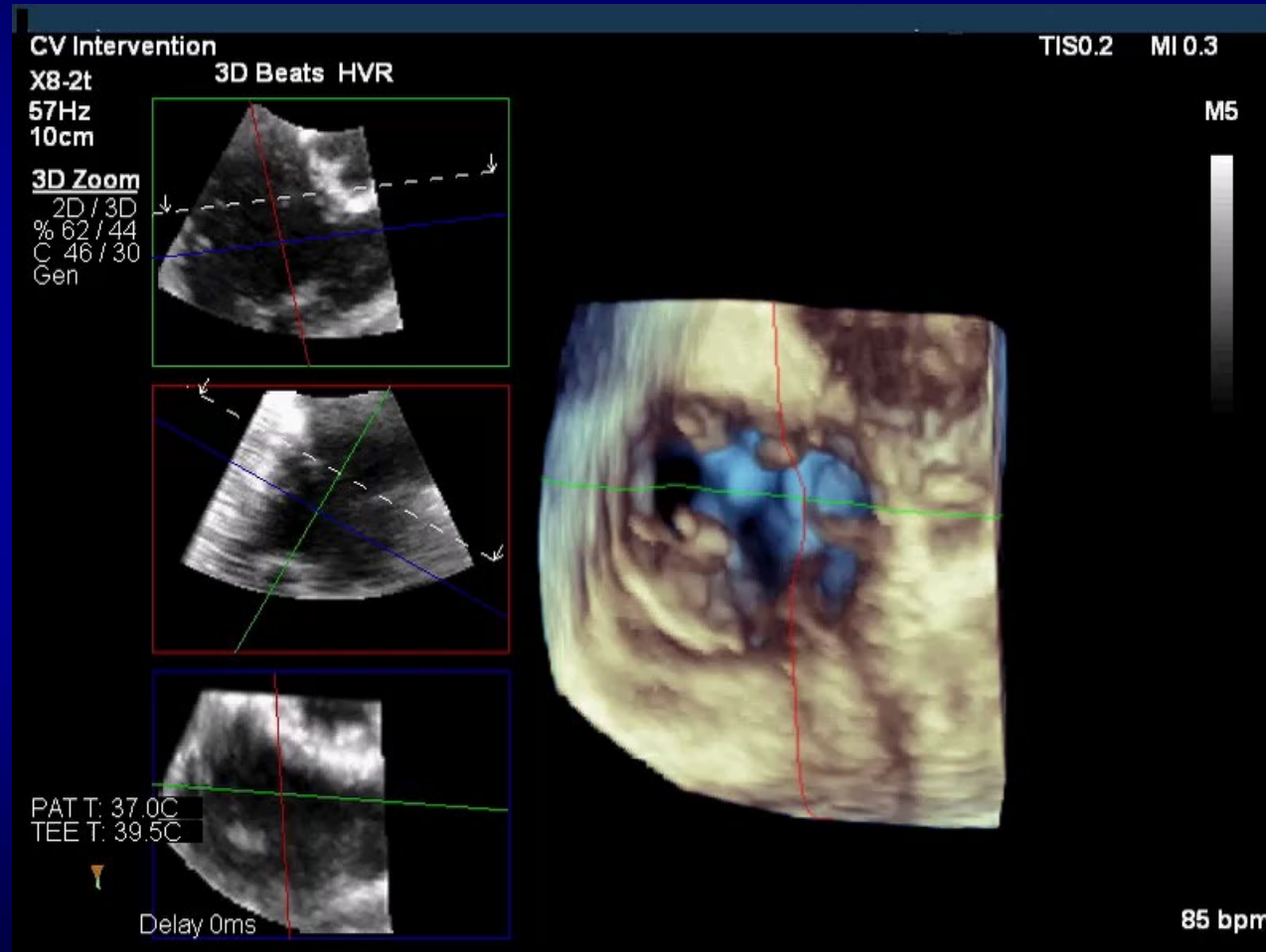
# RV Inflow-Xplane to Grasping View – Posterior-Septal



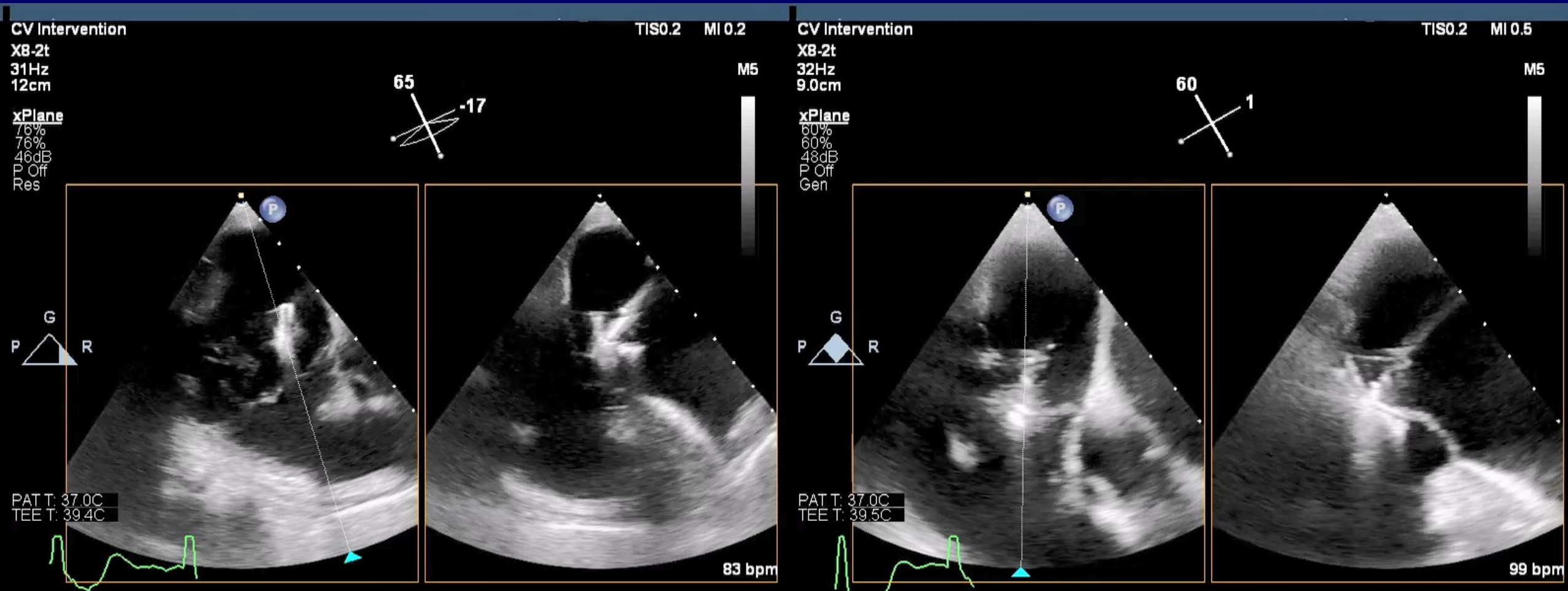
# Transgastric View



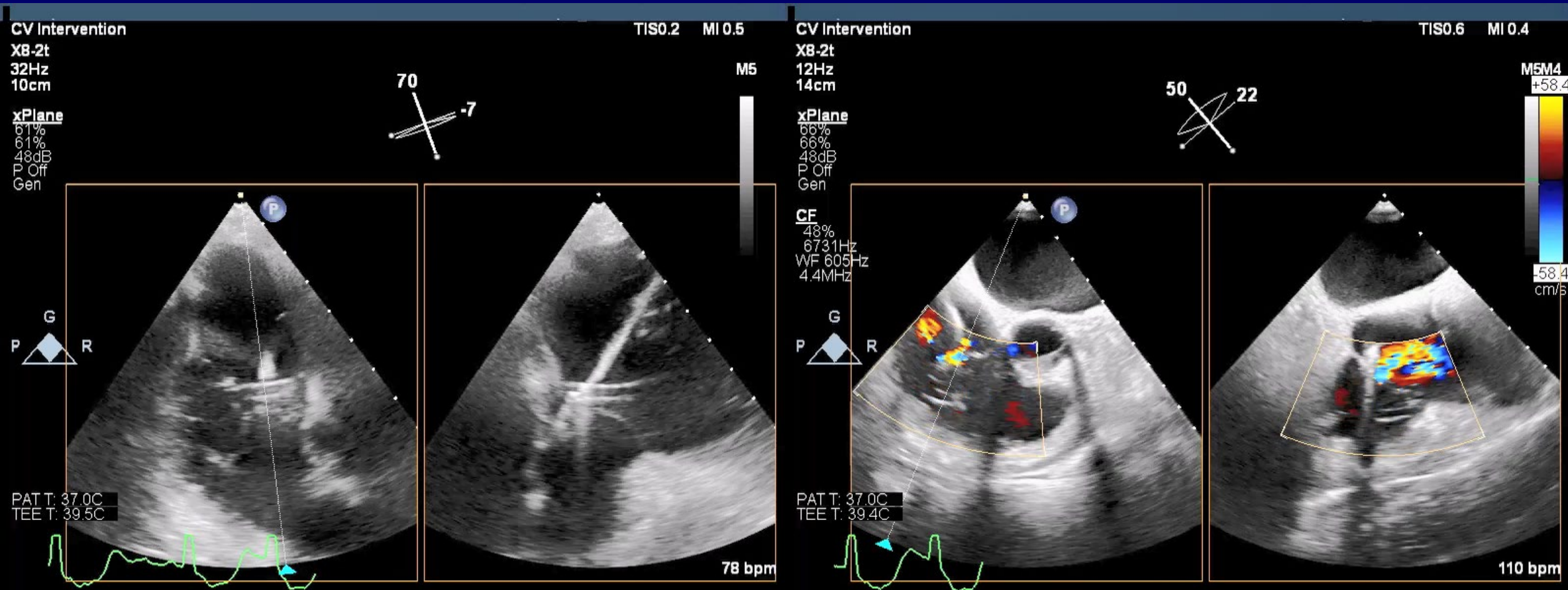
# 3D MPR View



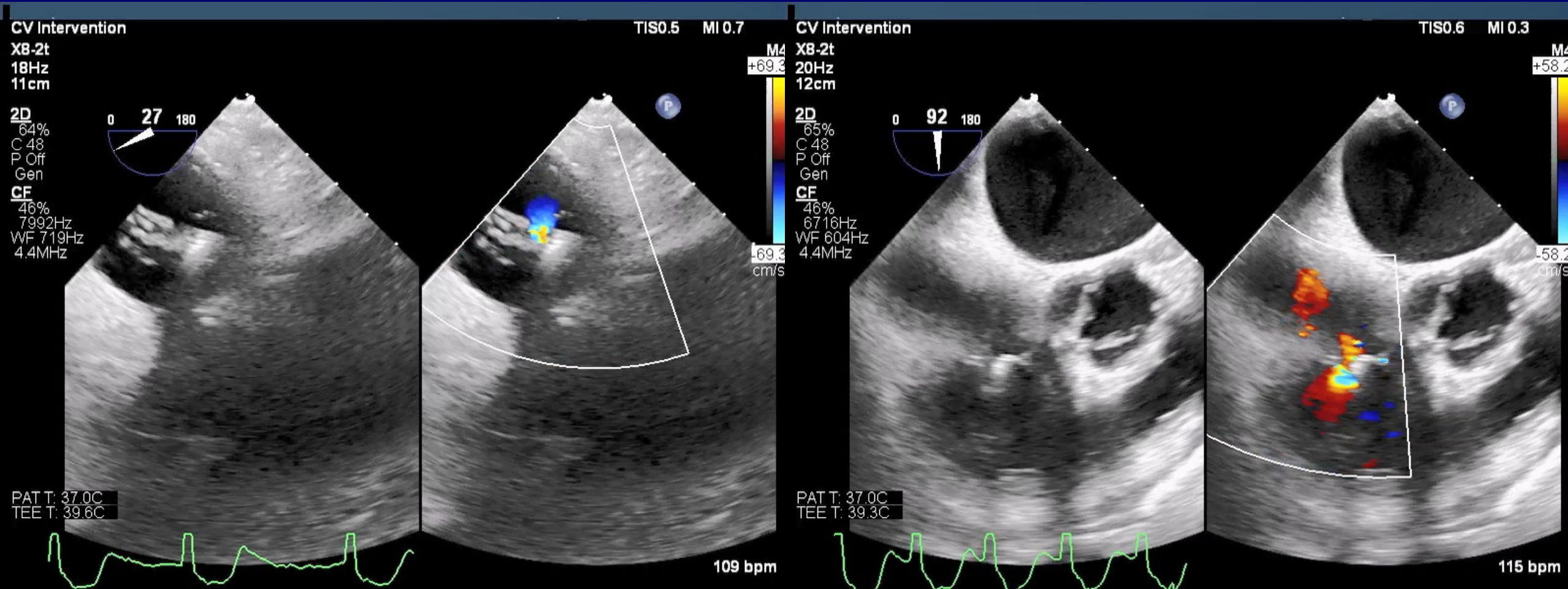
# First Clip – XT at A-S



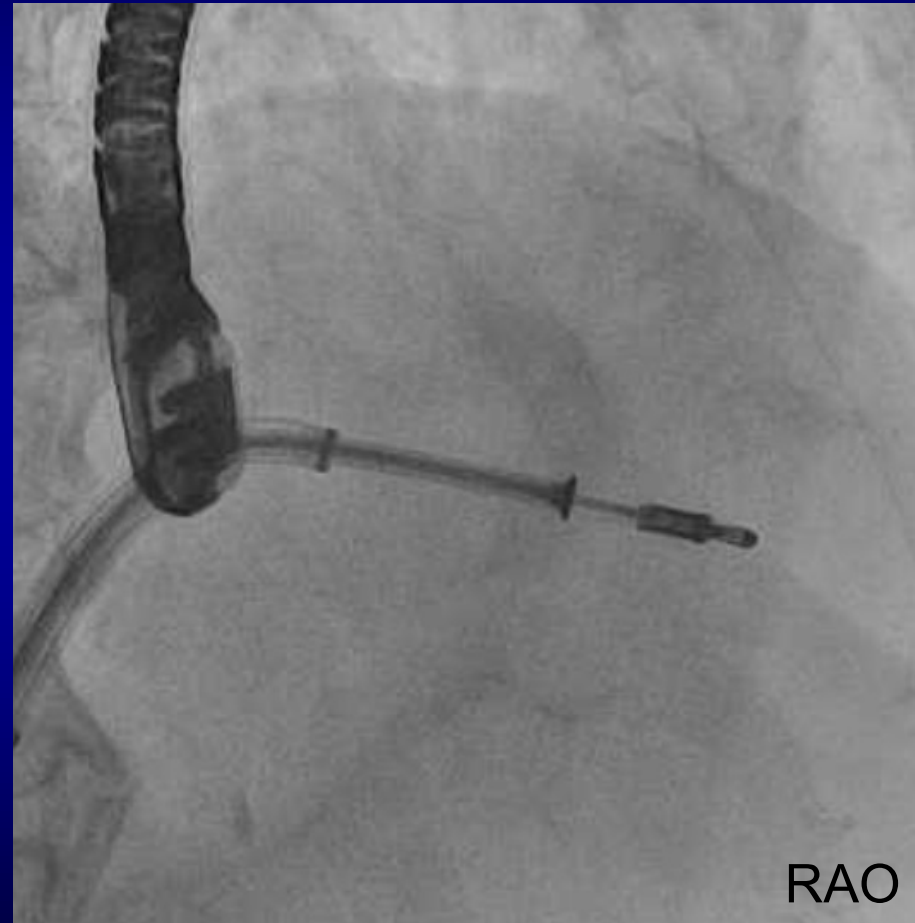
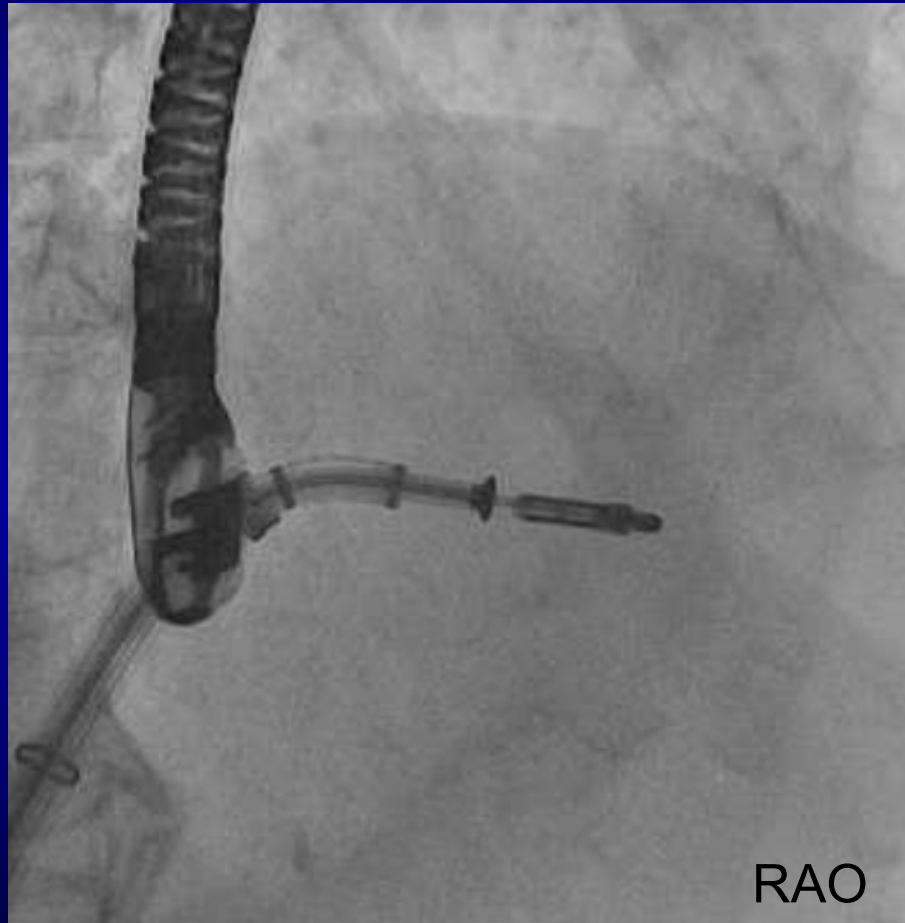
# Closing Clip and TR Assessment



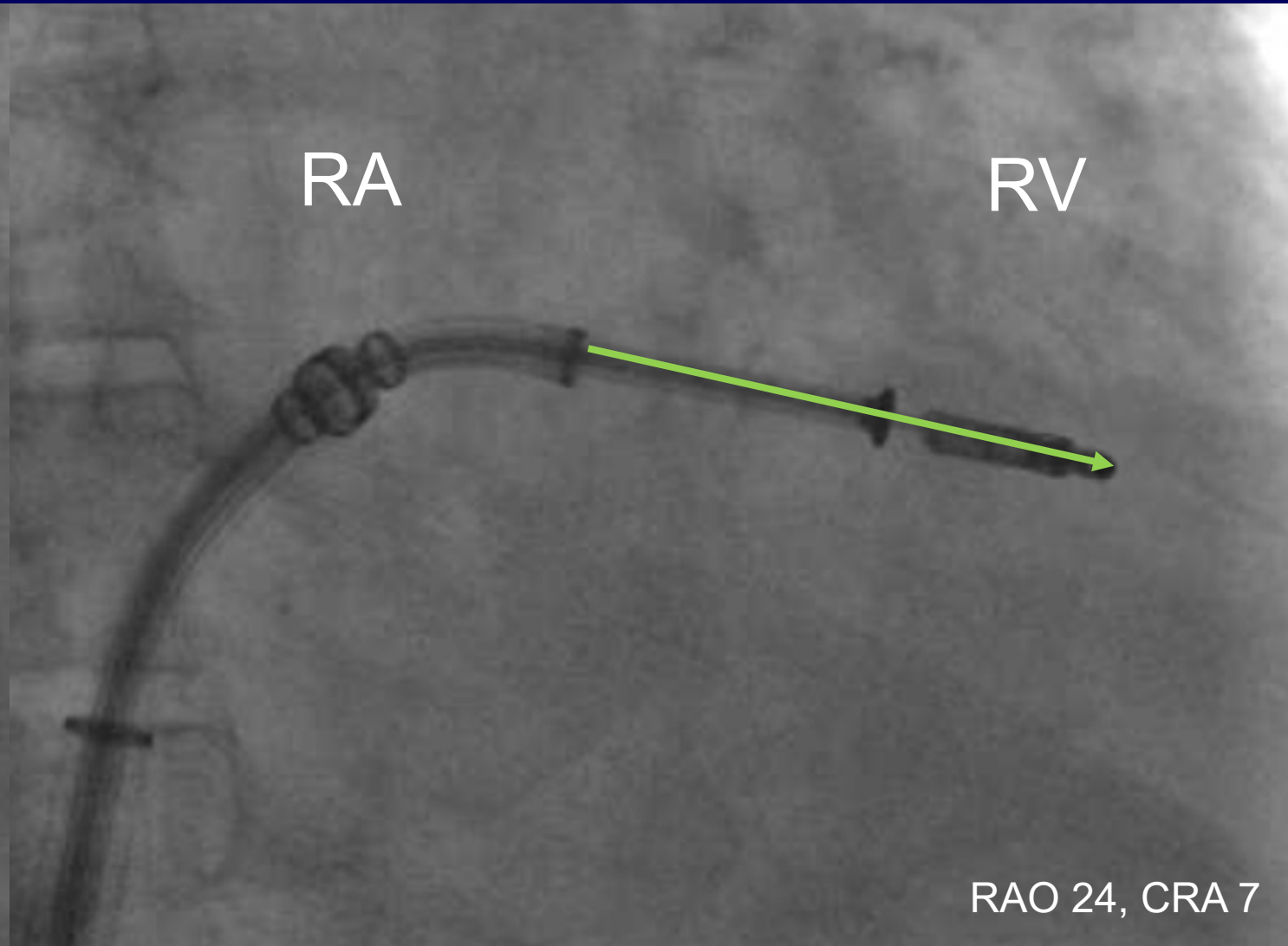
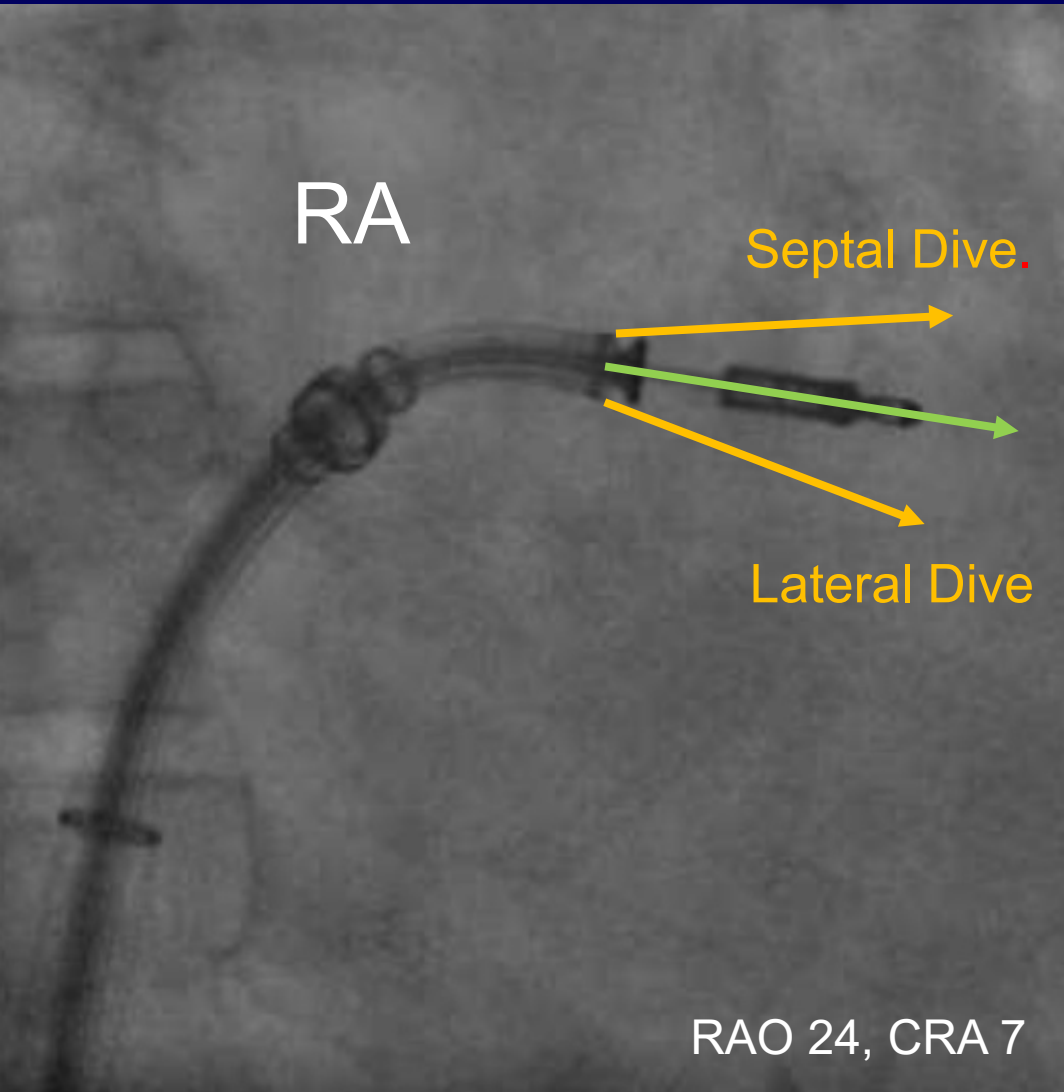
# TR Assessment After Deployment



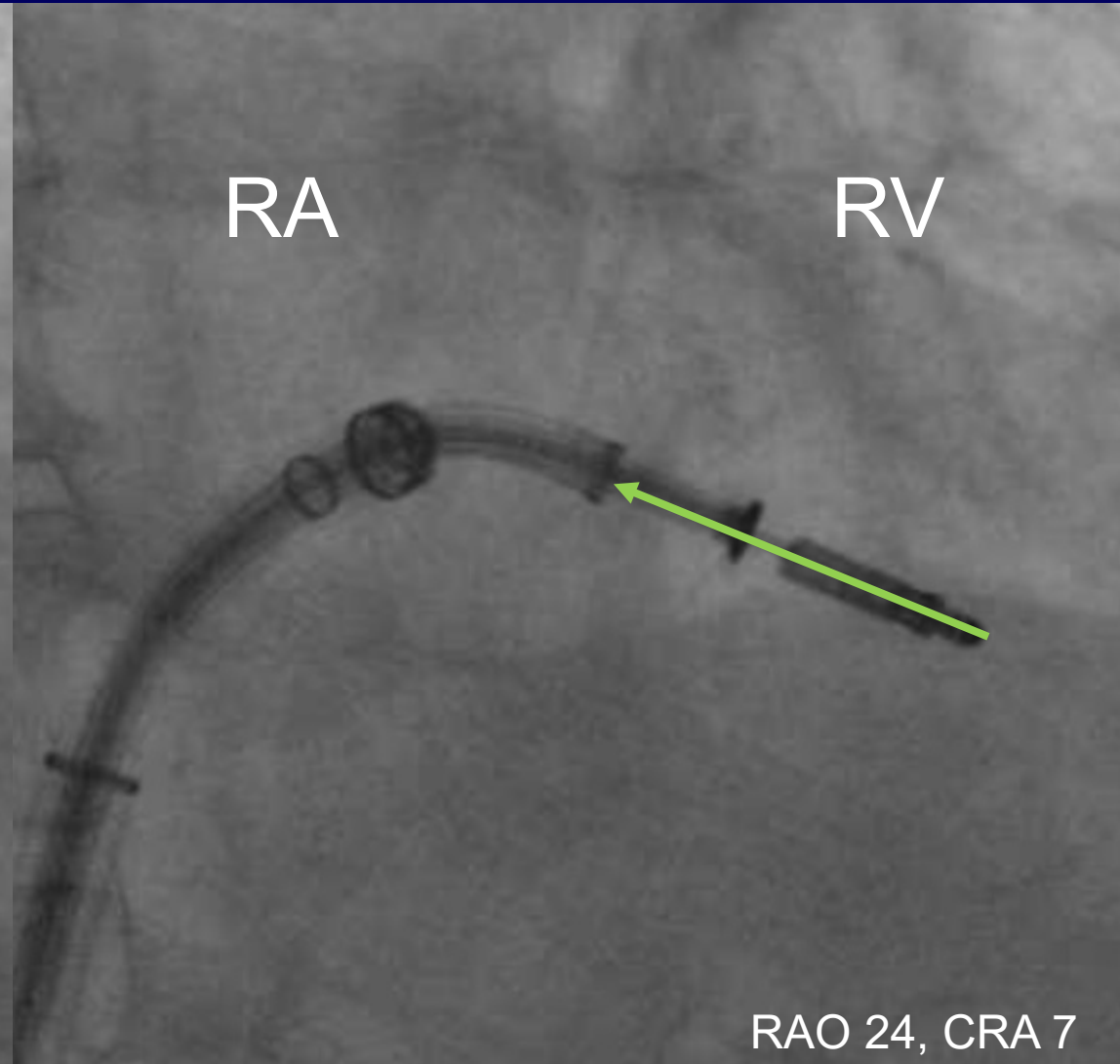
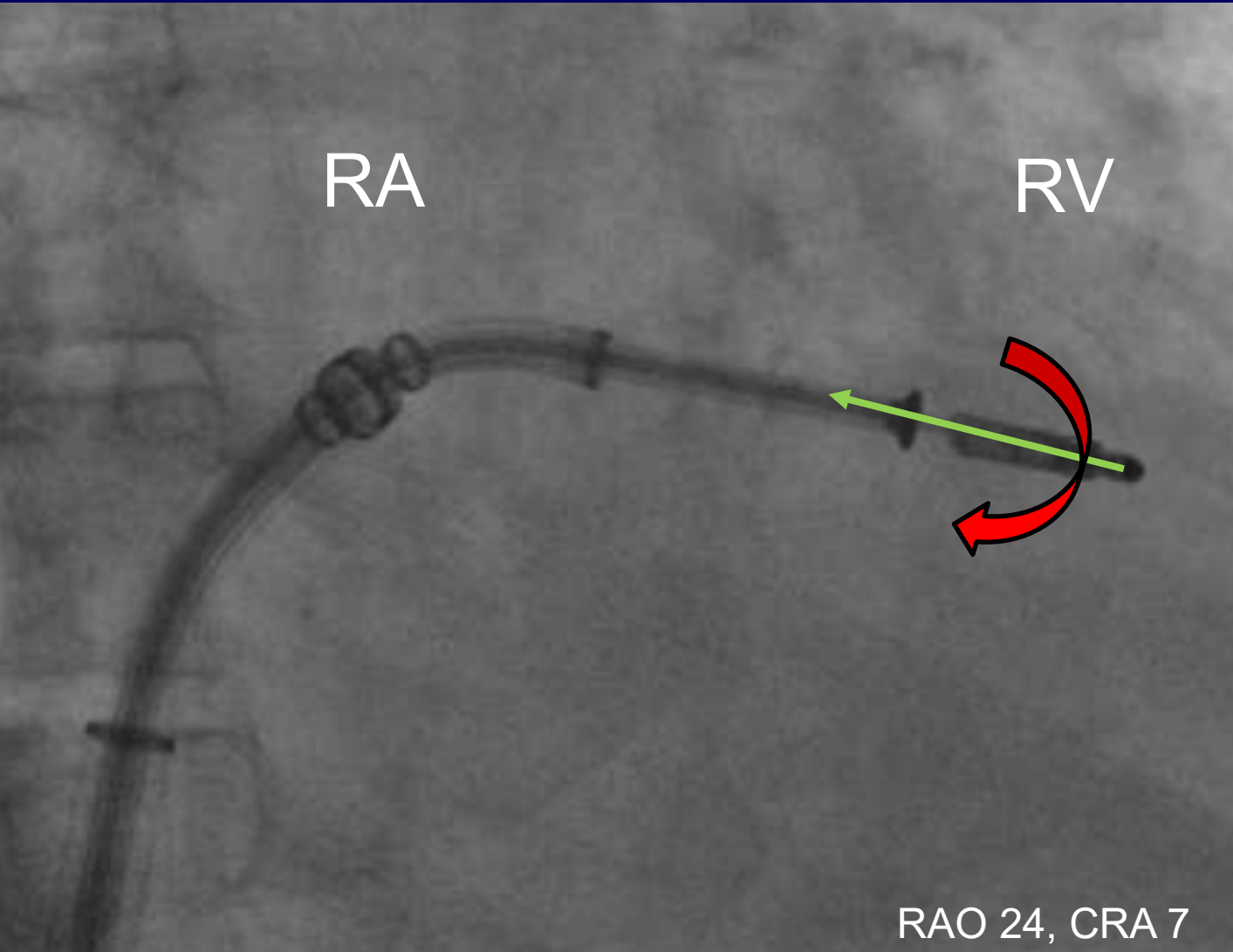
# Maintaining TriClip Trajectory on Fluoro



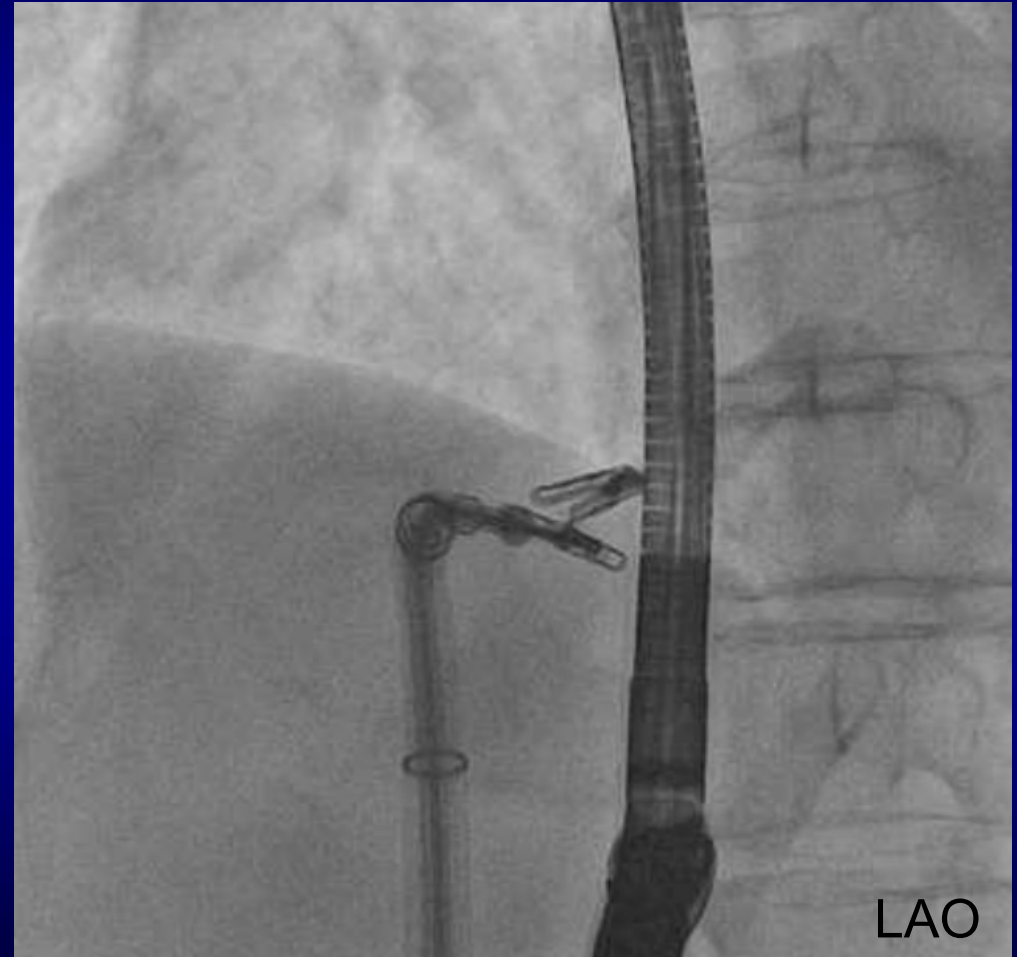
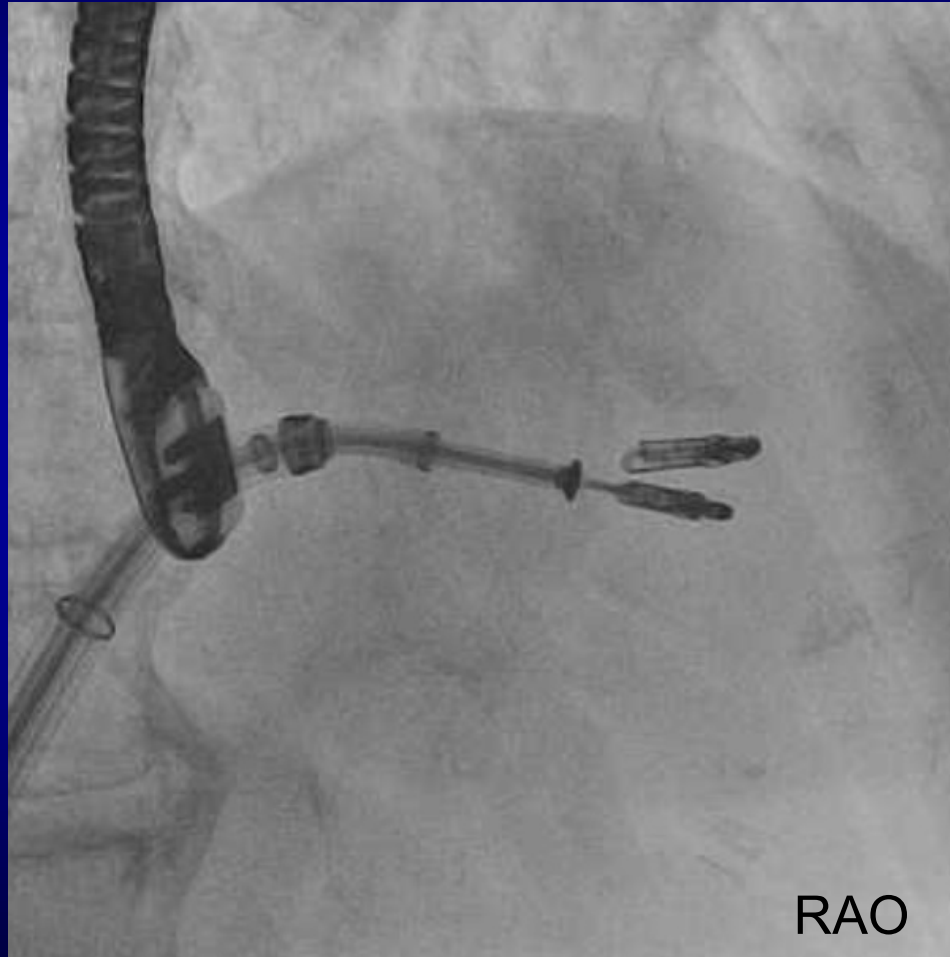
# Match Fluoro with TEE to Enter RV without Diving Septal/Lateral



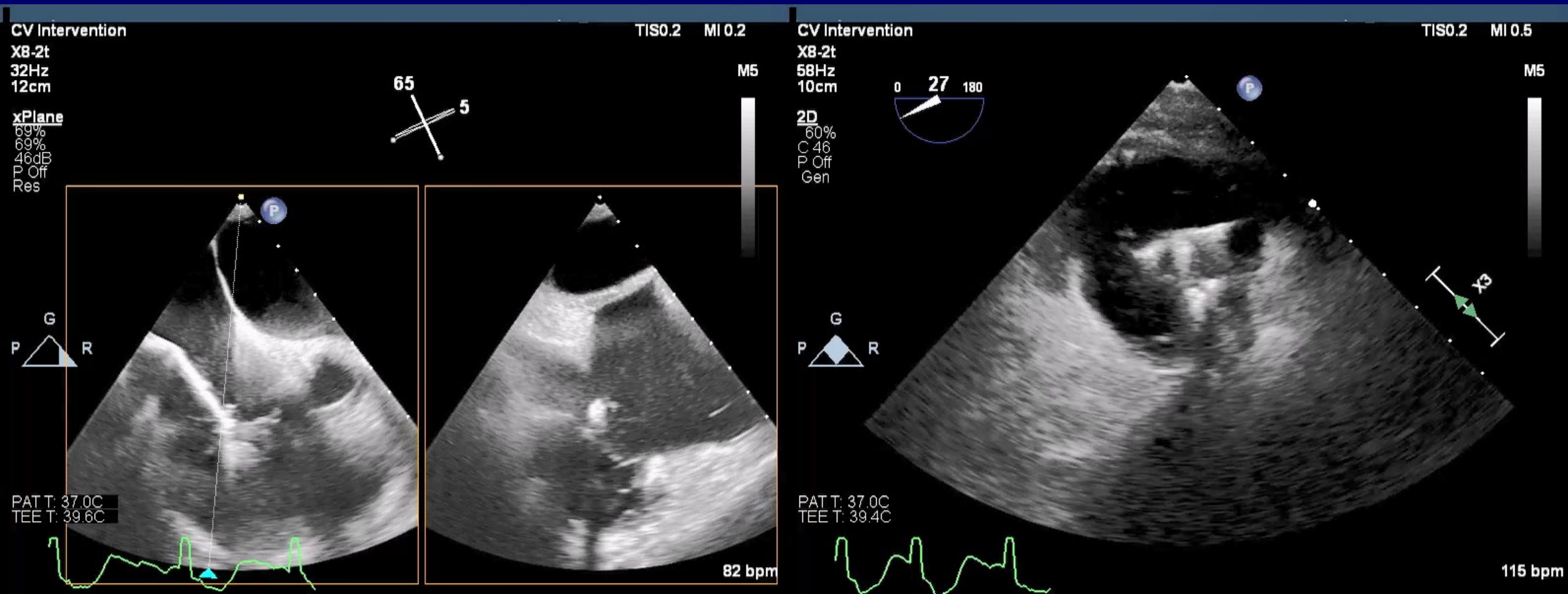
# When Grasping, use Fluoro to ensure Clip did not spin



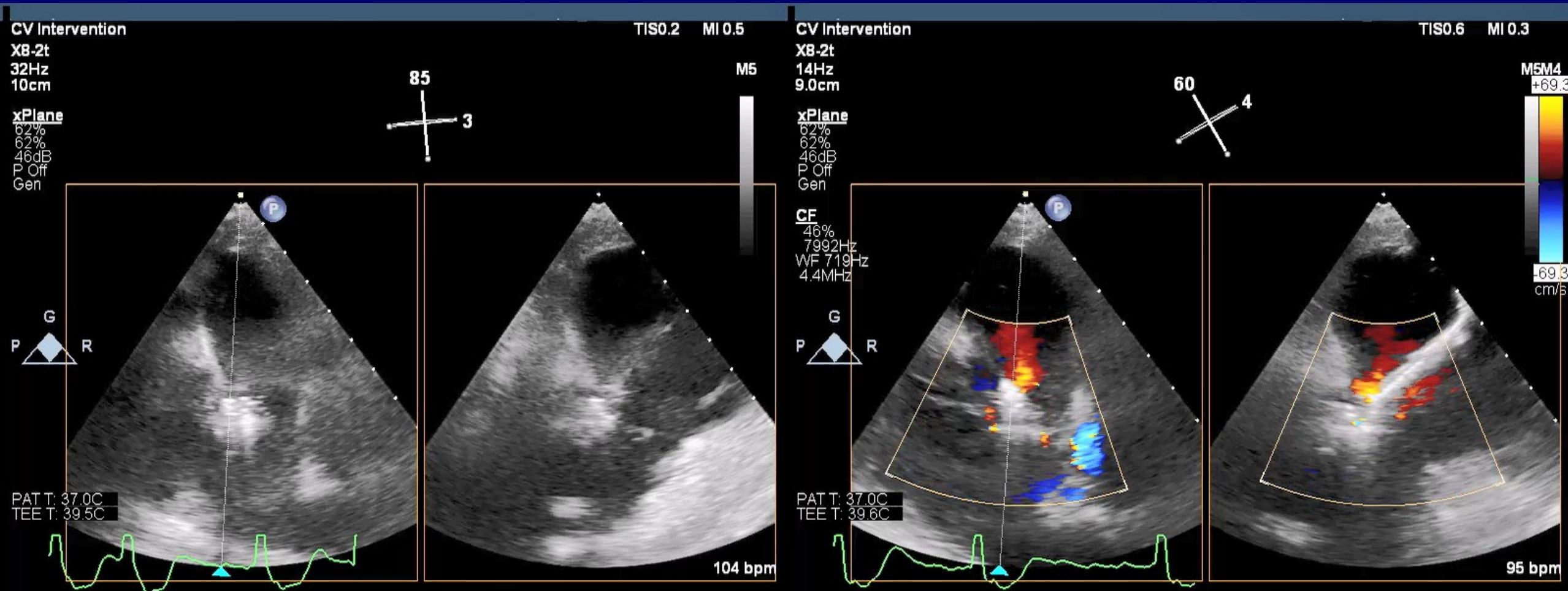
# Second TriClip on Fluoro



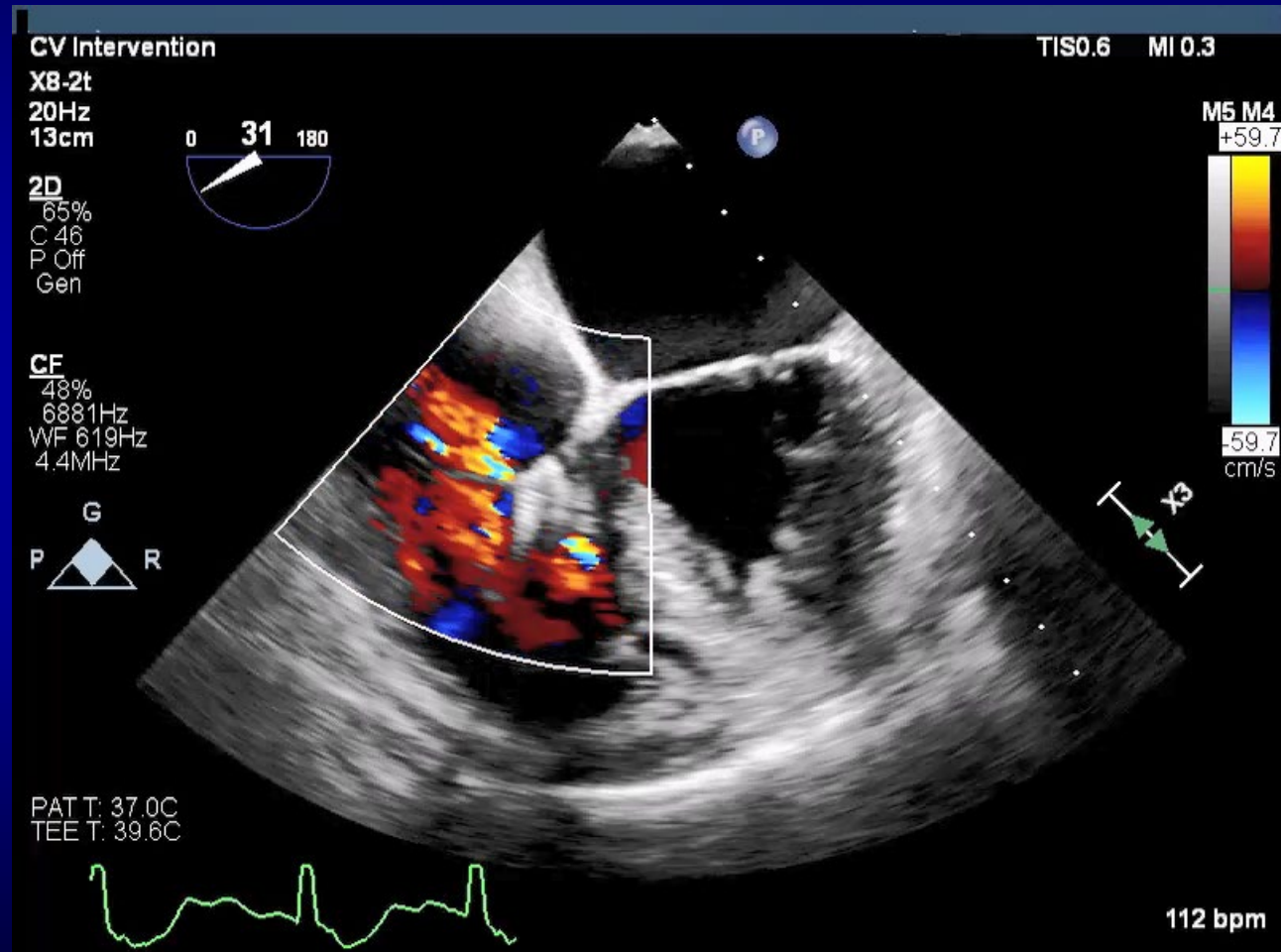
# Second Clip - NT



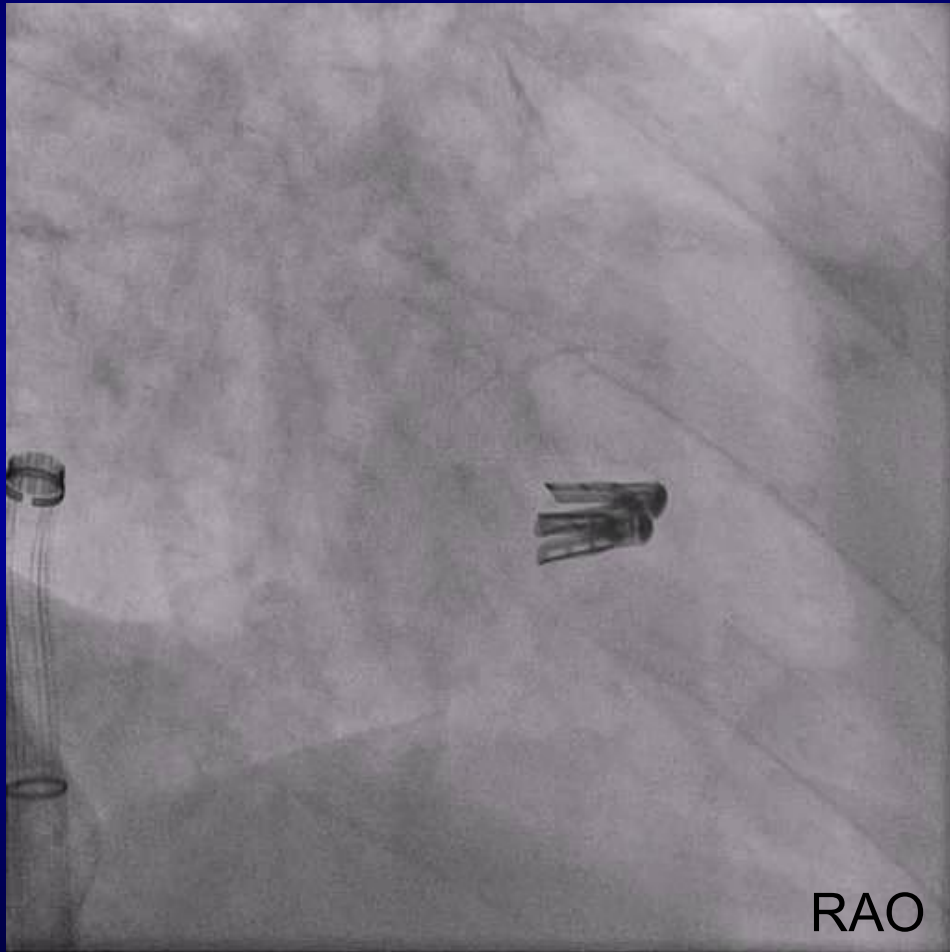
# Closing Clip and TR Assessment



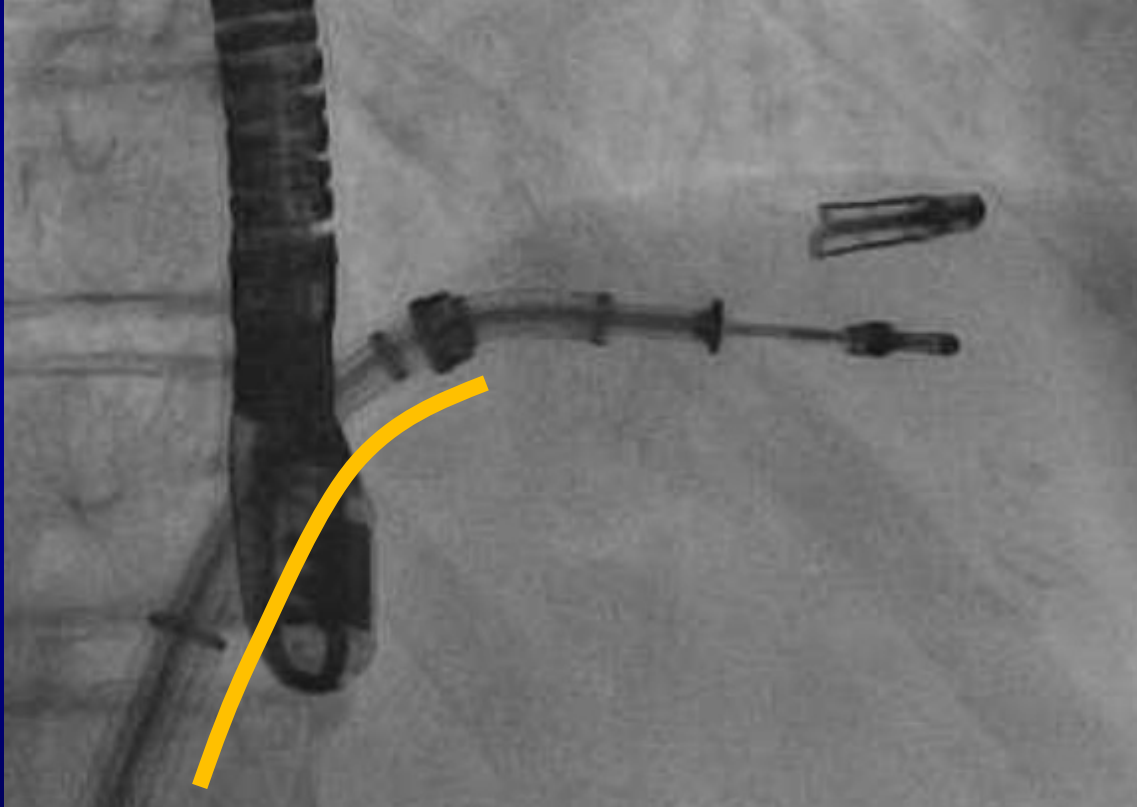
# Final Result



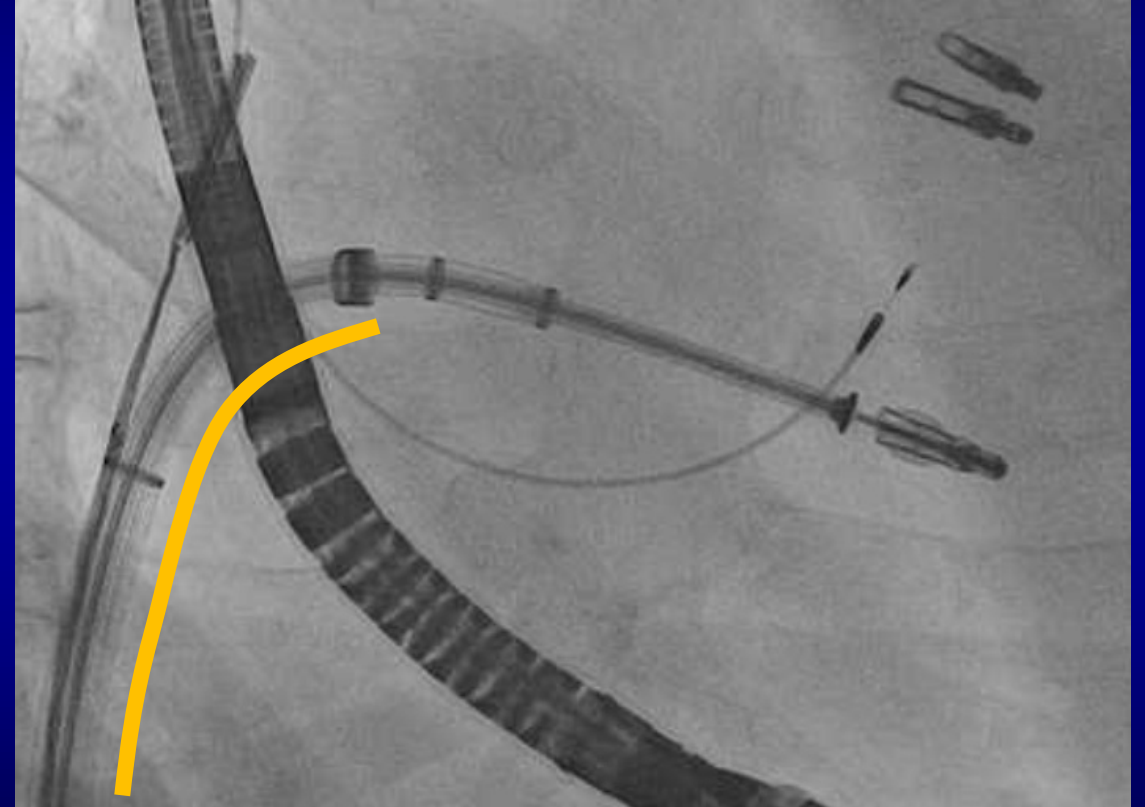
# Final Result



# L Femoral Access to Improve Trajectory?

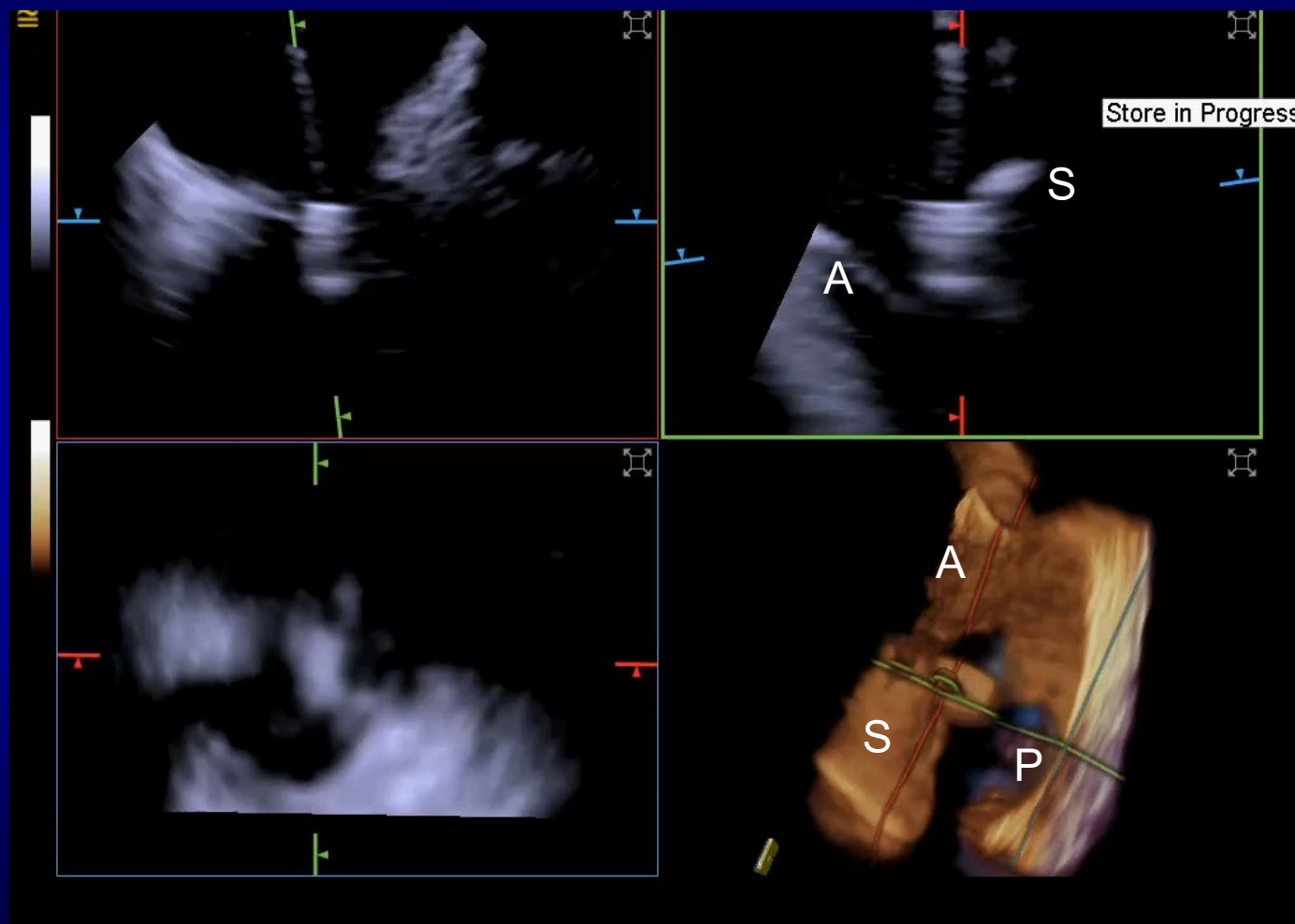


R Femoral: Closer to TV

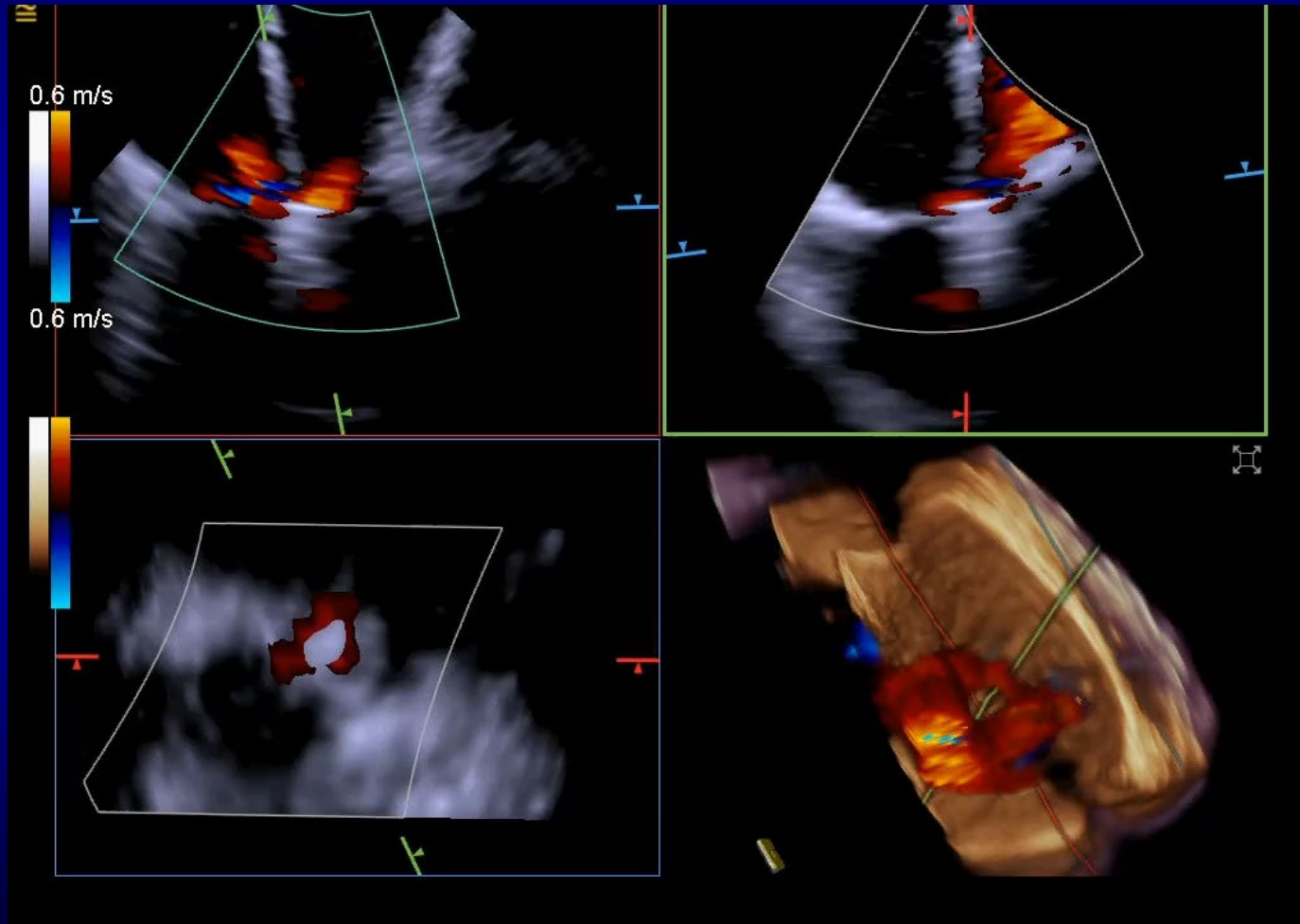


L Femoral: Away from TV, able to stand up the Clip more

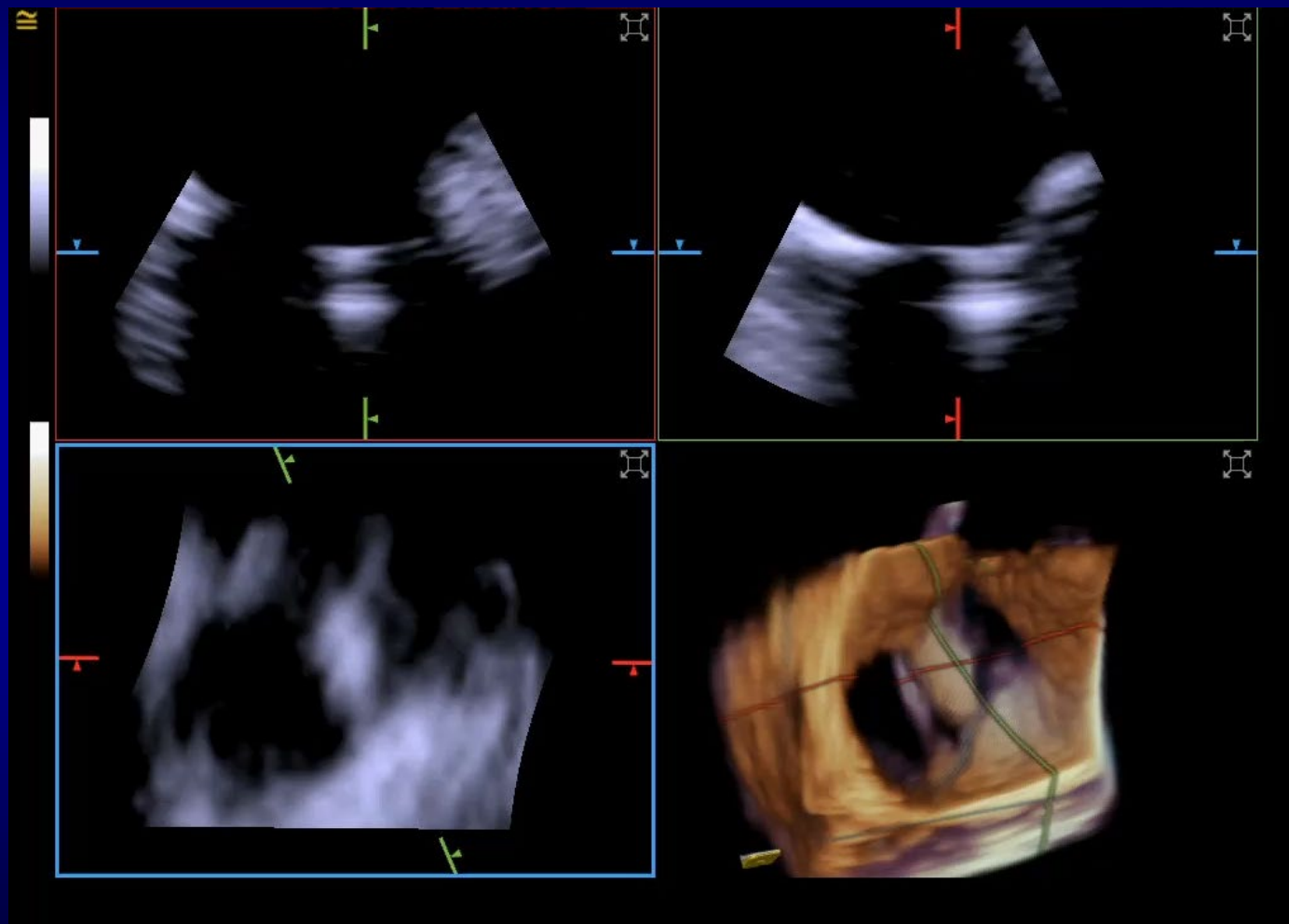
# Use of ICE



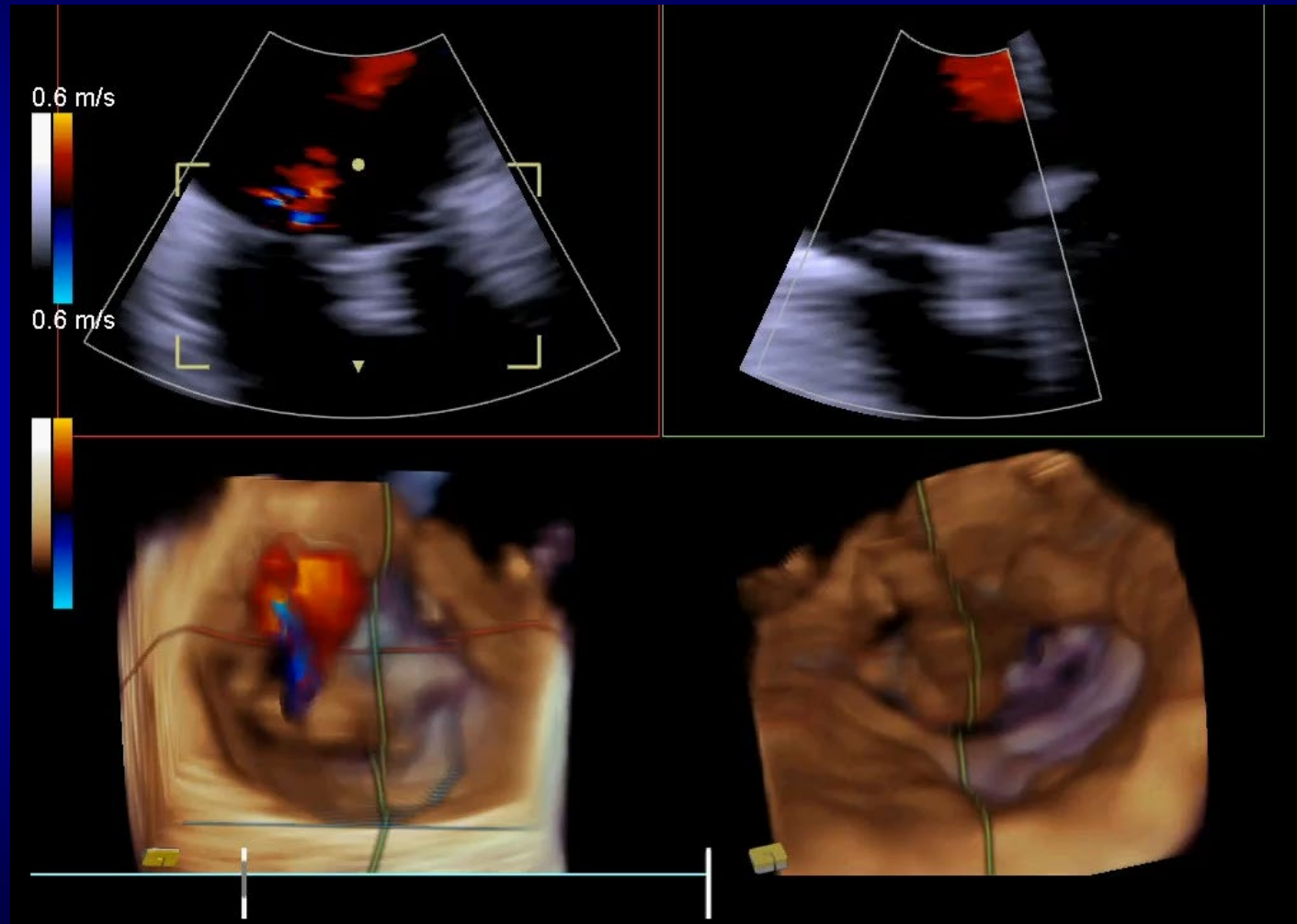
# Confirm TR Reduction on 4D ICE



# Final Clip Position on 4D ICE



# Final TR Assessment on 4D ICE

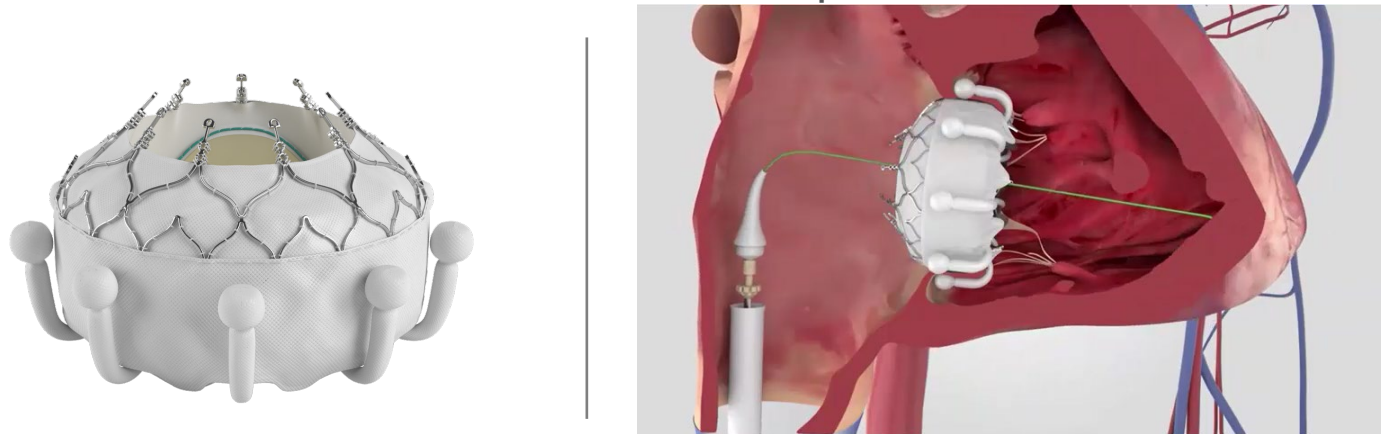


# OUTLINE

- Burden of Severe TR
- Challenges with Managing TR
- Transcatheter Tricuspid Landscape
- Patient Screening and Selection
- Case examples
- ***TTVR***

# EVOQUE: Tricuspid Valve Replacement System

**Unique valve design** engages leaflets, chords, and annulus to achieve secure placement

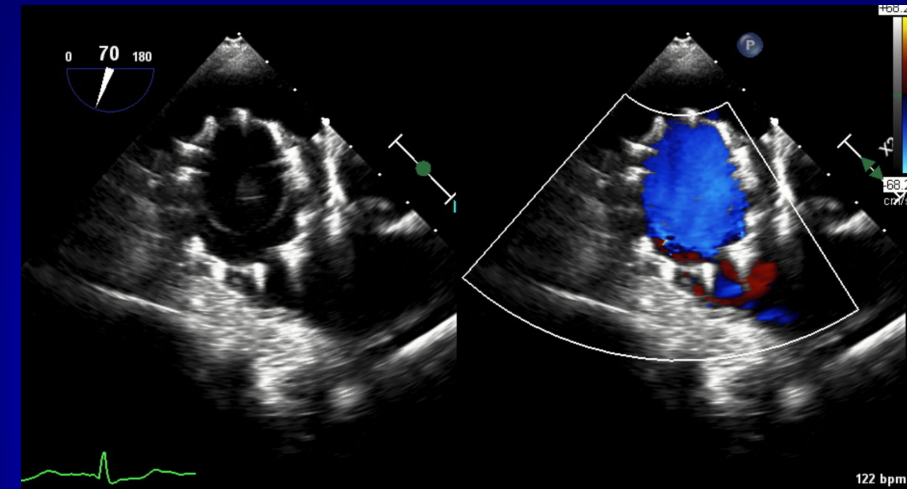


**Atraumatic anchors** compatible with pre-existing leads and respect the native anatomy

**Conforming frame** designed to achieve optimal retention force

**Multiple sizes** offer treatment for a broad range of tricuspid pathologies and anatomies (44, 48, 52 mm)

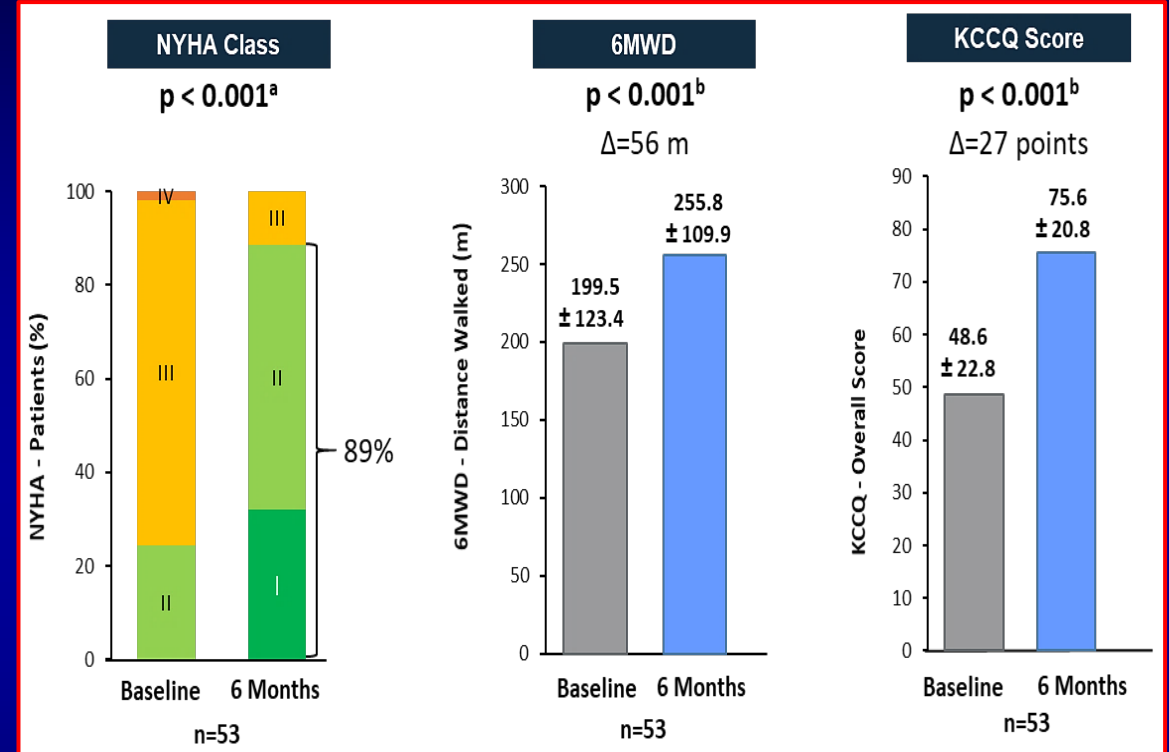
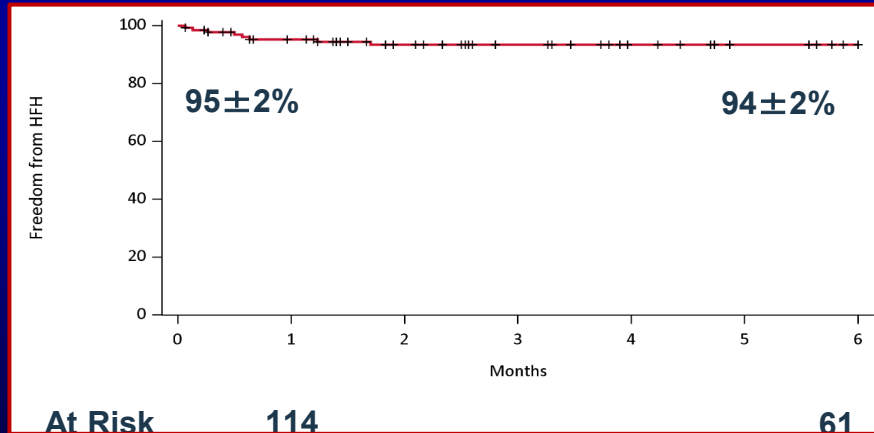
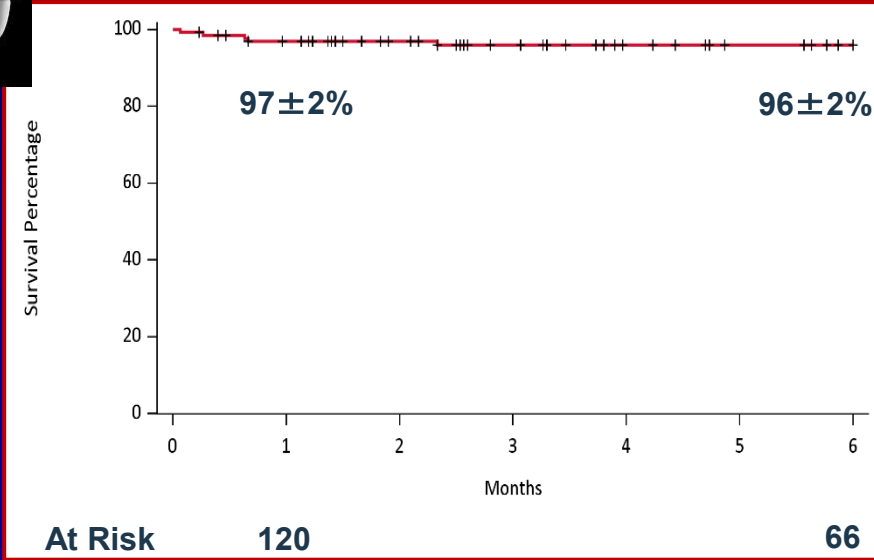
**28F transfemoral delivery system** compatible with all valve sizes



The main complications of EVOQUE

- Valve reintervention in 4%
- New conduction abnormalities requiring permanent PM implantation in 15%
- Major bleeding in 12%.

# TRISCEND Study: Survival, Freedom from HFH Admission and Improved Functional and QOL Outcomes



Early results with the transfemoral EVOQUE system for significant TR showed **high technical success, acceptable safety, TR reduction, and improved symptoms** at 30 days.

<sup>a</sup>Wilcoxon signed-rank test; <sup>b</sup>Paired t-test. NYHA Class, New York Heart Association functional classification; 6MWD, 6-minute walk distance; KCCQ, Kansas City Cardiomyopathy Questionnaire



# TRISCEND II Trial



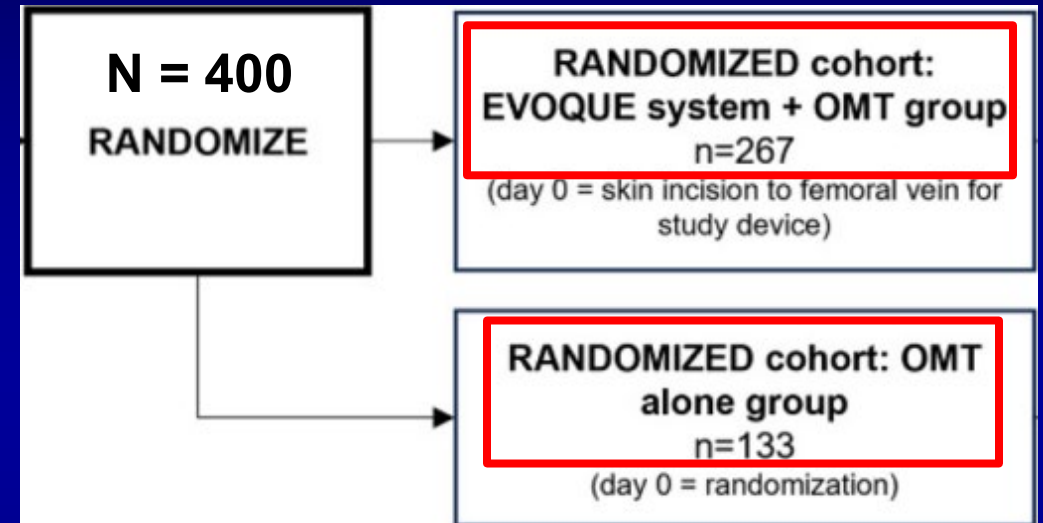
*Edwards EVOQUE Transcatheter Tricuspid Valve Replacement: Pivotal Clinical Investigation of Safety and Clinical Efficacy Using a Novel Device*

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

## Transcatheter Valve Replacement in Severe Tricuspid Regurgitation

R.T. Hahn, R. Makkar, V.H. Thourani, M. Makar, R.P. Sharma, C. Haeffele, C.J. Davidson, A. Narang, B. O'Neill, J. Lee, P. Yadav, F. Zahr, S. Chatterdon, M. Eleid, S. Pislaru, R. Smith, M. Szerlip, B. Whisenant, N.K. Sekaran, S. Garcia, T. Stewart-Dehner, H. Thiele, R. Kipperman, K. Koulogiannis, D.S. Lim, D. Fowler, S. Kapadia, S.C. Harb, P.A. Grayburn, A. Sannino, M.J. Mack, M.B. Leon, P. Lurz, and S.K. Kodali, for the TRISCEND II Trial Investigators\*



- 400 patients with symptomatic, severe TR
- TTVR + OMT vs OMT (2:1 ratio)
- The hierarchical composite primary outcome: all-cause death, implantation of a RV assist device or heart transplantation, postindex TV intervention, HFH, KCCQ.

# TRISCEND II Trial

## Baseline characteristics

**Table 1. Characteristics of the Patients at Baseline.\***

Variable	Valve Replacement (N=259)	Control (N=133)
Atrial fibrillation — no. (%)	249 (96.1)	123 (92.5)
Mean STS mortality score (95% CI) — % <sup>§</sup>		
Patients with mitral-valve repair	6.7 (6.1–7.3)	7.0 (6.2–7.7)
Patients with mitral-valve replacement	9.6 (9.0–10.2)	10.0 (9.1–10.9)
Pacemaker or cardiovascular implantable electronic device — no. (%)	99 (38.2)	53 (39.8)

- Total length of stay for the index hospitalization (IQR) from procedure date: **3.0 days (2.0, 6.0)**

## NEW pacemaker implantation

**Table 2. Safety Outcomes.\***

Safety Event	Early Events (≤30 Days) <sup>†</sup>		Late Events (31 to 365 Days) <sup>‡</sup>		Cumulative Events (0 to 365 Days) <sup>†</sup>		P Value <sup>§</sup>
	Valve Replacement (N=259)	Control (N=133)	Valve Replacement (N=247)	Control (N=128)	Valve Replacement (N=259)	Control (N=133)	
New pacemaker or cardiac implantable electronic device <sup>††</sup>							
In all patients	40 (15.4)	0	5 (2.0)	3 (2.3)	45 (17.4)	3 (2.3)	<0.001
In patients without pre-existing pacemaker <sup>†††</sup>	40/162 (24.7)	0/80	5/118 (4.2) <sup>¶¶</sup>	3/76 (3.9) <sup>¶¶</sup>	45/162 (27.8)	3/80 (3.8)	<0.001

## Medications for full cohort

Medication Class	Valve Replacement			Control		
	Baseline <sup>a</sup> N=258	30 Days <sup>b</sup> N=246	1 Year <sup>b</sup> N=219	Baseline <sup>a</sup> N=133	30 Days <sup>b</sup> N=127	1 Year <sup>b</sup> N=101
Angiotensin-converting enzyme inhibitors (ACEi) — no. (%)	32 (12.4)	9 (6.8)	24 (9.8)	9 (7.1)	20 (9.1)	9 (8.9)
Angiotensin II - receptor blockers (ARB) — no. (%)	65 (25.2)	26 (19.5)	46 (18.7)	23 (18.1)	36 (16.4)	19 (18.8)
Antiarrhythmics — no. (%)	23 (8.9)	7 (5.3)	22 (8.9)	8 (6.3)	14 (6.4)	3 (3.0)
Antithrombotic therapy <sup>c</sup> — no. (%)	249 (96.5)	128 (96.2)	239 (97.2)	123 (96.9)	212 (96.8)	99 (98.0)
Anticoagulant + antiplatelet(s)	48 (18.6)	29 (21.8)	117 (47.6)	27 (21.3)	79 (36.1)	19 (18.8)
At least 1 anticoagulant	224 (86.8)	115 (86.5)	233 (94.7)	110 (86.6)	199 (90.9)	88 (87.1)
No anticoagulation or antiplatelet therapy	9 (3.5)	5 (3.8)	7 (2.8)	4 (3.1)	7 (3.2)	2 (2.0)

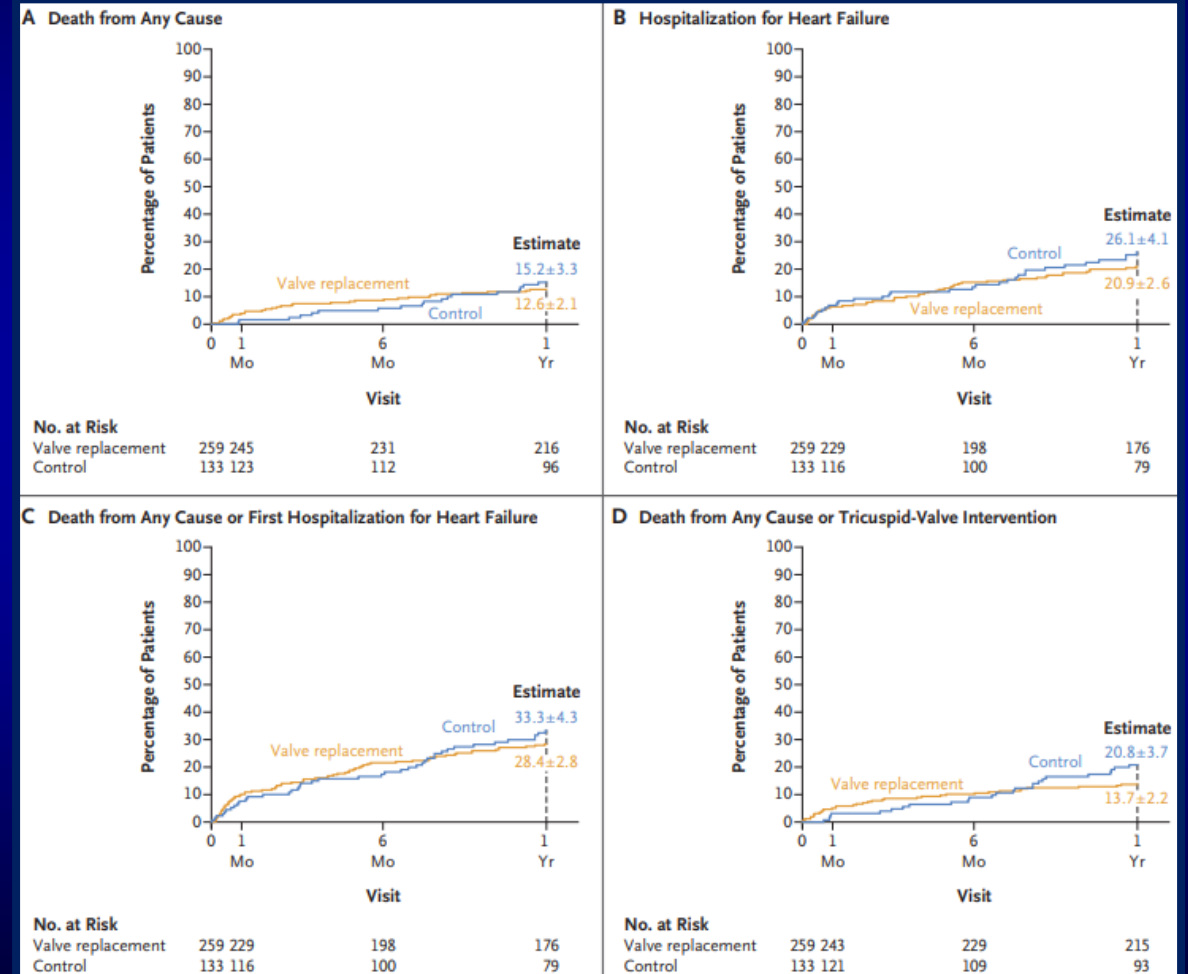
# TRISCEND II Trial

**Win ratio = 2.02 (95% CI, 1.56-2.62)**  
**Finkelstein-Schoenfeld: P<0.001**

## CEC-Adjudicated Clinical Event at 1 Year

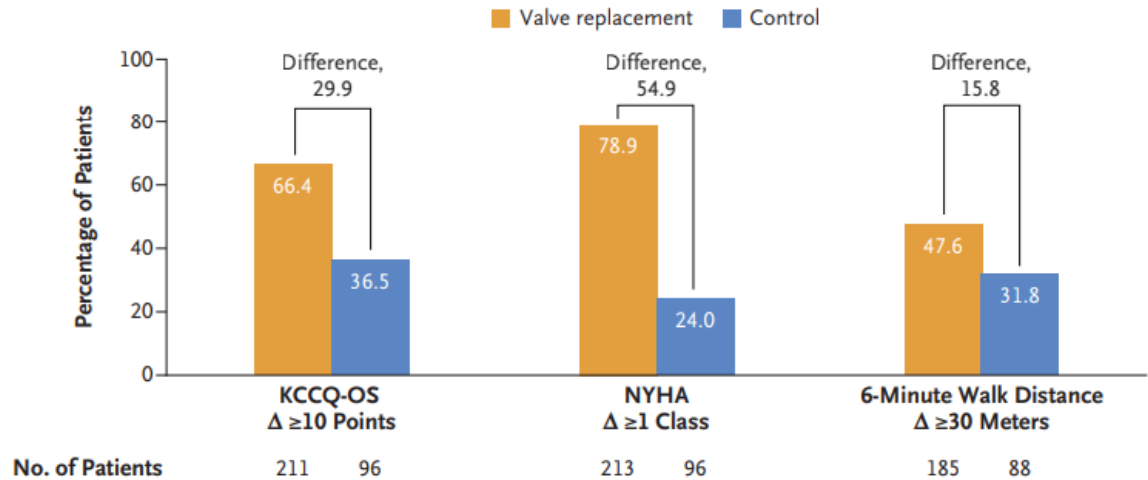
CEC: clinical events committee

	Valve Replacement (N=259) <small>Valve replacement wins</small>	34,447 Patient Pairs Ties <small>% (no. of pairs)</small>	Control (N=133) <small>Control wins</small>
Death from Any Cause (site reported and vital status sweep)	14.8 (5,100)	72.7 (25,050)	12.5 (4,297)
Right Ventricular Assist Device or Heart Transplant (clinical events committee adjudicated)	0	72.7 (25,050)	0
Tricuspid-Valve Intervention (clinical events committee adjudicated)	3.2 (1,105)	68.9 (23,731)	0.6 (214)
Annualized Rate of Hospitalization for Heart Failure (clinical events committee adjudicated)	9.7 (3,340)	49.2 (16,952)	10.0 (3,439)
KCCQ-OS Improvement ( $\Delta$ score $\geq 10$ points)	23.1 (7,959)	20.1 (6,927)	6.0 (2,066)
NYHA Improvement ( $\Delta \geq 1$ class)	10.2 (3,502)	9.1 (3,148)	0.8 (277)
6-Minute Walk Distance Improvement ( $\Delta \geq 30$ m)	1.1 (391)	7.1 (2,459)	0.9 (298)
	<b>62.1 (21,397)</b>		<b>30.7 (10,591)</b>

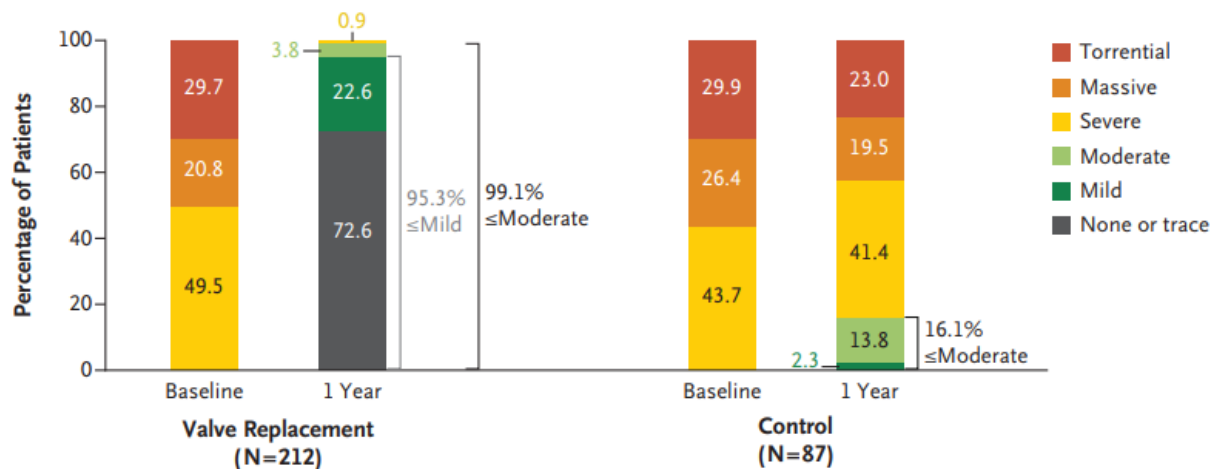


# TRISCEND II Trial

**A** KCCQ-OS, NYHA, and 6-Minute Walk Distance Improvements at 1 Year



**B** Reduction in Tricuspid Regurgitation at 1 Year (paired analysis)



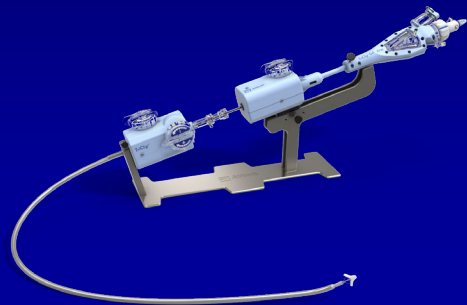
**CONCLUSIONS**

For patients with severe tricuspid regurgitation, transcatheter tricuspid-valve replacement was superior to medical therapy alone for the primary composite outcome, driven primarily by improvements in symptoms and quality of life. (Funded by Edwards Lifesciences; TRISCEND II ClinicalTrials.gov number, NCT04482062.)

- For patients with severe TR, **TTVR was superior to medical therapy alone for primary composite outcome, driven primarily by improvements in symptoms and quality of life.**

# T-TEER vs. TTVR

## T-TEER

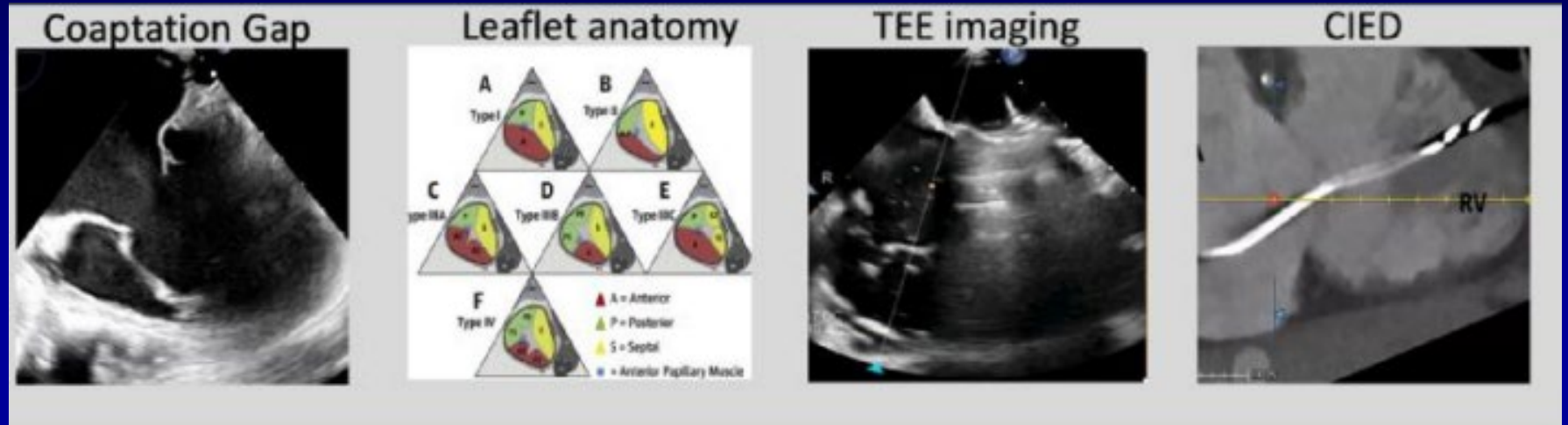


<6-8mm

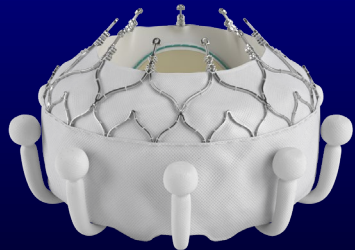
Leaflet mobility+  
Minimal annular dilation

Image quality+

CIED: cardiac implantable electronic device



## TTVR

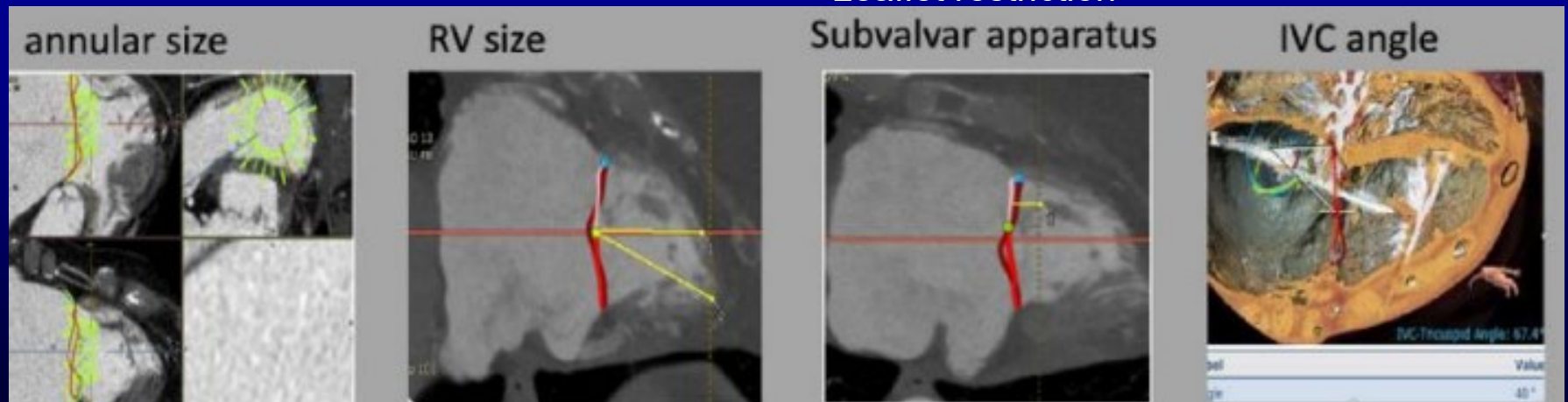


Large annular dilation

RV dilation

Tethering+  
Leaflet restriction

Favorable IVC angle



# Take Home Message

- TR worsens survival and quality of life, with limited surgical options
- Transcatheter therapies (T-TEER, TTVR) offer a less invasive, effective option for high-risk patients, improving symptoms and QOL.
- Smaller gap with better coaptation reserve more straightforward than larger gap / poorer coaptation reserve
  - Anterior-septal leaflets are the most common target
  - 4D ICE complementary to TEE in confirming leaflet insertion, especially in challenging imaging or anatomic situations