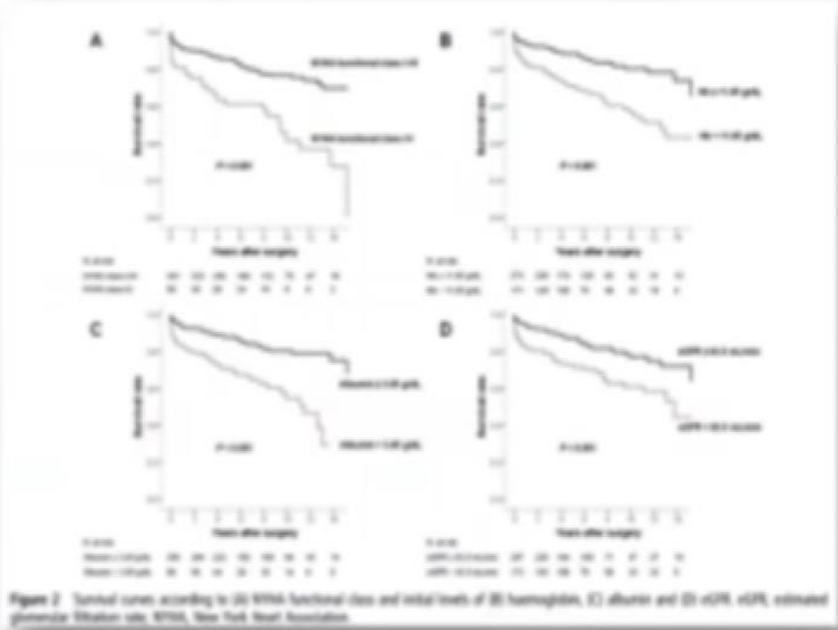
449 consecutive patients who underwent TV surgery (397 repairs and 52 replacements) due to severe TR between 1997 and 2010.

Cox-regression analysis revealed independent determinants of mortality:

- Age (HR=1.03; 95% CI 1.01 to 1.05)
- Male gender (HR=1.96; 95% CI 1.29 to 2.99)
- NYHA functional class IV (HR=2.08; 95% CI 1.31 to 3.30)
- Liver cirrhosis (HR=2.51; 95% CI 1.11 to 5.68)
- Preoperative levels of hemoglobin (HR=0.89; 95% CI 0.80 to 0.99)
- Albumin (HR=0.52; 95% CI 0.33 to 0.81)
- GFR (HR=0.86; 95% CI 0.78 to 0.95)

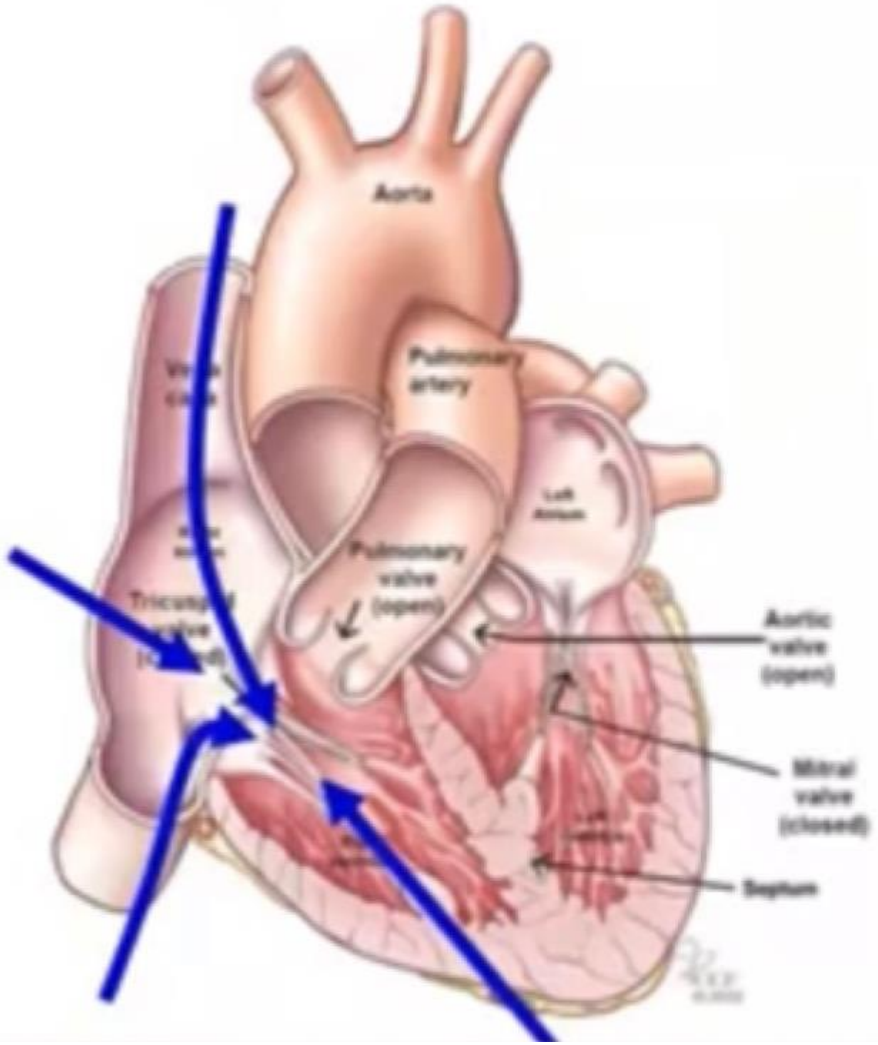
WE OPERATE TOO LATE!!



Procedural type was not predictive of mortality (p=0.58) or causes of TR (p=0.97)

Percutaneous Approaches for Tricuspid Regurgitation

Transcatheter Tricuspid Solutions



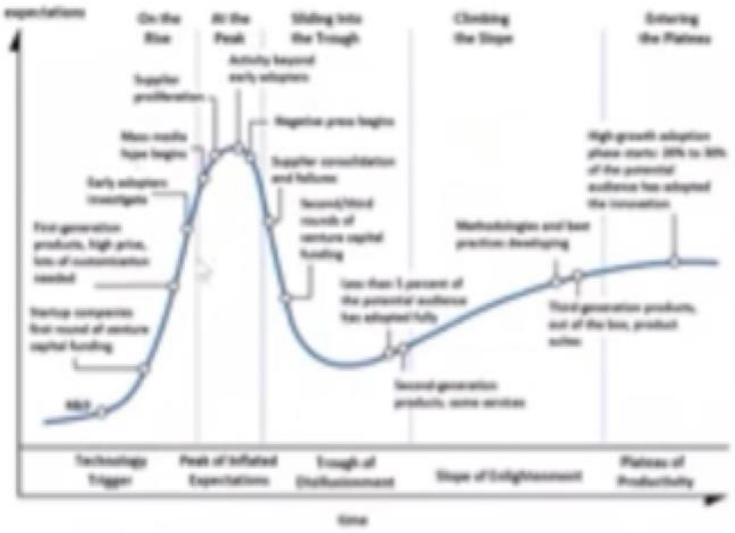
Approaches:

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

Anatomic Target

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

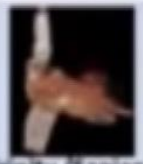
Innovation



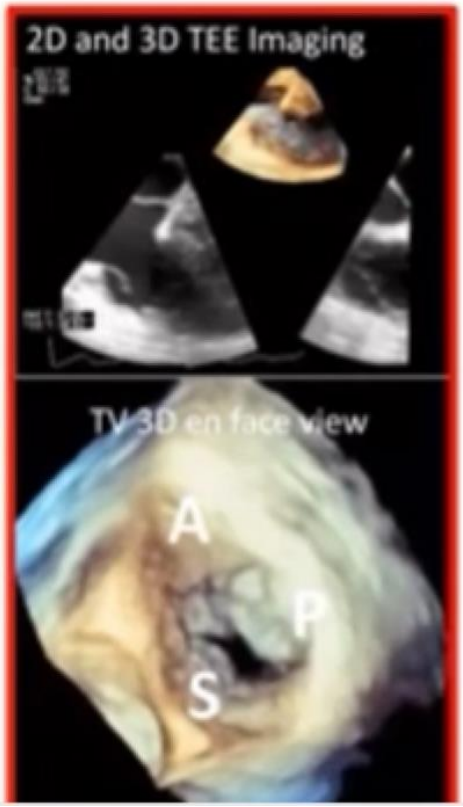
- TR interventions started in the sickest patients
- We learned to safely apply different technologies to reduce TR
- We are still on the rise as technology evolves - moving from patient selection based on technical feasibility to a comprehensive multi-factorial risk stratification

	Kilic et al. (2008-2010)	Alqahtani et al (2011-2014)	Zack et al (2004-2013)	Taramasso et al (2014-2018)
Age	64.9 ± 14.8	61 ± 16	62 (48 -72)	76 ± 8.6
Female sex	58.0%	61%	58%	56%
Prior sternotomy	-	13.4%	12.5%	-
Prior valve intervention	-	-	9.4%	33.5%
Trans-valvular lead	-	-	11.1%	23.4%
COPD	28.4%	18%	-	78%
Atrial Fibrillation	-	57.6%	49.7%	78%
Ascites				28%
Prev admission for RV failure				71%

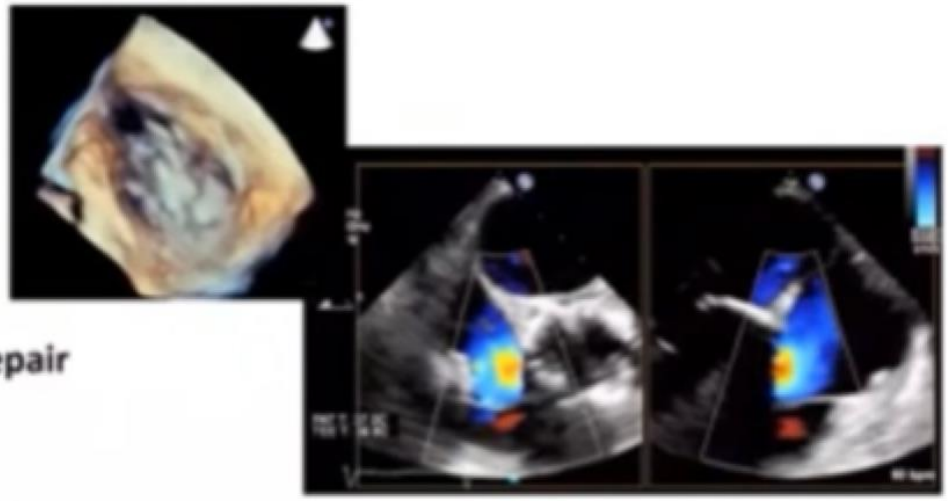
TRANSCATHETER TECHNOLOGIES

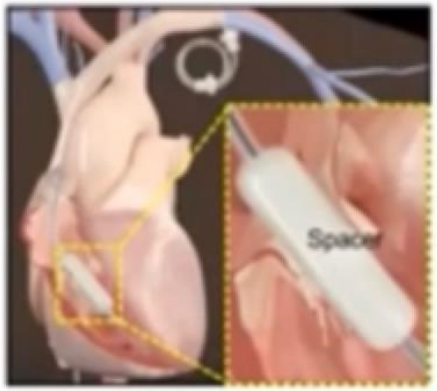
Mechanism	New Technologies
Annuloplasty (Direct and Indirect) Device	 TriAlign  Cardioband  4Tech  Milipede  Pasta  Cardiac Implants  MIA PolyCor Anchors
Leaflet Device	 Forma  MitraClip  PASCAL  Mistral
Heterotopic Valve (in IVC/SVC)	 Trinity /Sapien  TriCentro  SAPIEN in IVC
Orthotopic Valve Replacement	 Navigate  Trisol  LUX  Tri-Cares

Tricuspid Valve Interventions

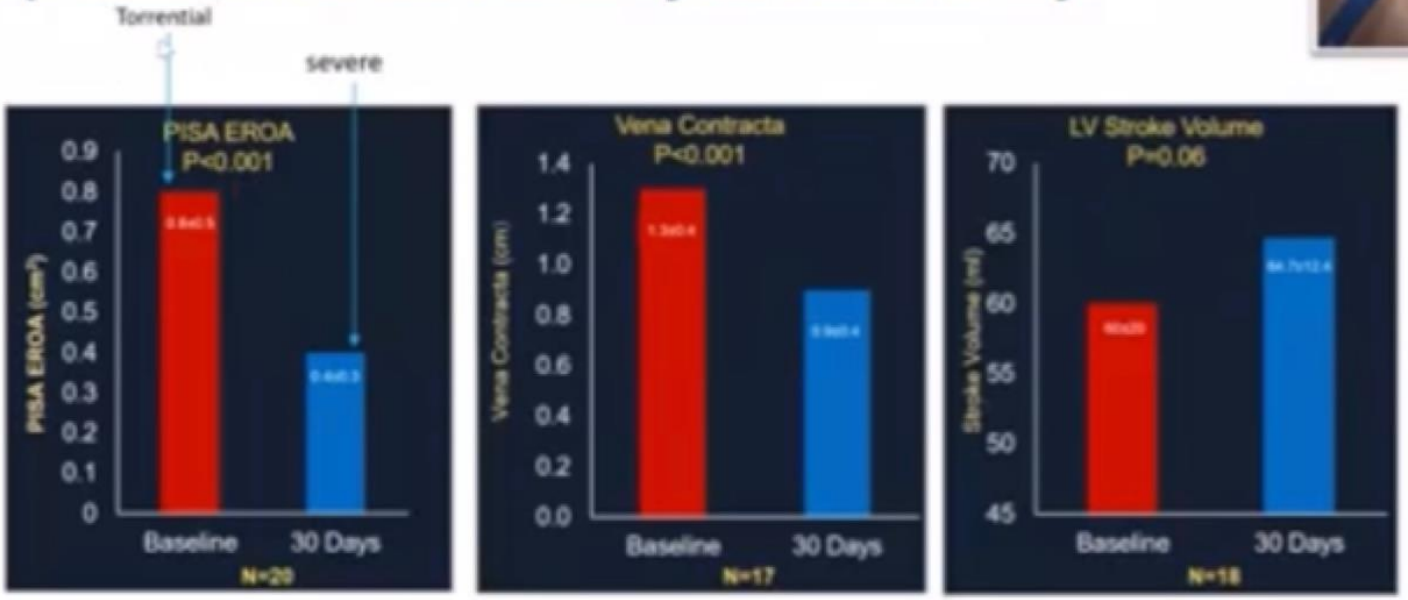


Edge-to-edge Repair



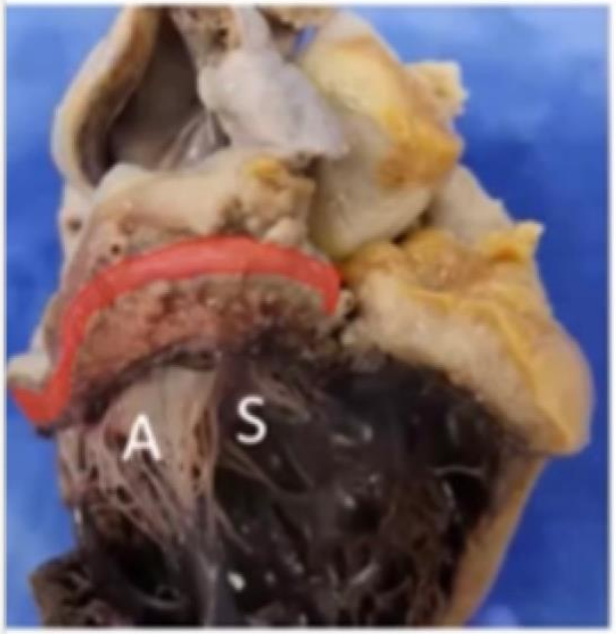


Edwards TRI-REPAIR Study-Cardioband Annuloplasty
50% reduction in PISA EROA, 31% reduction in vena contracta, and 7% improvement in stroke volume by core lab at 30 days

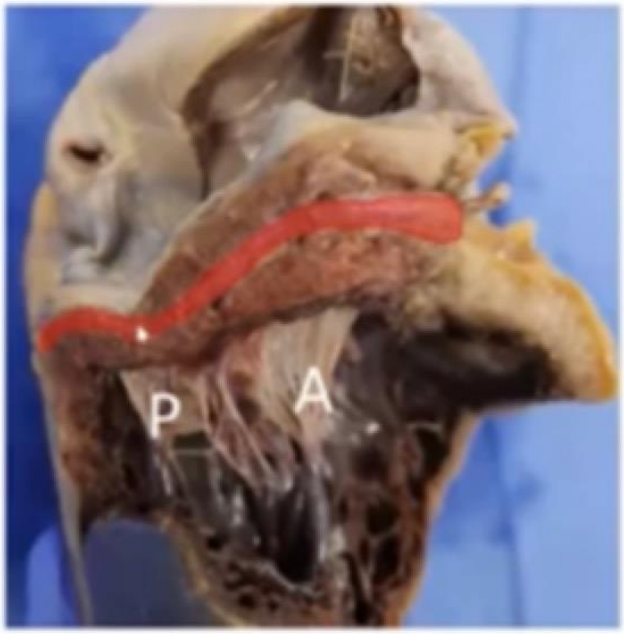


- Large proportion of patients treated with "torrential TR"
- Improvements resulted in most patients achieving lower severity or moderate TR at 30 days.

Cardioband Annuloplasty



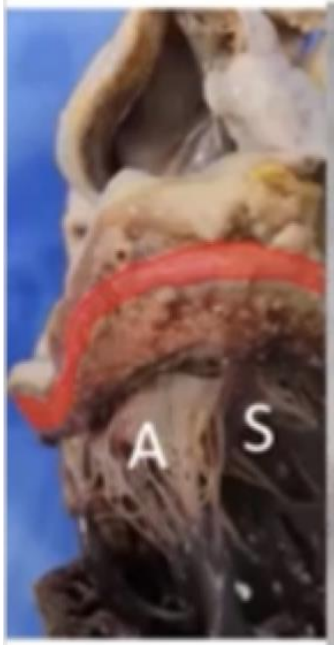
Proximal RCA

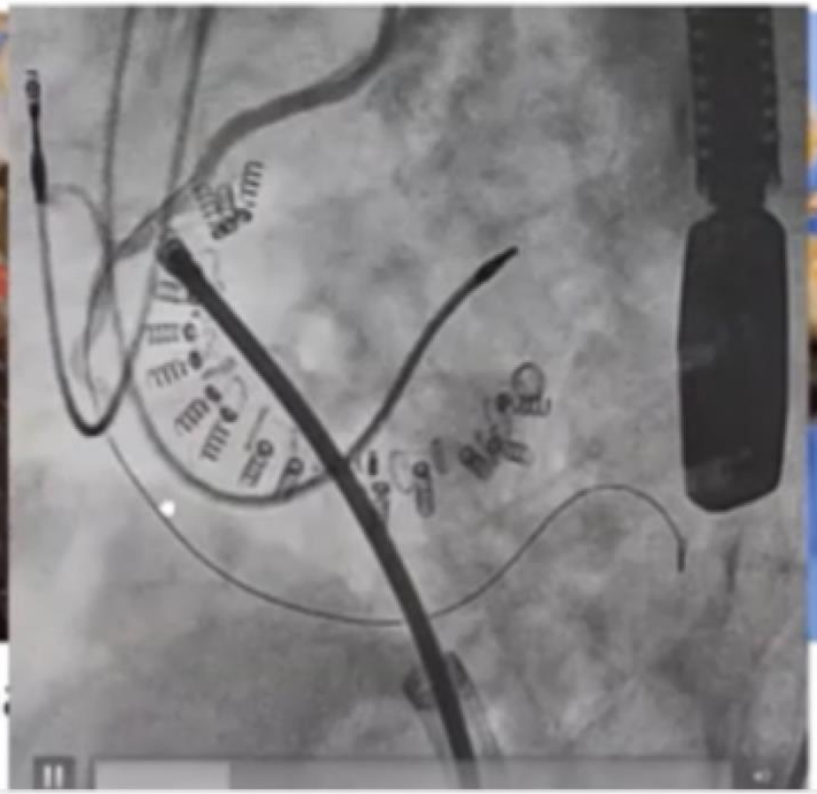


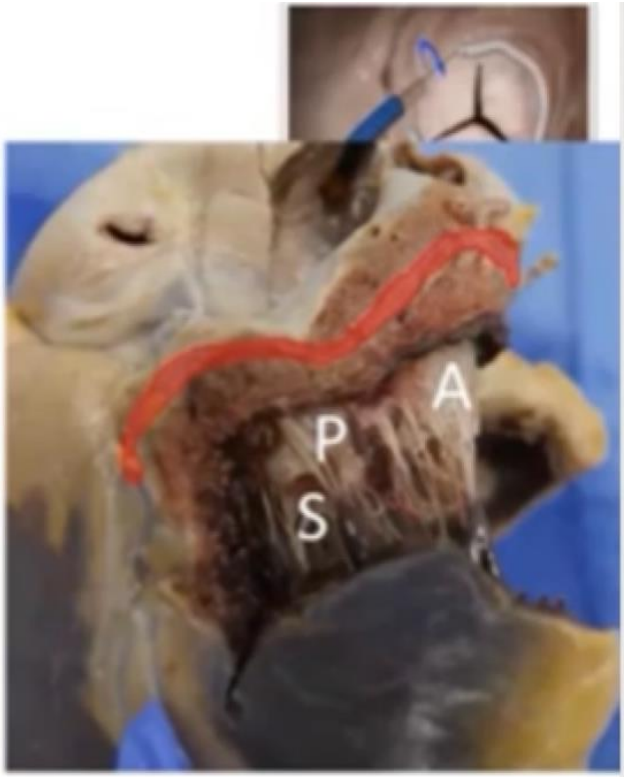
Mid RCA

Distal RCA

Cardioband Annuloplasty







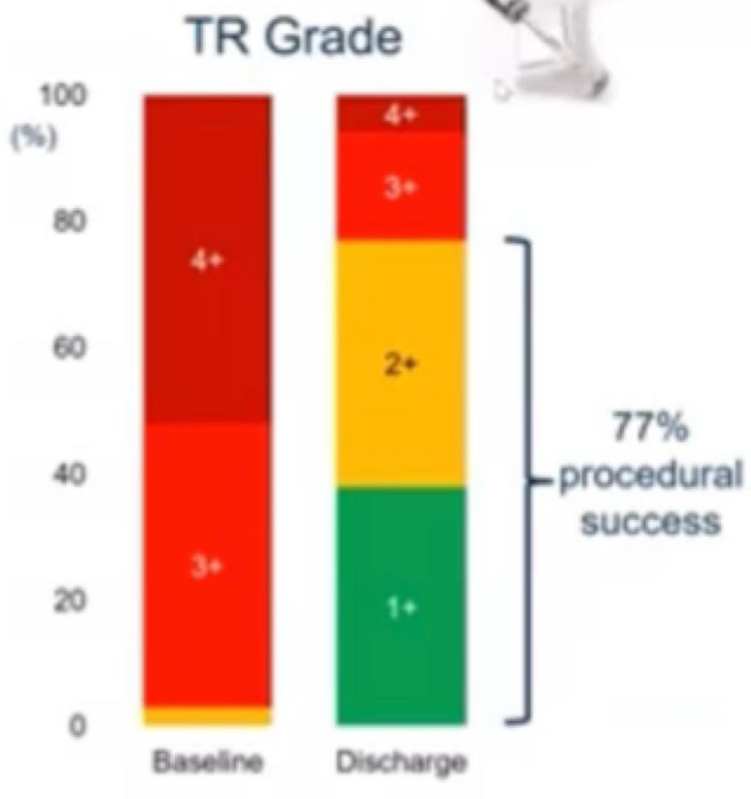
Proxima

Distal RCA

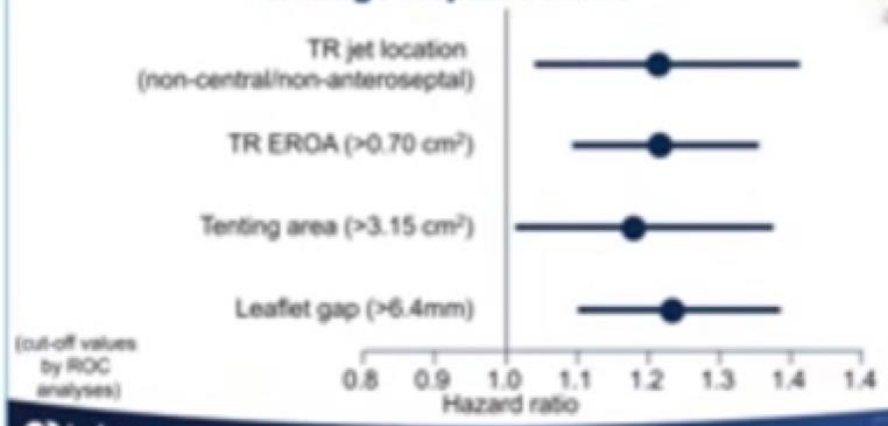
Procedural Results Tricuspid *Edge-to-Edge Repair*

(249 patients)

Number of clips	2 ± 1 (range: 0-5)
Clip location, n (%)	
Antero-septal	162 (65.1%)
Antero-septal + postero-septal	52 (20.9%)
Other	35 (14.0%)
Duration of TR procedure, min	136 ±62
Reduction of ≥1 TR grade, n (%)	222 (89.2%)
Concomitant MR treatment, n (%)	129 (51.8%)



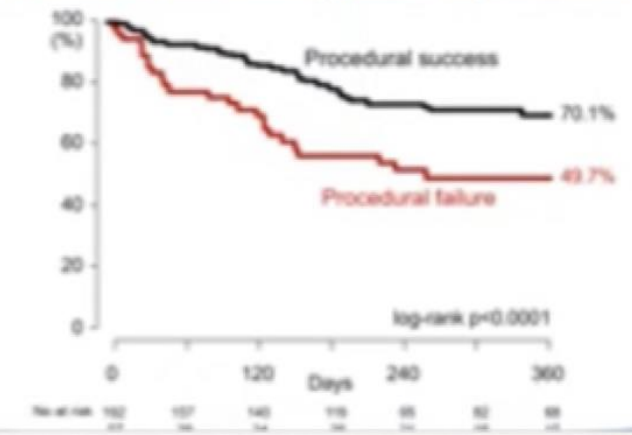
Independent Predictors for Tricuspid Edge-to-Edge Repair Failure



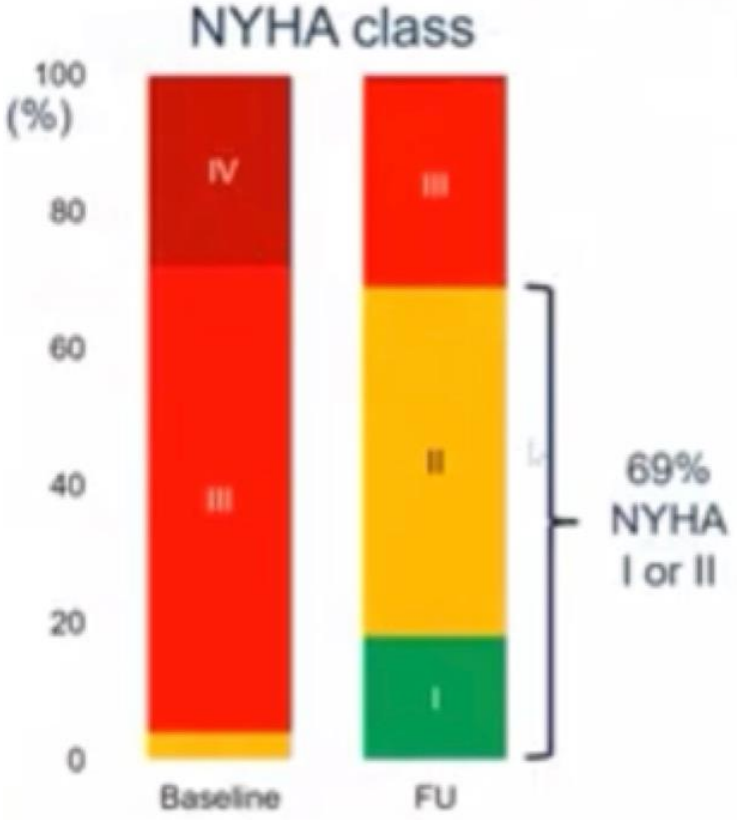
(cut-off values by ROC analyses)

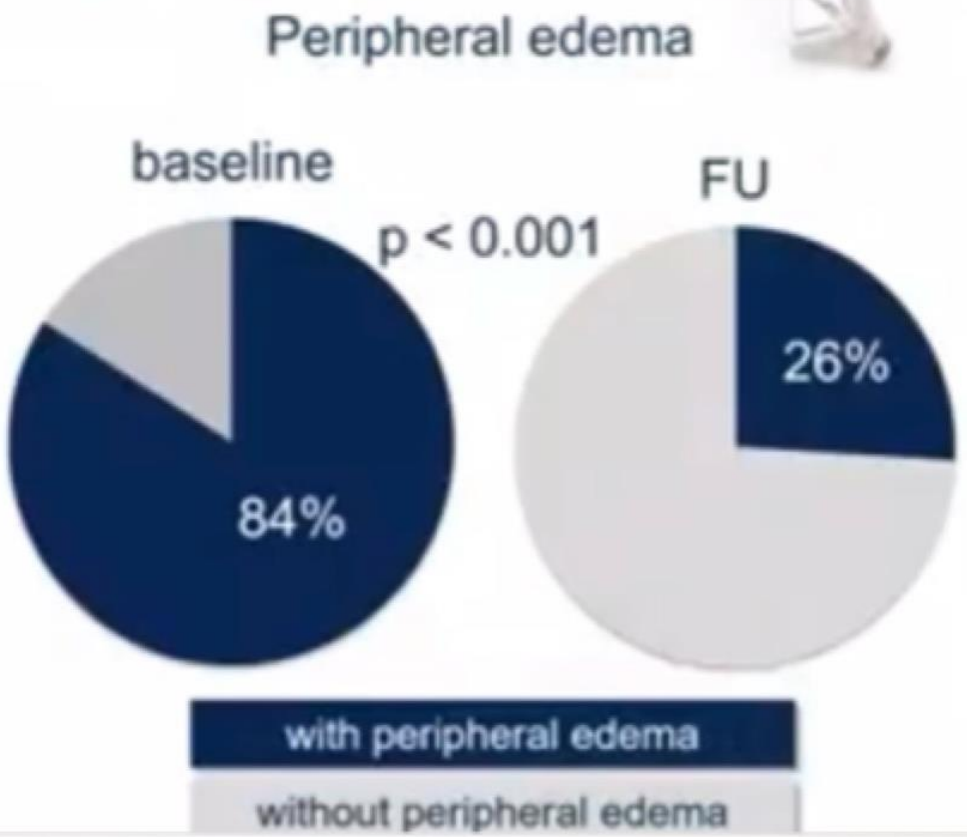
tct2018

Procedural Success and Mortality & Re-Hospitalization



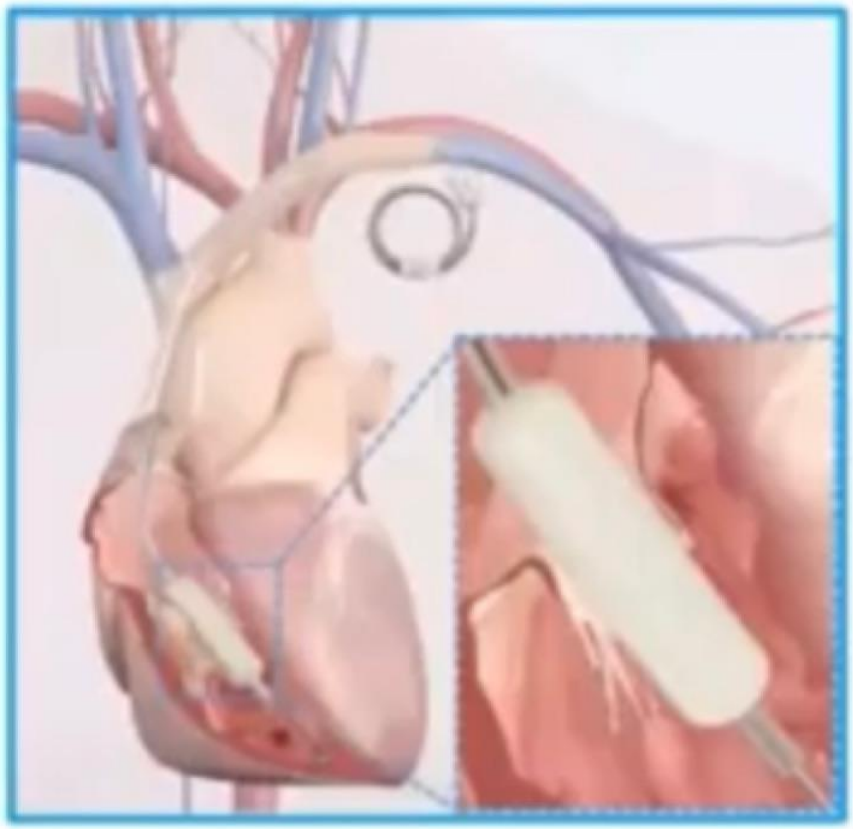
Clinical Improvement



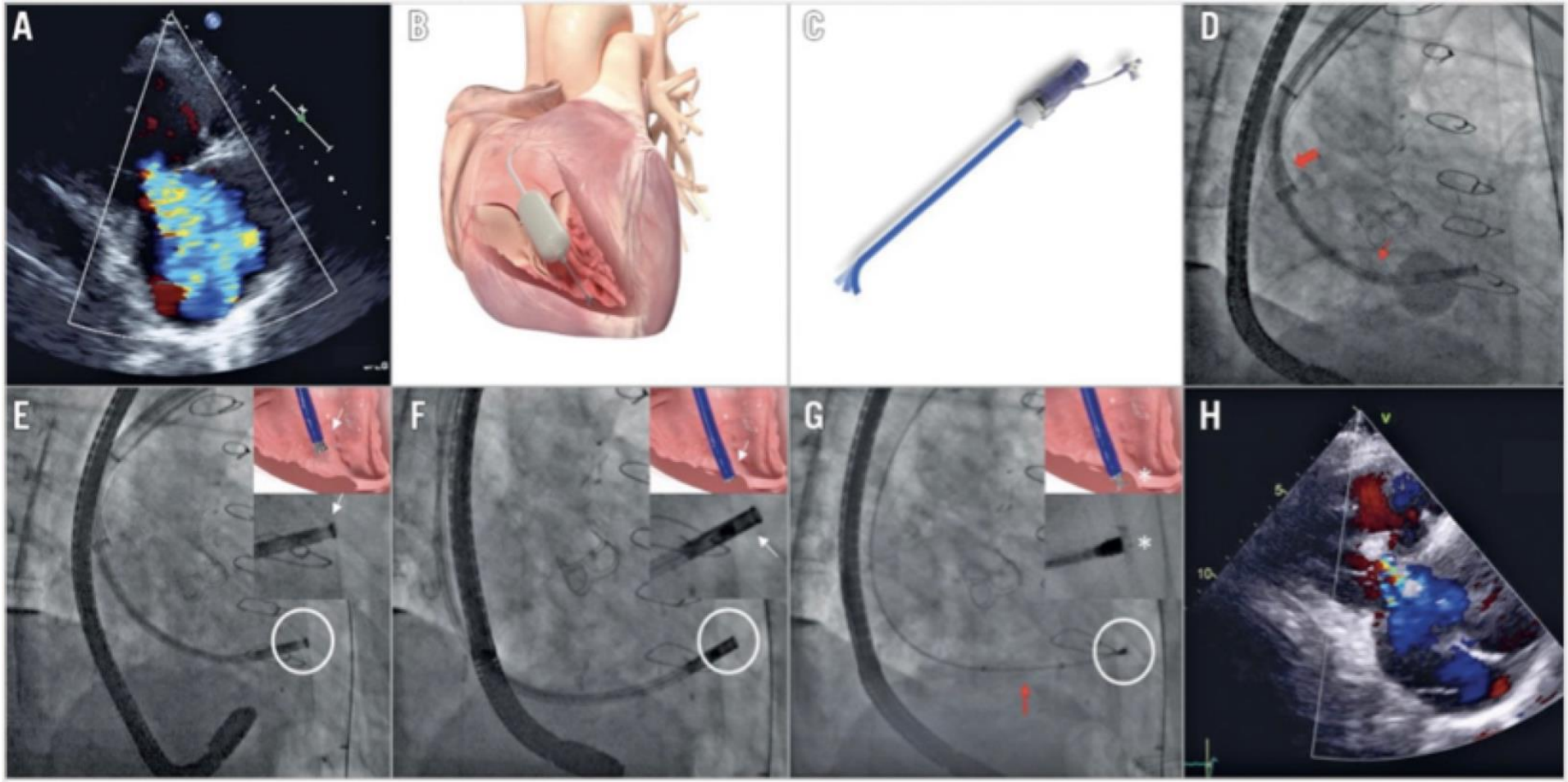



anterior
septal
log-rank p<0.0001
0
120
240
360
Days

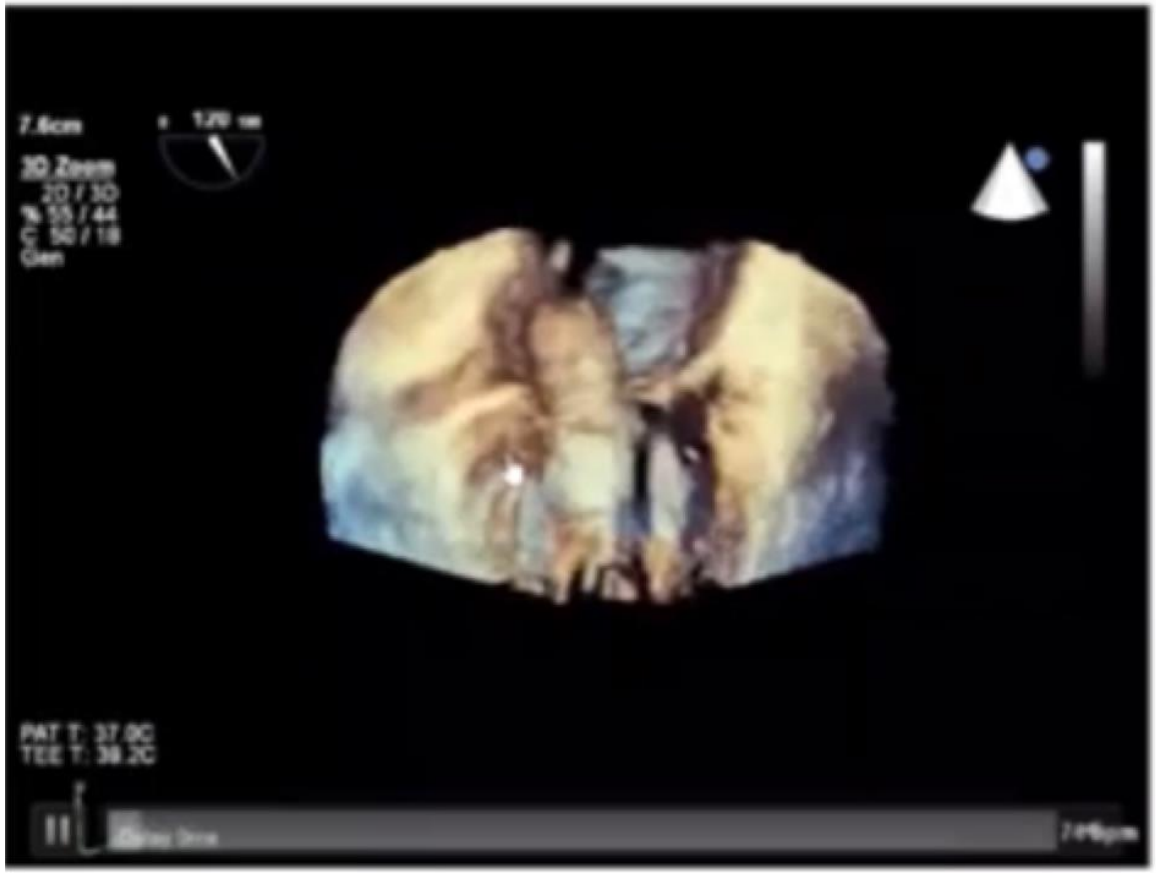
FORMA Tricuspid Valve Therapy System (Edwards Lifesciences)



- Spacer
  - Positioned within regurgitant orifice
  - Provides surface for native leaflets to coapt
  - 12, 15 and 18mm sizes
  - Advanced from left subclavian vein
- Rail
  - Tracks Spacer into position
  - Anchored at RV apex and subclavian vein


A
B
C
D
E
F
G
H

Final Assessment



Final ERO - .74 cm^2 (Pre – 1.72 cm^2)

No Tricuspid Stenosis – (mean gradient 0.6 cm^2)

US Feasibility Trial Results

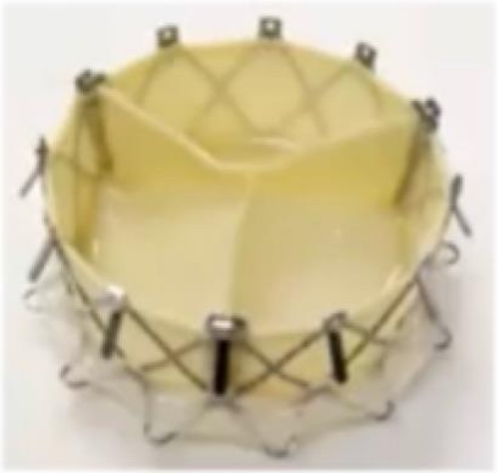
- Successful implant in 93% of patients
- Acute procedural complications
  - 2 RV perforations
  - 3 anchor migrations

  } Two deaths
- ~ 50% reduction in TR severity by 3D EROA (majority of patients with either massive or torrential TR)
- Improvement seen in LV stroke volume and decrease in RV size at 30 days
- Clinical improvement sustained out to one year
  - > 20 point increase in KCCQ
  - 6MWT time improved by 40 meters

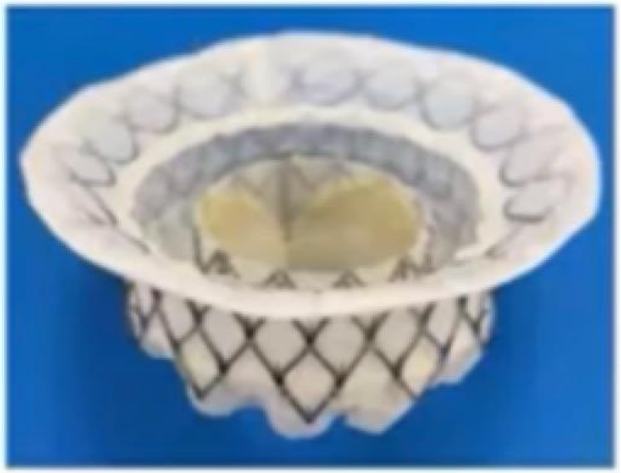
Challenges

- Stable safe anchor placement (2 acute RV injuries and 3 late migrations)
- Assessing and confirming adequate TR reduction after placement of FORMA device (3D EROA probably most accurate mechanism to assess but ability to obtain adequate images limited in study)
- Obtaining predictable stable TR reduction with precise placement of spacer, especially in patients with baseline torrential TR

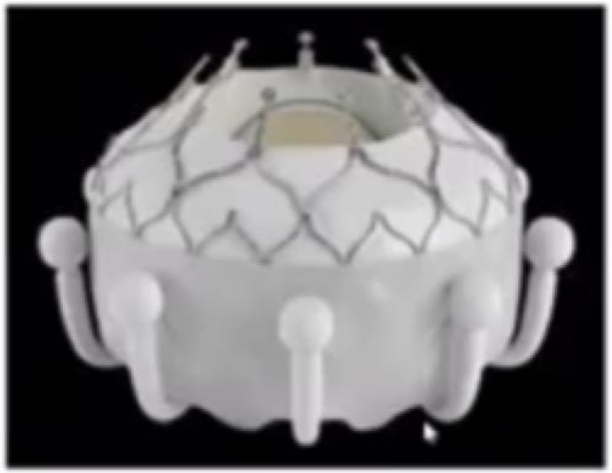
Transcatheter TV Replacement



Navigate

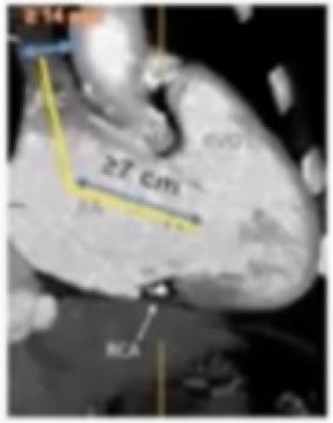


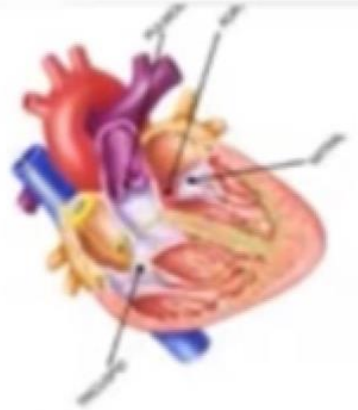
Intrepid

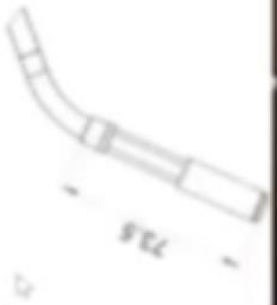


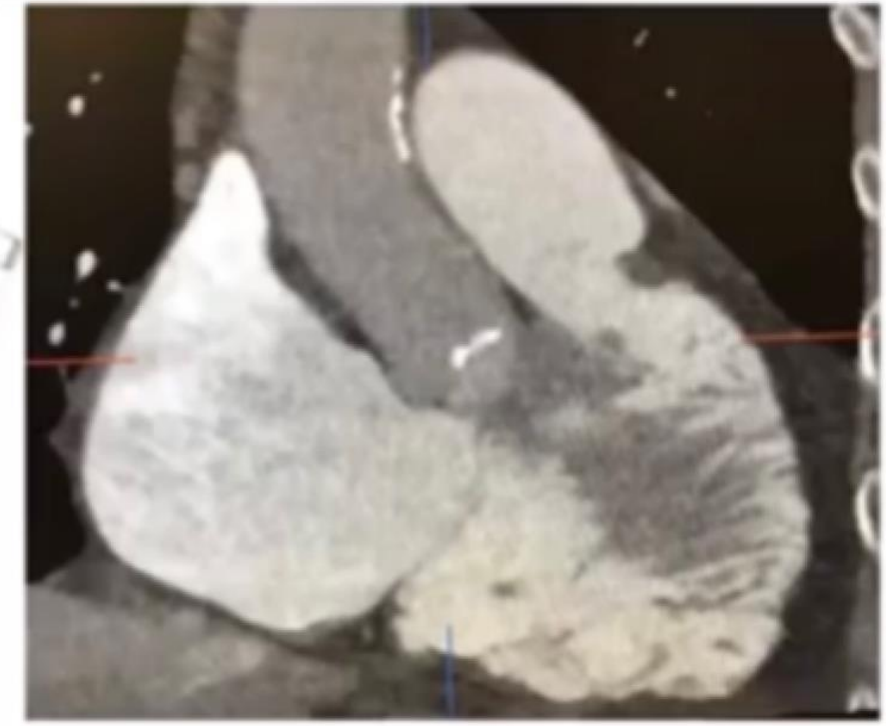
Evoque

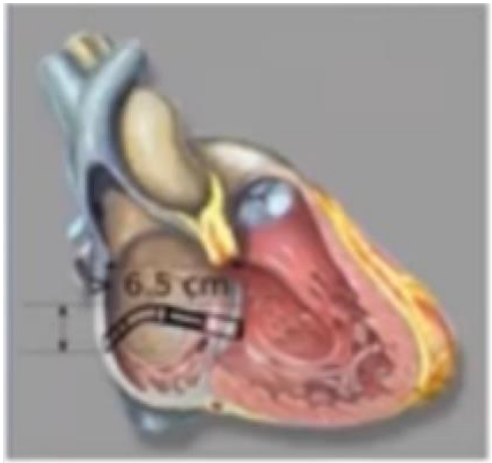
Trans Jugular Requirements

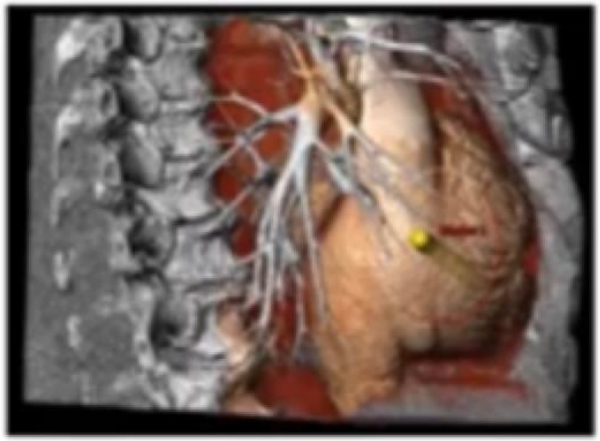


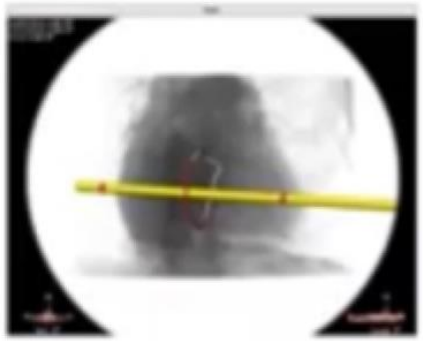


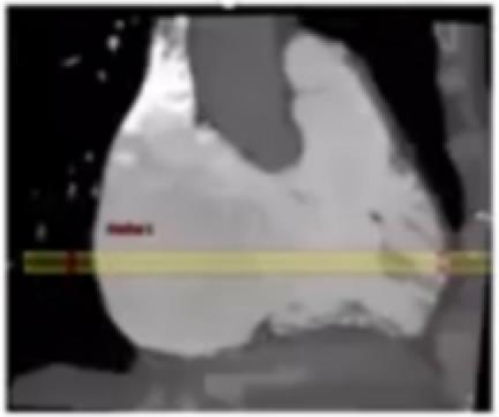


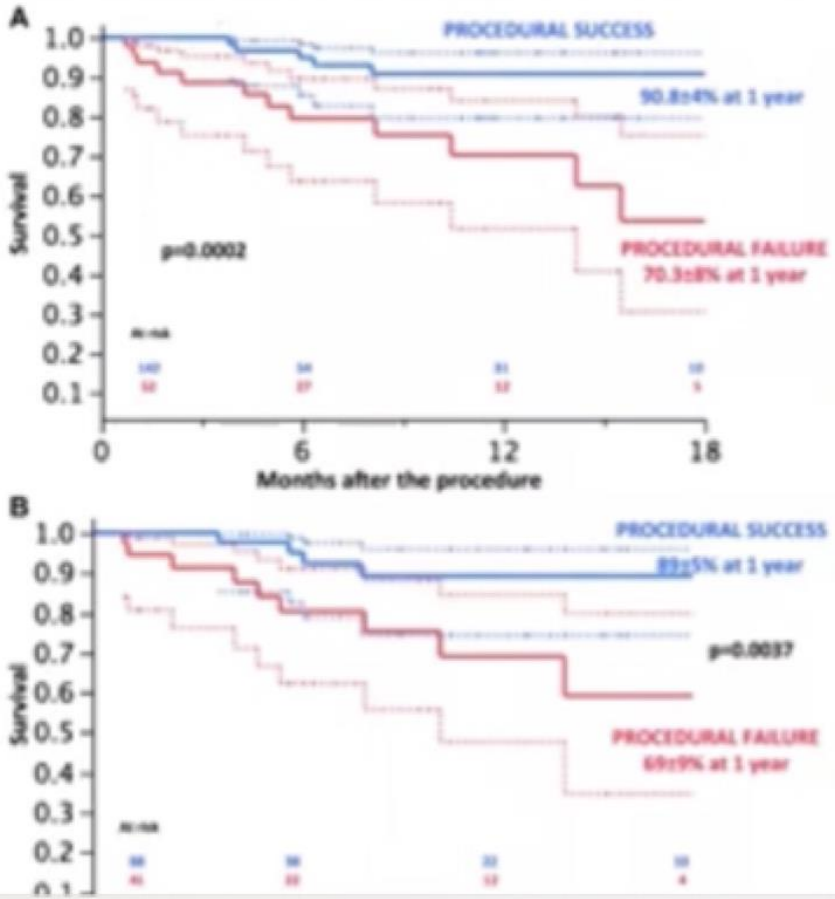



6.5 cm









Procedural success

- Procedural success (defined as the device successfully implanted and residual TR ≤2+) was 72.8%.
- Greater coaptation depth (odds ratio: 24.1; p = 0.002) was an independent predictor of reduced device success.
- Thirty-day mortality was 3.6% and was significantly lower among patients with procedural success (1.9% vs. 6.9%; p = 0.04); Actuarial survival at 1.5 years was 82.8 ± 4% and was significantly higher among patients who had procedural success achieved.
- A baseline coaptation depth >1 cm was identified as the best cutoff to predict the risk for procedural failure, with a sensitivity of 73.9% and a specificity of 60% (area under the curve 0.66).

Table 3. A summary of the available clinical data on percutaneous transcatheter devices for FTR.

	FORMA (n=18)	Trialign (n=15)	MitraClip (n=64)	TriCinch (n=24)	Cardioband (n=20)	CAVI (n=25)	NaviGate (n=27)	Millipede (n=2)
Age (years)	76	74	77	71	75	74	75	N/A
Females (%)	72	87	55	N/A	75	52	50	N/A
Secondary TR (%)	100	100	88	100	100	96	100	N/A
Atrial fibrillation (%)	89	67	84	N/A	61	N/A	N/A	N/A
LVEF (%)	59	60	47	N/A	54	51	N/A	N/A
Logistic ES (%)	9	N/A	28	12	5	18 (II)	N/A	N/A
Previous cardiac surgery (%)	72	N/A	40	N/A	45	76	75	N/A
30-day mortality (%)	0	0	7	0	10	12	9	0
30-day technical success (%)	89	80	97	75	100	92	89	100
Dislocation/dehiscence (%)	6	20	0	17	0	6	N/A	0
Residual moderate-severe TR (%)	64	N/A	72	45	20	N/A	0	0
Reduction in RegVol (ml)	N/A	23	26	N/A	38	N/A	N/A	N/A
Annular reduction (%)	8	5	13	N/A	27	1	N/A	44
NYHA Class I-II (%)	93	100	31	75	73	53	N/A	N/A
Change in 6MWT	+84 m	+53 m	+16 m	+53%	+58 m	N/A	N/A	N/A

6MWT: six-minute walk test; ES: EuroSCORE; FTR: functional tricuspid regurgitation; LVEF: left ventricular ejection fraction; NYHA: New York Heart Association; RegVol: regurgitation volume; TR: tricuspid regurgitation

When to Intervene will depend on our ability to accurately measure:

1. **TR severity and TV morphology**
2. **Right heart function and RV-PA coupling**

Comprehensive Evaluation of Secondary Tricuspid Regurgitation

Tricuspid Regurgitation Severity
- Qualitative Doppler parameters
- Vena contracta width (biplane average)
- Quantitative Assessment:
  - PISA EROA and RegVol
  - Quantitative Doppler EROA and RegVol
  - 3D vena contracta area and RegVol

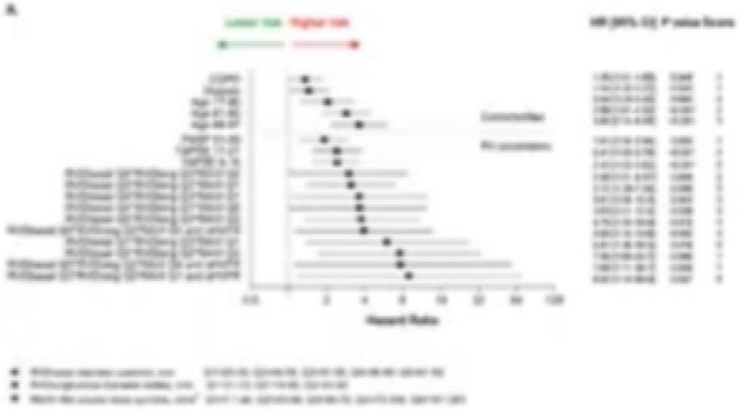
Tricuspid Annular Dilatation
- Annular diameter
- Annular area
- Change in dynamism

Leaflet Tethering
- Tenting length and area
- Tenting volume (3D echo)
- Leaflet angles

RV-PA Coupling
- Pulmonary artery pressures and resistance
- RV-PA Coupling
  - RV contractility indexed to afterload

Left Heart Size and Function
- Measures of LA and LV size
- Multiparametric assessment of LA and LV function
- Concomitant left valve disease

Right Ventricular Remodeling and Function
- RV size (2D and 3D)
- Multiparametric assessment of regional and global RV function:
  - TAPSE
  - S'TDI
  - FAC
  - RV dP/dT
  - 2D-longitudinal strain
  - 3D-RVEF
  - 4D flow



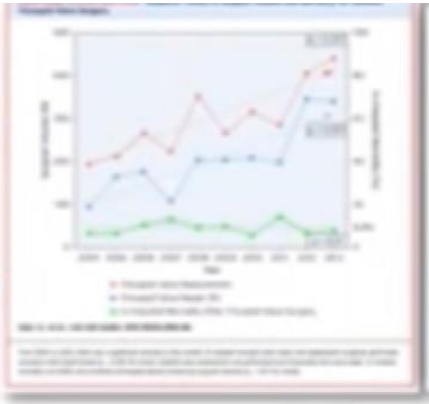
Transcatheter TV Therapy: No longer forgotten …

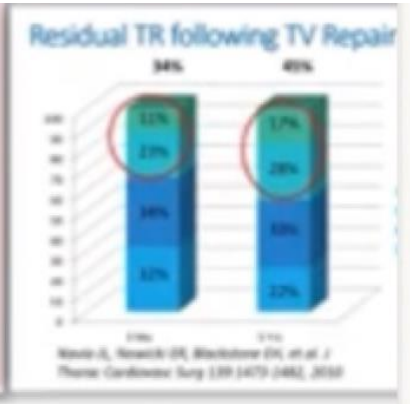
When to intervene and when not to intervene in tricuspid regurgitation is a "work in progress"

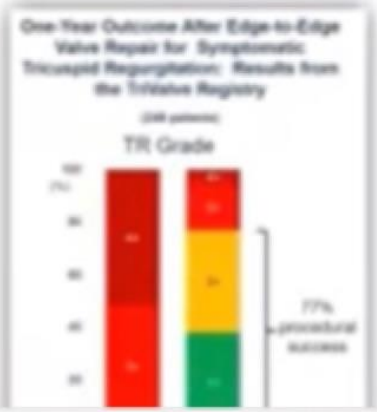
1. **Earlier in the disease process**
2. **Patient-specific anatomy**

Which Device:

1. **High Safety profile**
2. **Adequate Efficacy**







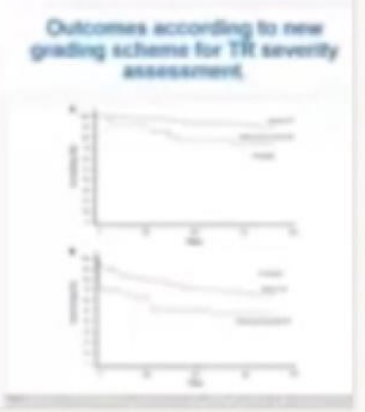
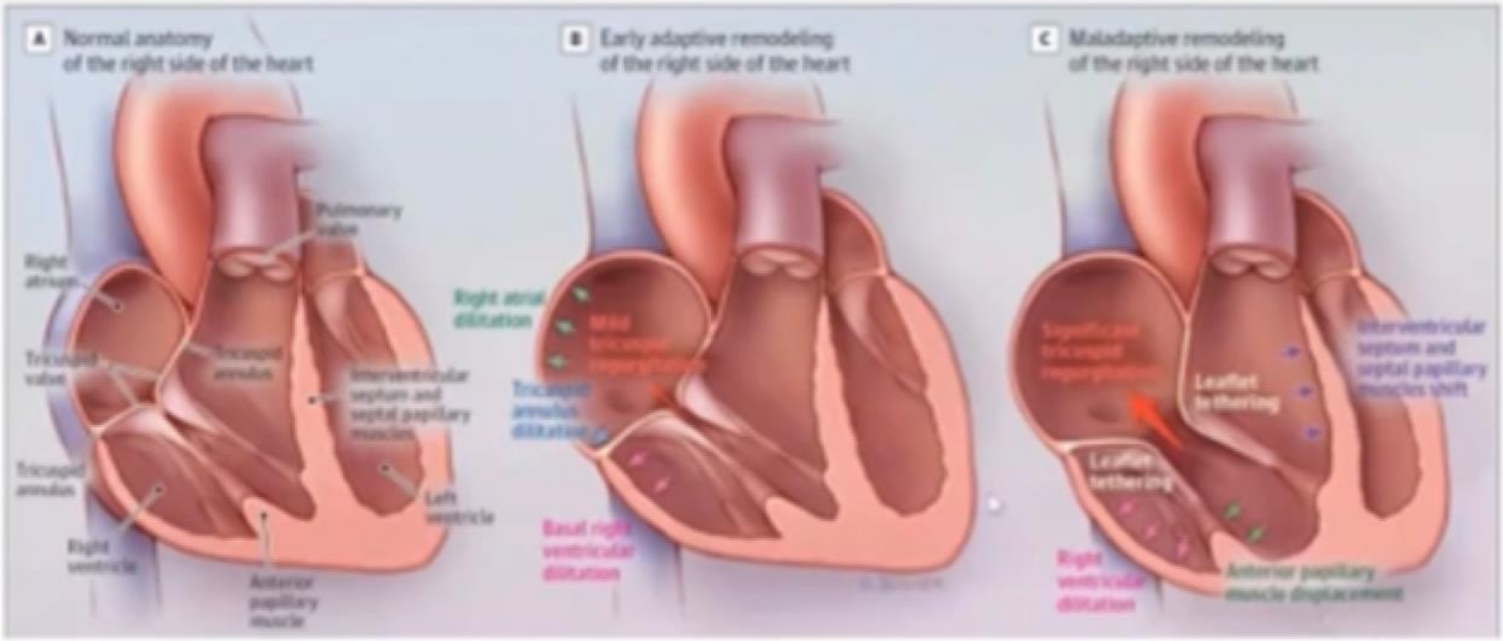


Figure 2. Schematic of the Changes Associated With the Progression of Tricuspid Regurgitation



Early

Initial Right Ventricular (RV) dilatation results in Tricuspid Annulus (TA) dilatation

Annular Device
Leaflet Device
Replacement Device

Progressive

Progressive RV and TA dilatation results in lack of leaflets coaptation

± Annular Device
Leaflet Device
Replacement Device

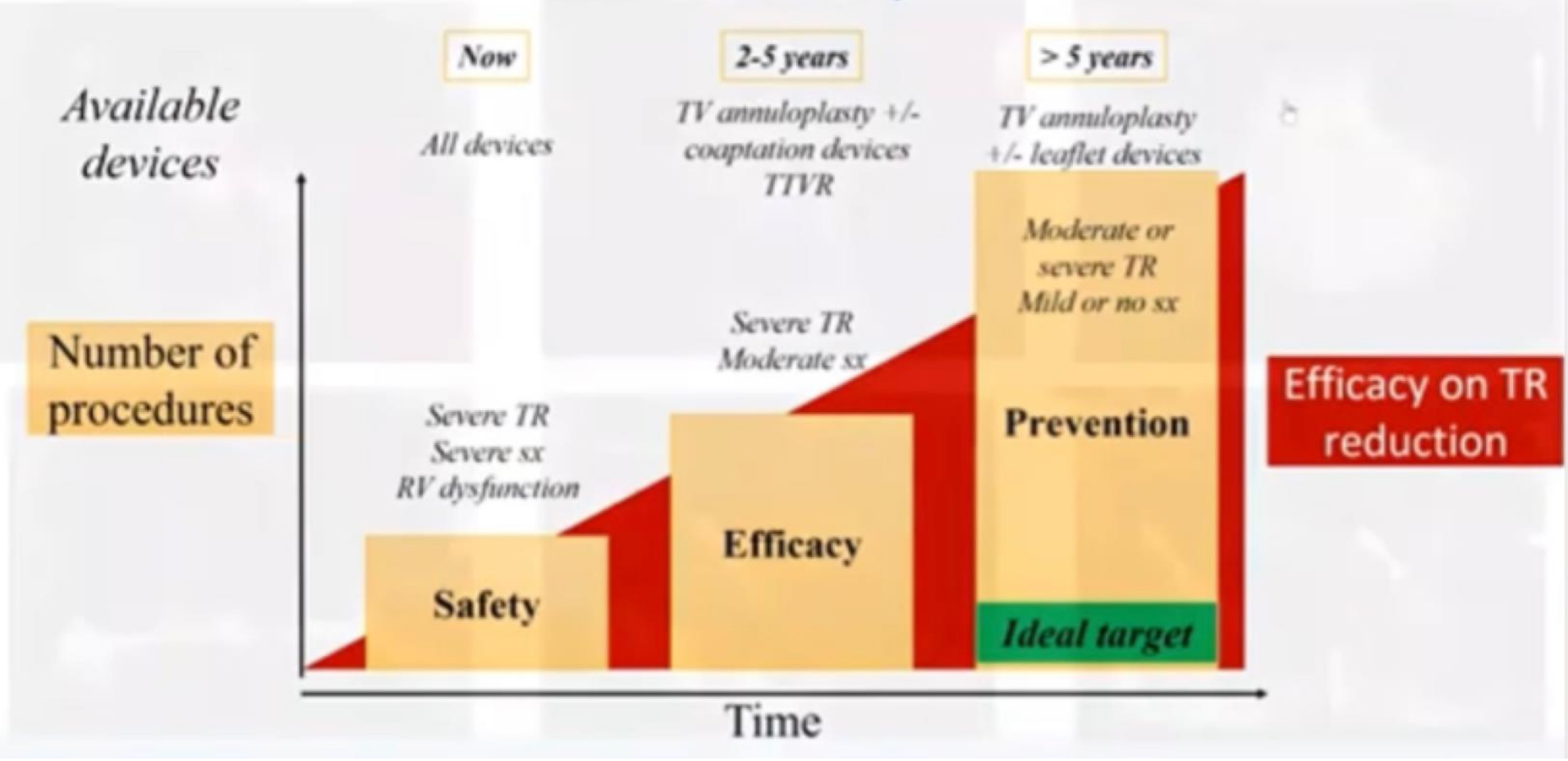
Late

Progressive RV distortion (±PHTN) results in further tethering of the leaflets

± Leaflet Device
Palliative Caval/FORMA Device
Replacement Device (?RV Fx)

Hahn RT et al. JAMA Cardiol. doi:10.1001/jamacardio.2019.0535 Published online April 17, 2019

Summary


Now
2-5 years
> 5 years
Available devices
All devices
TV annuloplasty +/- coaptation devices TTVR
TV annuloplasty +/- leaflet devices
Moderate or severe TR Mild or no sx
Severe TR Moderate sx
Number of procedures
Severe TR Severe sx RV dysfunction
Prevention
Efficacy on TR reduction
Efficacy
Safety
Ideal target
Time