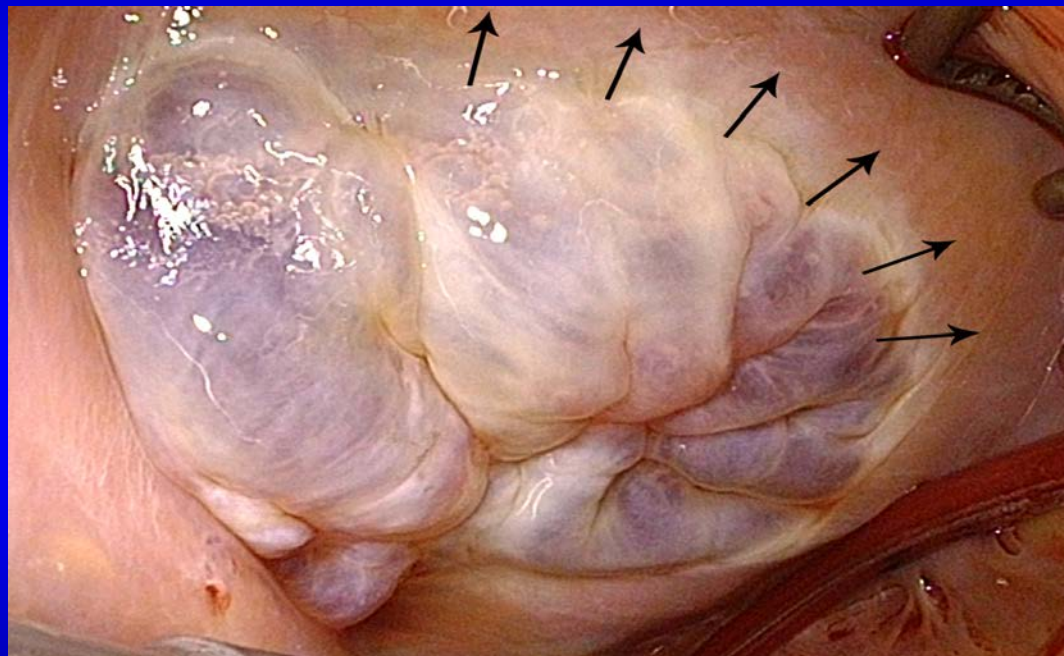


Concomitant Tricuspid Valve Repair : When, Why and How !



*Steven F Bolling, MD
Professor of Cardiac Surgery
University of Michigan*



Disclosures

- Consultant/Advisory Board: Abbott, Edwards Lifesciences
- Ownership Interest: Millipede, Pipeline

Is FTR important ?

Concomitant FTR :

85 to 95% of all TR !

Ebstein's

Endocarditis

Rheumatic

Pacer impingement

Valve repair for functional tricuspid valve regurgitation:
anatomical and surgical considerations

Is FTR important ?

Decreased CO

Fatigue, decreased exercise tolerance

“Right-sided” Heart Failure

Ascites, edema, decreased appetite, fullness

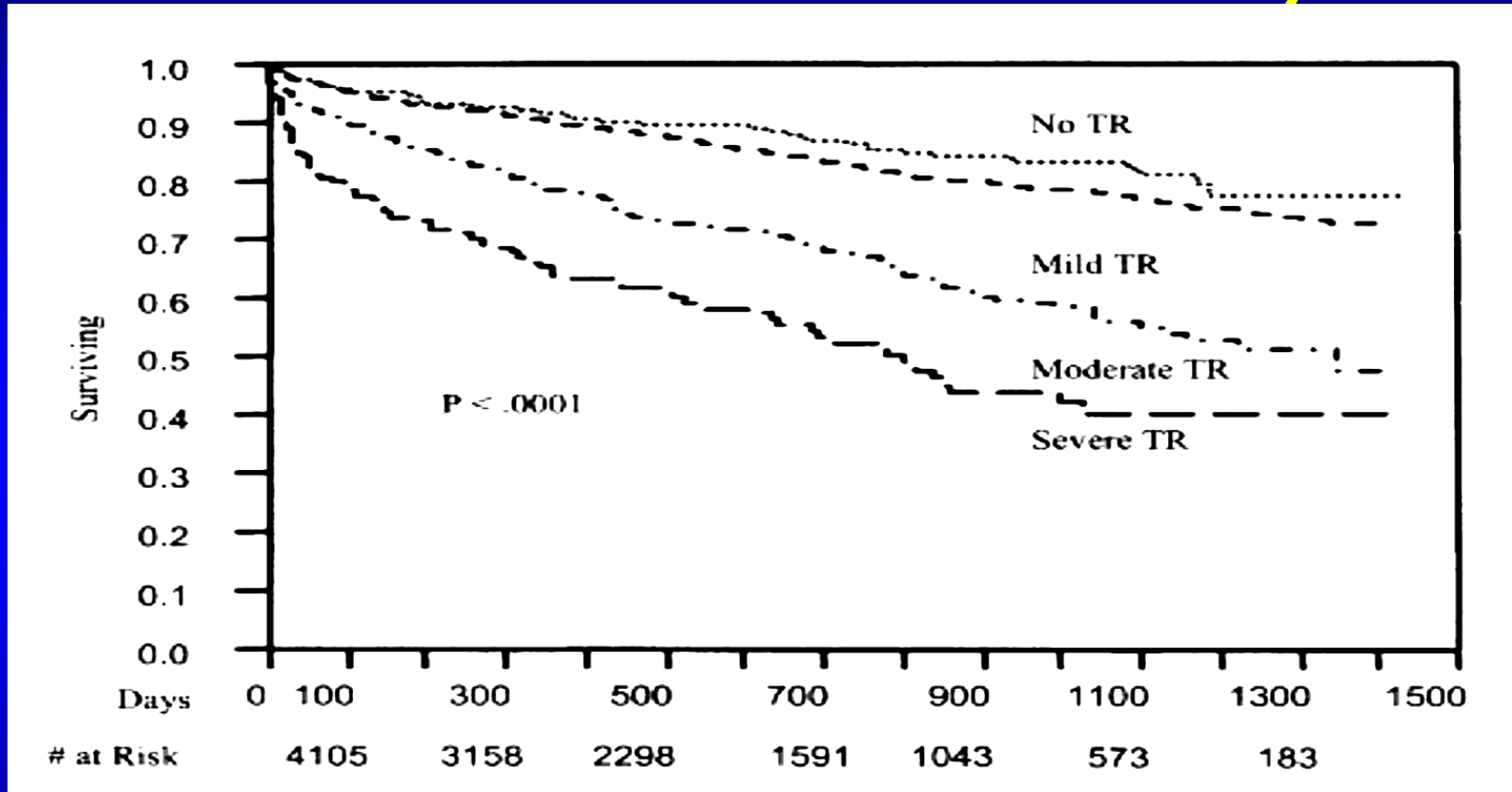
FTR patients feel terrible

Valve repair for functional tricuspid valve regurgitation:
anatomical and surgical considerations

Rogers JH Bolling SF Semin Thorac Cardiovasc Surg. 2010 ;22(1):84-9

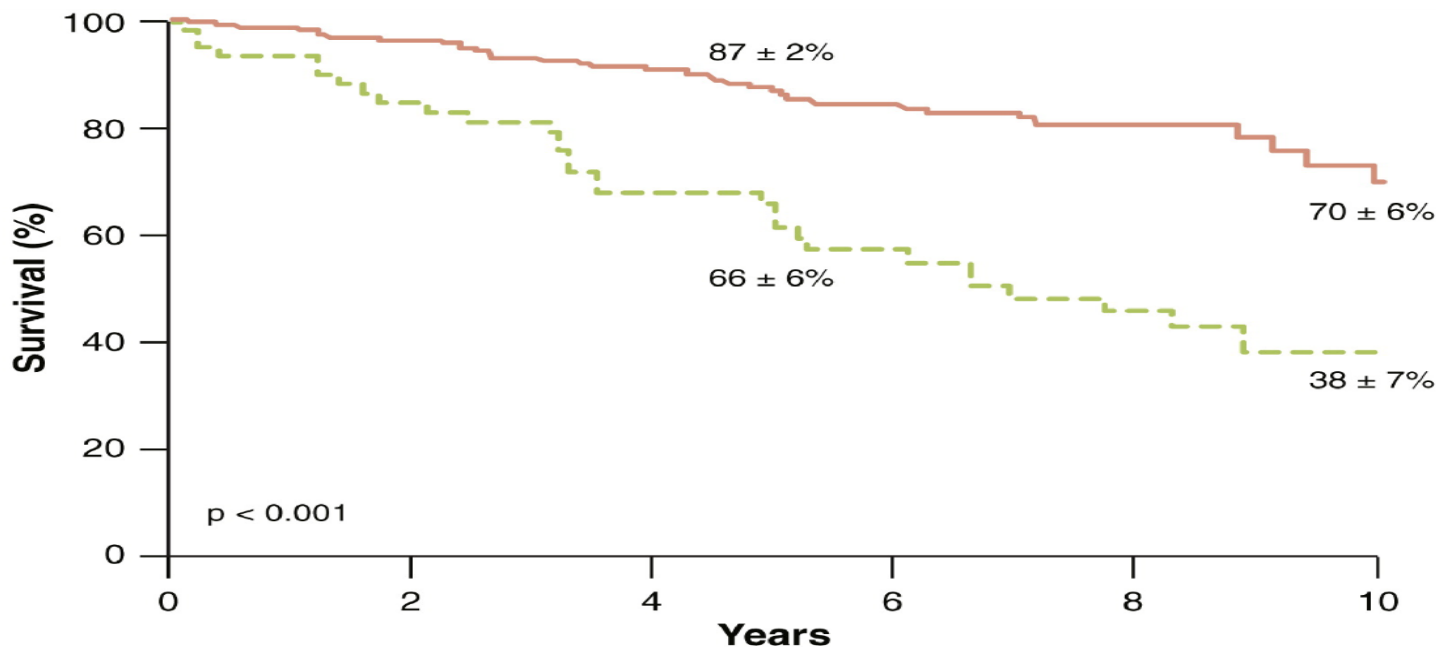
...and FTR patients die !

FTR increases Mortality



5223 pts : **Severe** and **Moderate** TR increase **mortality** independent of PASP, LVEF, IVC size, RV size/ function.

Severe and MODERATE FTR Decreases Survival



Number at Risk

Total	353	308	252	194	70	31
ERO < 40	285	253	210	163	46	23
ERO ≥ 40	68	55	42	31	24	8

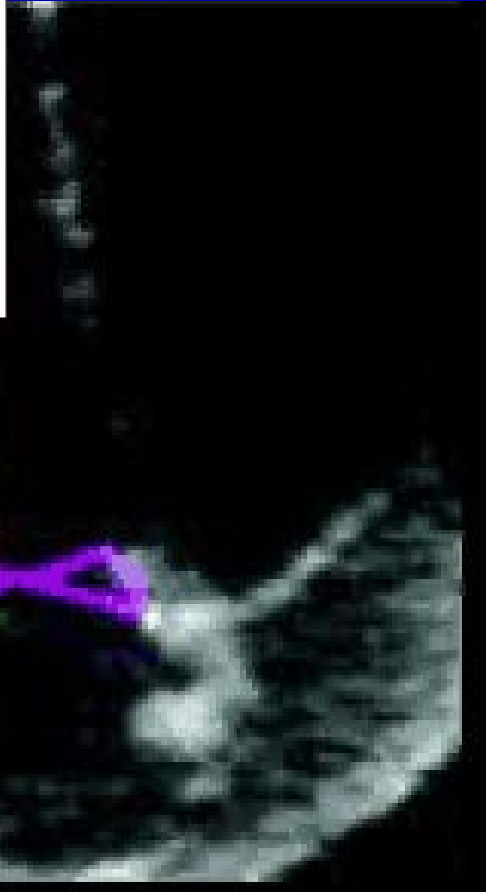
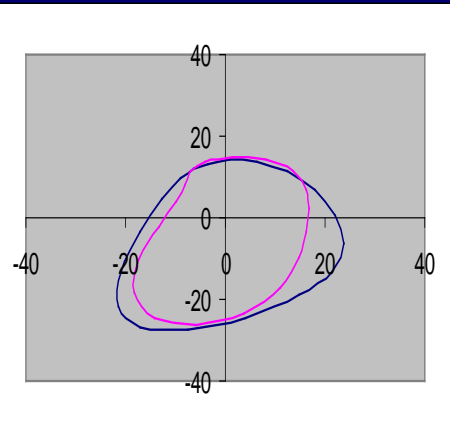
— ERO ≥ 40 mm² — ERO < 40 mm²

Topilsky. JACC 2014.

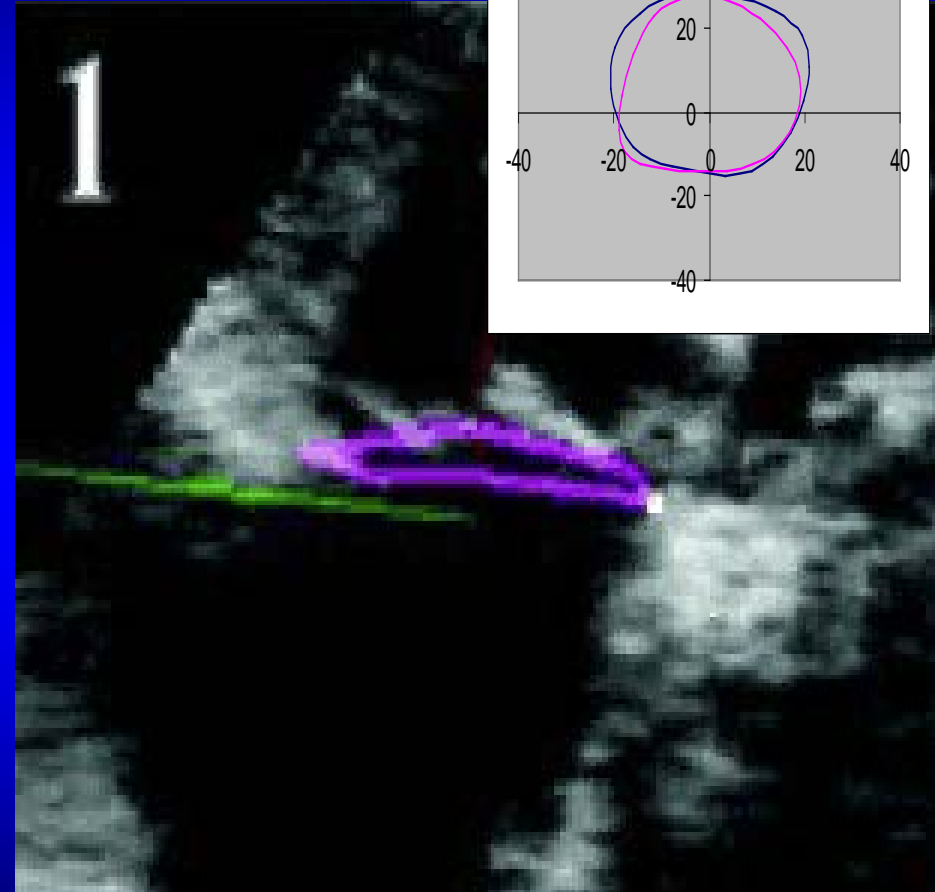
TR is bad. TR hurts quality of life and QUANTITY

Annular Dilation / Shape Change of FTR :

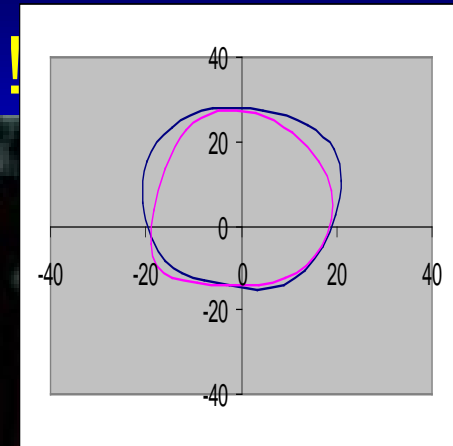
75% - all cases of MR !



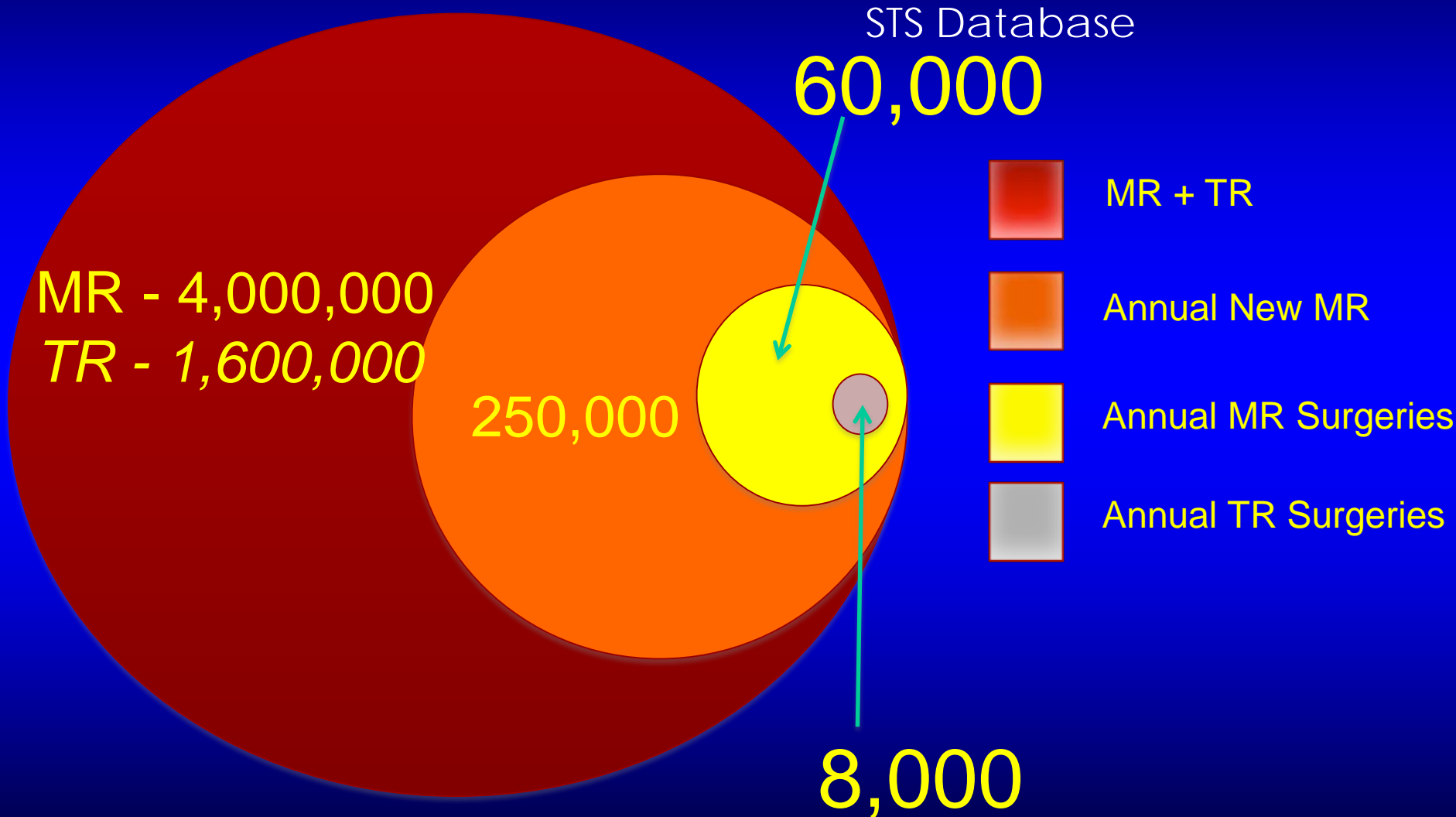
Normal Tricuspid Annulus



Tricuspid Annulus with Functional TR

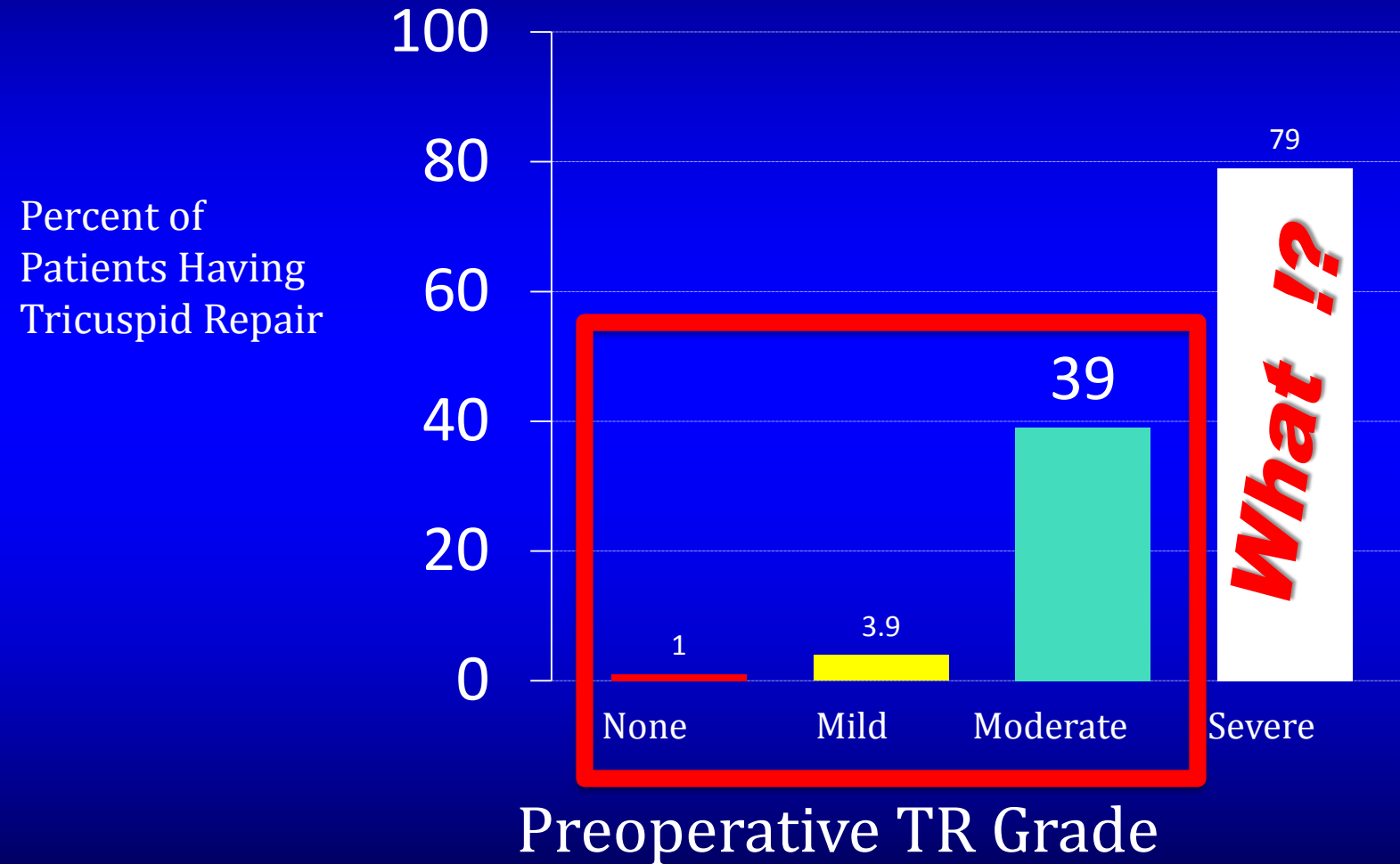


2017 - FTR is ignored !



Tricuspid repair when fixing MR

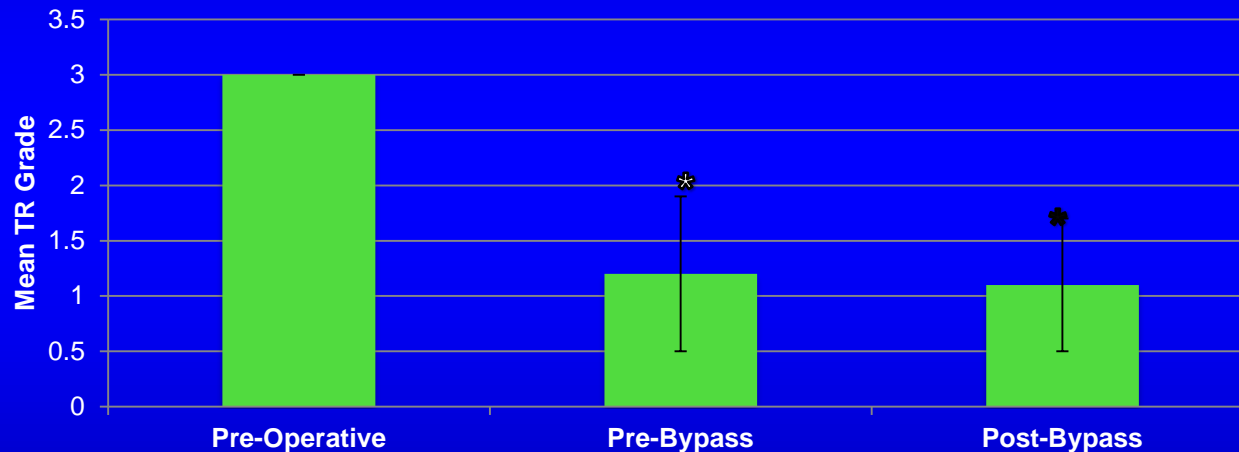
Based on TR Grade



When to look for FTR : *Pre-op*

Functional TR – *dynamic* !

under anesthesia 4+ TR, can become mild...



Regard any previous significant TR or a dilated annulus as indications for TV repair!

The Growing Clinical Importance of Secondary Tricuspid Regurgitation

Maurizio Taramasso, MD,* Hugo Vanermen, MD,† Francesco Maisano, MD,* Andrea Guidotti,* Giovanni La Canna, MD,* Ottavio Alfieri, MD*

Milan, Italy; and Aalst, Belgium

Functional or secondary tricuspid regurgitation (STR) is the most frequent etiology of tricuspid valve pathology in Western countries. Surgical tricuspid repair has been avoided for years, because of the misconception that tricuspid regurgitation should disappear once the primary left-sided problem is treated; this results in a large number of untreated patients with STR. Over the past few years, many investigators have reported evidence in favor of a more aggressive surgical approach to STR. Consequently, interest has been growing in the pathophysiology and treatment of STR. The purpose of this review is to explore the anatomical basis, pathophysiology, therapeutic approach, and future perspectives with regard to the management of STR. (J Am Coll Cardiol 2012;59:703-10) © 2012 by the American College of Cardiology Foundation



If in OR, don't just look for TR !
Look for annulus > 40 mm
RA, RV changes

FTR goes away by itself ?

5589 MVr only cases (McCarthy, ATS 2004)

Preop 16% had severe TR...
NO

Discharge (MVr without TVr)

62% had residual severe TR !...

TR does not !

and despite a “good” mitral result...



No guarantee of FTR “getting better” !

Tricuspid Valve Repair

Secondary Tricuspid Regurgitation or Dilatation: Which Should Be the Criteria for Surgical Repair?

Gilles D. Dreyfus, MD, Pierre J. Corbi, MD, K. M. John Chan, AFRCs, and

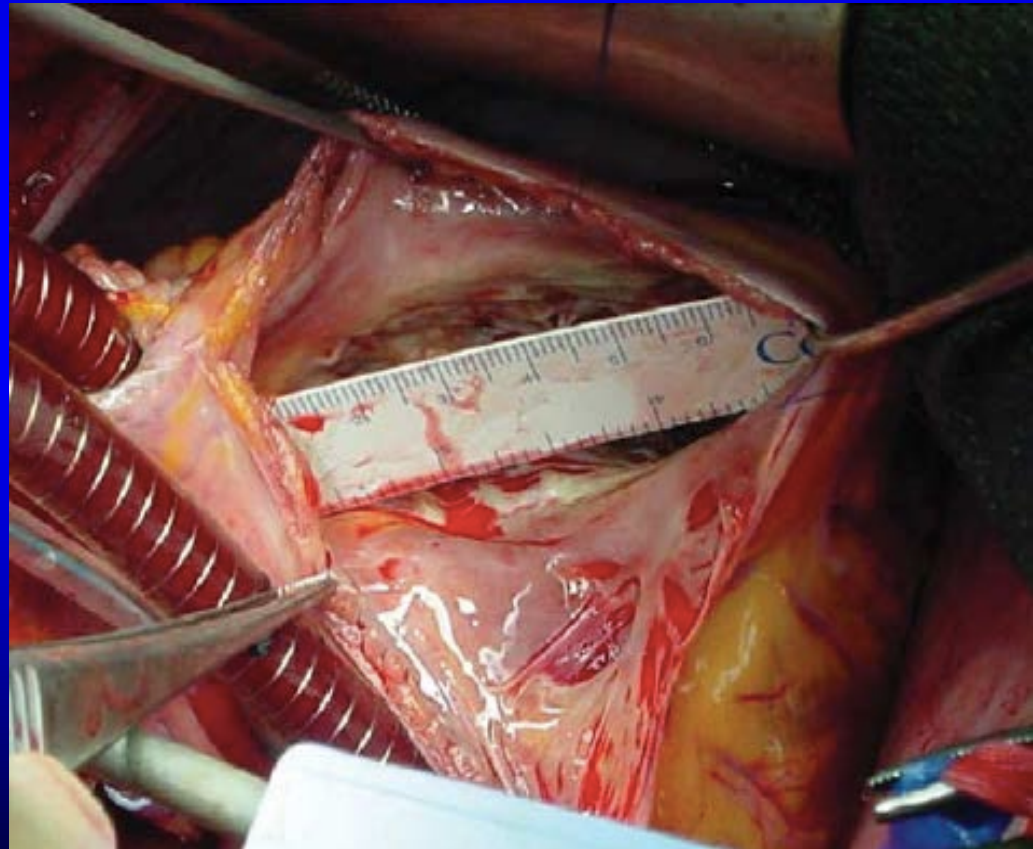
311 Patients MV Repair

Preop TR 0.7 – 0.9

93 % no/trace/mild

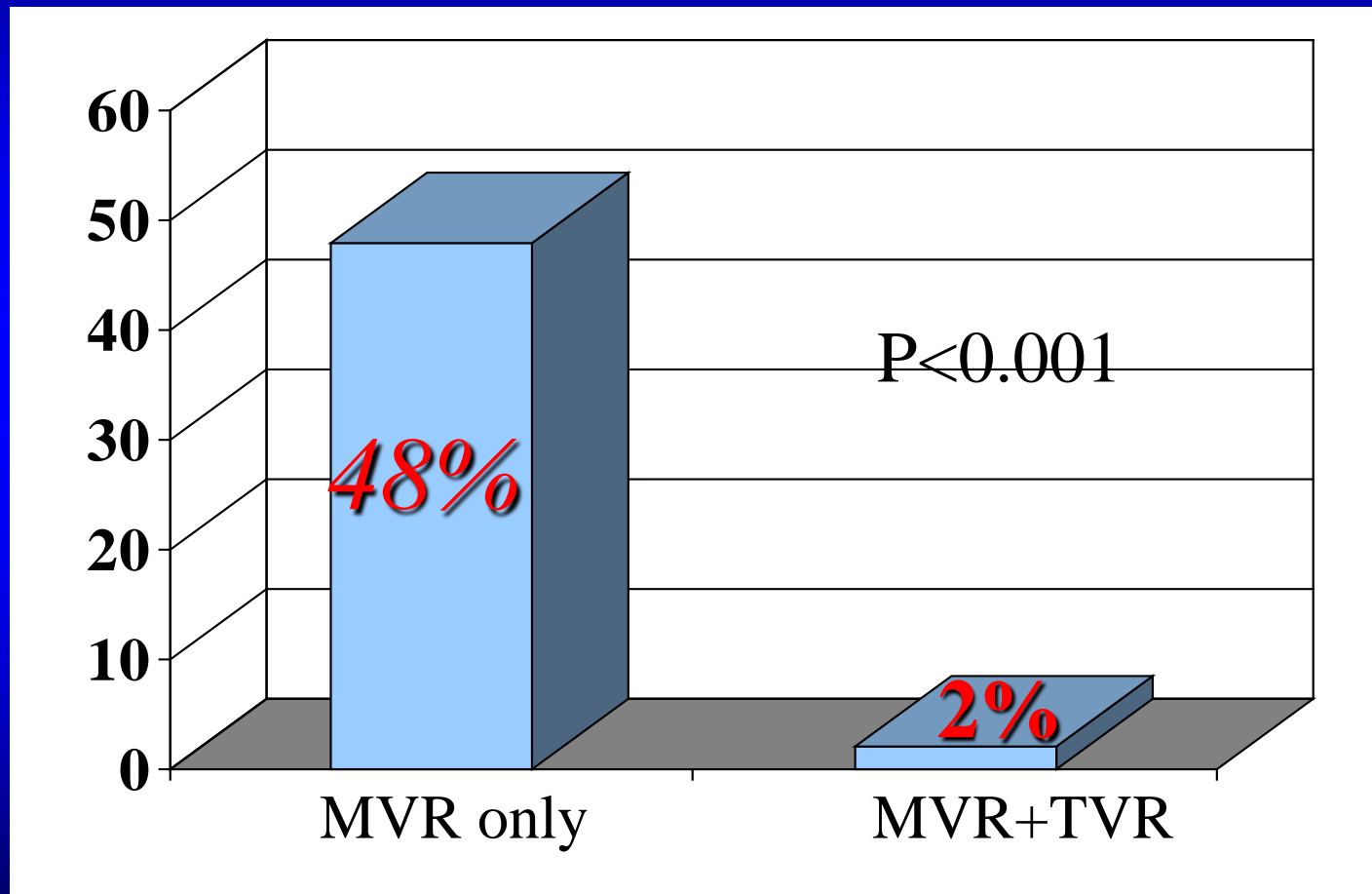
7 % moderate

NONE Severe !



TR Does Not Just “Go Away” After MVr

311 undergoing MVr, mostly degenerative, all with dilated TV annulus
TR Worsening by > 2 Grades



Adding TV repair adds risk

110 matched pts for MVr with FTR

8.5%

- 30 day mortality, no TVr vs

2%

- for MVr + TVr, $p=0.2$

TR progression rate was 40% vs 5%

5-yr survival was 45% vs 74%

Ann Thorac Surg. 2009 Mar;87(3):698-703..

Mitral valve surgery for functional mitral regurgitation: should moderate-or-more tricuspid regurgitation be treated? a propensity score analysis.

Calafiore AM



Adding TV repair adds risk ?

Performing Concomitant Tricuspid Valve Repair at the Time of Mitral Valve Operations Is **Not Associated** With Increased Operative Mortality



Vinay Badhwar, MD, J. Scott Rankin, MD, Max He, MS, Jeffrey P. Jacobs, MD, Anthony P. Furnary, MD, Frank L. Fazzalari, MD, Sean O'Brien, PhD, James S. Gammie, MD, and David M. Shahian, MD

Operation	TR Grade	Tricuspid Repair Rate	Morbidity OR (95% CI)	p Value	Mortality OR (95% CI)	p Value
Isolated MVRR	None-mild	4.0% (1,823 of 45,551)	1.44 (1.26-1.65)	<0.0001	1.16 (0.82-1.64)	0.4103
	Moderate	32.9% (3,565 of 10,813)	1.25 (1.09-1.43)	0.0011	0.99 (0.80-1.24)	0.9546
	Severe	77.3% (4,426 of 5,724)	1.50 (1.28-1.75)	<0.0001	0.89 (0.67-1.18)	0.4081
MVRR + CABG	None-mild	2.4% (485 of 20,218)	1.54 (1.27-1.86)	<0.0001	1.31 (0.92-1.88)	0.1376
	Moderate	25.0% (1,096 of 4,379)	1.18 (1.01-1.38)	0.0335	0.86 (0.63-1.18)	0.3511
	Severe	69.9% (1,228 of 1,758)	1.46 (1.14-1.86)	0.0025	1.17 (0.81-1.70)	0.3915

FTR - Don't Wait !

Bernal (JTCVS 129 2005)

Patients left with post-op FTR,
when returned for redo TVR

NO

30 day mortality was 35%!

Do it now!

Highest top mortality in STS !!

Reoperations after tricuspid valve repair

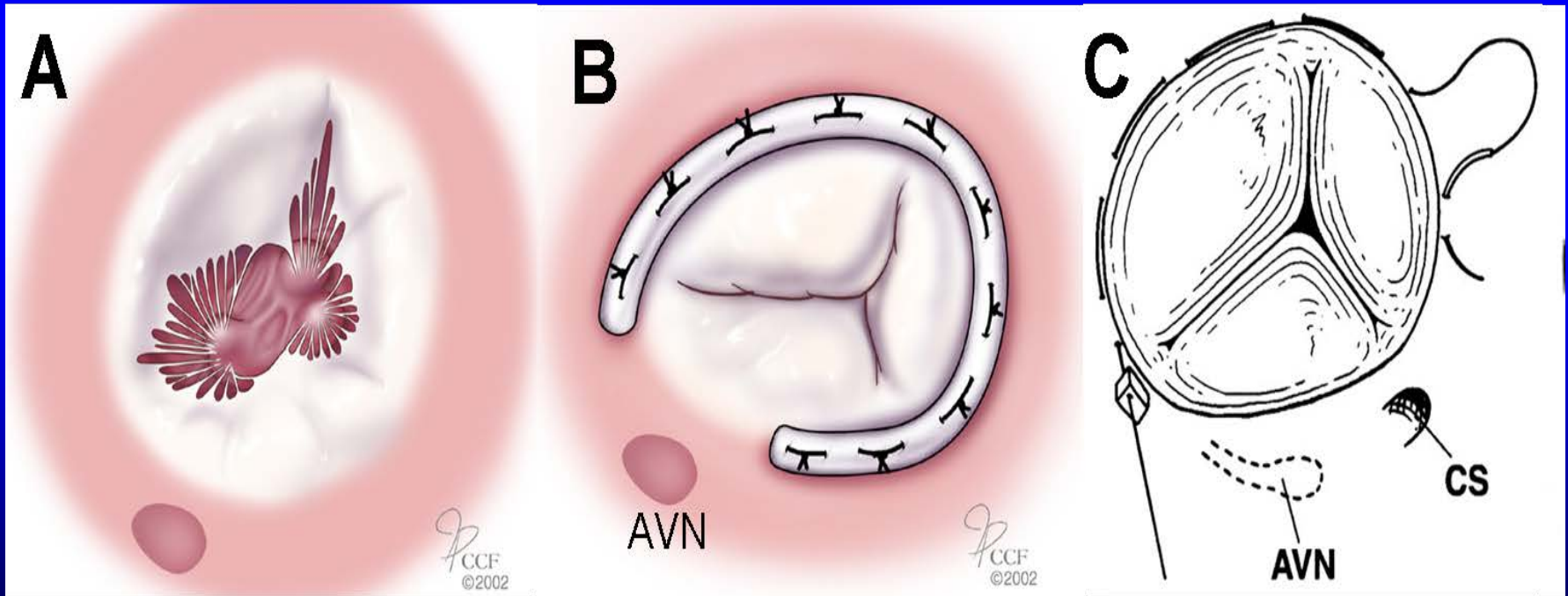
José M. Bernal, MD,^a Dieter Morales, MD,^a Carmen Revuelta, MD,^a Javier Llorca, MD,^b Jesús Gutiérrez-Morlote, MD,^a
and José M. Revuelta, MD^a

HOW to fix FTR :

New Repair Thinking for Functional TR

Annuloplasty Rings

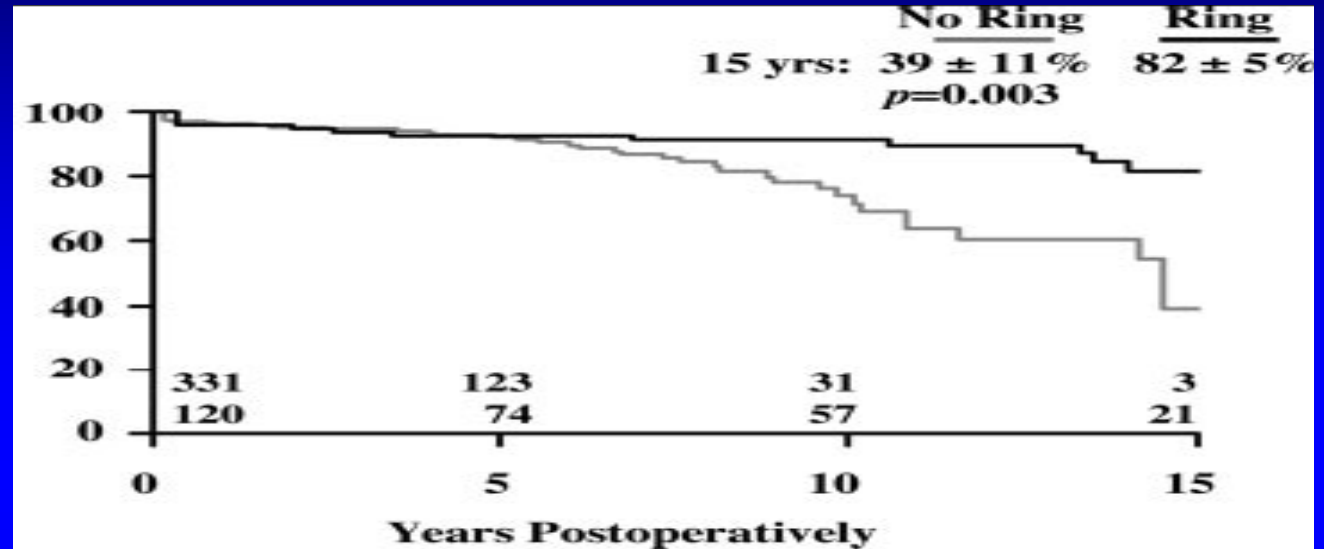
DeVega



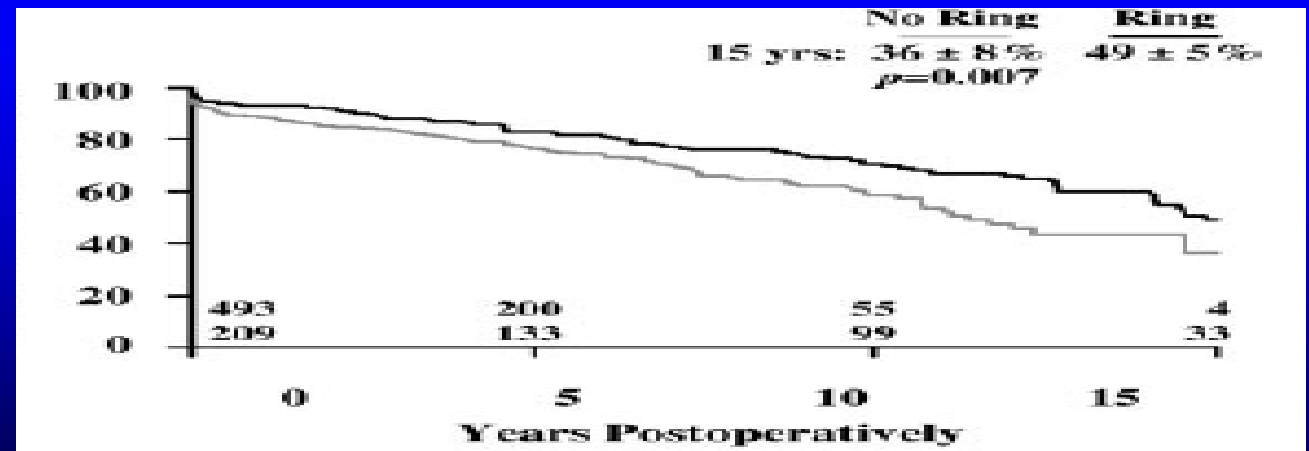
Use a Ring !

Less recurrent TR and better Survival

Freedom
From
Recurrent
TR (%)

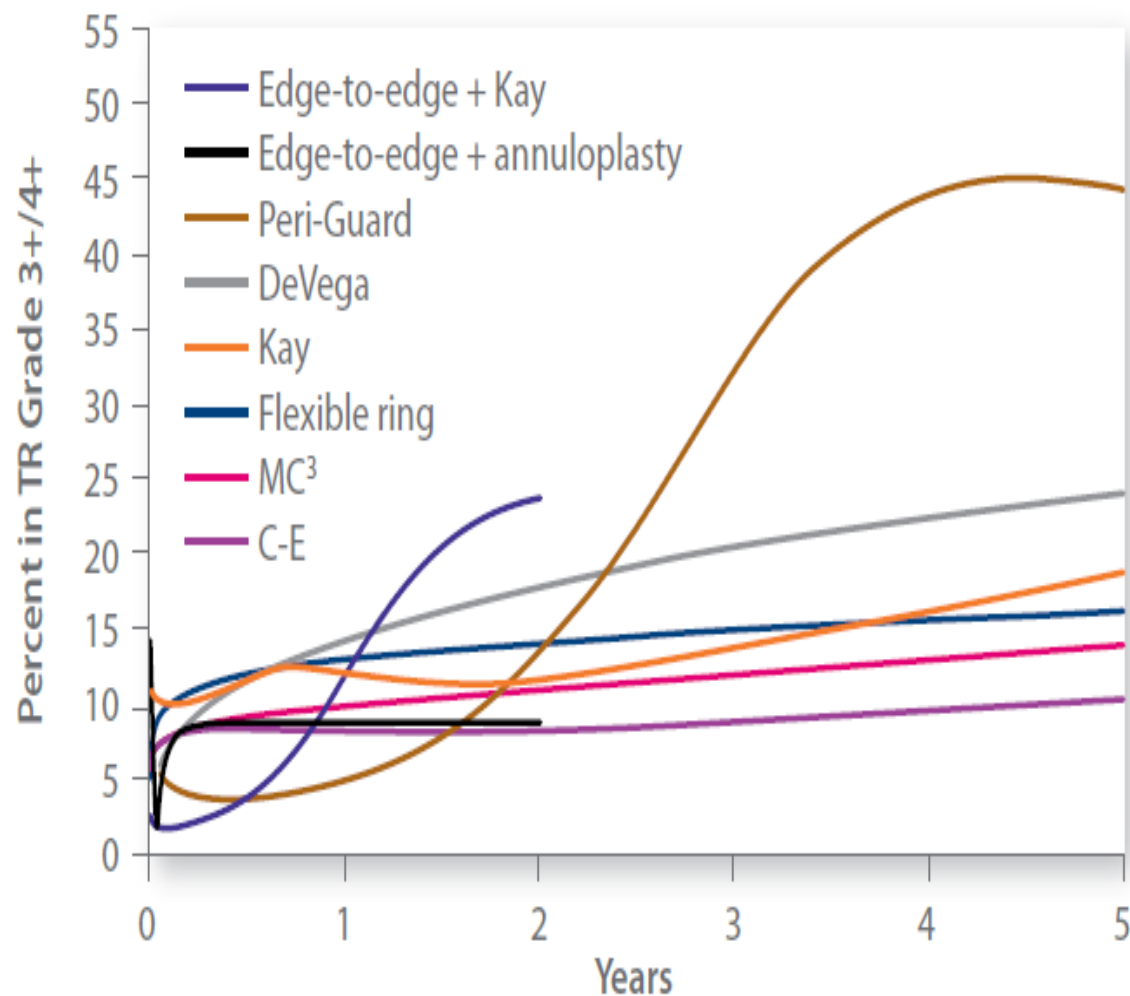


Freedom
From
Death
(%)



702 patients - TVR
493 DeVega
209 Ring

Prevalence of Post-Operative 3+/4+ Tricuspid Regurgitation for Various Procedure Groups



- Edge-to-edge technique (leaflet)
- Edge-to-edge + Kay commissure
- Edge-to-edge + flexible or rigid prosthetic annuloplasty
- Peri-Guard ring (Synovis Surgical Innovations, St. Paul, MN)
- De Vega suture technique
- Kay commissure
- Flexible ring – standard and 3-dimensional
- MC³ – 3-dimensional ring (Edwards MC3 Annuloplasty System)
- C-E – Carpentier-Edwards rigid ring
- TR = tricuspid regurgitation

Lines represent unadjusted estimates of TR grades of 3+/4+ for each procedure group over time.

2° FTR - *Use a rigid ring !*

Carrier JHVD 13:2004

463 patients for TV repairs

Freedom from recurrence:

Rigid ring - 94%

Flexible - 72%

DeVega - 66%

TV ring risks / fears

AV Node injury

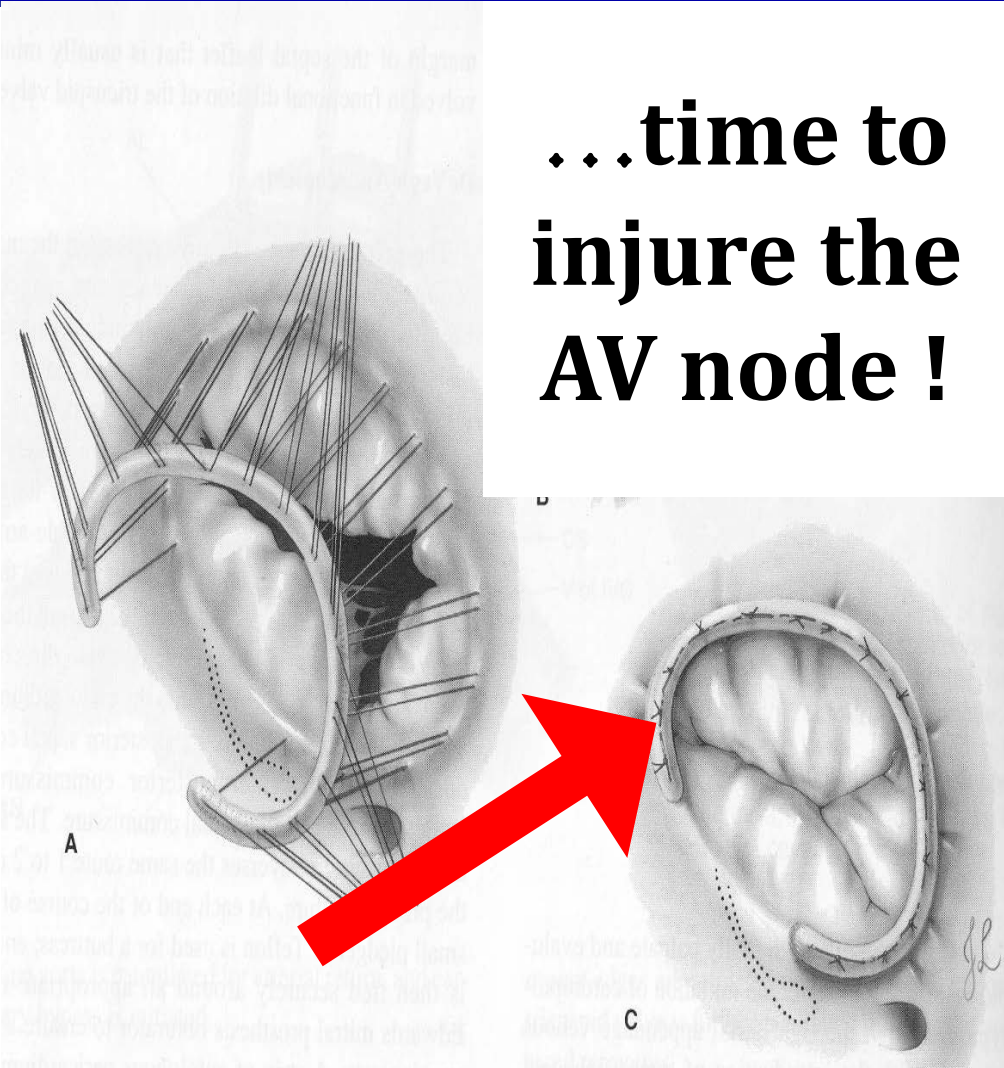
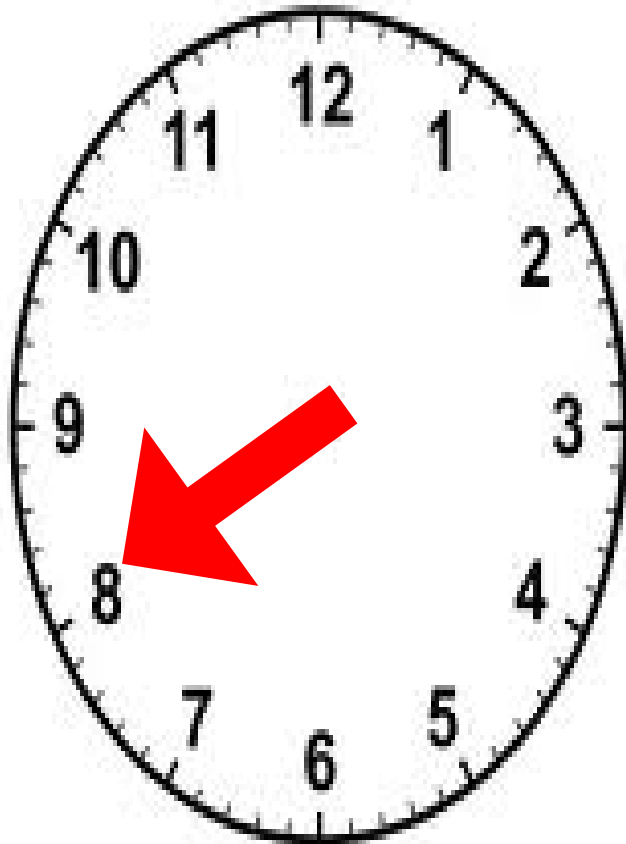
Dehiscence

Hemolysis

Endocarditis

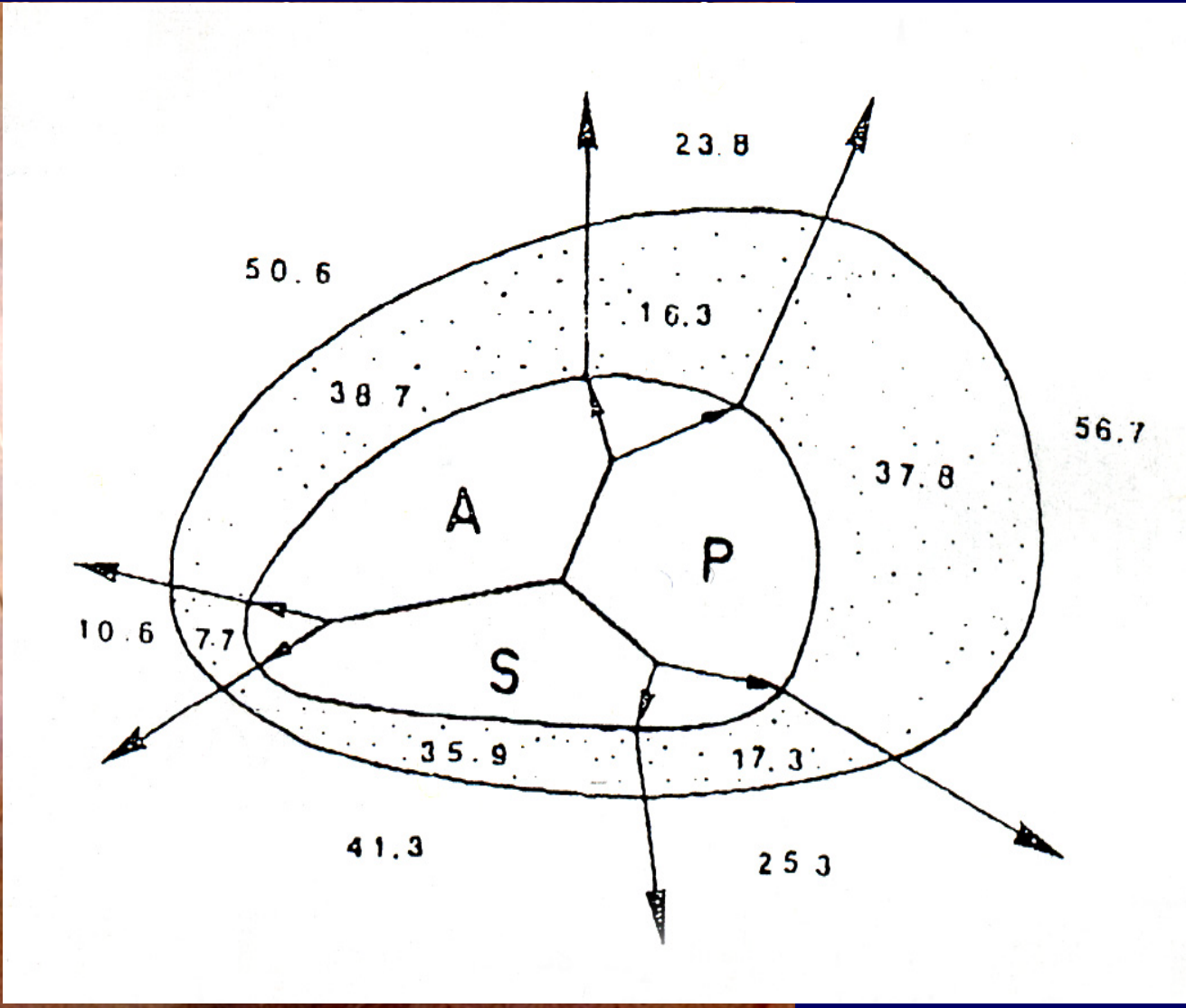
“Classic” Tricuspid Technique

What time is it?



...time to injure the AV node!

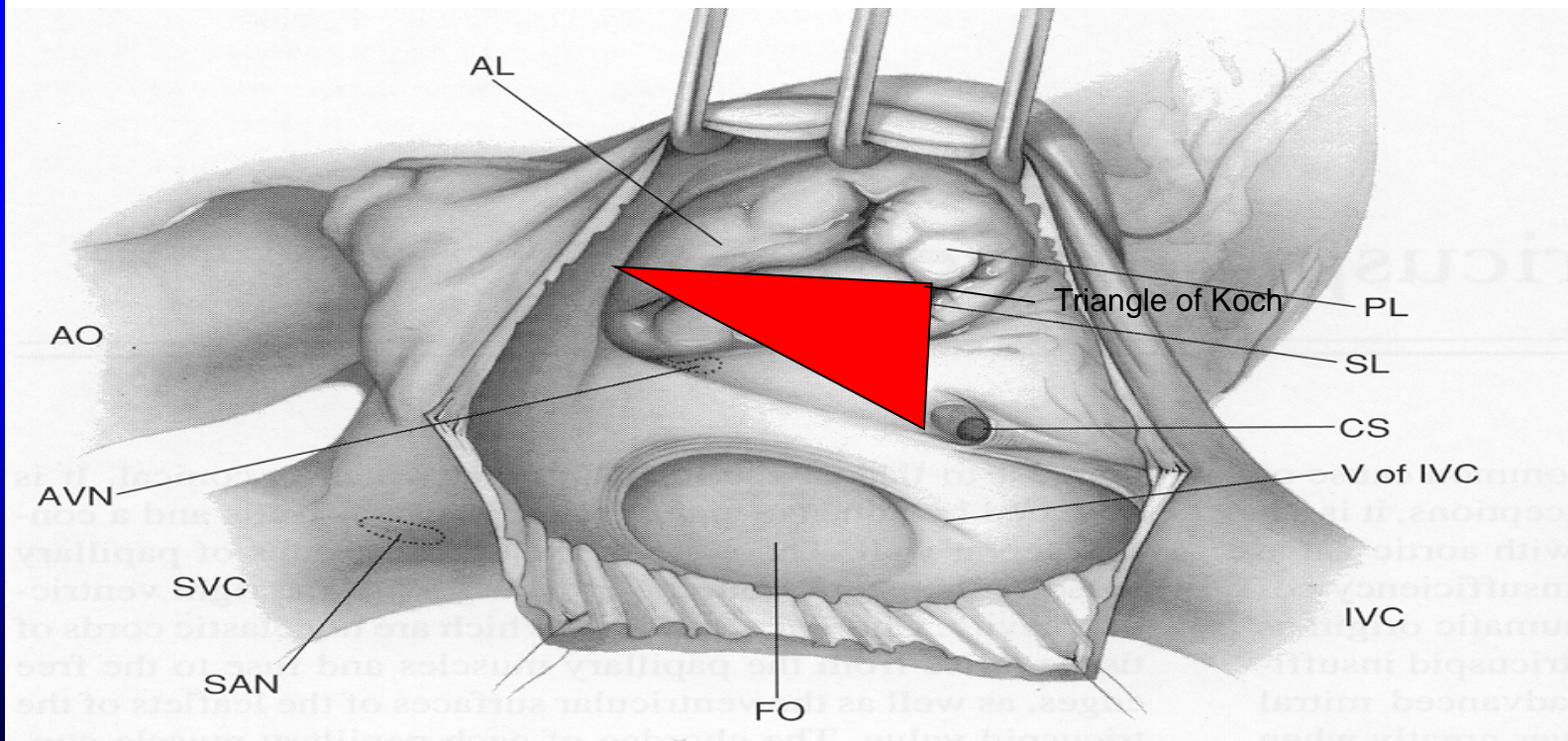
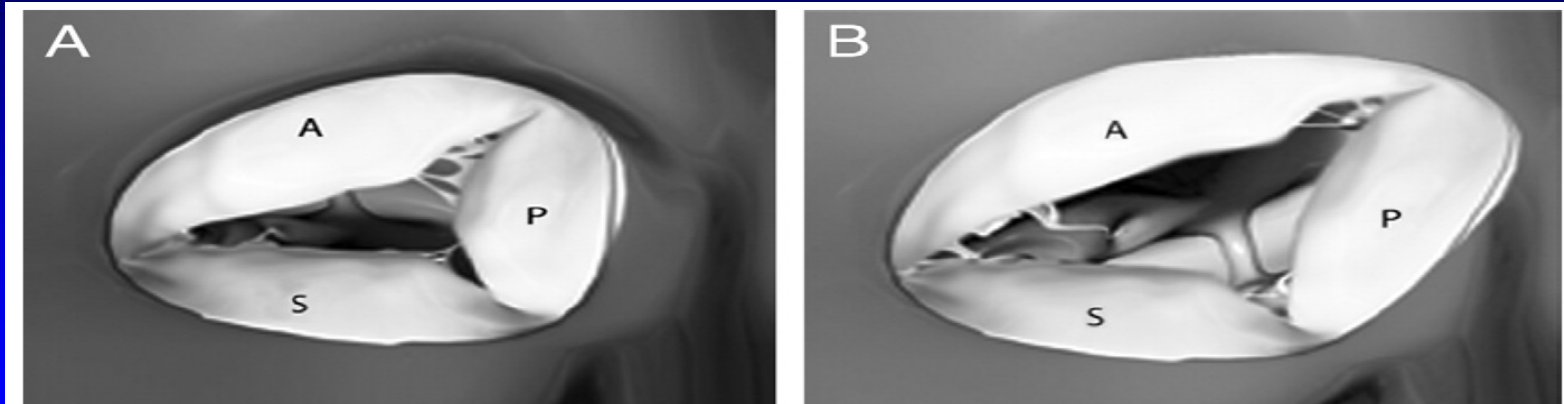
New "How to" : *Anatomy of FTR*



Annular, RA, RV and LV geometry changes of TR

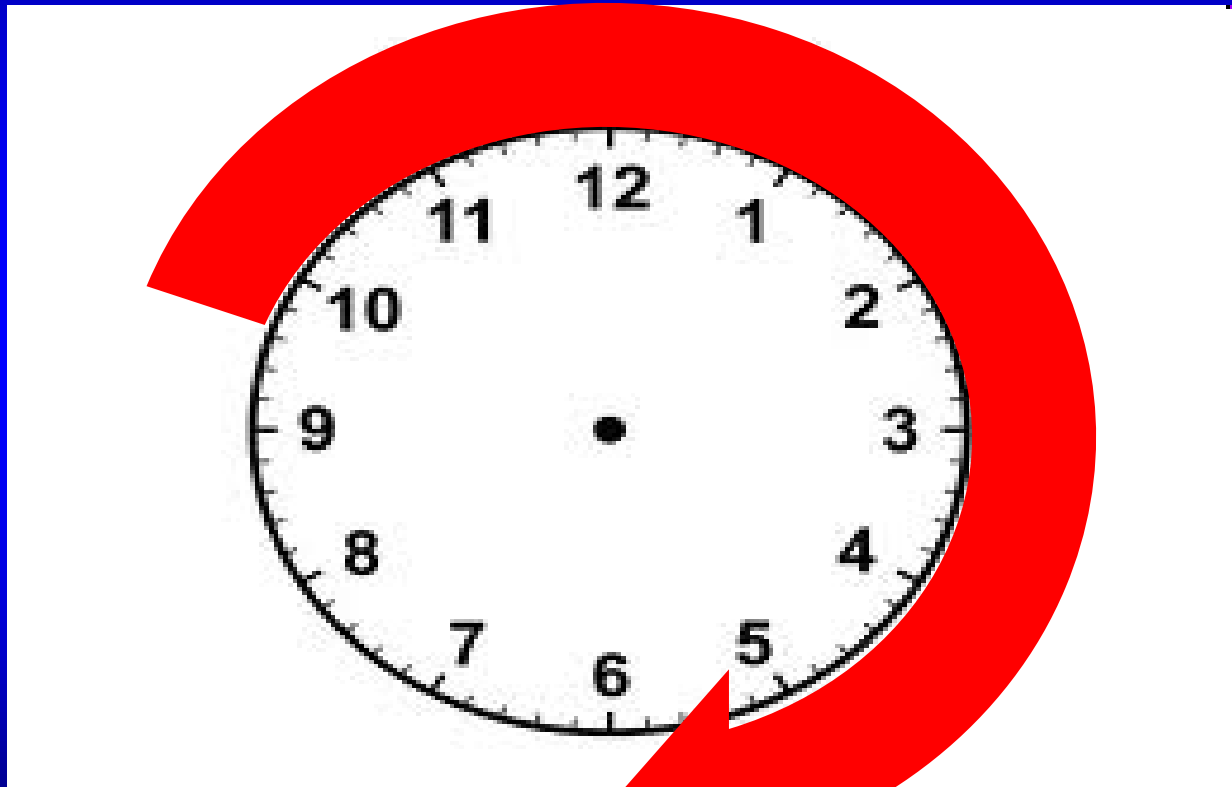
Carpentier, JTCVS 1974;67:53

New FTR - "Rule of TEN"



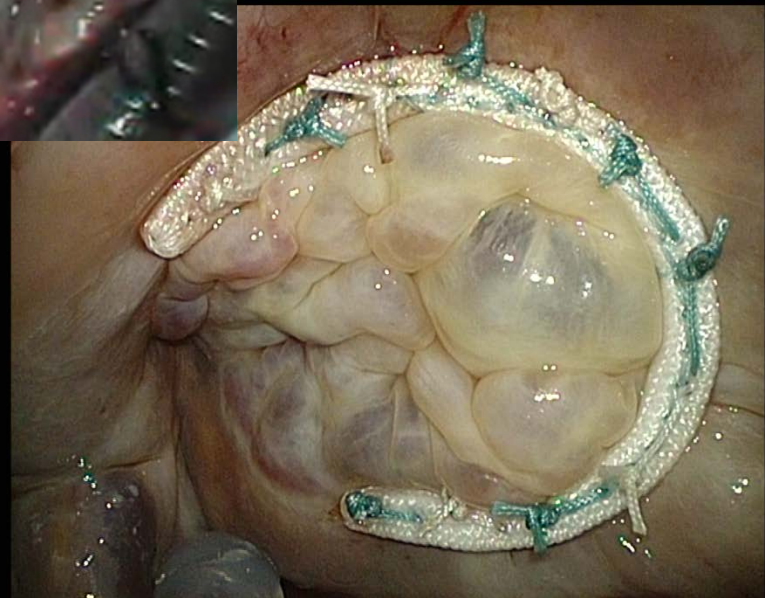
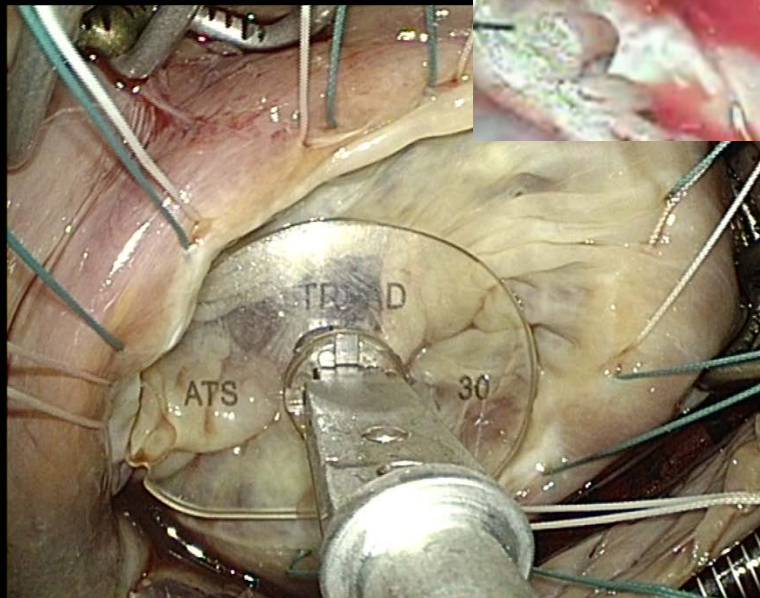
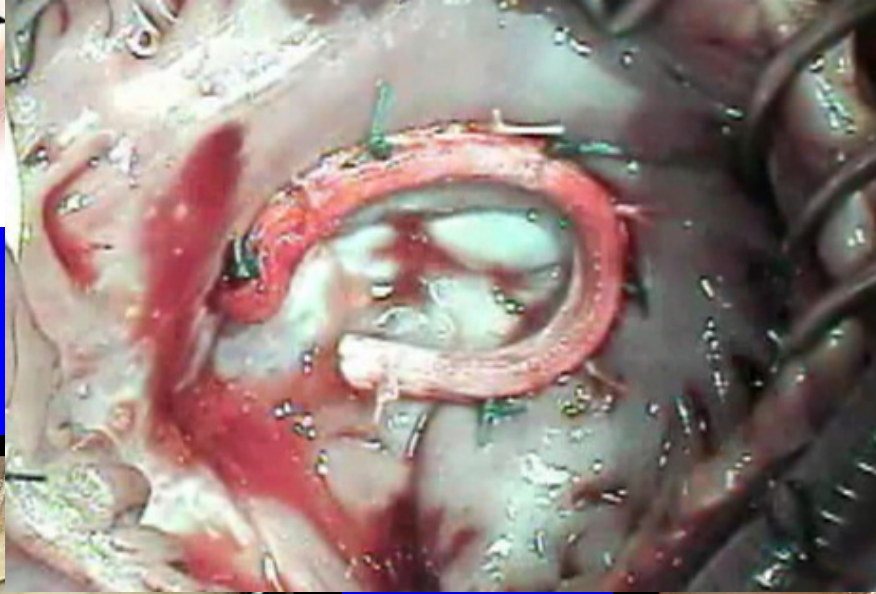
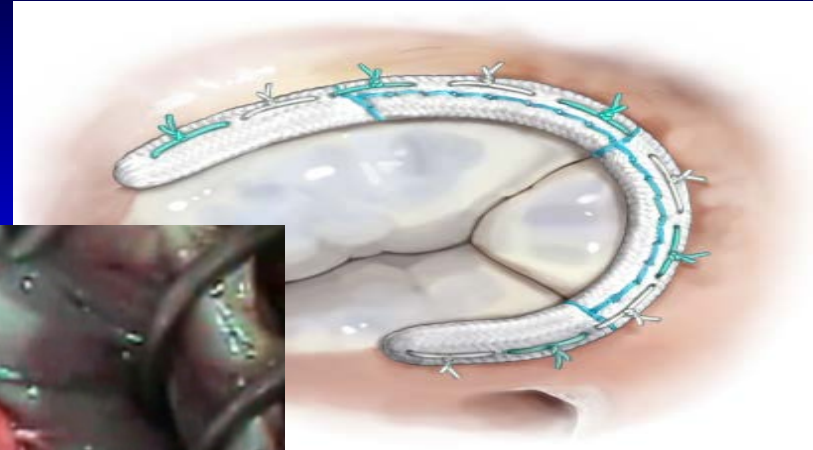
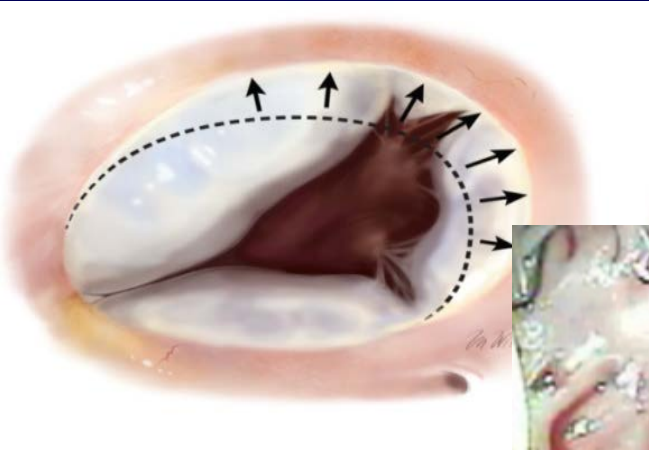
FTR repair - “10”

“Ten stitches - Ten minutes”



“10 o'clock to 6 o'clock”

FTR - 10 stitches, 10 o'clock to 6 o'clock



How to size FTR... *Don't size!*

26 / 28 RING

Huffman et al

Acquired Cardiovascular Disease

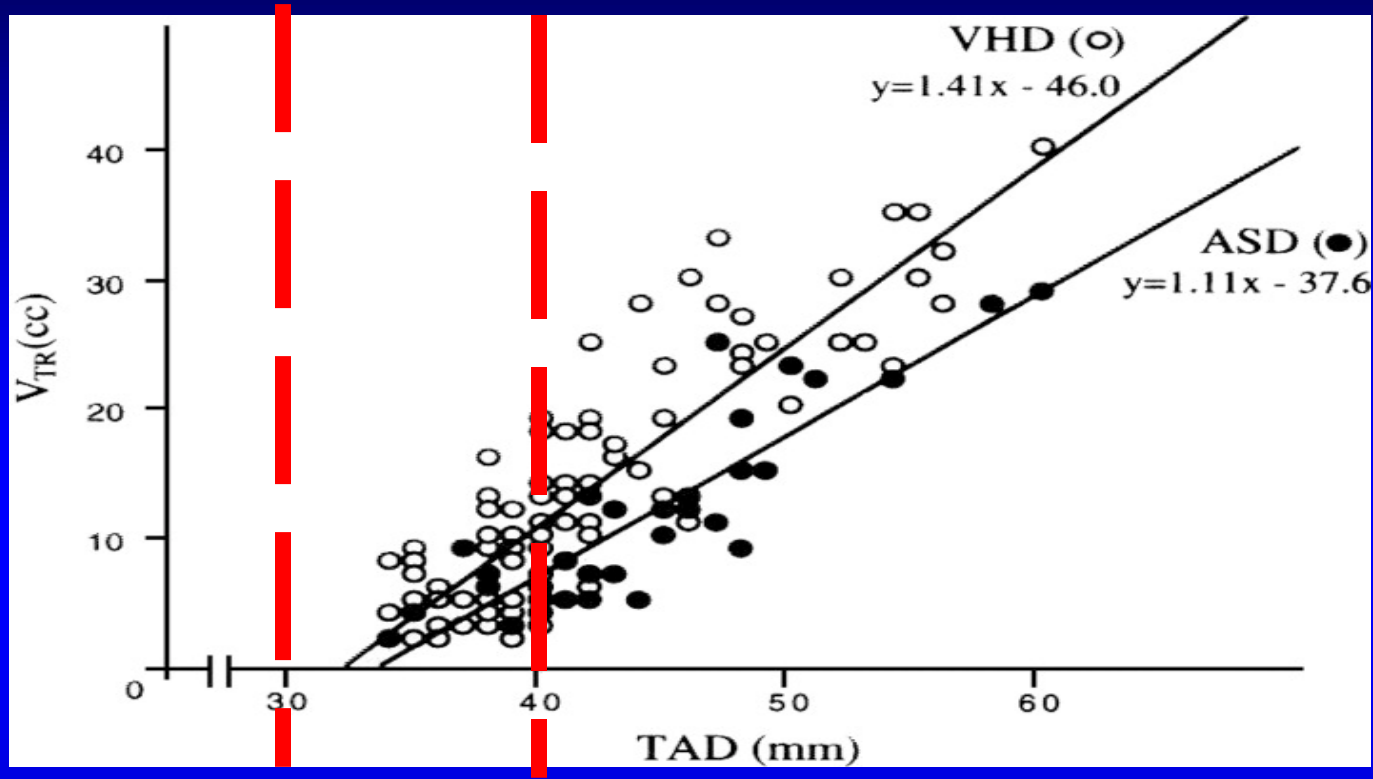
Identical tricuspid ring sizing in simultaneous functional tricuspid and mitral valve repair: A simple and effective strategy

Lynn C. Huffman, MD, Jennifer S. Nelson, MD, April N. Lehman, BS, Marguerite C. Krajacic, RN, BSN, and Steven F. Bolling, MD

(J Thorac Cardiovasc Surg 2013;

Association class was III or IV in 81% (43) and mean left ventricular ejection fraction was $33\% \pm 2.2\%$. All patients had moderate or greater mitral regurgitation preoperatively and moderate to severe tricuspid regurgitation or a preoperative tricuspid annulus diameter greater than 40 mm. There was no 30-day mortality. Mean immediate postoperative tricuspid valve gradient was 1.75 ± 0.12 mm Hg and was 2.3 ± 0.19 mm Hg at 4 weeks. Four weeks postoperatively 88% (42/48) of patients had tricuspid regurgitation considered to be mild or less. There was no significant decline in right ventricular function by echocardiography over this time period.

What size?



NORMAL TRICUSPID ANNULAR DIMENSION

2.8 ± 0.5 cm !

“Undersized” TV repair for FTR

Undersized Tricuspid Annuloplasty Rings Optimally Treat Functional Tricuspid Regurgitation

Mehrdad Ghoreishi, MD, Jamie M. Brown, MD, Craig E. Stauffer, BS, Cindi A. Young, Mary J. Byron, PA-C, Bartley P. Griffith, MD, and James S. Gammie, MD

Division of Cardiac Surgery, University of Maryland Medical Center, Baltimore, Maryland

Background. In contrast to mitral valve repair, residual and recurrent regurgitation after tricuspid valve (TV) repair for functional tricuspid regurgitation (TR) is common. We have systematically used undersized, rigid 3-dimensional annuloplasty rings to treat functional TR.

Methods. From March 2006 to October 2009, 101 consecutive patients with moderate or greater functional TR underwent TV repair with an undersized rigid 3-dimensional annuloplasty ring. All patients had a pre-discharge echocardiography evaluation in a core echocardiography laboratory. Follow-up echocardiography was available for 96% of surviving patients. Mean follow-up was 17 ± 9 months.

Results. Twenty-nine percent of patients had undergone previous cardiac operations, 74% were in New York Heart Association functional class III or IV, and 48% had atrial fibrillation. Mitral valve operations were performed in 93 patients, aortic valve operations in 17,

coronary artery bypass grafting in 21, and CryoMaze procedures in 40. Size 26 or 28 rigid tricuspid annuloplasty rings were used in 88% of patients, and no ring larger than a 28 has been used since November 2008. The operative mortality rate was 6% ($n = 6$). Freedom from significant TR (TR > moderate) at hospital discharge, as assessed by the clinical core laboratory, was 97%. Only 3% of patients had TR greater than moderate during follow-up. No patient required TV reoperation. New postoperative permanent pacemakers were inserted in 3 patients.

Conclusions. Tricuspid valve repair with an undersized (size 26 or 28) rigid 3-dimensional annuloplasty ring is the method of choice for reliable and durable treatment of functional TR.

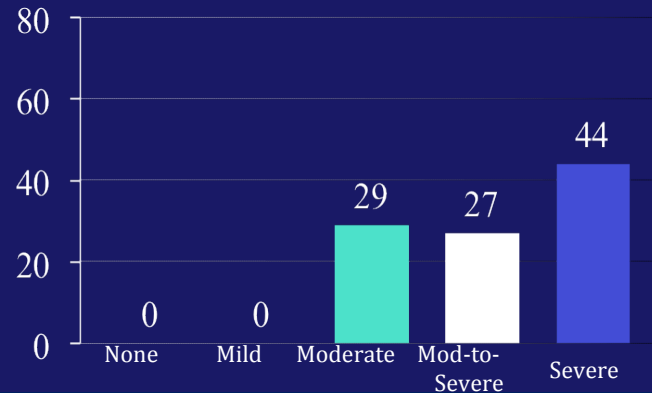
(Ann Thorac Surg 2011;92:89–96)

© 2011 by The Society of Thoracic Surgeons

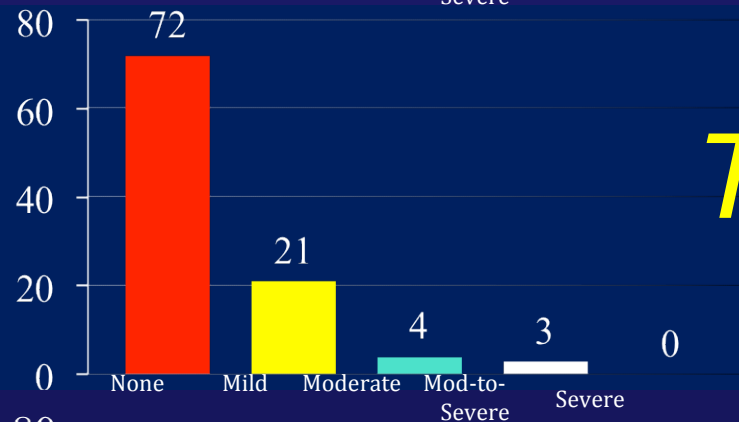
Actually RE-NORMAL size !

“Undersized” TV repair for FTR

Preoperative

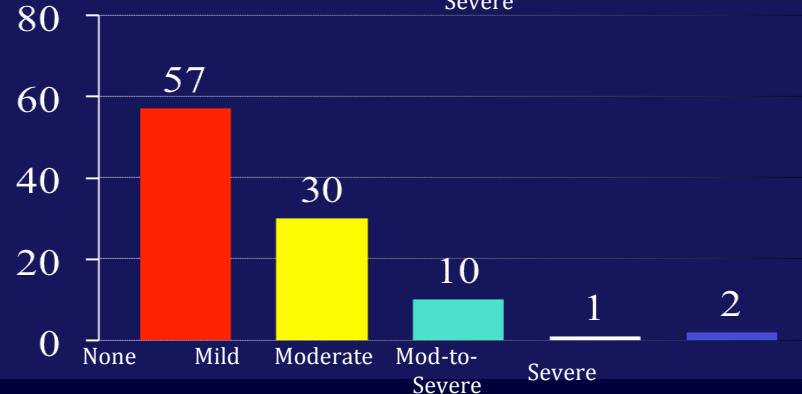


Predischarge



TR Grade

Follow-up
(mean = 1 yr)

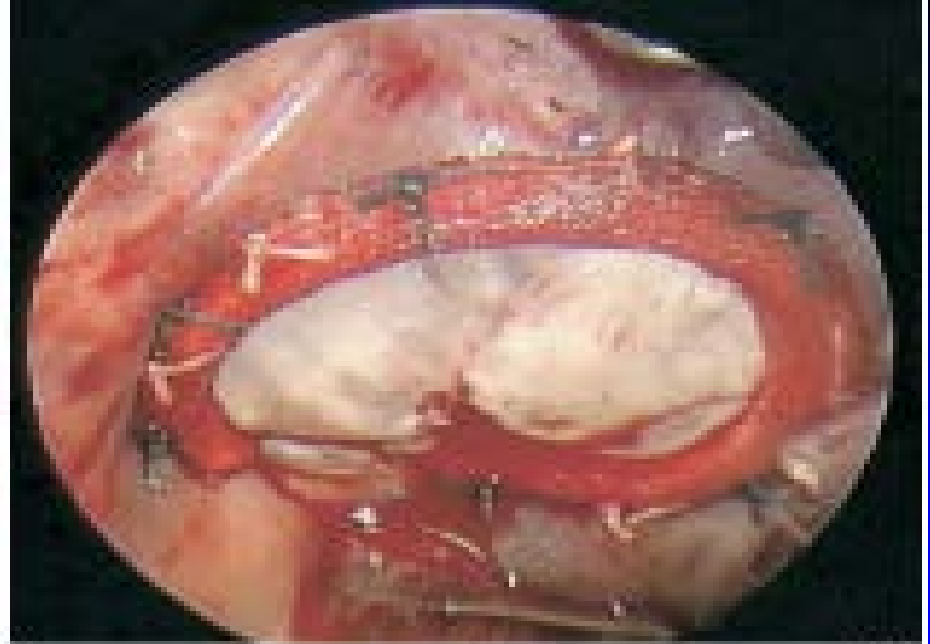


*Will I get
Stenosis ?*

NO ! - Πr^2

26 mm = 4 cm²

2-3 mm gradient

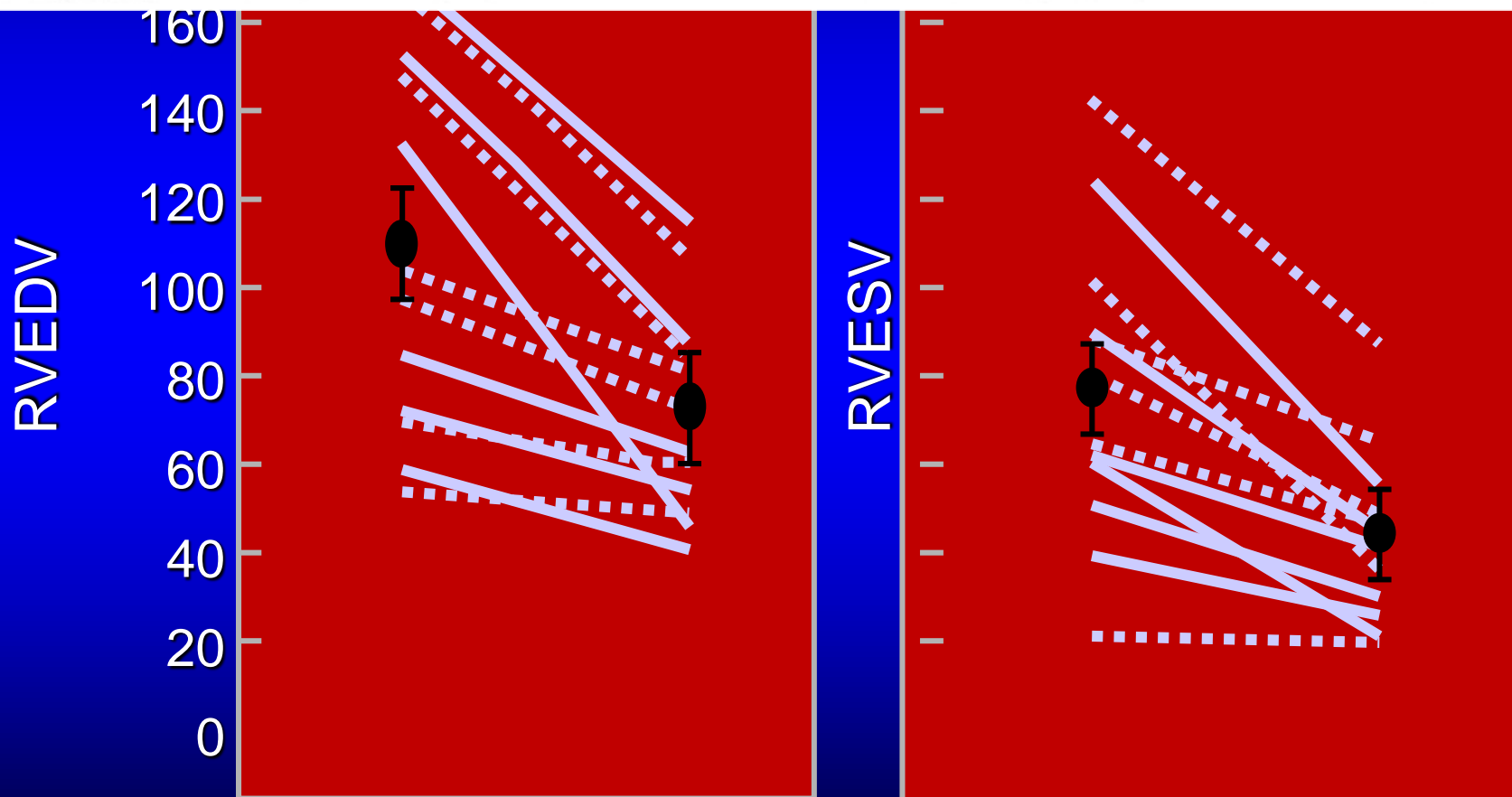


The tricuspid valve: current perspective and evolving management of tricuspid regurgitation.

Rogers JH, Bolling SF. Circulation. 2009 May 26;119(20):2718-25

Improvement in Right Ventricular Systolic Function After Surgical Correction of Isolated Tricuspid Regurgitation

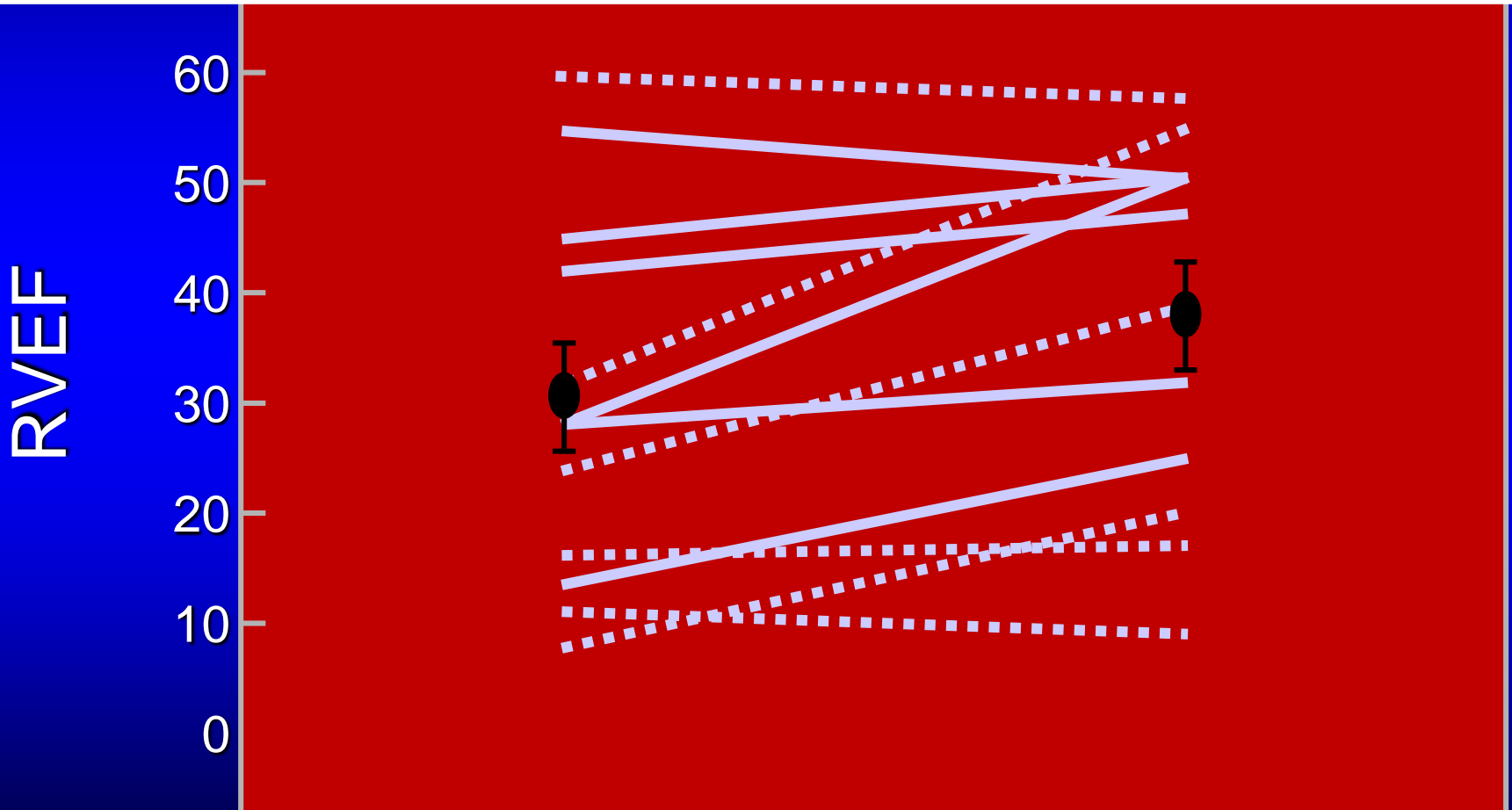
Debabrata Mukherjee, MD, Simone Nader, MD, Arrel Olano, MD, Mario J. Garcia, MD, and Brian P. Griffin, MD, *Cleveland, Ohio*



What about RV failure?

Improvement in Right Ventricular Systolic Function After Surgical Correction of Isolated Tricuspid Regurgitation

Debabrata Mukherjee, MD, Simone Nader, MD, Arrel Olano, MD, Mario J. Garcia, MD, and Brian P. Griffin, MD, *Cleveland, Ohio*



The RV gets better !

Tricuspid regurgitation and right ventricular function after mitral valve surgery with or without concomitant tricuspid valve procedure

Ravi R. Desai, BE,^a Lina Maria Vargas Abello, MD,^b Allan L. Klein, MD,^c Thomas H. Marwick, MD, PhD,^c Richard A. Krasuski, MD,^c Ying Ye, BS,^a Edward R. Nowicki, MD, MS,^b Jeevanantham Rajeswaran, MSc,^d Eugene H. Blackstone, MD,^{b,d} and Gösta B. Pettersson, MD, PhD^b

Tricuspid Annuloplasty Concomitant with Left-Sided Cardiac Surgery: Effects on Right Ventricular Remodeling

Philippe B. Bertrand MD MSc^{ab}, Gille Koppers MSc^b, Frederik H. Verbrugge MD^{ab}, Wilfried Mullens MD PhD^{ab}, Rozette Reyskens RN^a, Herbert Gutermann MD^a, Chris Van Kerrebroeck MD PhD^a, Robert Dion MD PhD^a, Pieter Vandervoort MD^{ab}, David Verhaert MD^a

Table 2 – Pre- and Postoperative Echocardiographic Measurements

Variables	TVP group (n=45)			Control group (n=33)			P
	baseline	follow-up	p-value	baseline	follow-up	p-value	
Mean follow-up, months							NS
RV end-diastolic area, indexed	12,0 ± 3,5	11,8 ± 3,6	NS	10,3 ± 1,9	13,1 ± 3,0	p=0,003	
RV sphericity index	1,99 ± 0,33	2,21 ± 0,42	p=0,001	2,34 ± 0,52	2,17 ± 0,13	p=0,047	
TV annulus diameter, cm	4,18 ± 0,63	TVP		3,37 ± 0,62	3,65 ± 0,50	p=0,006	
TR grade	2,0 ± 1,1	0,48 ± 0,70	p<0,001	0,53 ± 0,68	1,17 ± 1,15	p=0,001	
Right atrial area, cm ²	20,0 ± 7,2	14,4 ± 4,1	p<0,001	15,7 ± 4,99	15,0 ± 3,95	NS	
Systolic pulmonary artery pressure, mmHg	43,3 ± 16,8	37,4 ± 9,4	p=0,185*	44,6 ± 15,7	35,5 ± 11,6	p=0,008	

*paired samples: only n=21 available in TVP group (due to difficulty in measurement of echocardiographic TR signal post-TVP)

When FTR is fixed, the RV gets better!

Functional tricuspid regurgitation at the time of mitral valve repair for degenerative leaflet prolapse: The case for a selective approach

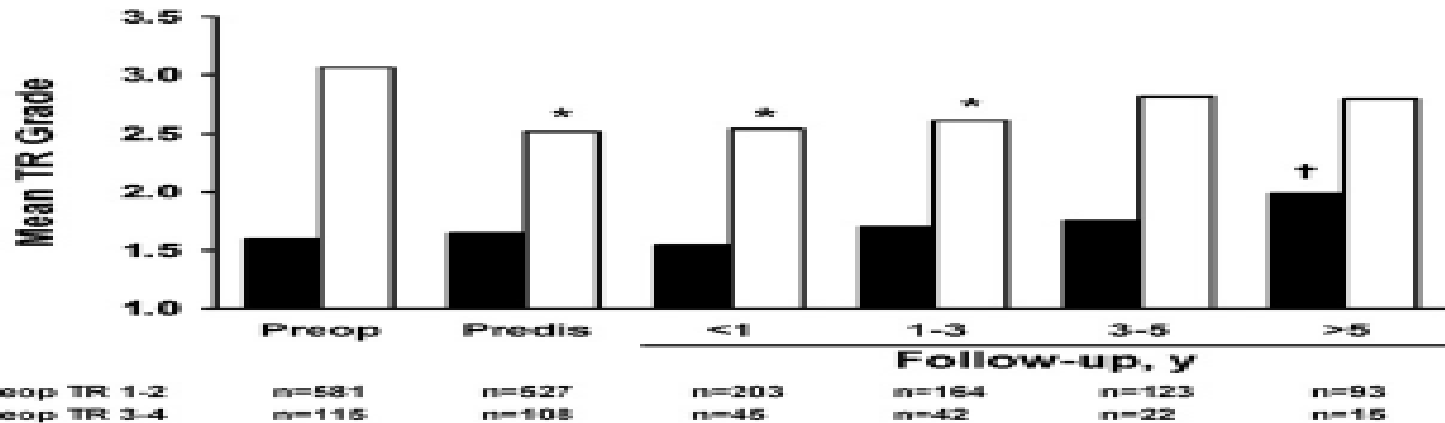
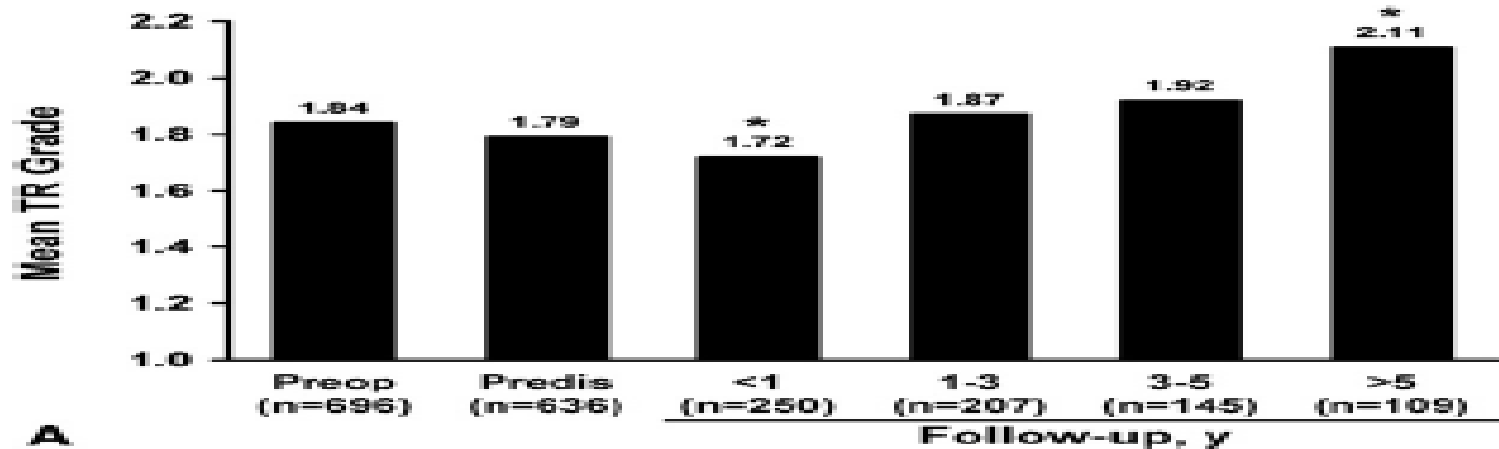
Oguz Yilmaz, MD,^a Rakesh M. Suri, MD, DPhil,^a Joseph A. Dearani, MD,^a Thoralf M. Sundt III, MD,^a Richard C. Daly, MD,^a Harold M. Burkhart, MD,^a Zhuo Li, MS,^b Maurice Enriquez-Sarano, MD,^c and Hartzell V. Schaff, MD^a

Results: In 699 patients who underwent mitral valve repair for severe mitral regurgitation, mean age was 60.4 years and 459 (66%) were male. At the time of mitral valve repair, tricuspid valve regurgitation was grade 3 or more in 115 (16%) patients and less than grade 3 in 584 (84%) patients. After mitral valve repair, overall grade of tricuspid valve regurgitation decreased significantly within the first year ($P = .01$). In patients with grade 3 regurgitation or more, the grade decreased at dismissal and until the third year ($P < .001$). Female sex, preoperative atrial fibrillation, and diabetes mellitus were independent risk factors for increased tricuspid valve regurgitation with time; preoperative regurgitation of grade 3 or more independently predicted decreased regurgitation with time. Only 1 patient required tricuspid reoperation 4.5 years after mitral repair.

Conclusions: Clinically silent nonsevere tricuspid valve regurgitation in patients with degenerative mitral valve disease is unlikely to progress after mitral valve repair. Tricuspid valve surgery is rarely necessary for most patients undergoing repair of isolated mitral valve prolapse. (J Thorac Cardiovasc Surg 2011;142:608-13)

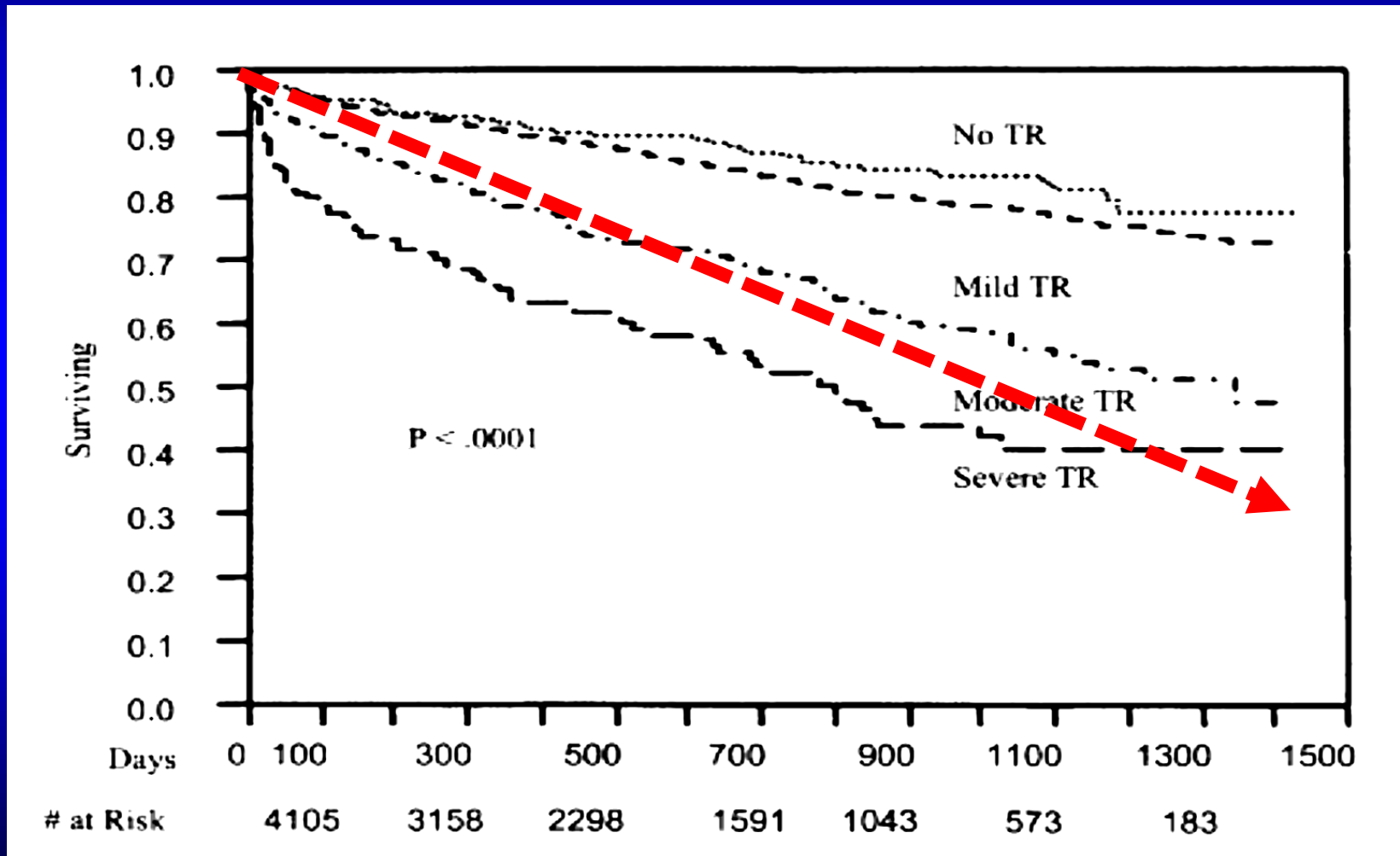
Residual Tricuspid Insufficiency

DON'T LEAVE MOD TR !!



Lack of reop is not the same as a good outcome !

“ I don't see these patients come back”...
Mod TR Increases Mortality



Fix TR ... if you are there ?

Current Guidelines for TV Surgery

2014 ACC/AHA

- Class I
 - Severe TR in a patient undergoing left sided valve surgery
- Class IIa
 - TV repair is beneficial for > Mild TR when there is tricuspid annular dilatation or right HF
- Class IIb
 - TV repair considered for FTR in presence of PH or RV dilation/dysfunction

2012 ESC/EACTS

- Class I
 - Severe TR in a patient undergoing left-sided valve surgery
- Class IIa
 - Moderate 2nd TR with dilated tricuspid annulus (>40 mm) in a patient undergoing left-sided valve surgery or with RV dilation/dysfunction

Facts ?

Impact of TVr in 645 patients

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<http://dx.doi.org/10.1016/j.jacc.2015.01.059>

Impact of Concomitant Tricuspid Annuloplasty on Tricuspid Regurgitation, Right Ventricular Function, and Pulmonary Artery Hypertension After Repair of Mitral Valve Prolapse



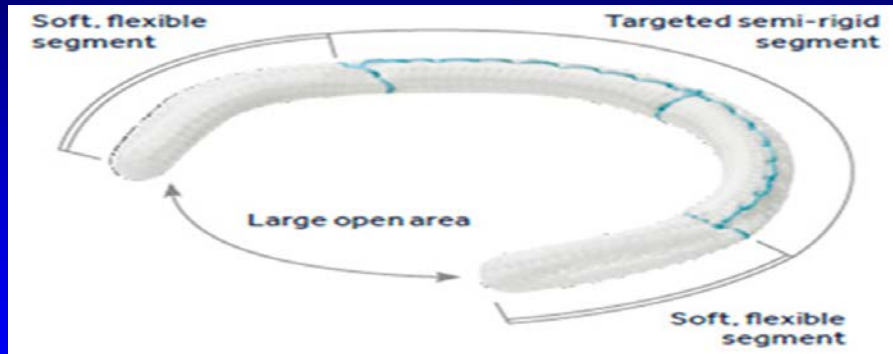
Joanna Chikwe, MD, Shinobu Itagaki, MD, Anelechi Anyanwu, MD, David H. Adams, MD

CONCLUSIONS In patients with moderate TR or tricuspid annular dilation who were undergoing degenerative mitral repair, concomitant tricuspid annuloplasty is safe, effective, and associated with improved long-term right-sided remodeling. Routine treatment of moderate TR or tricuspid annular dilation at the time of MV repair appears to be beneficial. (J Am Coll Cardiol 2015;65:1931-8) © 2015 by the American College of Cardiology Foundation.

Far less TR, better RV

NO ↑ mortality or PPM

Outcomes of Guideline directed Repair of FTR performed during MV surgery



Ward, Romano, Bolling : AATS 2017

262 pts TVr, mod/sev or ≤ moderate TR,

26/28/30 ring

No mortality, No TS, RV improved

1% progression to severe TR,

- 2.6 % de novo PPM rate

CTSN Net TR Trial - 137/400 pts

ClinicalTrials.gov

A service of the U.S. National Institutes of Health

Example: "Heart attack" AND "Los Angeles"

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Evaluating the Benefit of Concurrent Tricuspid Valve Repair During Mitral Surgery

This study is not yet open for participant recruitment. (see [Contacts and Locations](#))

Verified February 2016 by Icahn School of Medicine at Mount Sinai

Sponsor:

Icahn School of Medicine at Mount Sinai

Collaborators:

National Heart, Lung, and Blood Institute (NHLBI)

Canadian Institutes of Health Research (CIHR)

German Society for Thoracic and Cardiovascular Surgery

ClinicalTrials.gov Identifier:

NCT02675244

First received: January 29, 2016

Last updated: February 3, 2016

Last verified: February 2016

[History of Changes](#)

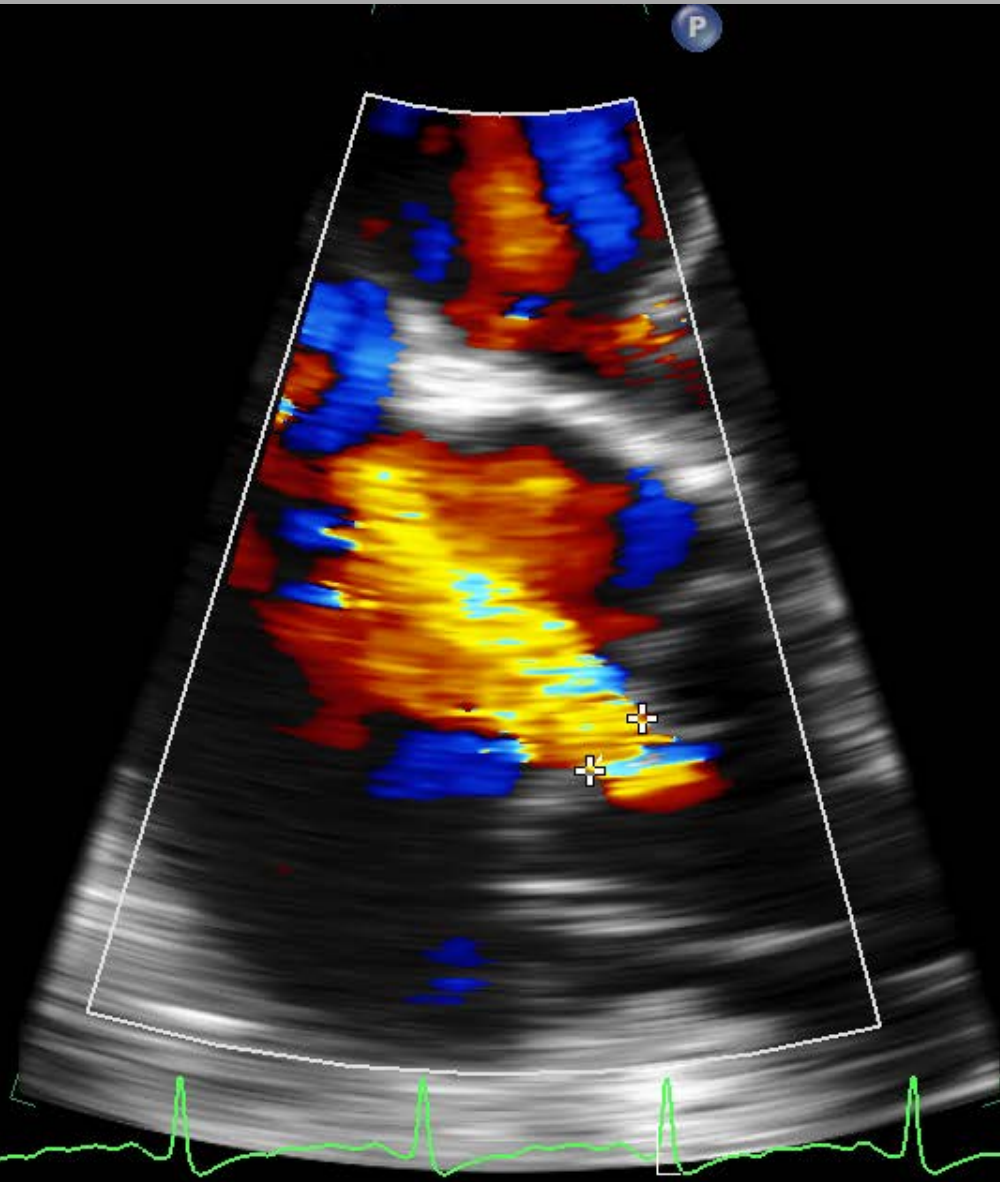
- DMR repair
- Mod TR or mild TR with annular dilation > 40
- Randomized: ±TV annuloplasty

Percutaneous Implications for TR

2D
64%
C 50
P Off
Gen



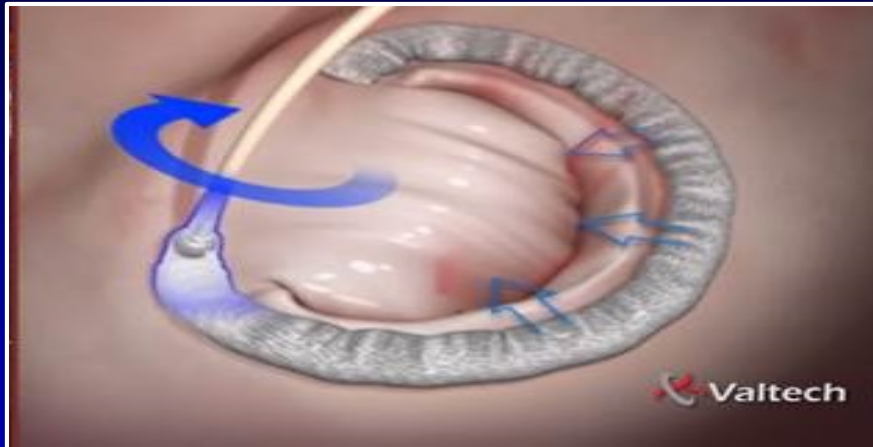
CF
59%
4.4MHz
WF High
Med



+ Dist 0.470 cm
Area 0.174 cm²

88bpm

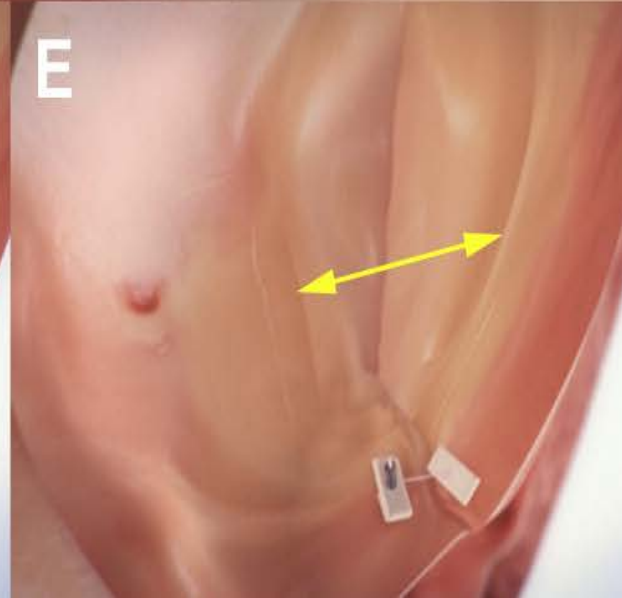
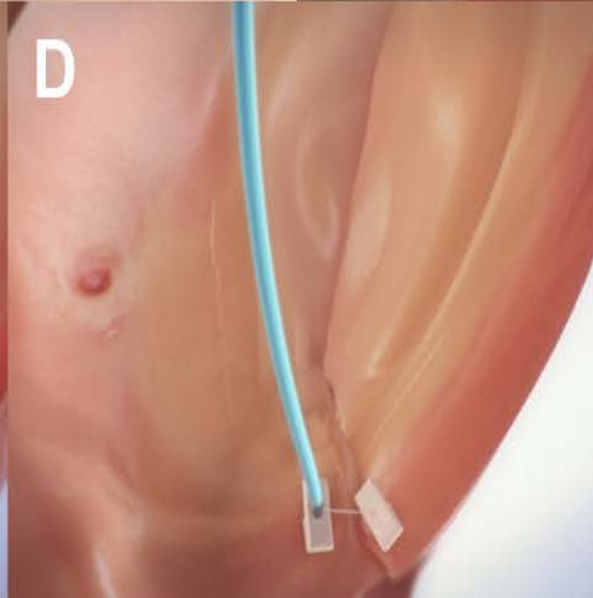
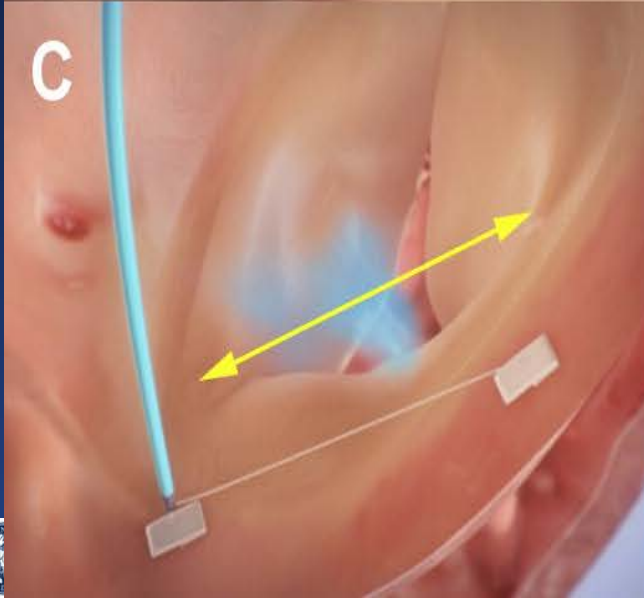
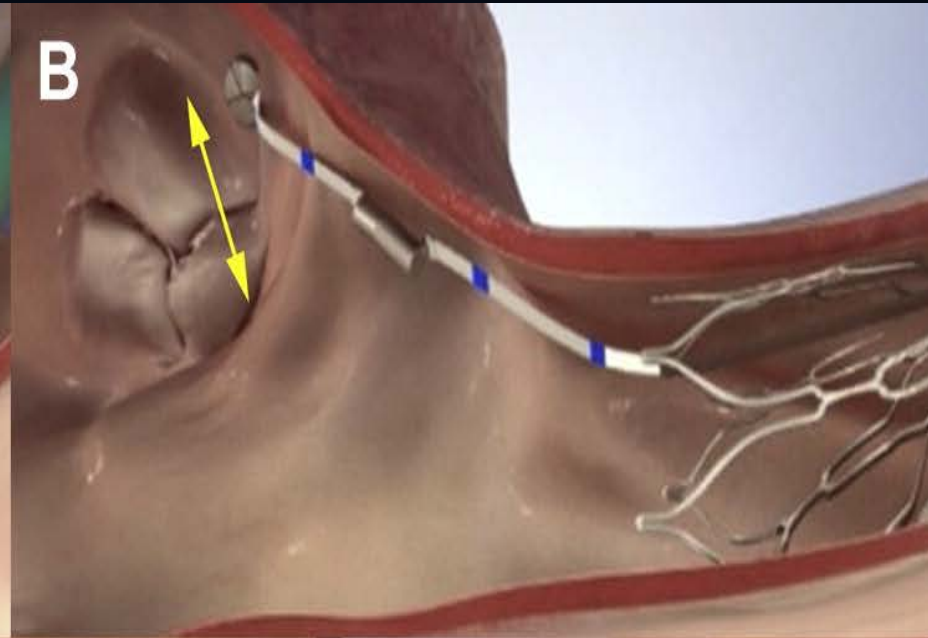
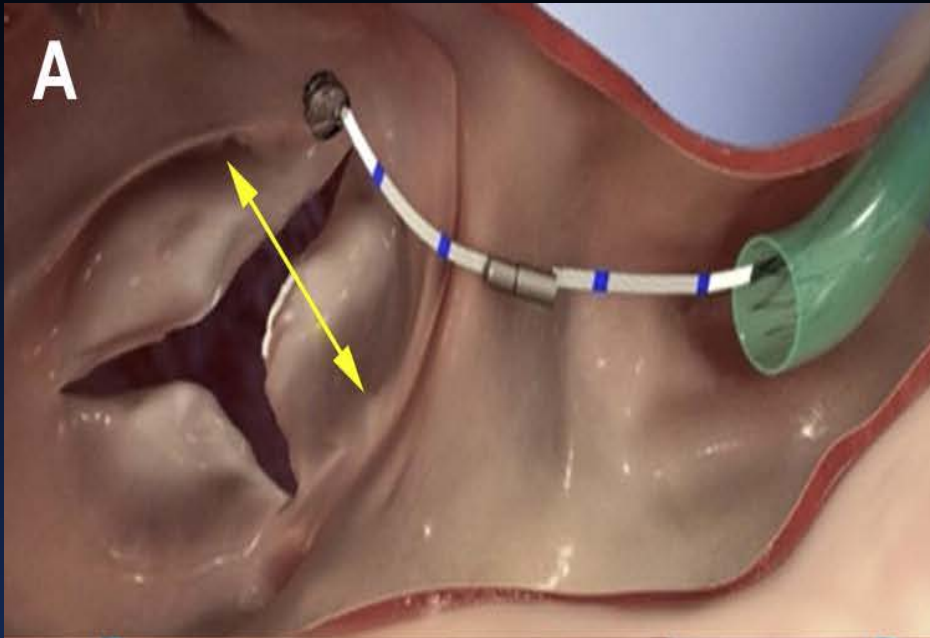
FTR Surgery : Percutaneous Implications



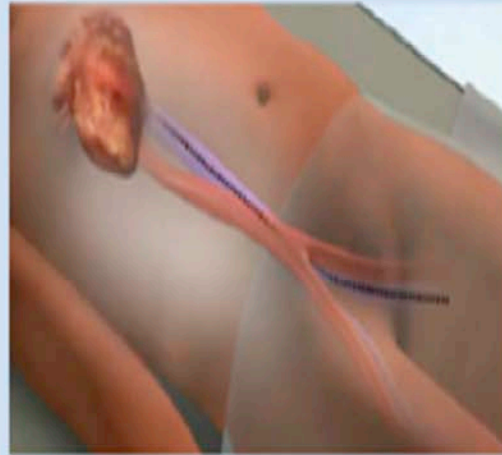
TV Perc Rings !



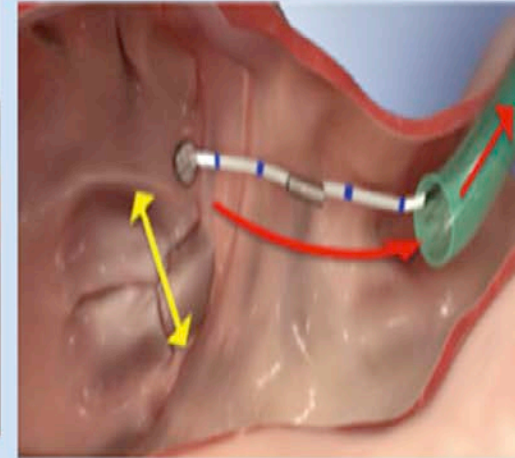
FTR: Percutaneous “Not” Rings



Tricuspid Regurgitation 4-TECH



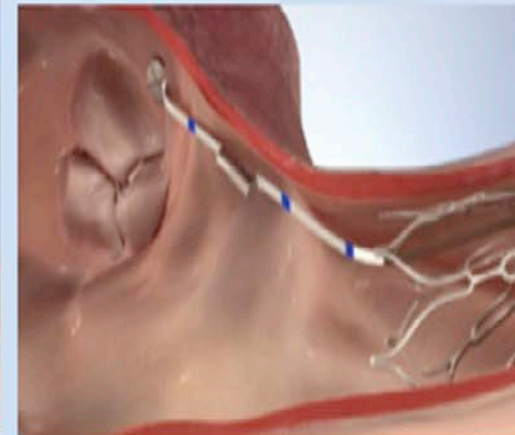
Step 1: Access via Inferior Vena Cava



Step 3: Implant the anchor on the annulus



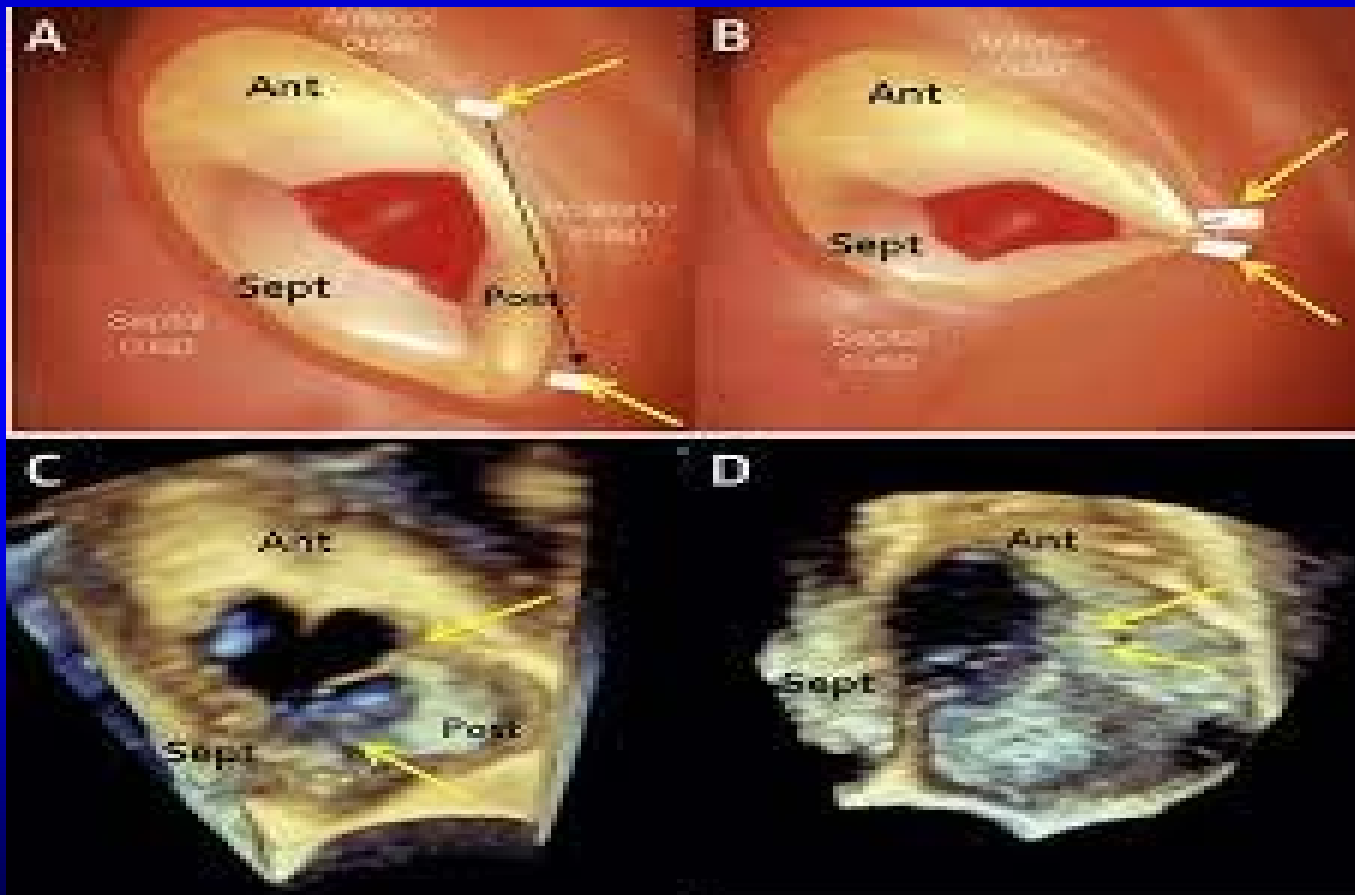
Step 2: Aim at the anterior annulus



Step 4: Pull tension, check, secure.

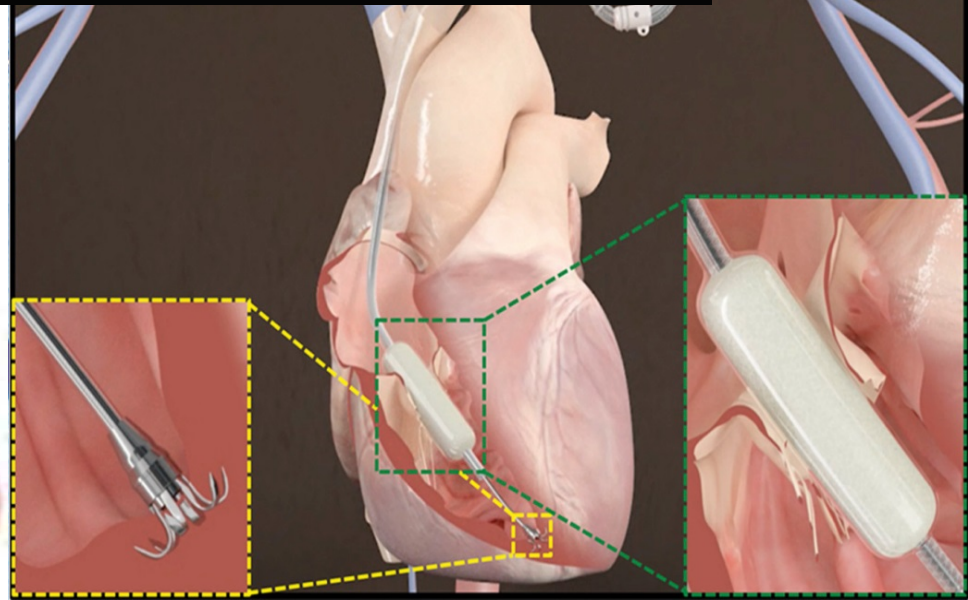
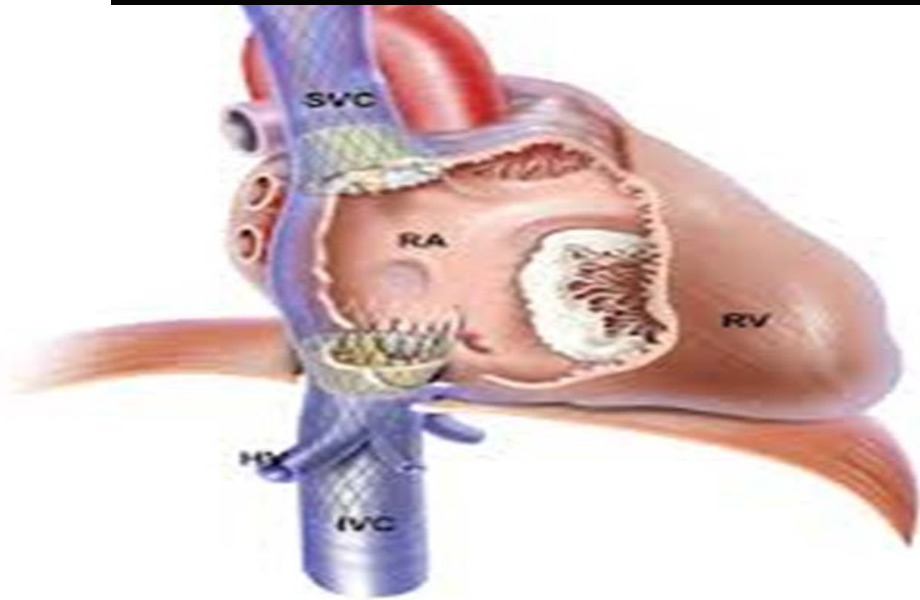
Tricuspid Regurgitation

Mitralign... Trialign



FTR: Percutaneous “other things”

***More data
needed...***



FTR: when, why and how NOW !

TR not important...	NO
Look for TR in OR...	NO
Not much TR around....	NO
Repair Mitral, TR goes away ...	NO
Adds operative mortality to do a TVr...	NO
Don't know how to...	NO
RV will fail...	NO
Will get TS...	NO
Won't make long-term difference...	NO
Guidelines are vague...	NO

FTR : Don't ignore it...

FTR: *Put a ring on it!*

