

Tricuspid regurgitation after left-sided valve surgery

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Declaration of conflict of interest

I do not have any conflict of interest

Tricuspid Regurgitation

Clinical Scenarios

- Isolated primary (organic) TR
- Secondary (functional) TR in patients undergoing left-sided valve surgery
- Late TR following left sided valve surgery

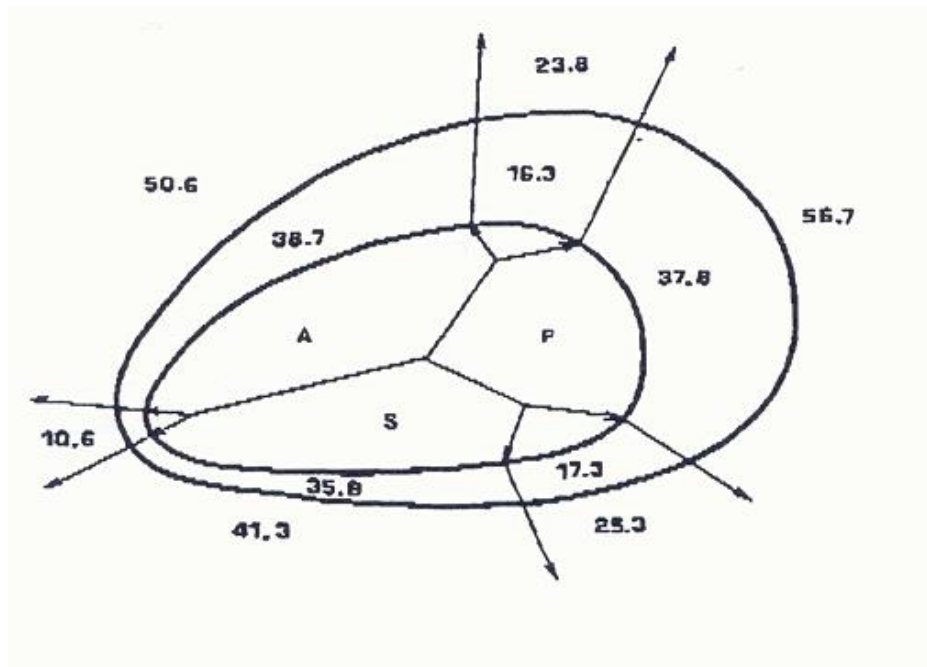
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Secondary (functional) TR

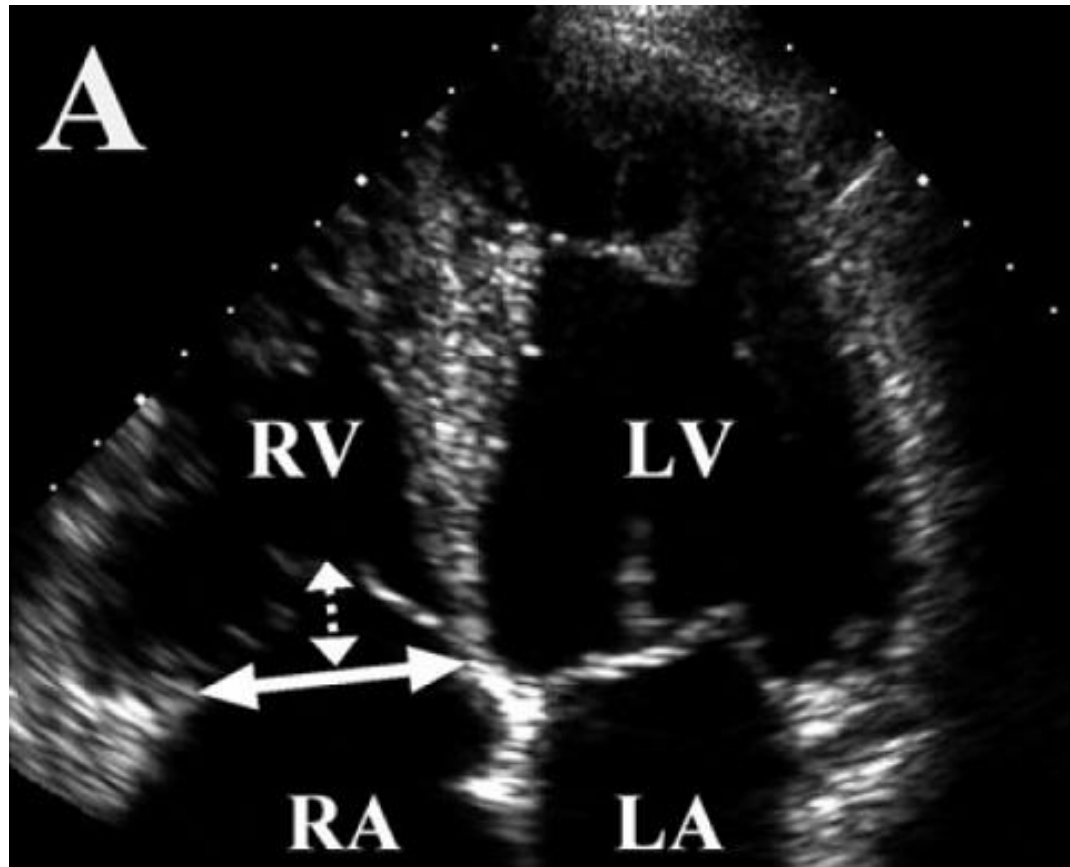
Asymmetric annular dilatation



Deloche et al. Ann Chir Thorac Cardiovasc 1973

Secondary (functional) TR

Leaflet tethering



Fukuda S et al. J Am Soc Echocardiogr 2007;20:1236-1242

Indications for surgery in tricuspid disease (ESC/EACTS Guidelines)

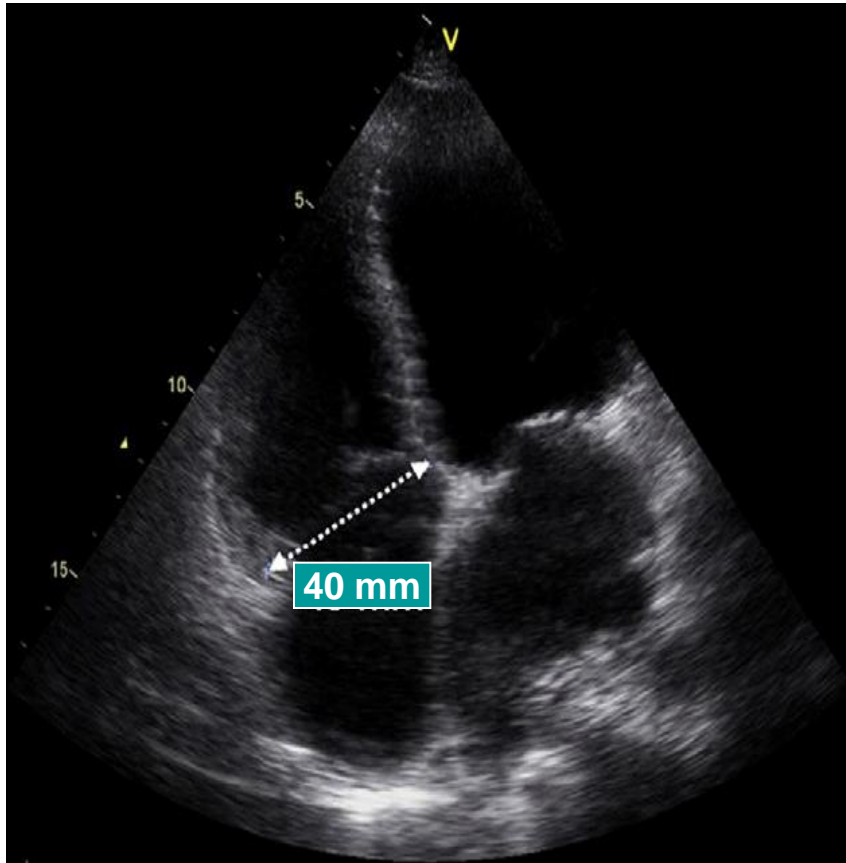
	Class	Level
Surgery is indicated in symptomatic patients with severe TS	I	C
Surgery is indicated in patients with severe TS undergoing left-sided valve intervention.	I	C
Surgery is indicated in patients with severe primary, or secondary, TR undergoing left-sided valve surgery.	I	C
Surgery is indicated in symptomatic patients with severe isolated primary TR without severe right ventricular dysfunction.	I	C
Surgery should be considered in patients with moderate primary TR undergoing left-sided valve surgery.	IIa	C
<i>Surgery should be considered in patients with mild or moderate secondary TR with dilated annulus (≥ 40 mm or > 21 mm/m²) undergoing left-sided valve surgery.</i>	IIa	C
<i>Surgery should be considered in asymptomatic or mildly symptomatic patients with severe isolated primary TR and progressive right ventricular dilation or deterioration of right ventricular function.</i>	IIa	C
After left-sided valve surgery, surgery should be considered in patients with severe TR who are symptomatic or have progressive right ventricular dilatation/dysfunction, in the absence of left-sided valve dysfunction, severe right or left ventricular dysfunction, and severe pulmonary vascular disease.	IIa	C

Indications for surgery in tricuspid disease (ESC/EACTS Guidelines)

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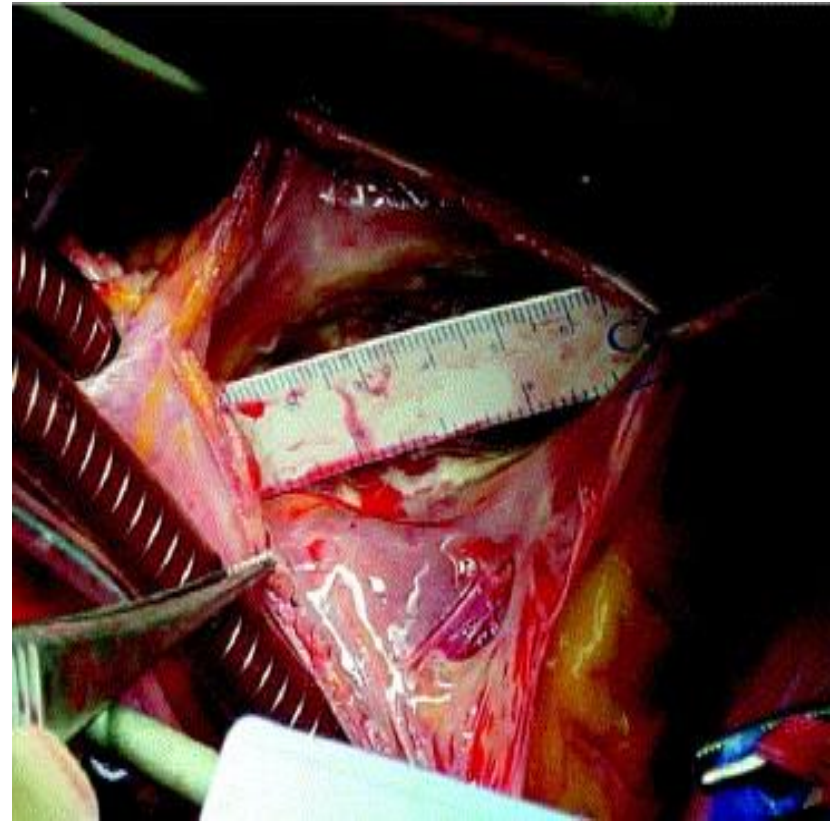
Tricuspid annulus dilatation

TT apical 4-chamber view
in late diastole



≥ 4 cm or 21 mm/sqm

Surgical view



**Antero-septal to antero-posterior
commissure distance > 7 cm**

Progression of not significant TR ($\leq 2+$) (untreated at the time of initial MV surgery)

	Before Surgery		After Surgery	
	Group 1 (MVR)	Group 2 (MVR + TVR)	Group 1 (MVR)	Group 2 (MVR + TVR)
Grade 0	54	38	8	102
Grade 1	102	92	33	41
Grade 2	7	16	67	4
Grade 3	0	2	40	1
Grade 4	0	0	15	0
Mean TR grade	0.7 ± 0.5^a	0.9 ± 0.6^a	2.1 ± 1.0^b	0.4 ± 0.6^b

^a $p = 0.027$ Mann-Whitney. ^b $p < 0.001$ Mann-Whitney.

In pts who did not receive concomitant tricuspid annuloplasty
-progression of none or mild TR to 3+ or 4+ occurred in 34% of the cases

Dreyfus GD et al. Ann Thorac Surg 2005;79:127-132.

Tricuspid annuloplasty prevents right ventricular dilatation and progression of tricuspid regurgitation in patients with tricuspid annular dilatation undergoing mitral valve repair

Nico R. Van de Veire, MD, PhD,^a Jerry Braun, MD,^b Victoria Delgado, MD,^a Michel I. M. Versteegh, MD,^b Robert A. Dion, MD, PhD,^b Robert J. M. Klautz, MD, PhD,^b and Jeroen J. Bax, MD, PhD^a

Objectives: We hypothesize that concomitant tricuspid annuloplasty in patients with tricuspid annular dilatation who undergo mitral valve repair could prevent progression of tricuspid regurgitation and right ventricular remodeling.

Methods: In 2002, 80 patients underwent mitral valve repair. Concomitant tricuspid annuloplasty was performed in 13 patients with grade 3 or 4 tricuspid regurgitation. In 2004, 102 patients underwent mitral valve repair. Concomitant tricuspid annuloplasty was performed in 21 patients with grade 3 or 4 tricuspid regurgitation and in 43 patients with an echocardiographically determined tricuspid annular diameter of 40 mm or greater. Patients underwent transthoracic echocardiographic analysis preoperatively and at the 2-year follow-up.

Results: In the 2002 cohort right ventricular dimensions did not decrease (right ventricular long axis, 69 ± 7 vs 70 ± 8 mm; right ventricular short axis, 29 ± 7 vs 30 ± 7 mm); tricuspid regurgitation grade and gradient remained unchanged. In the 2004 cohort right ventricular reverse remodeling was observed (right ventricular long axis, 71 ± 6 vs 69 ± 9 mm; right ventricular short axis, 29 ± 5 vs 27 ± 5 mm; $P < .0001$); tricuspid regurgitation diminished (1.6 ± 1.0 vs 0.9 ± 0.6 , $P < .0001$), and transtricuspid gradient decreased (28 ± 13 vs 23 ± 15 mm Hg, $P = .021$). Subanalysis of the 2002 cohort showed that in 23 patients without grade 3 or 4 tricuspid regurgitation but baseline tricuspid annular dilatation, the degree of tricuspid regurgitation was worse at the 2-year follow-up. Moreover, this caused right ventricular dilatation. Subanalysis of the 2004 cohort demonstrated reverse right ventricular remodeling and decreased tricuspid regurgitation in 43 patients with preoperative tricuspid annular dilatation who underwent tricuspid annuloplasty.

Conclusions: Concomitant tricuspid annuloplasty during mitral valve repair should be considered in patients with tricuspid annular dilatation despite the absence of important tricuspid regurgitation at baseline because this improves echocardiographic outcome. (J Thorac Cardiovasc Surg 2011;141:1431-9)

Randomized study on prophylactic tricuspid annuloplasty

Prophylactic Tricuspid Annuloplasty in Patients with Dilated Tricuspid Annulus Undergoing Mitral Valve Surgery

Umberto Benedetto, Giovanni Melina, Emiliano Angeloni, Antonino Roscitano, Riccardo Sinatra

Objective(s): Late occurrence of severe tricuspid regurgitation (TR) is not uncommon after mitral valve surgery and it is associated with poor outcomes. Current guidelines suggest the opportunity of tricuspid annuloplasty in patients with moderate secondary TR with annular dilatation undergoing left-sided valve surgery to prevent TR progression. However, final conclusions about the role of prophylactic tricuspid annuloplasty are still lacking.

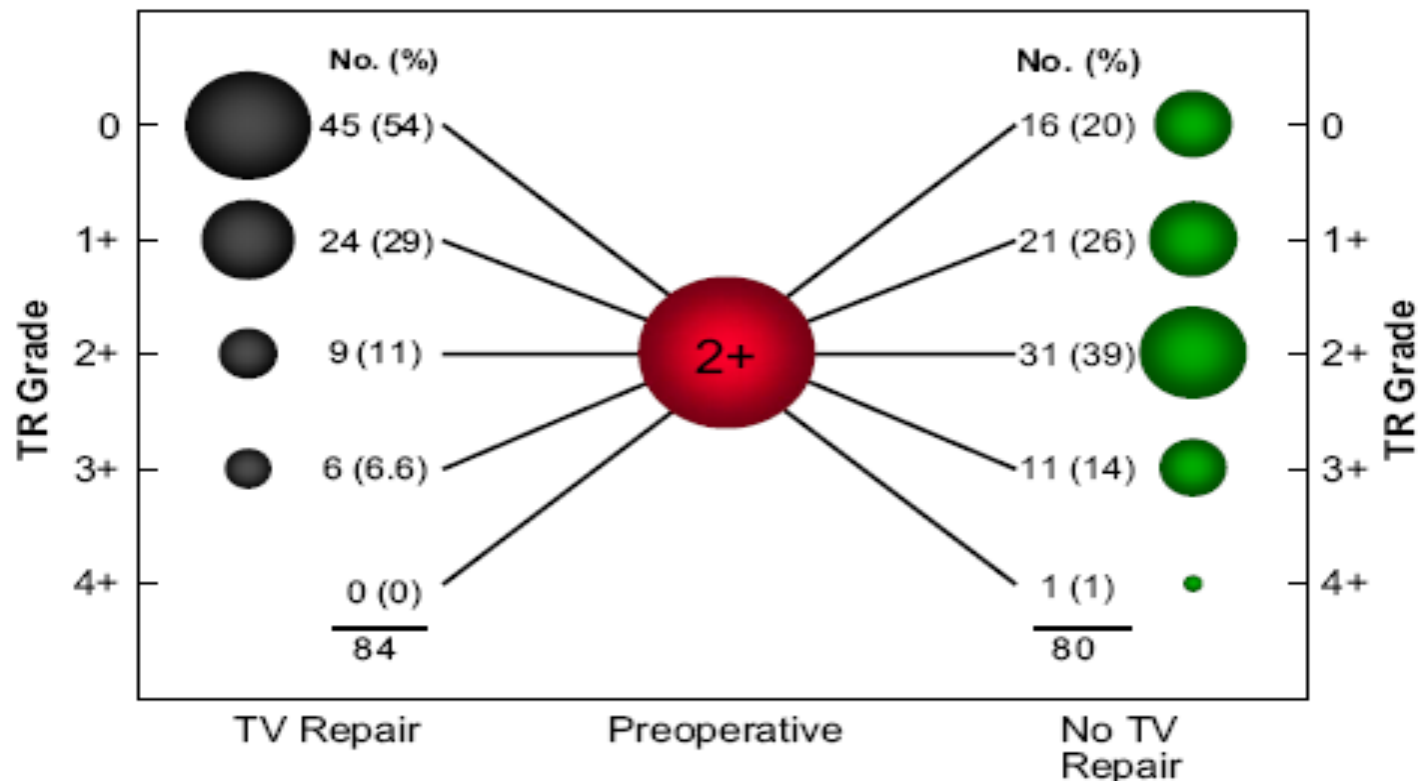
Methods: We enrolled 44 patients undergoing mitral valve surgery (both repair or replacement) presenting less than moderate ($\leq +2$ degree) secondary TR and dilated tricuspid annulus (≥ 40 mm) at preoperative echo. They were randomized to receive ($n=22$) or not ($n=22$) concomitant tricuspid annuloplasty (Cosgrove-Edwards annuloplasty ring) at the time of mitral valve surgery. Clinical and echocardiographic follow-up was performed at 12 months after surgery.

Results: Preoperative clinical and echocardiographic characteristics were comparable in the two groups. Operative mortality was 2.2% (one death in each group). At 12 months follow-up TR was completely absent in 15/21 (71%) patients receiving tricuspid annuloplasty and in 4/21 (19%) patients who did not ($P=0.001$). Severe TR ($\geq +3$ degree) was present in 0/21 (0%) patients receiving tricuspid annuloplasty and 8/21 (38%) patients who did not ($P=0.003$). Pulmonary artery systolic pressure significantly decreased from baseline in all cases ($P<0.001$) and it was comparable in the two groups (41 ± 8 mmHg vs 40 ± 5 mmHg; $P=0.4$). Right ventricular dimensions improved in patients receiving tricuspid annuloplasty (RV long axis from 71 ± 7 to 65 ± 8 mm; $P=0.01$; RV short axis: 33 ± 4 vs 27 ± 5 mm; $P=0.001$) but it remained unchanged in the control group (RV long axis from 72 ± 6 to 70 ± 9 mm; $P=0.08$; RV short axis: from 34 ± 5 to 33 ± 5 mm; $P=0.1$). 6-minute walk test improved from baseline in both groups ($P<0.001$) but this improvement was greater in patients receiving tricuspid annuloplasty than patients who did not ($+115 \pm 23$ m from baseline vs $+75 \pm 35$ m; $P=0.008$).

Conclusions: Prophylactic tricuspid annuloplasty in patients with dilated tricuspid annulus undergoing mitral valve surgery did not add operative risk and it was associated with a reduced rate of TR progression and better echocardiographic and clinical outcomes.

Moderate Tricuspid Regurgitation With Left-Sided Degenerative Heart Valve Disease: To Repair or Not to Repair?

Jose L. Navia, MD, Nicolas A. Brozzi, MD, Allan L. Klein, MD, Lee Fong Ling, MBBS, Chanapong Kittayarak, MD, Edward R. Nowicki, MD, MS, Lillian H. Batizy, MS, Jiansheng Zhong, MS, and Eugene H. Blackstone, MD



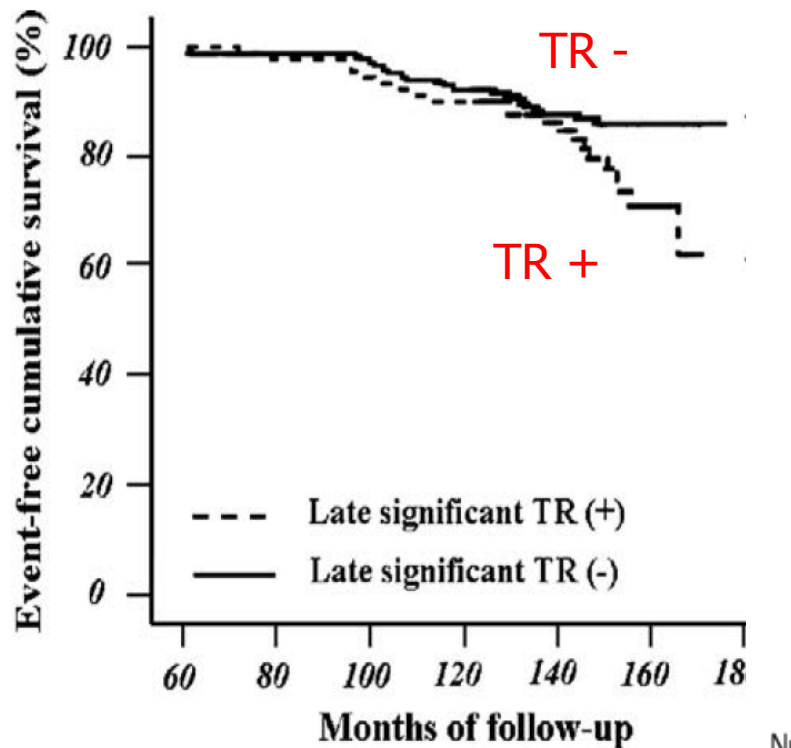
Tricuspid Regurgitation

Clinical Scenarios

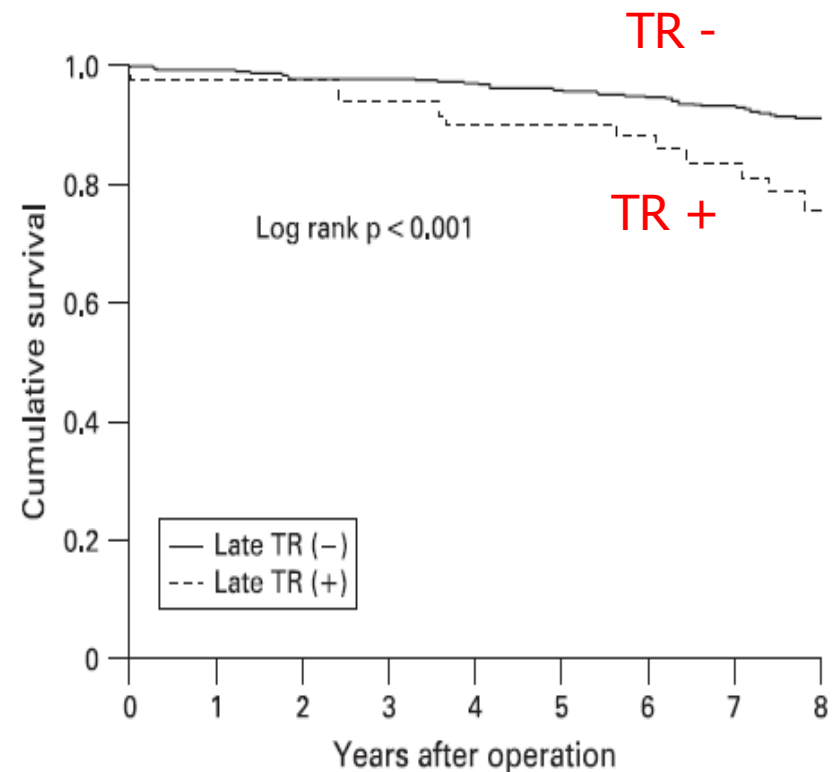
- Isolated primary (organic) TR
- Secondary (functional) TR in patients undergoing left-sided valve surgery
- Late TR following left sided valve surgery

Late mortality after MV surgery is
strictly related to the presence of
significant TR

Late TR after left-sided valve surgery (mainly MV surgery) is associated to lower survival



Kwak JJ et al.
Am Heart J 2008;155:732-7

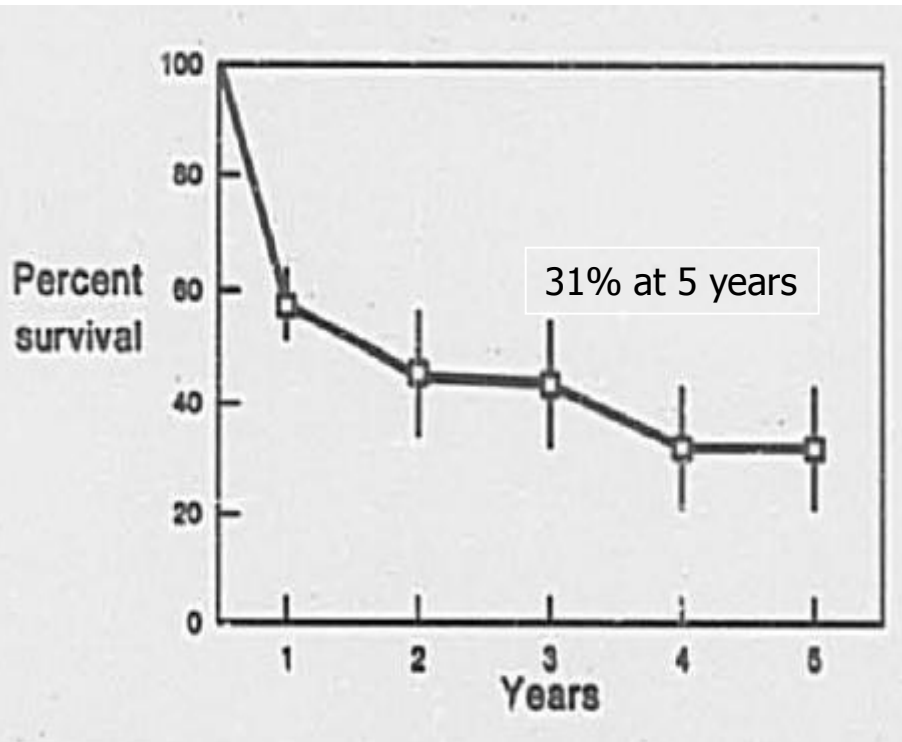


Song H et al.
Heart 2009;95:931-936.

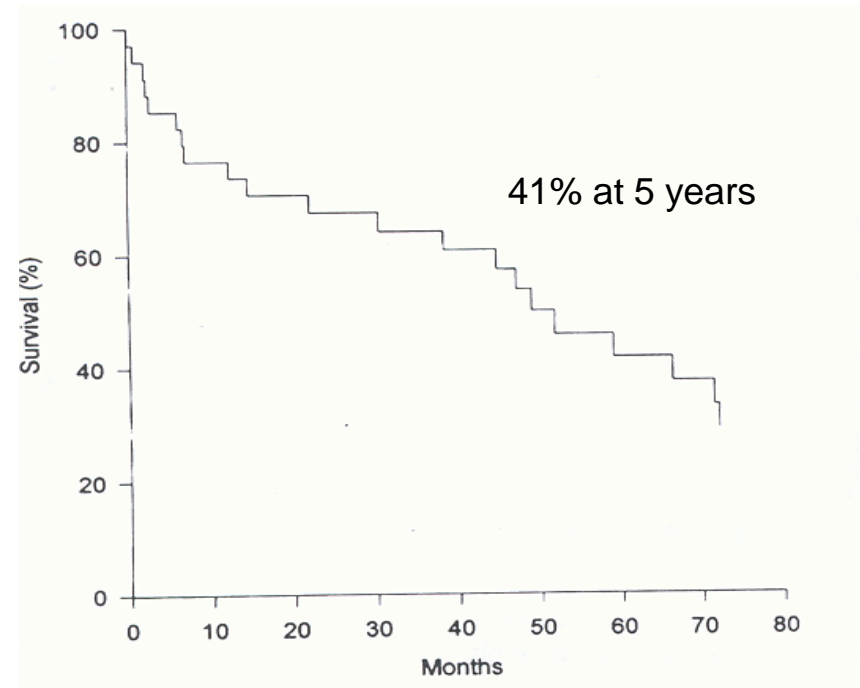
Hospital mortality for late TR surgery

	Year	Hospital mortality (%)
King	1984	25%
Kaul	1991	23.5%
Staab	1999	8.8%
Izumi	2002	14.2%
McCarthy	2004	37%
Dong-A Kwon	2006	25%
Kwak	2008	16.6%

Late survival after surgery for TR following MV replacement or repair



King et al.
Circulation 1984;70 (suppl.I): I-193.



Staab ME et al.
J Heart Valve Dis. 1999 Sep;8(5):567-74

Late survival after surgery for TR following MV replacement or repair

Tricuspid valve repair: Durability and risk factors for failure

Patrick M. McCarthy, MD
Sunil K. Bhudia, MD
Jeevanantham Rajeswaran, MSc
Katherine J. Hoercher, RN
Bruce W. Lytle, MD
Delos M. Cosgrove, MD
Eugene H. Blackstone, MD

McCarthy et al. JTCVS 2004;127:675

Objectives: To compare durability of tricuspid valve annuloplasty techniques, identify risk factors for repair failure, and characterize survival, reoperation, and functional class of surviving patients.

Methods: From 1990 to 1999, 790 patients (mean age 65 ± 12 years, 51% New York Heart Association functional class III or IV, and mean right ventricular systolic pressure 56 ± 18 mm Hg) underwent tricuspid valve annuloplasty for functional regurgitation using 4 techniques: Carpentier-Edwards semi-rigid ring, Cosgrove-Edwards flexible band, De Vega procedure, and customized semicircular Peri-Guard annuloplasty. Of these patients, 89% had concomitant mitral valve surgery. A total of 2245 follow-up transthoracic echocardiograms were retrieved. Tricuspid regurgitation was analyzed, and risk factors for worsening regurgitation were identified, by multivariable ordinal longitudinal methods.

Results: Tricuspid regurgitation 1 week after annuloplasty was 3+ or 4+ in 14% of patients. Regurgitation severity was stable across time with the Carpentier-Edwards ring ($P = .7$), increased slowly with the Cosgrove-Edwards band ($P = .05$), and rose more rapidly with the De Vega ($P = .002$) and Peri-Guard ($P = .0009$) procedures. Risk factors for worsening regurgitation included higher preoperative regurgitation grade, poor left ventricular function, permanent pacemaker, and repair type other than ring annuloplasty. Right ventricular systolic pressure, ring size, preoperative New York Heart Association functional class, and concomitant surgery were not risk factors. Tricuspid reoperation was rare (3% at 8 years), and hospital mortality after reoperation was 37%.

Conclusions: Tricuspid valve annuloplasty did not consistently eliminate functional regurgitation, and across time regurgitation increased importantly after Peri-Guard and De Vega annuloplasties. Therefore, these repair techniques should be abandoned, and transtricuspid pacing leads should be replaced with epicardial leads.

Survival after surgery for late TR:
19% at 3 years

From the Department of Thoracic and Cardiovascular Surgery, The Cleveland Clinic Foundation, Cleveland, Ohio.

Read at the Eighty-third Annual Meeting of The American Association for Thoracic Surgery, Boston, Mass, May 4-7, 2003.

Supported in part by an education grant from Edwards Lifesciences. Drs McCarthy and Cosgrove have developed annuloplasty rings for tricuspid valve repair (Cosgrove-Edwards, Edwards-MC²).

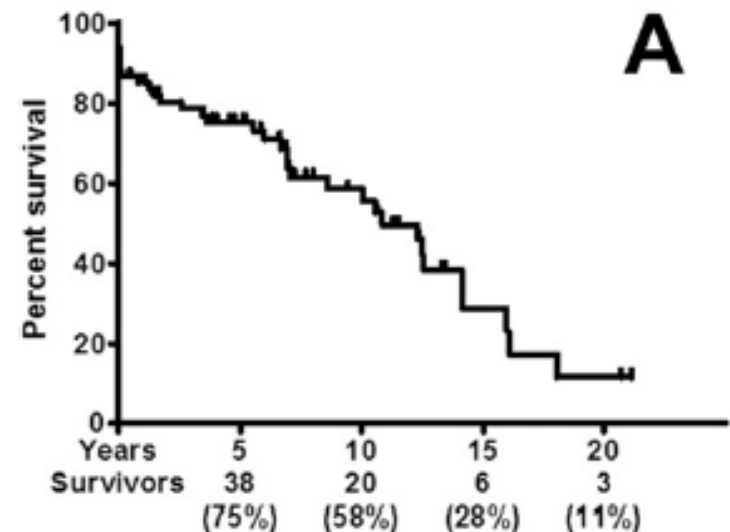
Received for publication May 5, 2003; revised manuscript received May 2, 2004; accepted for publication May 2, 2004.

The Risk and Outcomes of Reoperative Tricuspid Valve Surgery

Reubendra Jeganathan, FRCSI (CTh), Susan Armstrong, MS, Bassel Al-Alao, MRCS, and Tirone David, MD

Table 1. Continued

Characteristics	Number (%)
Postoperative:	
Days postoperative	12 (0–92)
≤12 days	36 (53%)
13+ days	32 (47%)
Intensive care duration (days)	4 (0–56)
≤4 days	36 (53%)
5+ days	26 (38%)
Ventilation (days)	0 (0–4)
≤1 day	64 (94%)
>1 day	2 (3%)
Exploration for bleeding	9 (13.2%)
Postoperative low cardiac output syndrome ^a	11 (16.2%)
Renal failure requiring dialysis	5 (7.4%)
Pacemaker insertion	13 (19.1%)
Stroke	3 (4.4%)
Surgical mortality	9 (13.2%)
Long-term survivals	34 (50%)
NYHA (long-term survivals)	
Class I	19
Class II	6
Class III	6



Isolated tricuspid valve surgery in patients with previous cardiac surgery

Bettina Pfannmüller, MD, Monica Moz, MD, Martin Misfeld, MD, PhD, Michael A. Borger, MD, PhD, Anne-Kathrin Funkat, PhD, Jens Garbade, MD, PhD, and Friedrich W. Mohr, MD, PhD

Objectives: Few studies have been published in literature on outcomes of isolated tricuspid valve (TV) surgery when performed as a reoperation. Hence, we analyzed our early and midterm results of TV surgery in this unique group of patients.

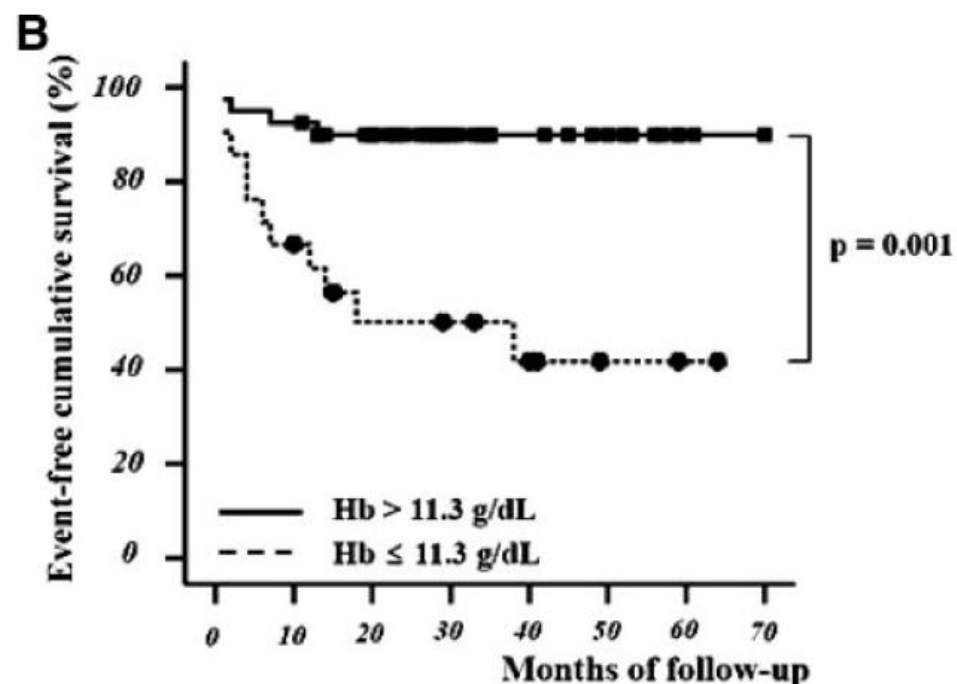
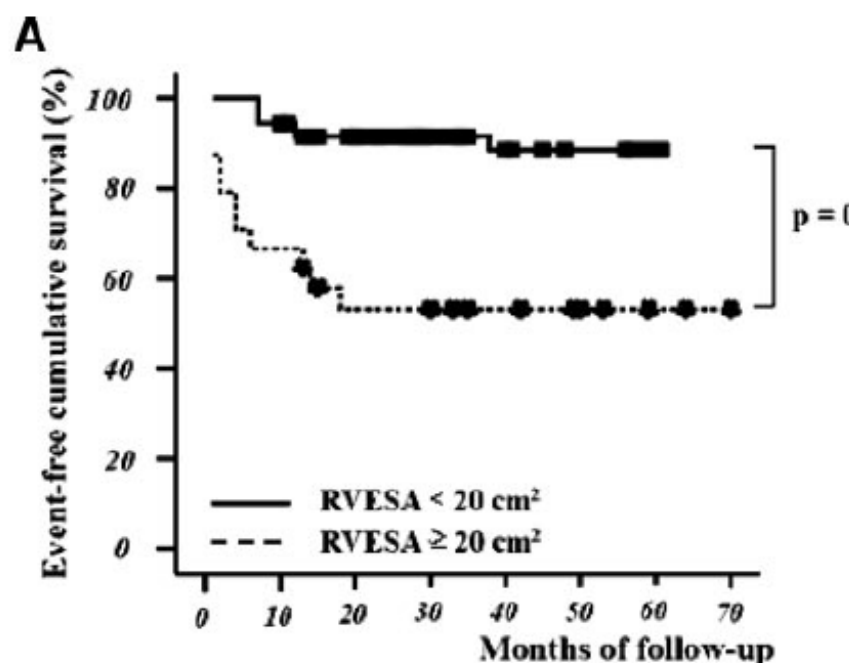
Methods: We performed a retrospective analysis of 82 consecutive patients who underwent isolated TV surgery as a reoperation at our institution between 1997 and 2010. Symptomatic TV regurgitation (84.2%), acute endocarditis (14.6%), and valve thrombosis after TV repair (1.2%) were the indications for surgery. A minimally invasive access through a right anterolateral thoracotomy was the preferred approach in 60% of the patients. Previous cardiac operations included mitral, aortic, and TV surgery in 60%, 29%, and 27% and coronary bypass surgery in 18%, usually performed as combined procedures. Elective surgery was performed in 67.1% of the patients. Mean patient age was 64.1 ± 11.9 years, 28% being male with an average logistic EuroSCORE of $16.4\% \pm 14.3\%$. Follow-up was 96% complete, with a mean duration of 2.6 ± 2.4 years.

Results: Overall thirty-day mortality was 14.6%; for patients without and with endocarditis, it was 12.9% and 25%. Thirty-day mortality for patients undergoing elective surgery was 4.0%. Overall 2-year survival was $63.0\% \pm 5.5\%$. The 2-year freedom from TV-related reoperation was $93.5\% \pm 3.3\%$.

Conclusions: Postoperative results of isolated TV surgery as a reoperation are acceptable when performed electively but dismal in patients undergoing nonelective surgery. Thus, redo TV surgery, when indicated, should be performed sooner rather than later. Minimally invasive surgery through a right lateral minithoracotomy is a safe approach for patients with elective surgery. (J Thorac Cardiovasc Surg 2012; ■:1-7)

Determinants of Surgical Outcome in Patients With Isolated Tricuspid Regurgitation

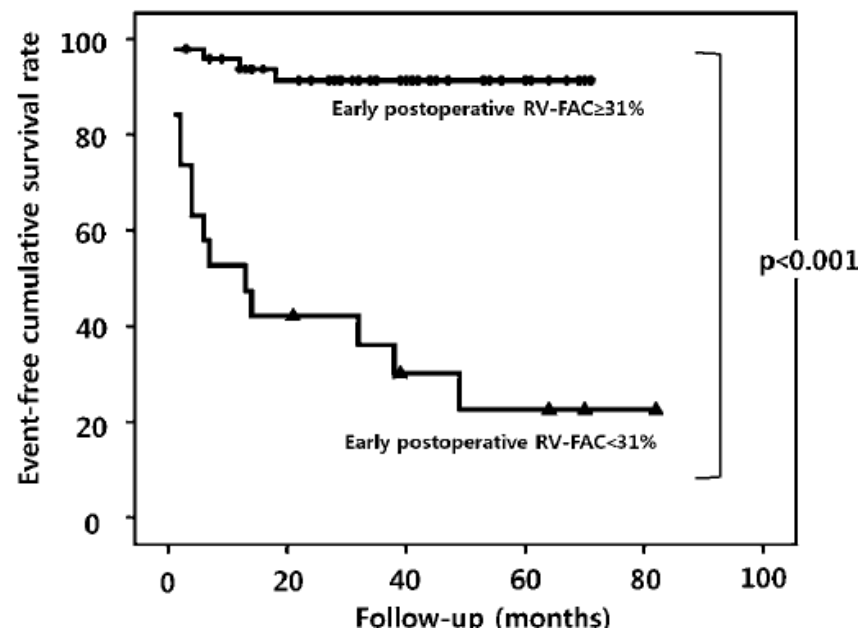
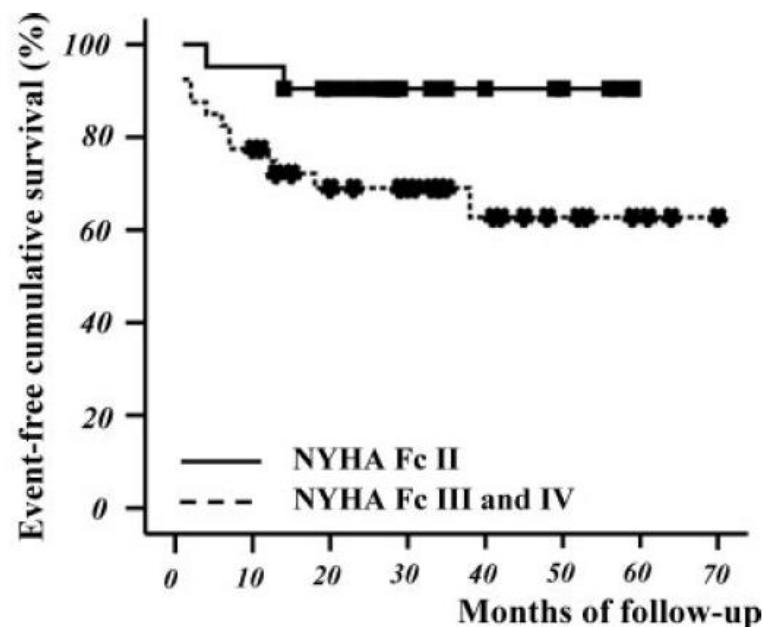
Yong-Jin Kim, MD; Dong-A Kwon, MD; Hyung-Kwan Kim, MD; Jin-Shik Park, MD;
Seokyeung Hahn, PhD; Kyung-Hwan Kim, MD; Ki-Bong Kim, MD; Dae-Won Sohn, MD;
Hyuk Ahn, MD; Byung-Hee Oh, MD; Young-Bae Park, MD



Hb > 11.3 g/dL	40	37	36	36	36	36	36	36
Hb ≤ 11.3 g/dL	21	14	11	11	10	10	10	10

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Hyuk Ahn, MD; Byung-Hee Oh, MD; Young-Bae Park, MD



NYHA Fc II	21	20	19	19	19	19	19
NYHA Fc III and IV	40	31	28	28	27	27	27

Late TR after left-sided valve surgery: Earlier surgical timing

Severe TR and symptoms, after left-sided valve surgery, in the absence of left-sided myocardial, valve, or right ventricular dysfunction and without severe pulmonary hypertension (systolic pulmonary artery pressure > 60 mmHg) **IlaC**

2007

After left-sided valve surgery, surgery should be considered in patients with severe TR who are symptomatic or have progressive right ventricular dilatation/dysfunction, in the absence of left-sided valve dysfunction, severe right or left ventricular dysfunction, and severe pulmonary vascular disease.

Ila

C

2012

Late TR after left-sided valve surgery: From pulmonary hypertension to pulmonary artery disease concept

Severe TR and symptoms, after left-sided valve surgery, in the absence of left-sided myocardial, valve, or right ventricular dysfunction and without severe pulmonary hypertension (systolic pulmonary artery pressure > 60 mmHg)

IlaC

2007

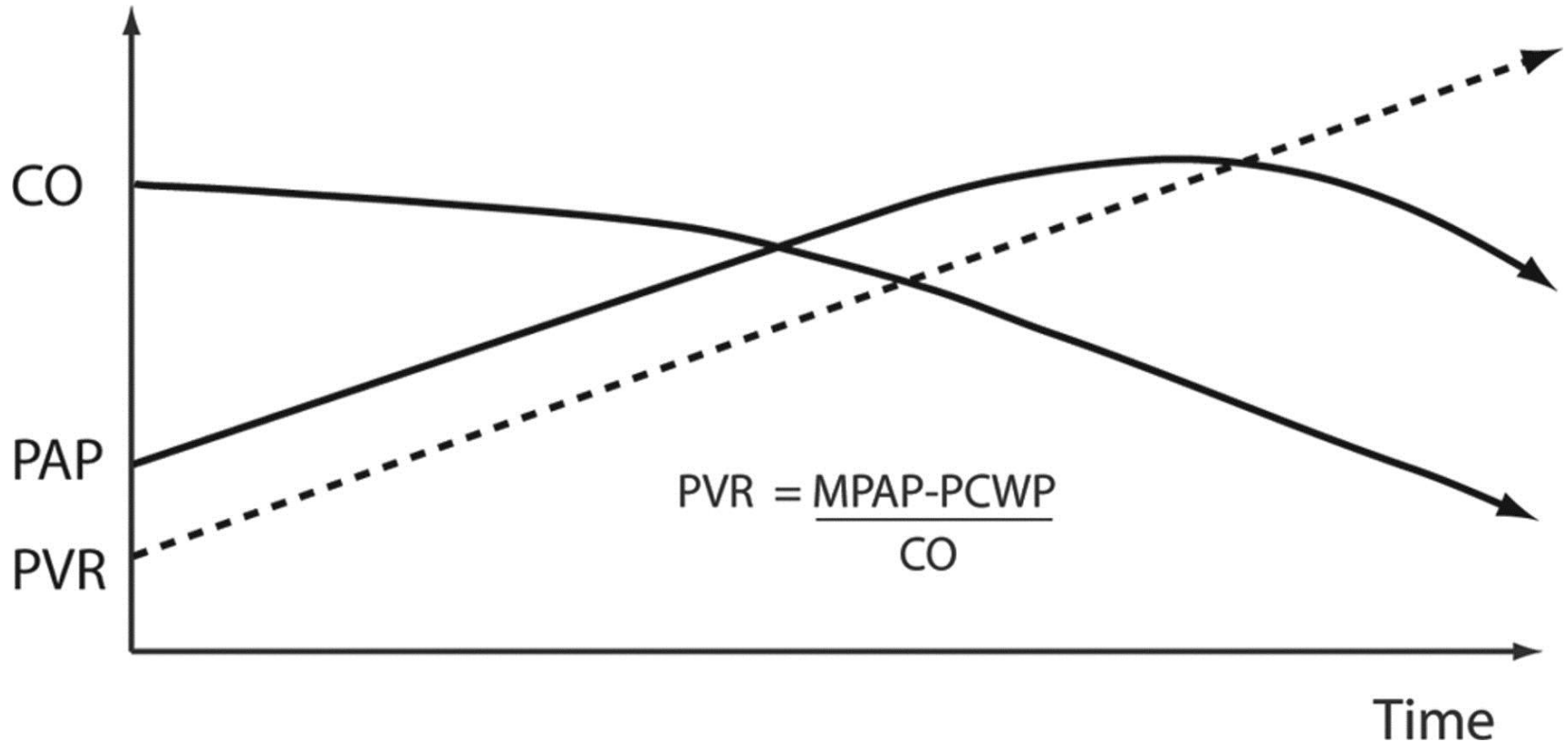
After left-sided valve surgery, surgery should be considered in patients with severe TR who are symptomatic or have progressive right ventricular dilatation/dysfunction, *in the absence of* left-sided valve dysfunction, severe right or left ventricular dysfunction, and severe pulmonary vascular disease.

Ila

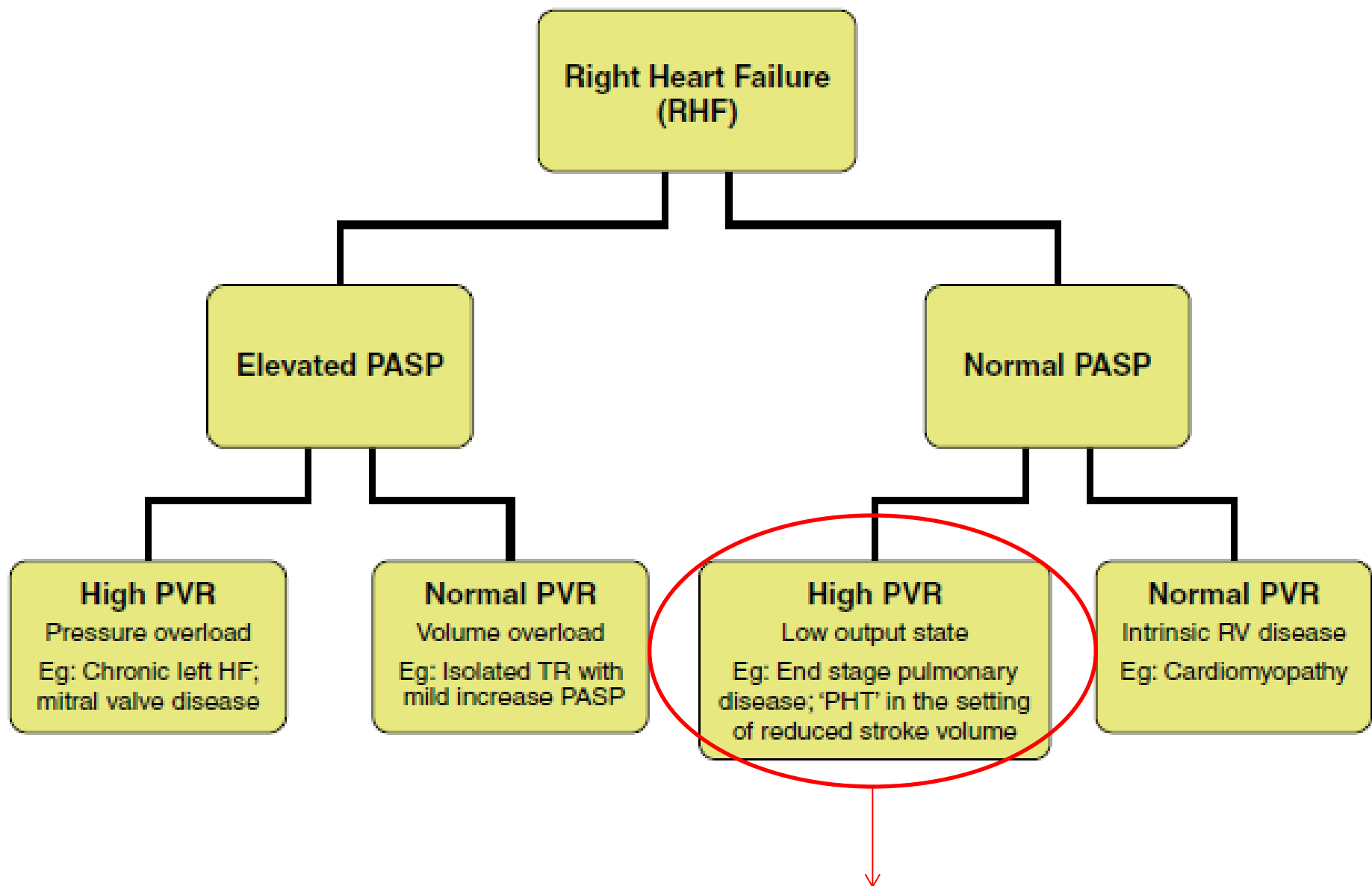
C

2012

Hemodynamics in progressive pulmonary vascular disease: **importance of right heart catheterization**



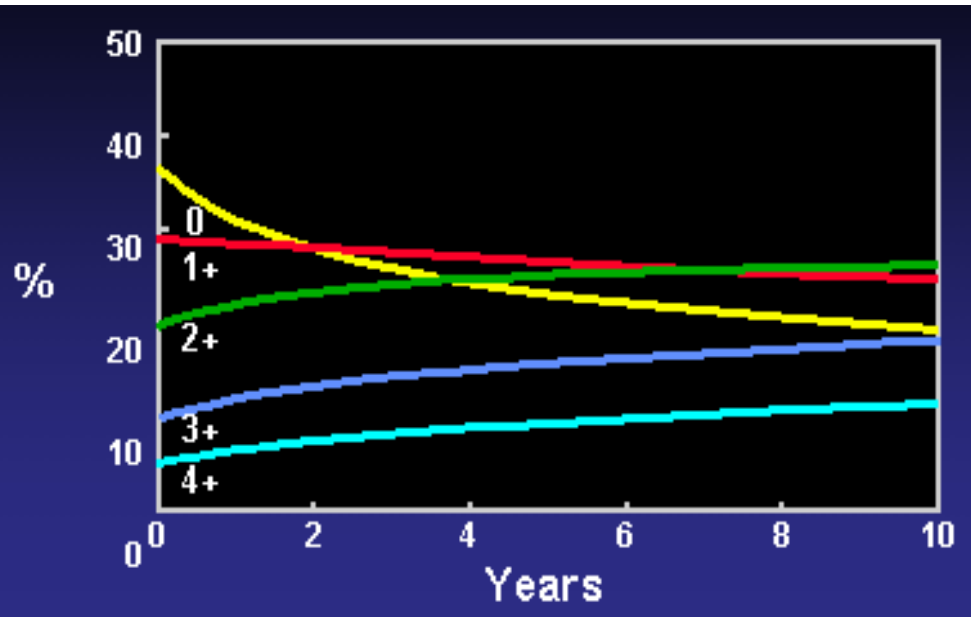
- **In case of severe TR, CO is not reliable → transpulmonary gradient to estimate PVR**



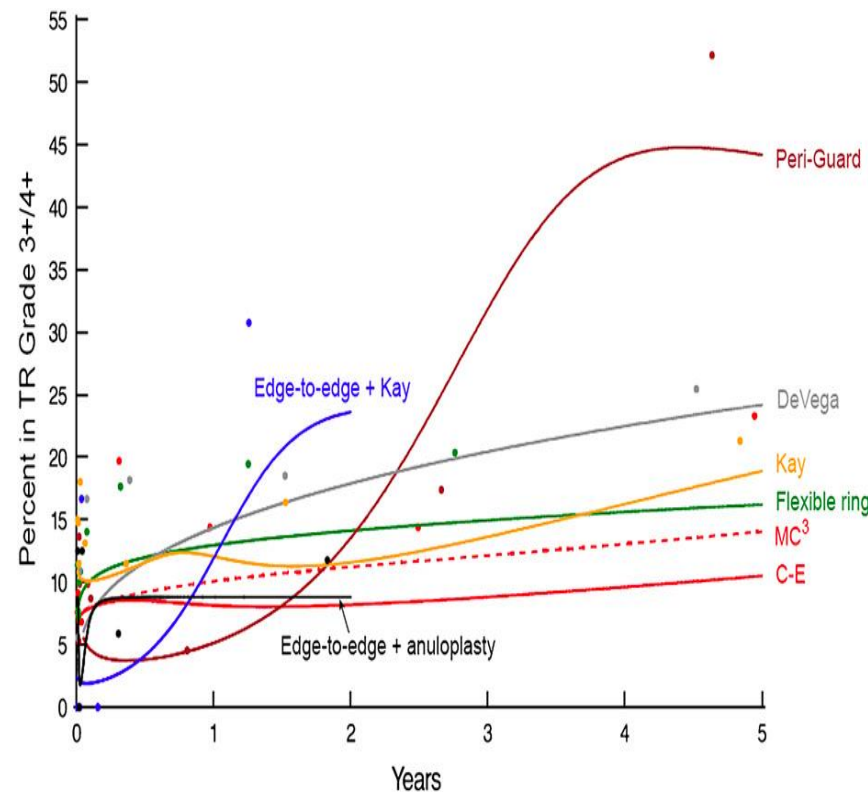
Inoperable patients with normal sPAP

Late TR should be prevented by addressing more **aggressively** and **effectively** the tricuspid valve during the primary MV operation

Current results of tricuspid annuloplasty are suboptimal



McCarthy et al. JTCVS 2004;127:675



Navia et al. JTCVS 2010;139

TR due to annular dilatation alone

remodeling
annuloplasty with a
semirigid ring is
associated with the
most durable
results

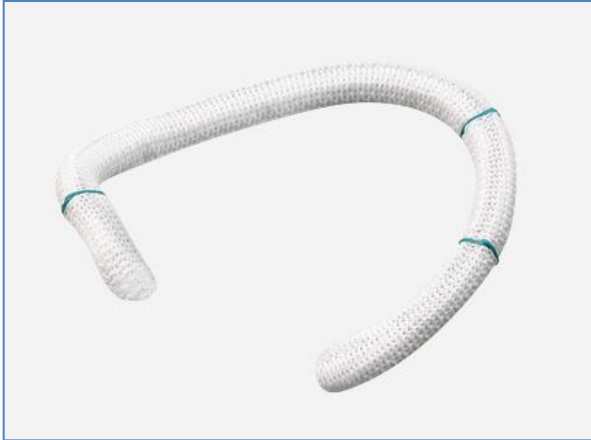


New remodeling rings



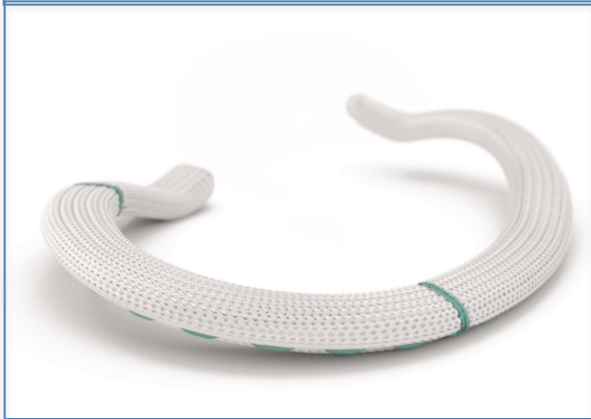
Medtronic Tri-Ad

- Design adapts to the three-dimensional geometry of the tricuspid valve in systole and diastole
- Braided sewing ring construction provides smooth needle penetration and prevents bunching for easy implantation
- A semi-rigid segment is supported by soft, flexible segments for suturing delicate tissue



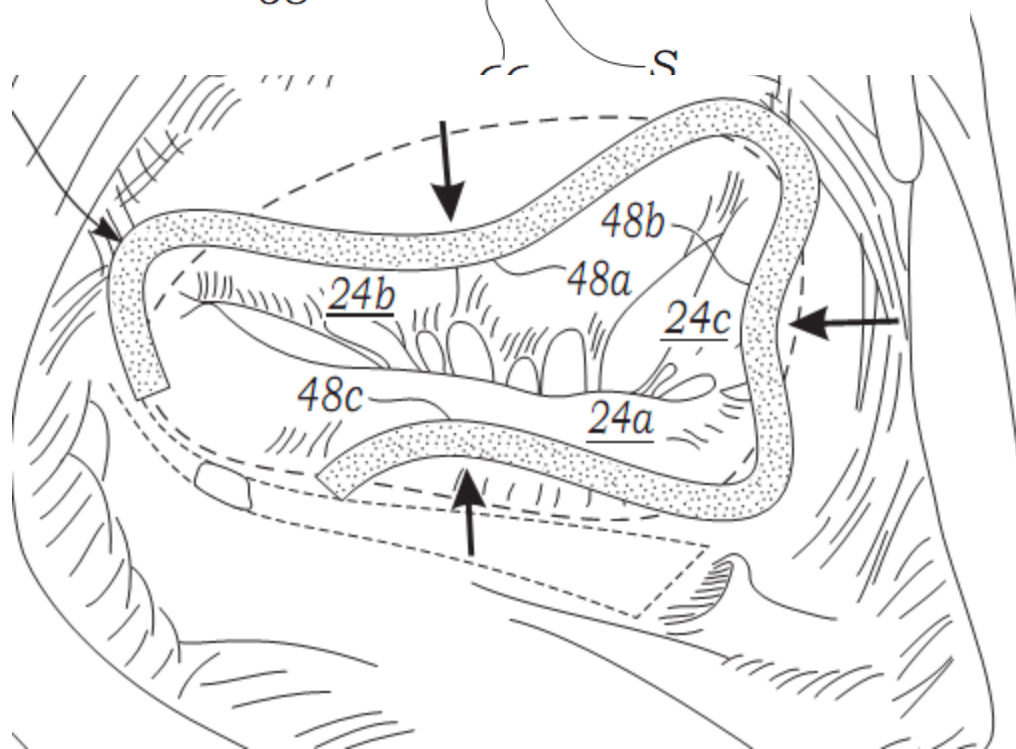
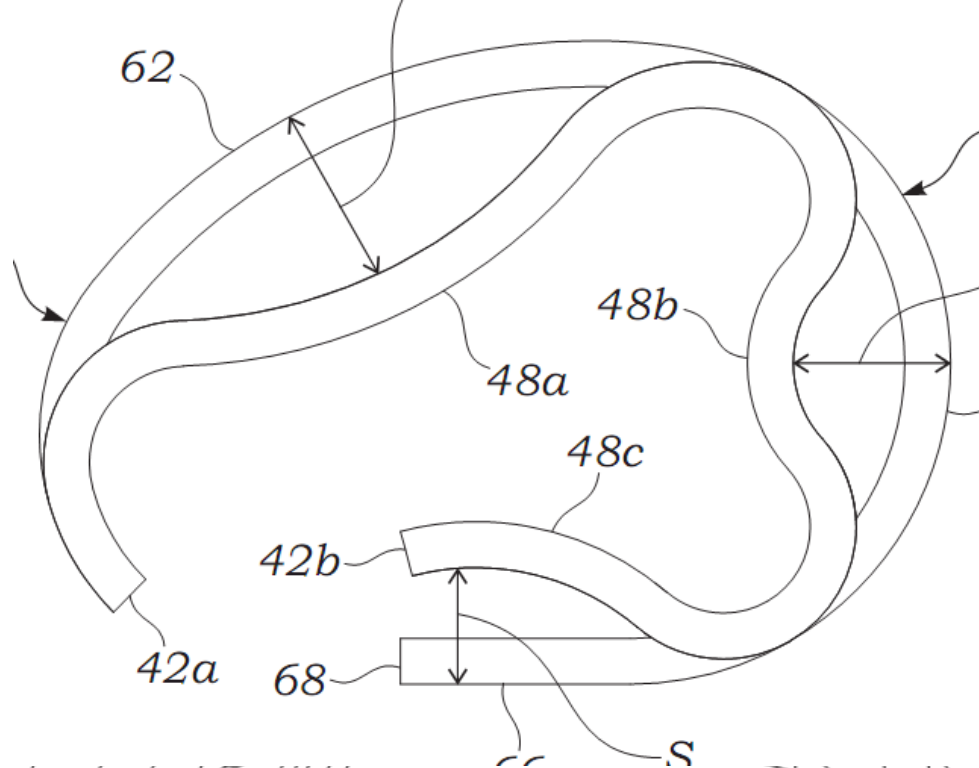
Medtronic Contour 3D

- The first annuloplasty system to offer single-use and reusable sizes
- Incorporates septal lateral compression to address annular dilation
- Ring profile height is 3.3 mm, 15% lower than the Edwards Lifesciences MC3 Ring

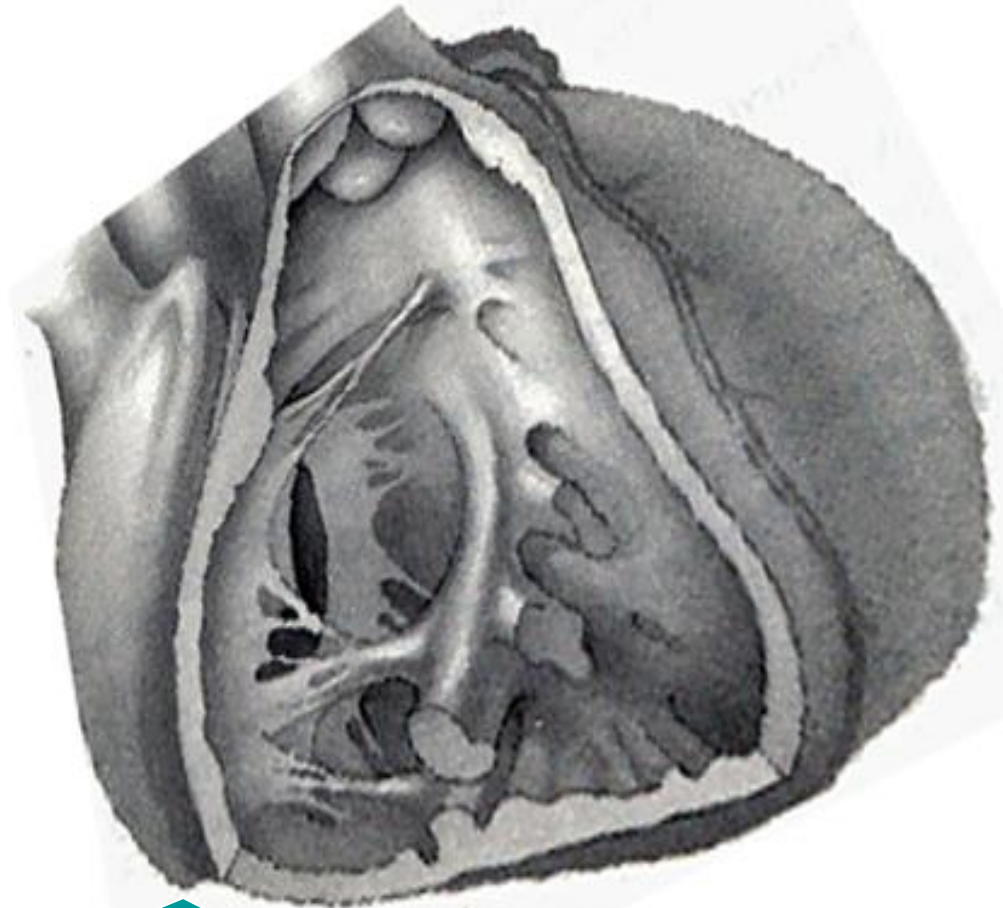
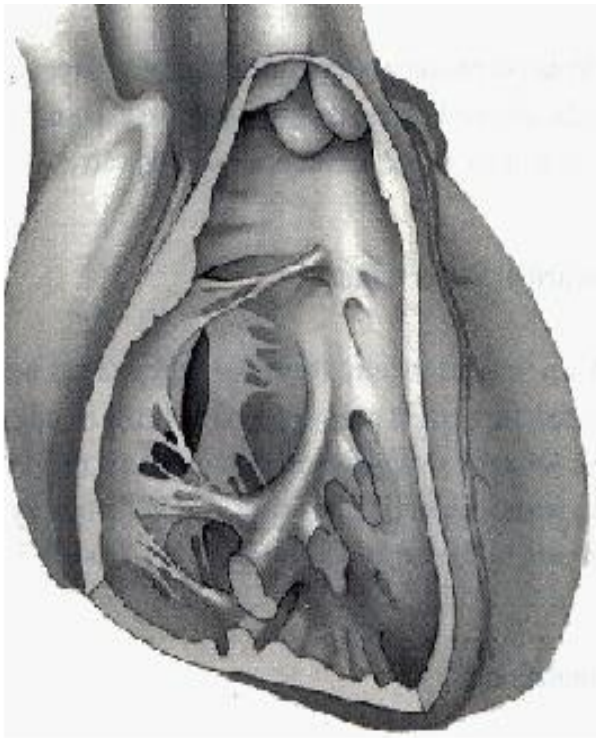


Edwards PHYSIO Tricuspid ring

- 3D Waveform shape and Selective Flexibility design help reduce stress on annular tissue
- increased septal segment opening by over 25%
- Distinct sewing ledge facilitates intuitive suture placement and easy suture pass through.

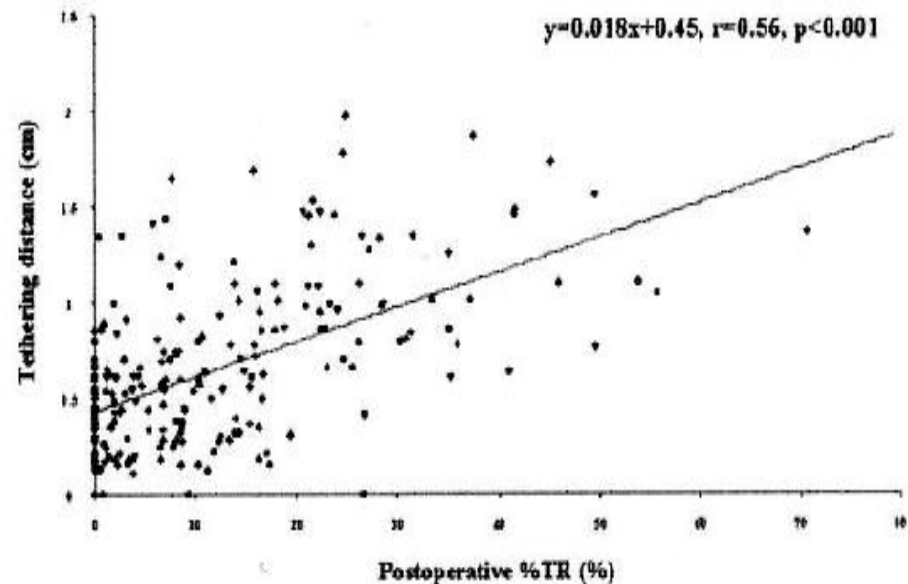
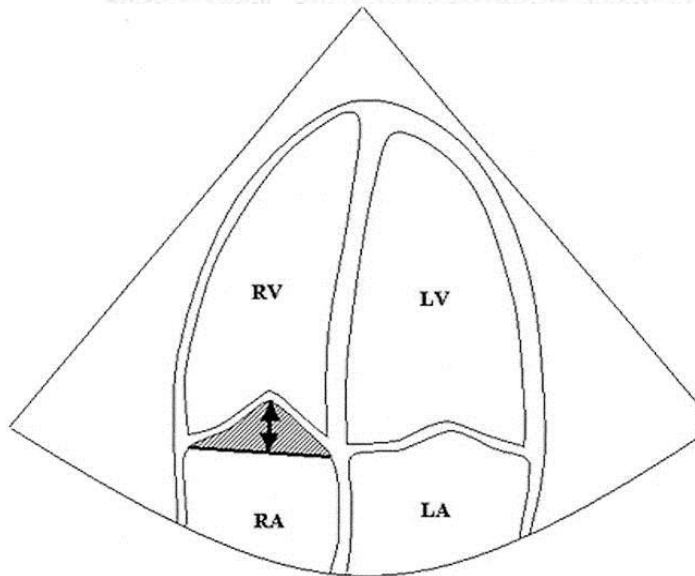


TR due to annular dilatation associated to significant leaflet tethering



Tricuspid Valve Tethering Predicts Residual Tricuspid Regurgitation After Tricuspid Annuloplasty

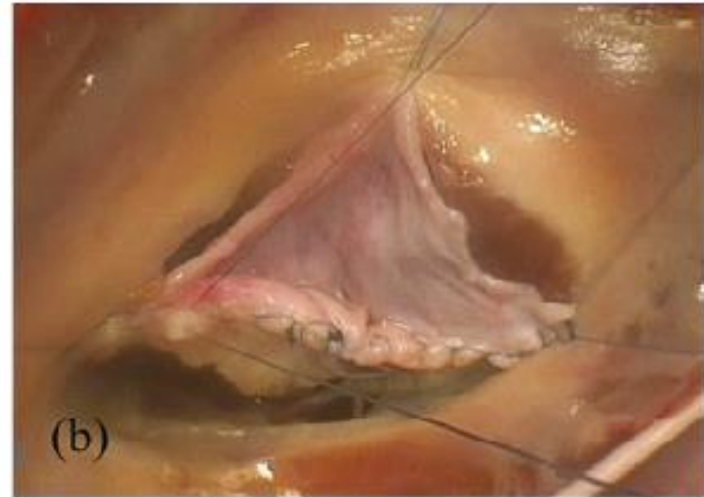
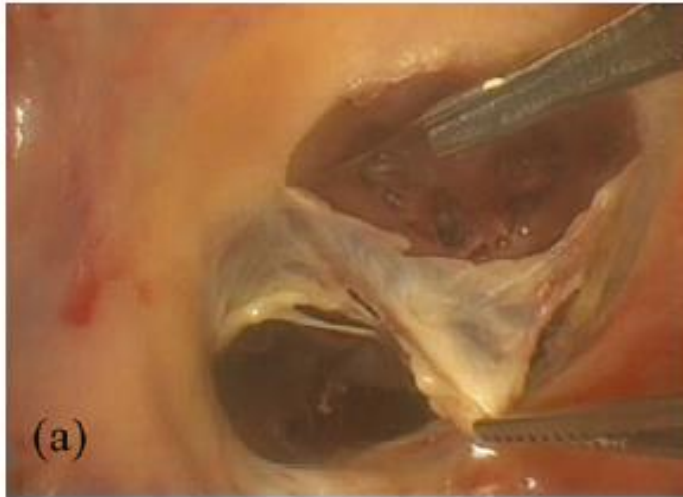
Shota Fukuda, MD; Jong-Min Song, MD; A. Marc Gillinov, MD; Patrick M. McCarthy, MD; Masao Daimon, MD; Vorachai Kongsarepong, MD; James D. Thomas, MD; Takahiro Shiota, MD



Conclusion:

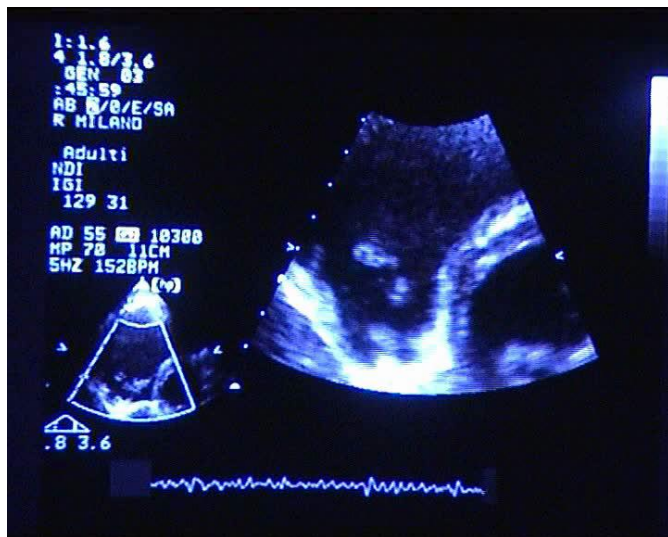
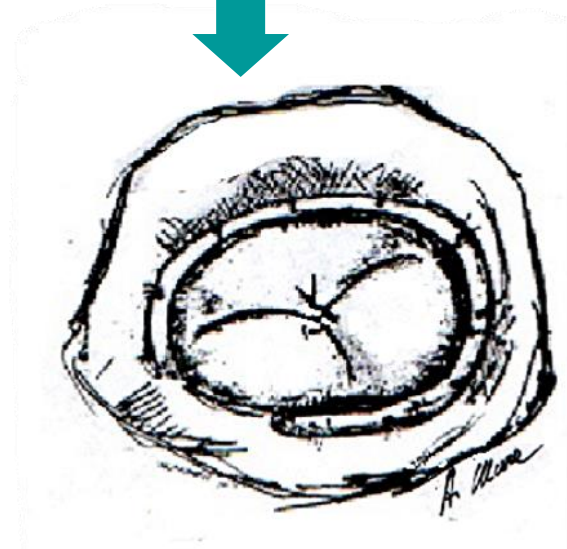
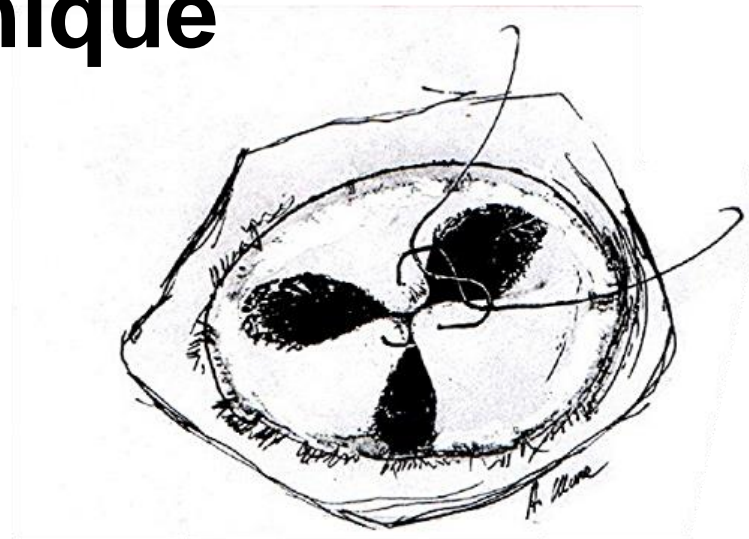
..... patients with extensive leaflet tethering (>1.0 cm) require additional maneuvers to ensure valve competence. (J Am Soc Echocardiogr 2007;20:1236-1242.)

Tricuspid leaflet augmentation



Dreyfus GD et al. Eur J Cardiothor Surg 2008;34:908-10

Clover technique



How to improve overall results in pts with TR

- Lower the threshold for repair
- Improve annuloplasty devices / surgical techniques
- Find new solutions for high risk patients

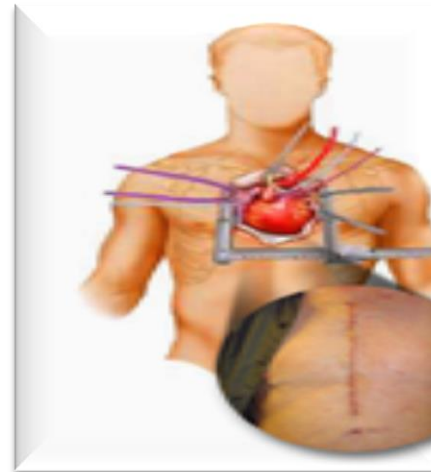
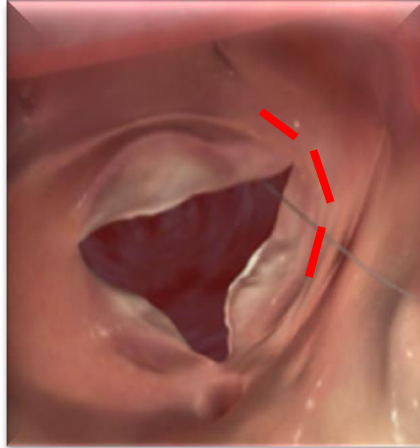
How to improve overall results in pts with TR

- Lower the threshold for repair
- Improve annuloplasty devices / surgical techniques
- Find new solutions for high risk patients

Transcatheter Tricuspid Annuloplasty

A pragmatic approach

- Replicate a proven surgical procedure, **the Kay technique (or Bicuspidization)**, in a percutaneous intervention



Transcatheter Tricuspid Annuloplasty

Status and Future Milestones

- US patent granted March 2013
- Pre-clinical trial completed
- FIM planned in Q4 2013





Thank you!

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