Tricuspid Rigurgitation after Mitral Valve Surgery

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

Recommendations on secondary tricuspid regurgitation		
Surgery is recommended in patients with severe secondary tricuspid regurgitation undergoing left-sided valve surgery [423–427].	I	B
Surgery should be considered in patients with mild or moderate secondary tricuspid regurgitation with a dilated annulus (≥40 mm or >21 mm/m^2 by 2D echocardiography) undergoing left-sided valve surgery [423, 425–427].	IIa	B
Surgery should be considered in patients with severe secondary tricuspid regurgitation (with or without previous left-sided surgery) who are symptomatic or have RV dilatation, in the absence of severe RV or LV dysfunction and severe pulmonary vascular disease/hypertension [418, 433]. [e]	IIa	B
Transcatheter treatment of symptomatic secondary severe tricuspid regurgitation may be considered in inoperable patients at a Heart Valve Centre with expertise in the treatment of tricuspid valve disease.[f]	IIb	C

TRICUSPID VALVE SURGERY

- **is recomended in severe TR (Class I)**

But

- **Prevalence of severe TR is low: 10%-15%**
- **Assessment of TR severity is challenge**

How TR should be assessed ?

Pre/post-operative assessment of TR is not reliable :

- Quantification by echo is not accurate

- regurgitation grading is related to :

preload
after load
RV function

How TR should be assessed ?

- **Preload is often decreased** by vasodilators and diuretics

- **RV function is often impaired :**
  . **RV dilated** (how dilated is too dilated ?)

  . **What is an acceptable RV function ?**

- **Afterload is often / always left sided related**
  . Early repair of mitral valve allows predictability of lowering afterload for the RV

How TR should be assessed ?

Once all required features are present :

RV remodelling (from crescent to spherical)

RV dilatation/dysfunction

Pulmonary hypertension

Absence of TR can be misleading :

as any changes in preload , afterload, RV function can unmask presence of TR

TR or annular dilatation ?

TRICUSPID VALVE SURGERY

- **Surgery should be considered for mild to moderate secondary TR with annular dilatation in patients undergoing life-side valve surgery (Class IIa)**

But

It’s not widely applied in routine practice

Many Questions need to be answered?

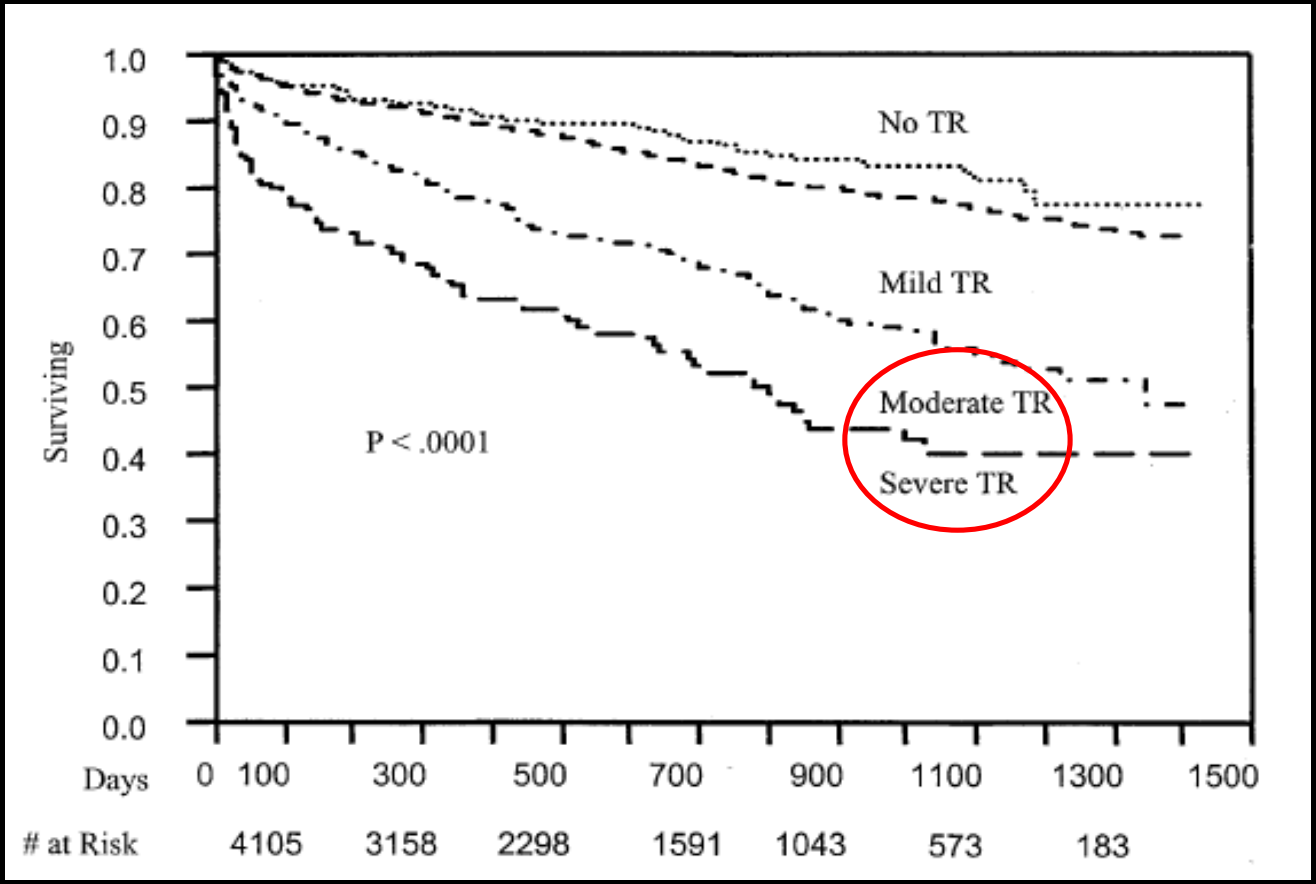
1. What is the fate/progression of uncorrected mild or moderate TR?

2. Is there a survival penalty of equal or less than moderate TR?

3. What is the impact of mild to moderate TR on late outcomes?

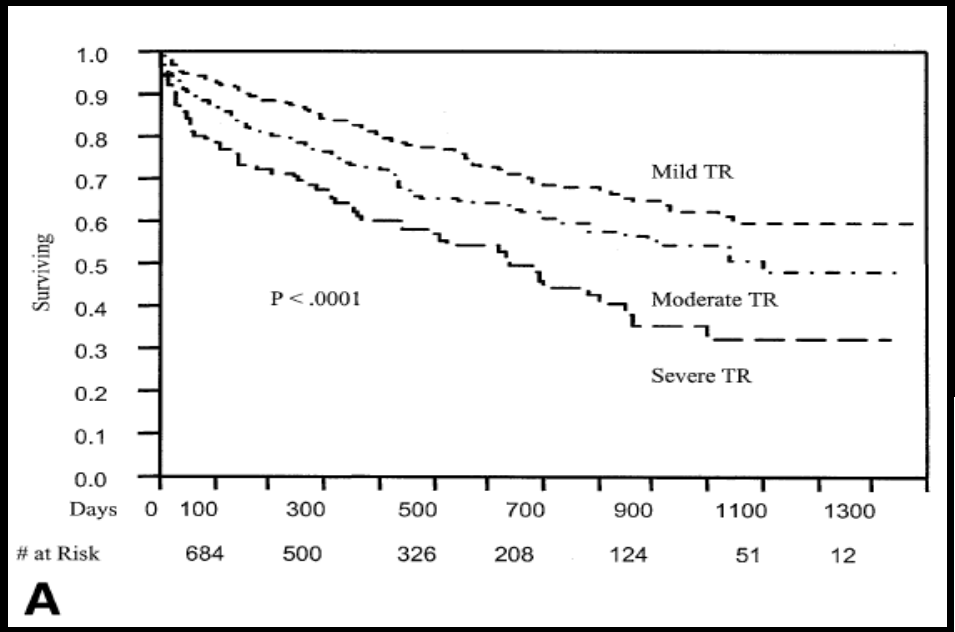
Impact of Tricuspid Regurgitation on Long-Term Survival

Jayant Nath, MD,* Elyse Foster, MD, FACC,† Paul A. Heidenreich, MD*
Palo Alto and San Francisco, California



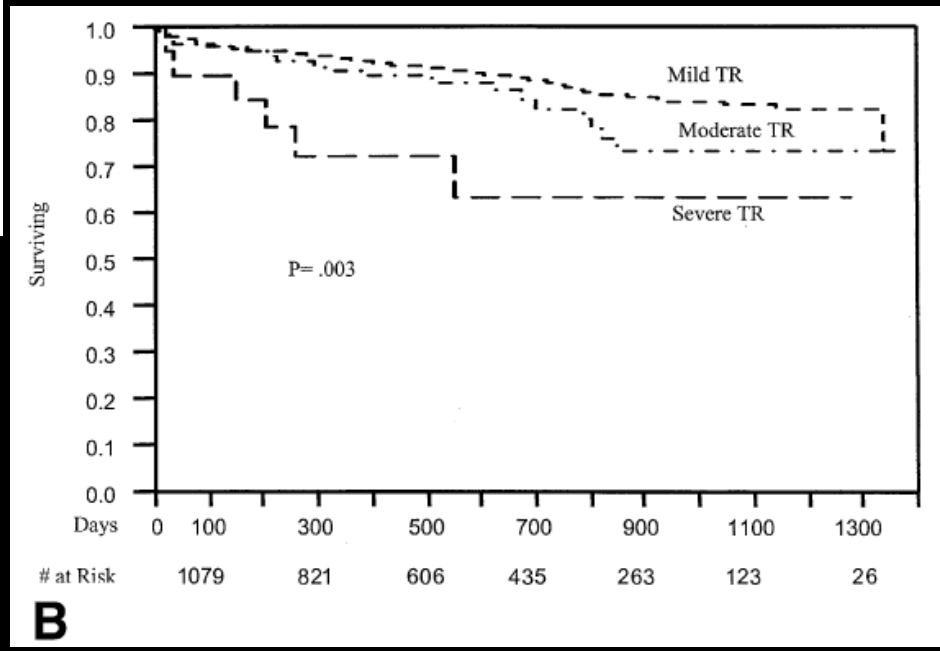
J Am Coll Cardiol 2004;43:405–9

TR and PULMONARY ARTERY SYSTOLIC PRESSURE

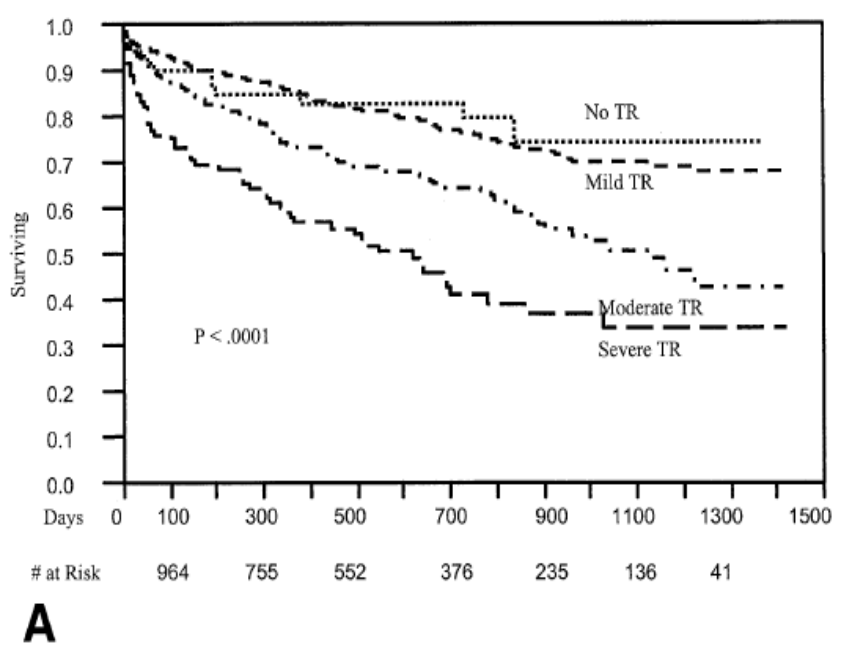


(A) patients with TR and PAPs > 40 mm Hg

Patients with moderate or greater TR have worse survival than patients with mild or less TR, regardless of pulmonary artery pressure.



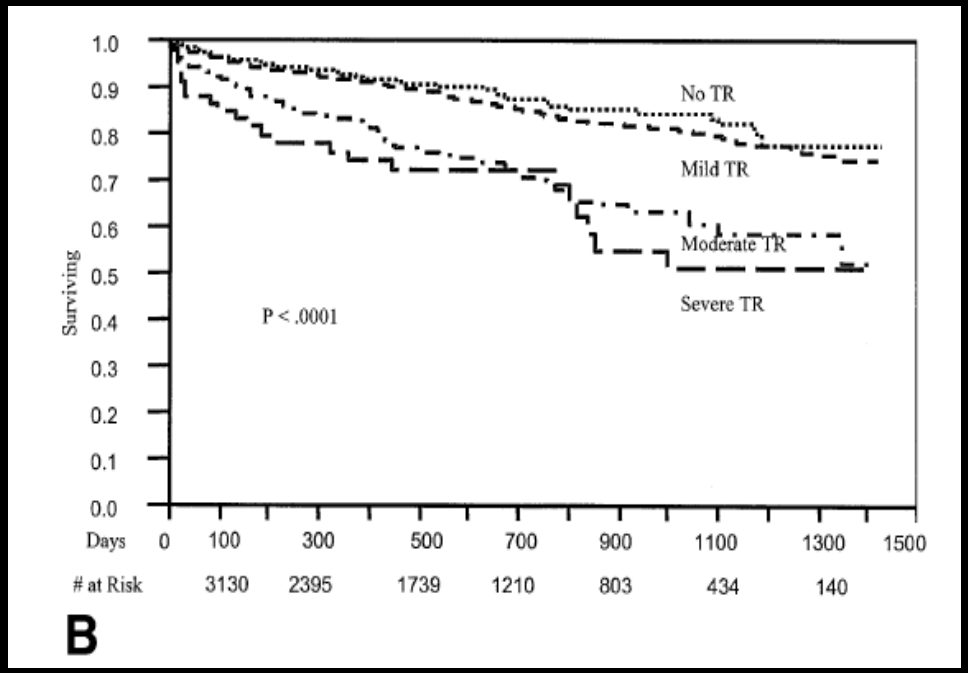
(B) patients with TR and PAPs ≤ 40 mm Hg.



(A) patients with tricuspid regurgitation (TR) and a low left ventricular ejection fraction (50%) and

Patients with moderate or greater TR have worse survival than patients with mild or less TR, regardless of left ventricular ejection fraction

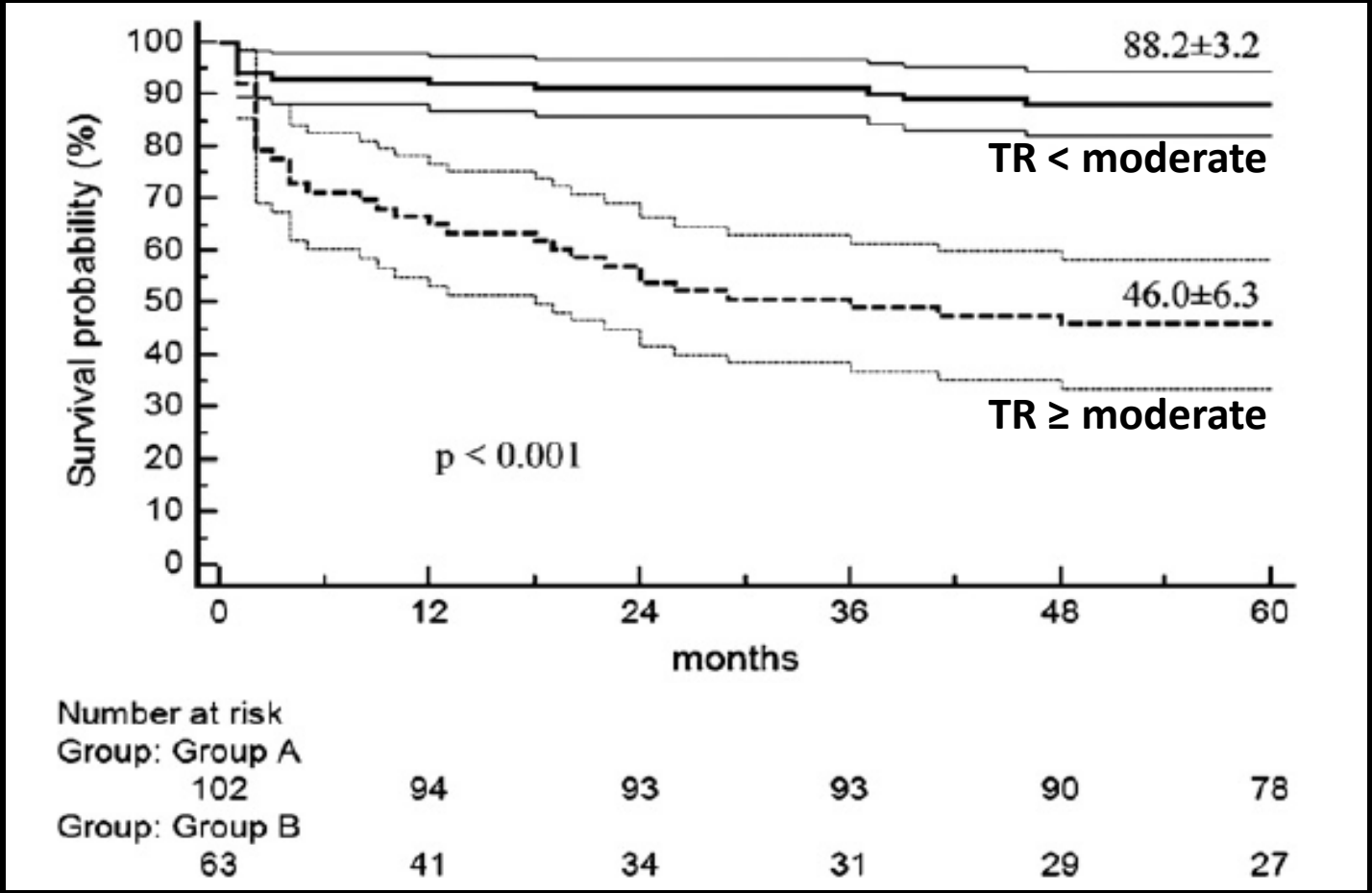
TR and LEFT VENTRICULAR EJECTION FRACTION



(B) patients with TR and a normal left ventricular ejection fraction (50%).

Mitral valve surgery for functional mitral regurgitation: prognostic role of tricuspid regurgitation☆

Michele Di Mauro[a], Antonio Bivona[a], Angela L. Iacò[a], Marco Contini[a], Massimo Gagliardi[a], Egidio Varone[a], Sabina Gallina[b], Antonio M. Calafiore[a,*]



European Journal of Cardio-thoracic Surgery 35 (2009) 635–640

Evolution of tricuspid regurgitation after mitral valve repair for functional mitral regurgitation in dilated cardiomyopathy☆

Michele De Bonis*, Elisabetta Lapenna, Flavia Sorrentino, Giovanni La Canna, Antonio Grimaldi, Francesco Maisano, Lucia Torracca, Ottavio Alfieri

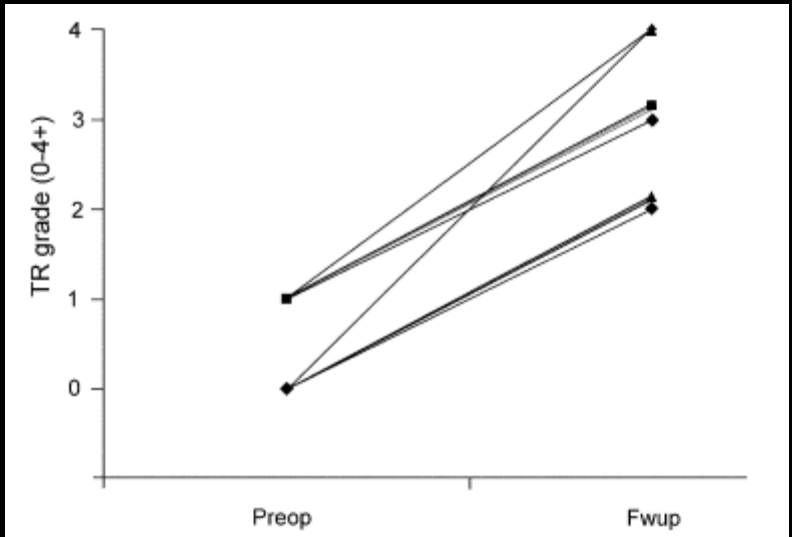


Fig. 1. Patients with progression of at least two grades of untreated preoperative TR ≤2+ (14/78 pts, 18%).

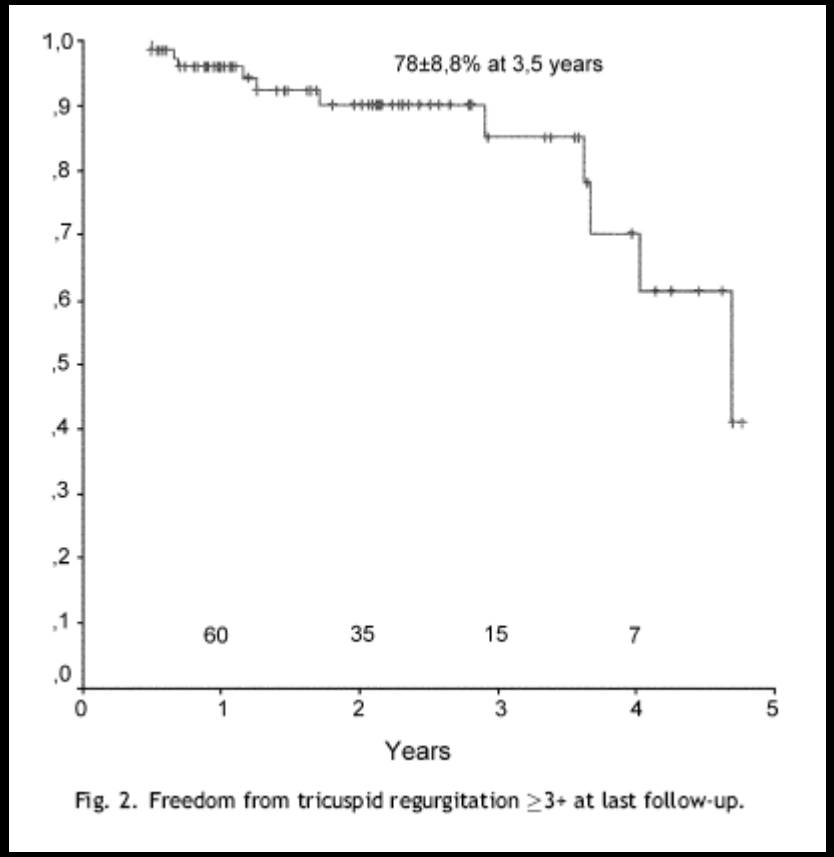


Fig. 2. Freedom from tricuspid regurgitation ≥3+ at last follow-up.

Predictors of tricuspid regurgitation ≥3+

	Univariate		Multivariate	
	Odds ratio	*p* value	Odds ratio	*p* value
Preoperative variables				
LVEF	1	0.6		
LVEDVI	1	0.4		
LVESVI	1	0.6		
SPAP >40 mmHg	2.8	0.2		
RV dilatation	8.3	0.009	1.7	0.6
RV dysfunction	13.7	0.0001	19.6	0.02
Tricuspid repair	0.5	0.6		
TR at discharge	3	0.01	5.4	0.01

European Journal of Cardio-thoracic Surgery 33 (2008) 600—606

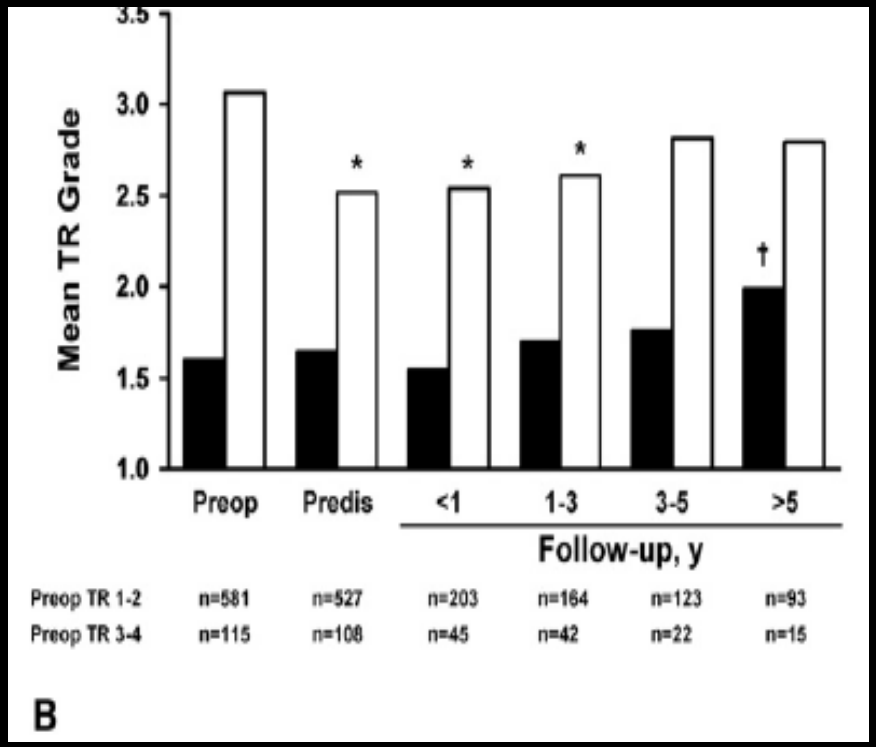
Functional tricuspid regurgitation at the time of mitral valve repair for degenerative leaflet prolapse: The case for a selective approach

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]

TABLE 1. Patient baseline characteristics

Characteristic	Value* (N = 699)
Age, y	60.4 (13.7)
Male sex	459 (65.7)
Preoperative EF, %	65.12 (7.57)
Preoperative TR grade	
1	233 (33.3)
2	351 (50.2)
3–4	115 (16.5)
Preoperative AF	122 (17.5)
Preoperative dilatation	
RA	203 (29.0)
RV	31 (4.4)
NYHA class	
I	199 (28.5)
II	258 (36.9)
III	220 (31.5)
IV	22 (3.1)

EF, Ejection fraction; *TR,* tricuspid valve regurgitation; *AF,* atrial fibrillation; *RA,* right atrium; *RV,* right ventricle; *NYHA,* New York Heart Association. *Values are no. (%) or mean (standard deviation).



J Thorac Cardiovasc Surg 2011;■:1-6

TABLE 3. Univariate and multivariate predictors of late mortality

Variable	Univariate HR	Univariate *P* value	Multivariate HR	Multivariate *P* value
Female sex		.76		
Age	1.09	<.001	2.63	<.001
Hypertension		.37		
Diabetes mellitus		.19		
Renal failure		.54		
COPD		.007		
Previous AF		.22		
Preoperative TR ≥ grade 3		.02		
RA dilatation		.24		
RV dilatation		.28		
EF	0.98	.19		
LVEDD	0.93	.005		
LVESD	0.97	.33		
LAVI	1.01	.20		
LVMI	1.01	.23		

TABLE 2. Predictors of change in TR grade*

Parameter	Univariate *P* value	Univariate Parameter estimate	Multivariate *P* value	Multivariate Parameter estimate
Female sex	.02	0.405	.009	0.441
Age	.37	0.006		
Hypertension	.08	0.312		
Diabetes mellitus	.02	1.181	.02	1.112
Previous AF	<.001	0.642	<.001	0.628
Preoperative echocardiography				
RA dilatation	.03	0.577		
RV dilatation	.18	0.510		
EF	.10	–0.017		
LVMI	.67	–0.001		
LAVI	.56	0.005		
PAP	.71	0.003		
TR velocity	.64	0.100		
Preoperative TR (grade 3-4)	.03	–0.525	.008	–0.614
Operative finding, MV prolapse				
Anterior	.03	–1.200		
Posterior	.03	–0.893		
Both	.07	–0.762		

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.

Our conclusions

- The data presented by authors did not support their conclusion.
- At the beginning, 13% of pts had 3+ or 4+ TR, and at 5 years followup 29.6 % had a 3+ or 4+ TR. They conclude that there was no spontaneous evolution. We can conclude that it was an ongoing disease that requires action at an early stage.

JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
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PUBLISHED BY ELSEVIER

VOL. 77, NO. 6, 2021

Progression of Tricuspid Regurgitation After Surgery for Ischemic Mitral Regurgitation

Philippe B. Bertrand, MD, PhD,[a,*] Jessica R. Overbey, DrPH,[b,*] Xin Zeng, MD, PhD,[a] Robert A. Levine, MD,[a] Gorav Ailawadi, MD,[c] Michael A. Acker, MD,[d] Peter K. Smith, MD,[e] Vinod H. Thourani, MD,[f] Emilia Bagiella, PhD,[b] Marissa A. Miller, DVM, MPH,[g] Lopa Gupta, MPH,[b] Michael J. Mack, MD,[h] A. Marc Gillinov, MD,[i] Gennaro Giustino, MD,[b] Alan J. Moskowitz, MD,[b] Annetine C. Gelijns, PhD,[b] Michael E. Bowdish, MD,[j] Patrick T. O'Gara, MD,[k] James S. Gammie, MD,[l] Judy Hung, MD,[a] on behalf of the Cardiothoracic Surgical Trials Network (CTSN)

FIGURE 1 Study Flowchart

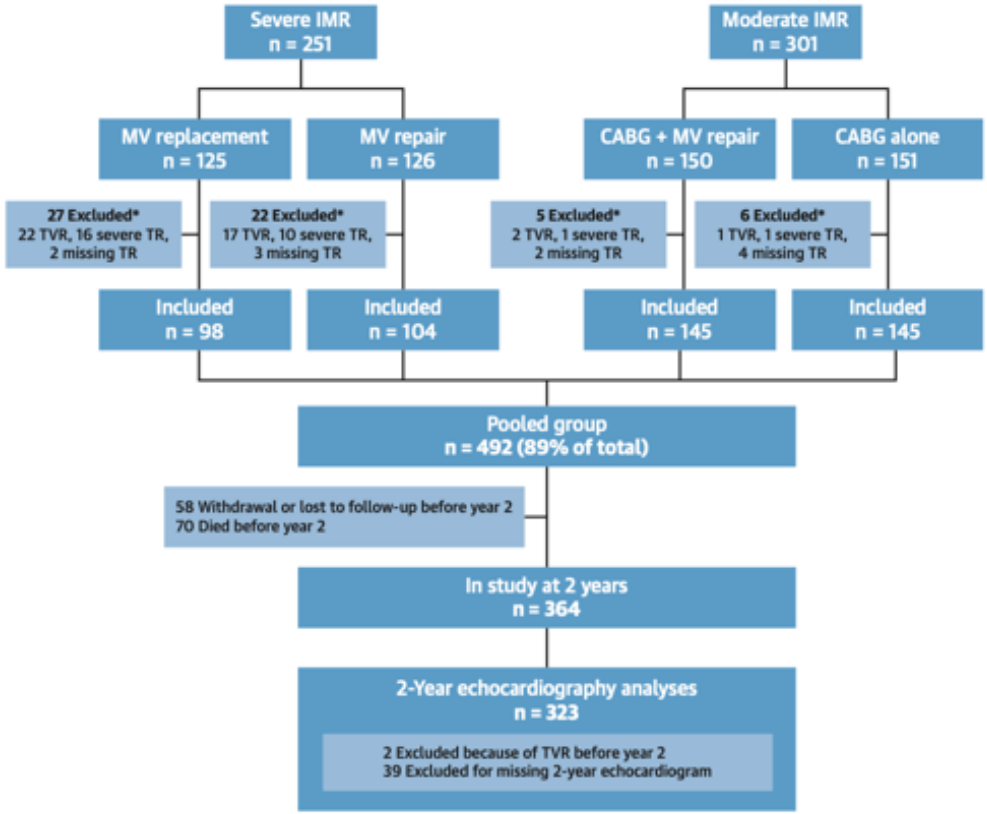
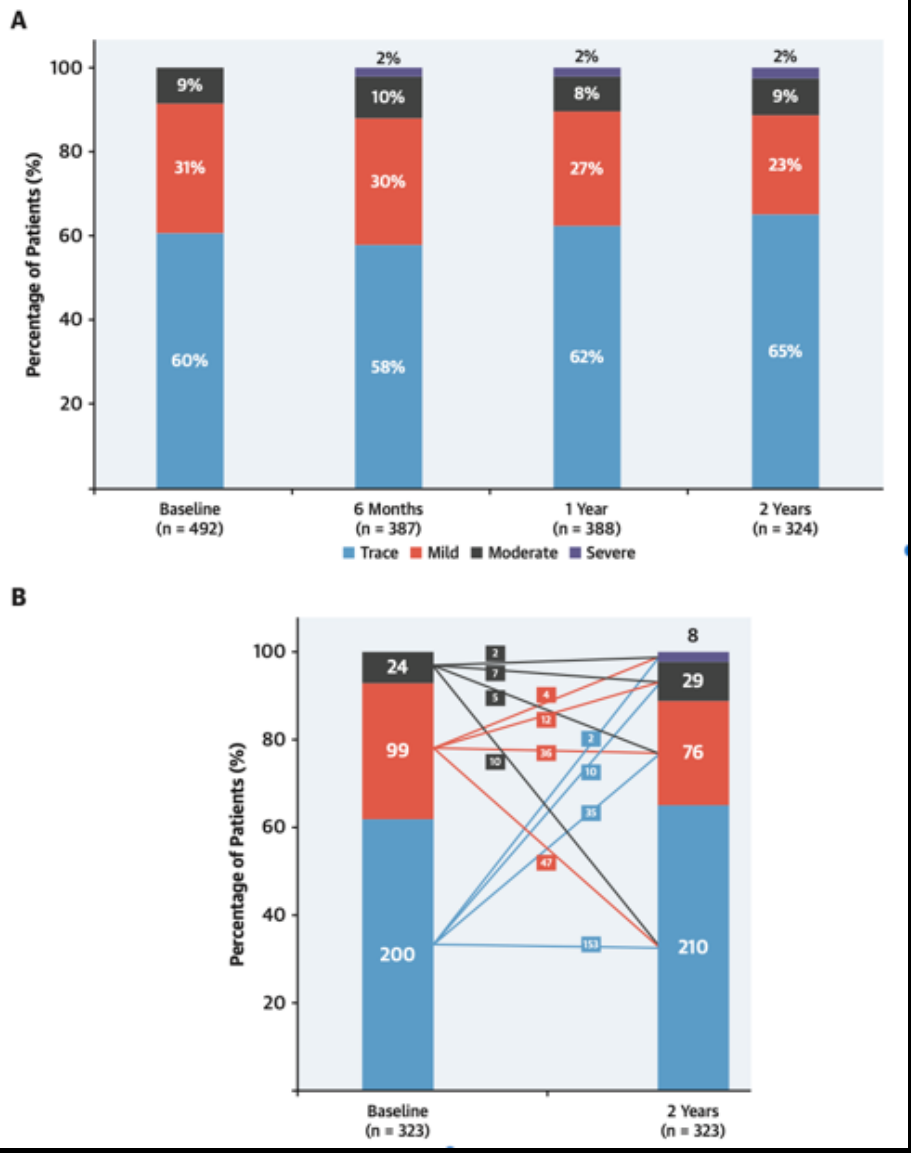


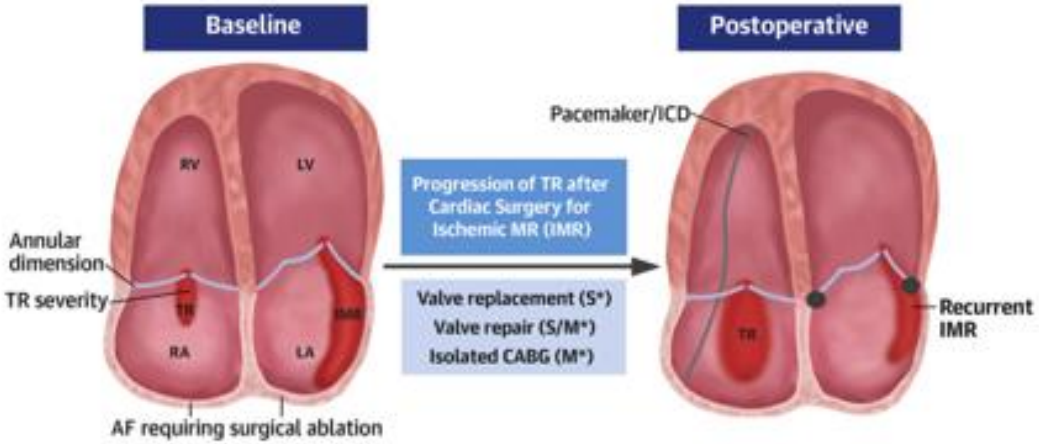
TABLE 1 Baseline Characteristics of the Patient Cohort

	Total Cohort (N = 492)	Severe IMR Group (n = 202)	Moderate IMR Group (n = 290)	p Value
Age, yrs	66.3 ± 10.4	68.4 ± 9.8	64.8 ± 10.5	0.0001
Male	328 (66.7)	127 (62.9)	201 (69.3)	0.14
BSA, m^2	1.9 ± 0.3	1.9 ± 0.2	2.0 ± 0.3	0.03
Medical and surgical history				
Diabetes	205 (41.8)	71 (35.3)	134 (46.2)	0.02
Hypertension	405 (82.3)	162 (80.2)	243 (83.8)	0.30
Renal insufficiency	103 (21.0)	54 (26.7)	49 (17.0)	0.009
Myocardial infarction	343 (69.7)	150 (74.3)	193 (66.6)	0.07
Heart failure	293 (59.6)	141 (69.8)	152 (52.4)	0.0001
Atrial fibrillation	108 (22.0)	58 (28.7)	50 (17.4)	0.003
Permanent pacemaker or ICD	60 (12.2)	36 (17.8)	24 (8.3)	0.002
Echocardiography data				
LV ejection fraction, %	40.4 ± 11.3	40.8 ± 11.6	40.2 ± 11.2	0.53
LVESVI, ml/m^2	60.3 ± 26.0	64.2 ± 26.3	57.6 ± 25.5	0.006
MR effective regurgitant orifice area, cm^2	0.29 ± 0.14	0.39 ± 0.15	0.23 ± 0.09	<0.0001
Tricuspid regurgitation				<0.0001
None/trace	297 (60.4)	97 (48.0)	200 (69.0)	
Mild	153 (31.1)	79 (39.1)	74 (25.5)	
Moderate	42 (8.5)	26 (12.9)	16 (5.5)	
Tricuspid annular diameter, mm	38.3 ± 5.2	38.2 ± 5.5	38.3 ± 5.1	0.88
Tricuspid annular index, mm/m^2 BSA	20.3 ± 3	20.5 ± 3	20.1 ± 2.9	0.09
TAPSE, mm	16.8 ± 3.8	16.4 ± 3.7	17 ± 3.9	0.11
RV fractional area change, %	42.4 ± 8.5	42.2 ± 7.8	42.6 ± 9	0.63
Tricuspid regurgitation peak velocity, cm/s	293.1 ± 54.5	305 ± 49	283.7 ± 56.8	0.0002
Operative data				
Cardiopulmonary bypass time, min	136.5 ± 54.6	139.8 ± 47.3	134.3 ± 59.2	0.25
Aortic cross-clamp time, min	98.2 ± 40.8	101.2 ± 39.6	96.1 ± 41.6	0.17
MV repair	246 (50.0)	97 (48.0)	149 (51.4)	0.46
MV replacement	106 (21.5)	105 (52.0)	1 (0.3)	<0.0001
CABG	448 (91.1)	158 (78.2)	290 (100.0)	<0.0001
Surgical AF ablation	42 (8.5)	22 (10.9)	20 (6.9)	0.12

FIGURE 2 TR at Baseline and at Different Stages of Follow-Up



CENTRAL ILLUSTRATION **Progression of Tricuspid Regurgitation After Cardiac Surgery for Ischemic Mitral Regurgitation**



	Rate	Associated with	
	At 2 years	Baseline	Postoperative
TR progression	6.2%		• Recurrent IMR
≥ Moderate TR	11.5%	• Baseline TR grade • Tricuspid annular dimension (indexed) • Surgical AF ablation	• Recurrent IMR • Permanent pacemaker/ICD

Bertrand, P.B. et al. J Am Coll Cardiol. 2021;77(6):713-24.

At 2 years after surgery for ischemic mitral regurgitation (IMR), progression of tricuspid regurgitation (TR) is not as common as generally expected. Post-operative TR depends not only on pre-operative risk factors (baseline TR, tricuspid annular size, or atrial fibrillation) but is associated with post-operative factors such as mitral regurgitation recurrence and permanent pacemaker/defibrillator as well. *M = moderate IMR trial; *S = severe IMR trial; AF = atrial fibrillation; CABG = coronary artery bypass graft; ICD = implantable cardioverter-defibrillator; LA = left atrium; LV = left ventricle; RA = right atrium; RV = right ventricle.

CONCLUSIONS After IMR surgery, progression of unrepaired nonsevere TR is uncommon. Baseline TAD is not predictive of TR progression and is poorly discriminative of ≥moderate TR at 2 years. TR progression and presence of ≥moderate TR are associated with clinical events. (Comparing the Effectiveness of a Mitral Valve Repair Procedure in Combination With Coronary Artery Bypass Grafting [CABG] Versus CABG Alone in People With Moderate Ischemic Mitral Regurgitation, NCT00806988; Comparing the Effectiveness of Repairing Versus Replacing the Heart's Mitral Valve in People With Severe Chronic Ischemic Mitral Regurgitation, NCT00807040) (J Am Coll Cardiol 2021;77:713–24)

Tricuspid regurgitation is uncommon after mitral valve repair for degenerative diseases

Tirone E. David, MD, Carolyn M. David, BN, Chun-Po

TABLE 6. Multivariable factors associated with postoperative isolated moderate/severe tricuspid valve regurgitation

Factor	Reliability	M.HR (LCL-UCL)	*P* value
Age at operation (per 5 y)	99.8%	1.487 (1.239-1.786)	<.001
Postoperative (<1 mo) TR grade	98.2%	2.842 (1.815-4.448)	<.001
Insertion of permanent pacemaker	95.4%	7.428 (3.066-18.00)	<.001
Preoperative atrial fibrillation	83.2%	2.200 (1.209-4.002)	.01

M.HR, Multivariable hazard ratio; *LCL*, lower confidence limit (95%); *UCL*, upper confidence limit (95%); *TR*, tricuspid regurgitation.

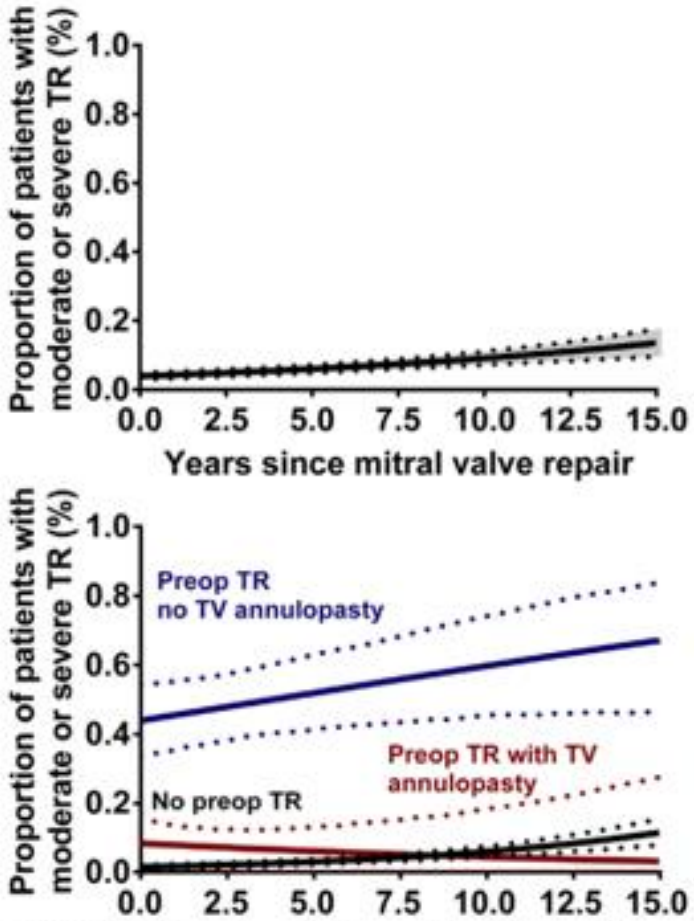


FIGURE 3. Incidence of moderate/severe tricuspid regurgitation over time for all patients (*top*) and stratified by preoperative tricuspid valve regurgitation and concomitant tricuspid annuloplasty (*bottom*). *Dotted lines* represent the 95% confidence interval. *TR*, Tricuspid regurgitation;

TABLE 7. Incidence of TR (moderate) over time (note: <5% of all TR was greater than moderate)

Years	Overall	No preoperative TR	Preoperative TR without tricuspid annuloplasty	Preoperative TR with tricuspid annuloplasty
1	4.3% (3.3%, 5.3%)	1.7% (1.2%, 2.3%)	45.5% (35.5%, 55.4%)	7.8% (1.9%, 13.5%)
5	6.0% (4.9%, 7.1%)	3.0% (2.2%, 3.8%)	51.9% (41.4%, 63.0%)	6.1% (0.1%, 13.2%)
10	9.1% (7.2%, 11.1%)	5.9% (4.4%, 7.4%)	59.8% (45.5%, 74.1%)	4.4% (0.0%, 18.3%)
15	13.6% (9.6%, 17.5%)	11.5% (7.9%, 15.4%)	67.1% (46.4%, 83.8%)	3.1% (0.0%, 27.7%)

Numbers in parentheses show 95% confidence interval. *TR*, Tricuspid regurgitation.

TABLE 8. Multivariable factors associated with recurrent TR

Factor	M.HR (LCL-UCL)	*P* value
Age at operation (per 10 y)	2.13 (1.64-2.92)	<.001
Preoperative TR/TA		
No TR	Reference	
TR with TA	2.96 (0.92-9.19)	.06
TR without TA	98.3 (39.7-344.4)	<.001
Postoperative MR grade*		
Less than moderate	0.20 (0.10-0.35)	<.001

TR, Tricuspid regurgitation; *M.HR*, multivariable hazard ratio; *LCL*, lower confidence limit (95%); *UCL*, upper confidence limit (95%); *TA*, tricuspid annuloplasty; *MR*, mitral regurgitation. *Collected longitudinally.

CONCLUSIONS

Patients with MR due to degenerative diseases develop TR because of older age, chronic AF, advanced functional class, impaired left ventricular function, congenital heart septal defects, and female sex. These factors adversely affect long-term survival, and TA does not seem to restore life span to the level of patients without TR. Patients with moderate and severe TR at the time of MV repair probably should have concomitant TA to reduce the probability of developing TR. New TR after MV repair is uncommon during the first 15 years of follow-up, but when it happens it is associated with poor prognosis largely because of the factors associated with it. The findings of this study are compelling reasons to recommend MV repair early on the course of severe MR due to degenerative diseases.

Tricuspid regurgitation is uncommon after mitral valve repair for degenerative diseases

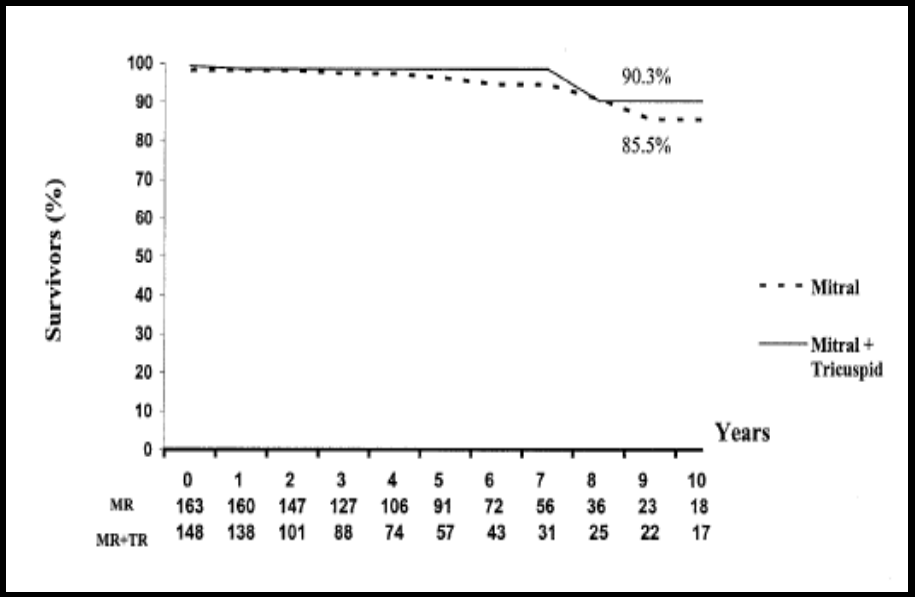
Tirone E. David, MD, Carolyn M. David, BN, Chun-Po S. Fan, PhD, and Cedric Manlhiot, PhD

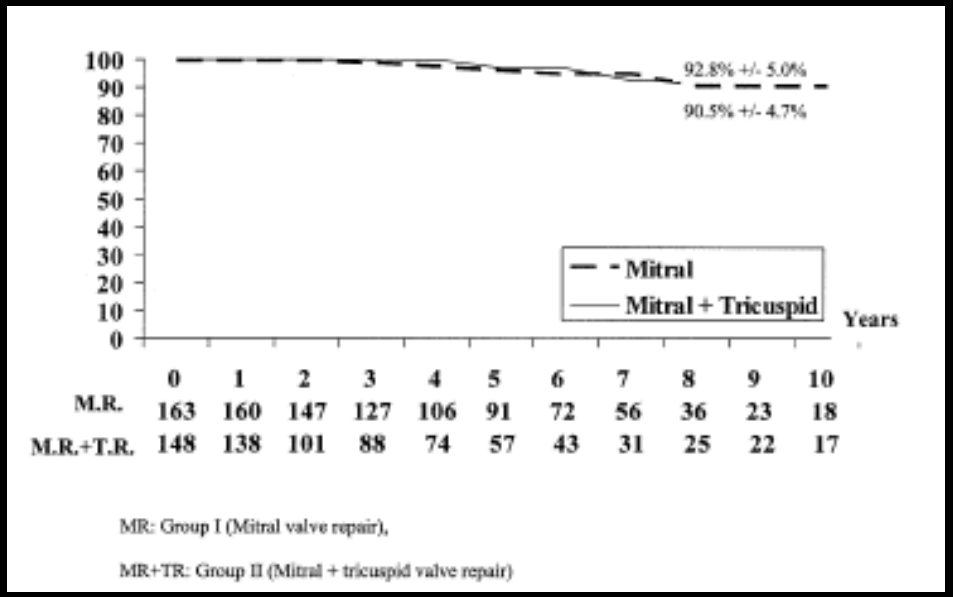
Tricuspid annular dilatation should be corrected despite presence of TR?

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 Toufan Bahrami, MD

Ann Thorac Surg 2005;79:127–32





Survival

Cardiac-related events

Table 3. Tricuspid Regurgitation Grade Measured by Transthoracic Echocardiography

	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.

MVR = mitral valve repair; TR = tricuspid regurgitation; TVR = tricuspid valve repair.

Conclusions. Remodeling annuloplasty of the tricuspid valve based on tricuspid dilation improves functional status irrespective of the grade of regurgitation. Considerable tricuspid dilatation can be present even in the absence of substantial TR. Tricuspid dilatation is an ongoing disease process that will, with time, lead to severe TR.

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, Jerry Braun, Victoria Delgado, Michel I.M. Versteegh, Robert A. Dion, Robert J.M. Klautz and Jeroen J. Bax

J Thorac Cardiovasc Surg 2011;141:1431-1439

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)

2002 Cohort: concomitant tricuspid annuloplasty was performed in patients with grade 3 or 4 TR (16%)

2004 Cohort: tricuspid annuloplasty was performed in patients with grade 3 or 4 TR and in patients with tricuspid annular diameter of 40 mm or greater (63%)

TABLE 3. Two-year follow-up: Entire 2002 cohort

	Baseline	Follow-up	*P* value
New York Heart Association class	2.6 ± 0.8	1.4 ± 0.6	<.0001
Canadian Cardiac Society class	1.3 ± 0.6	1.0 ± 0.2	<.001
LA diameter (mm)	50 ± 10	43 ± 8	<.0001
LV end-diastolic diameter (mm)	61 ± 9	52 ± 10	<.0001
LV end-systolic diameter (mm)	42 ± 11	35 ± 11	<.0001
Mitral regurgitation grade	3.4 ± 0.7	0.7 ± 0.8	<.0001
RV long axis (mm)	69 ± 7	70 ± 8	.301
RV short axis (mm)	29 ± 7	30 ± 7	.080
Tricuspid regurgitation grade	1.6 ± 1.0	1.3 ± 1.0	.211
Transtricuspid gradient (mm Hg)	25 ± 10	23 ± 9	.091

LA, Left atrial; *LV*, left ventricular; *RV*, right ventricular.

TABLE 4. Two-year follow-up: Entire 2004 cohort

	Baseline	Follow-up	*P* value
New York Heart Association class	2.6 ± 0.8	1.8 ± 0.8	<.0001
Canadian Cardiac Society class	1.3 ± 0.8	1.1 ± 0.2	<.001
LA diameter (mm)	48 ± 7	44 ± 7	<.0001
LV end-diastolic diameter (mm)	59 ± 8	53 ± 9	<.0001
LV end-systolic diameter (mm)	42 ± 11	38 ± 12	<.0001
Mitral regurgitation grade	3.3 ± 0.5	0.8 ± 0.8	<.0001
RV long axis (mm)	71 ± 6	69 ± 9	.001
RV short axis (mm)	29 ± 5	27 ± 5	<.0001
Tricuspid regurgitation grade	1.6 ± 1.0	0.9 ± 0.6	<.0001
Transtricuspid gradient (mm Hg)	28 ± 13	23 ± 15	.021

LA, Left atrial; *LV*, left ventricular; *RV*, right ventricular.

reverse in right ventricular remodeling and reduction in TR.

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

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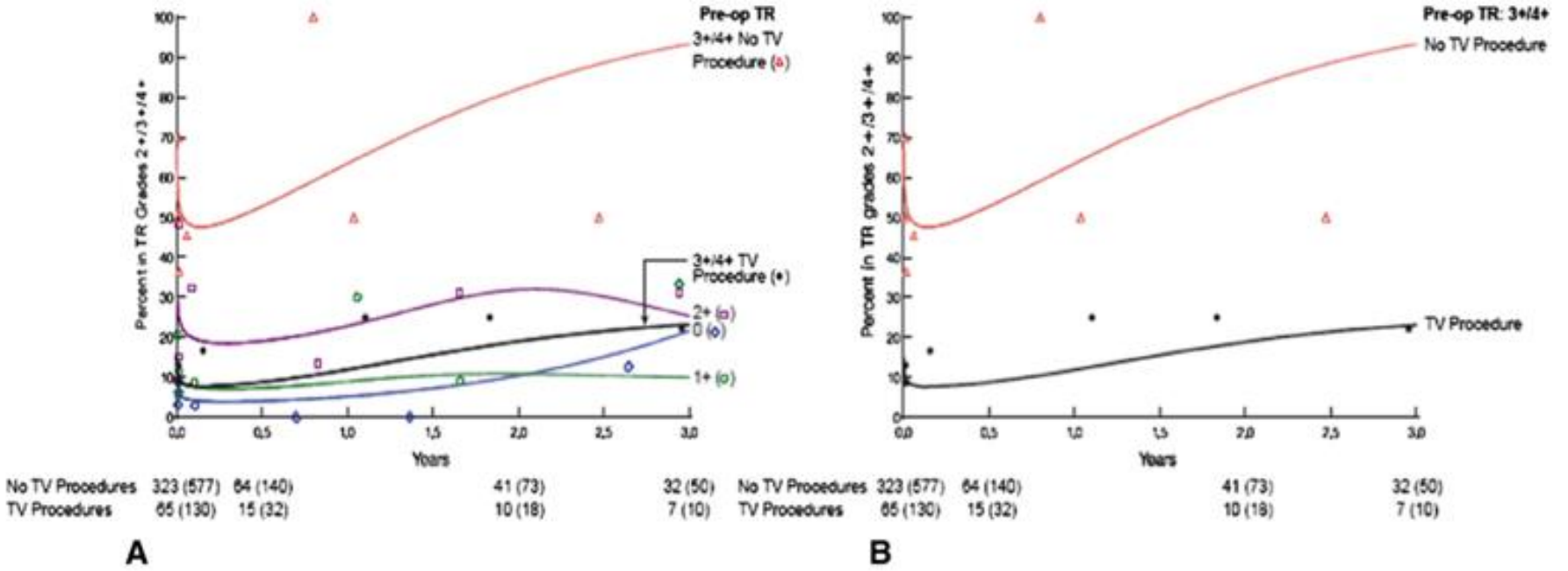

FIGURE 1. Percentage of patients with grade 2+/3+/4+ tricuspid regurgitation *(TR)* grades postoperatively over time stratified by preoperative *(pre-op)* TR grades. *Open diamonds and blue line* indicate patients with preoperative TR grade 0; *open circles and green line*, those with preoperative grade 1+; *open squares and purple line*, those with preoperative grade 2+; *closed circles and black line*, those with preoperative grade 3+/4+ and undergoing a tricuspid valve *(TV)* procedure; and *open triangles and red line*, those with preoperative grade 3+/4+ and no TV procedure. A, TR grade 2+/3+/4+ postoperatively according to preoperative TR grade and TV procedure; and (B) TR grade 2+/3+/4+ postoperatively for patients with severe preoperative TR according to whether a TV procedure was performed.

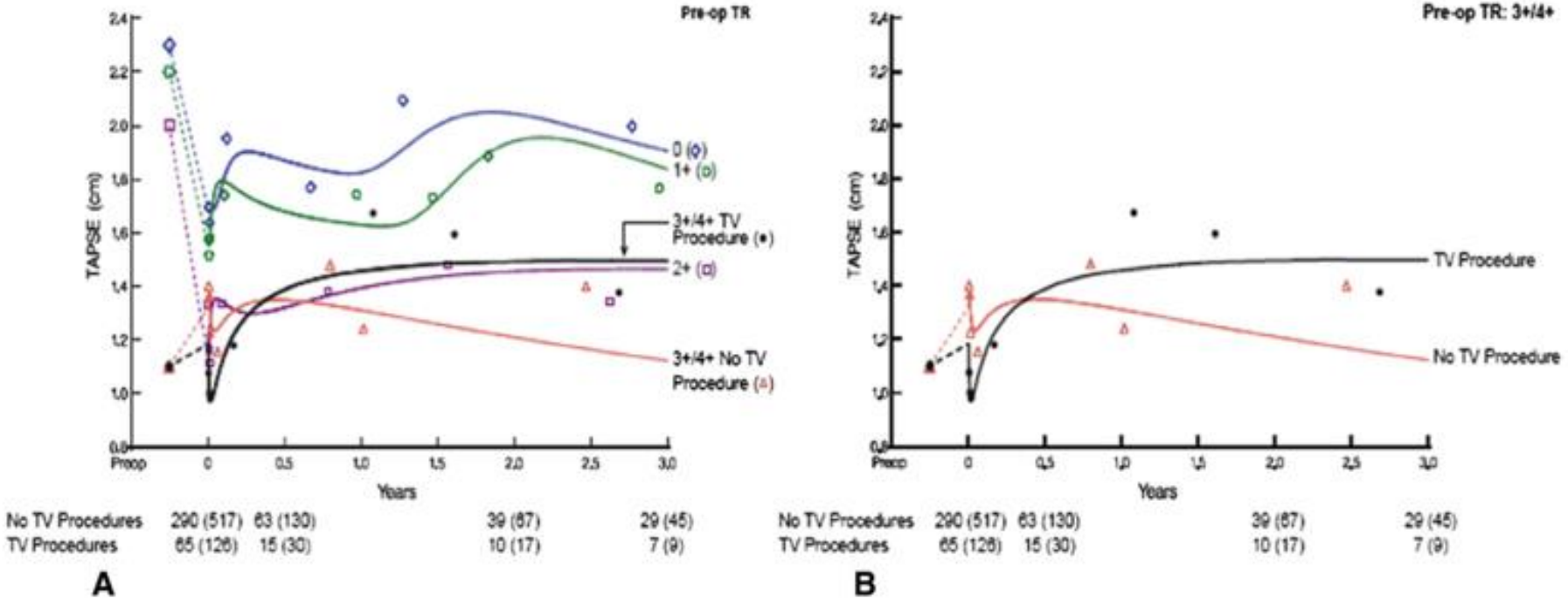

FIGURE 2. Tricuspid annular plane systolic excursion *(TAPSE)* over time stratified by preoperative tricuspid regurgitation *(TR)* grade. Depiction by preoperative TR grade and tricuspid valve *(TV)* procedure as in Figure 1. A, TAPSE for all preoperative TR grades and TV procedure. B, TAPSE for patients with severe preoperative TR according to whether a TV procedure was performed.

TABLE 1. Risk factors associated with higher grade of postoperative tricuspid regurgitation

Factor	Estimate ± SE	*P* value	Reliability (%)*
Overall			
Older age†	1.1 ± 0.23	<.0001	77
Women	1.02 ± 0.26	.0001	52
Higher grade of preoperative TR‡	–1.7 ± 0.53	.001	71
Early phase			
Higher preoperative MPI§	4.1 ± 1.8	.02	61
Absence of TV procedure	–4.2 ± 1.1	.0001	
Late phase			
Lower LV ejection fraction‖	3.9 ± 1.3	.003	61
Higher MR grade	1.4 ± 0.56	.02	78
Absence of TV procedure	–2.3 ± 0.58	<.0001	

LV, Left ventricular; *MPI*, myocardial performance index; *MR*, mitral regurgitation; *SE*, standard error; *TR*, tricuspid regurgitation; *TV*, tricuspid valve. *Percentage of times variable appeared in 500 bootstrap models. †$(\text{Age}/50)^2$, squared transformation. ‡(1/[TR grade+1]), inverse transformation. §MPI^2, squared transformation. ‖(50/ejection fraction), inverse transformation.

Conclusions: In patients with mitral valve disease and severe tricuspid regurgitation, mitral valve repair alone was associated with improved tricuspid regurgitation and right ventricular function. However, the improvements were incomplete and temporary. In contrast, concomitant tricuspid valve repair effectively and durably eliminated severe tricuspid regurgitation and improved right ventricular function toward normal, supporting an aggressive approach to important functional tricuspid regurgitation. (J Thorac Cardiovasc Surg 2013;146:1126-32)

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

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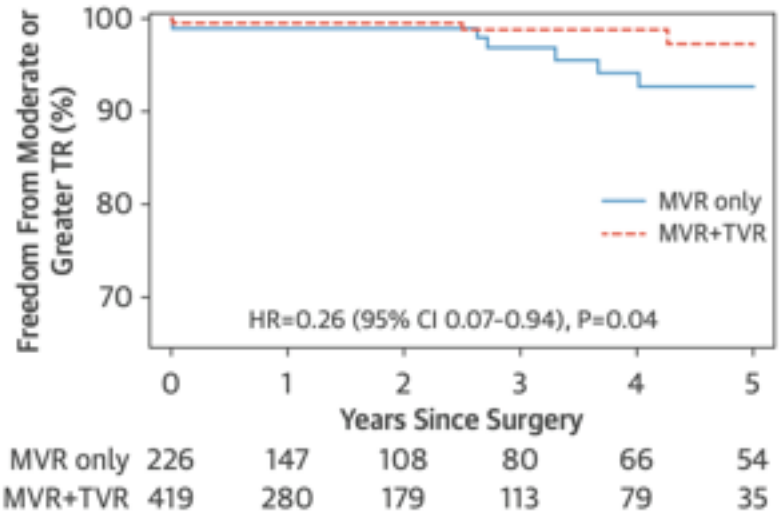
JACC VOL. 65, NO. 18, 2015
MAY 12, 2015:1931–8

FIGURE 1 Freedom From Moderate or Greater TR



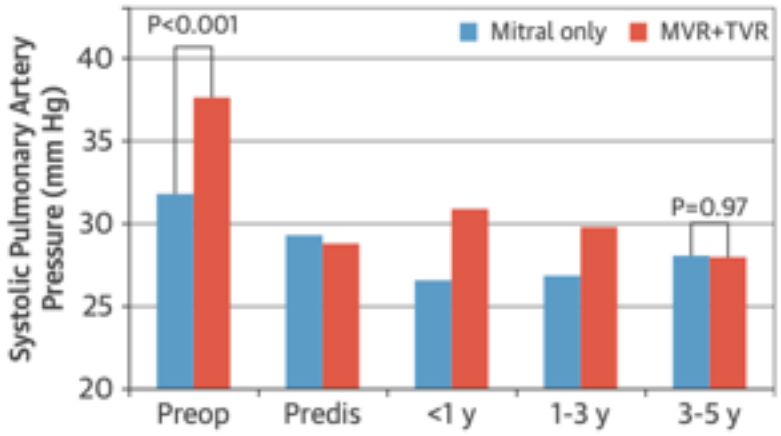
Greater freedom from late moderate tricuspid regurgitation (TR) was observed in patients who underwent mitral valve repair (MVR) and tricuspid annuloplasty **(red dotted line)** compared with those who underwent only mitral valve repair **(blue solid line)**. CI = confidence interval; HR = hazard ratio; TVR = tricuspid valve repair.

TABLE 2 Determinants of Recurrent TR (Moderate or Greater)

	Univariate		Multivariate	
	p Value	HR	p Value	HR (95% CI)
Age	0.03	1.06	0.01	1.09 (1.02-1.16)
Female	0.31	1.76		
Hypertension	0.17	0.41	0.06	
Diabetes mellitus	0.08	6.87	0.12	
Coronary artery disease	0.12	2.58	0.42	
Etiology (Barlow disease as reference)				
FF	0.42	2.24	0.99	
FED	0.07	4.23	0.26	
LV ejection fraction <60%	0.91	1.07		
LV end-systolic diameter >40 mm	0.22	0.28	0.26	
Pulmonary artery systolic pressures >50 mm Hg	0.45	1.64		
Atrial fibrillation	0.98	1.02		
Tricuspid annulus diameter	0.58	1.06		
Pre-operative RV dysfunction	0.75	1.24		
Tricuspid annuloplasty	0.08	0.345	0.04	0.26 (0.07-0.94)

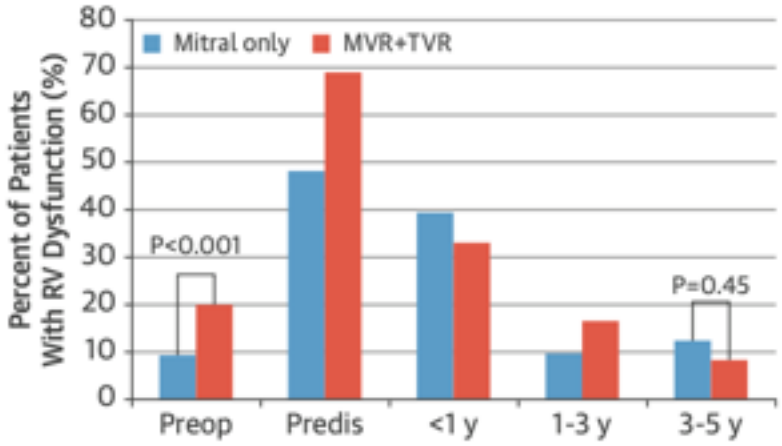
CI = confidence interval; FED = fibroelastic deficiency; FF = forme fruste; HR = hazard ratio; TR = tricuspid regurgitation; other abbreviations as in Table 1.

FIGURE 2 Longitudinal Change in Pulmonary Artery Systolic Pressure



Patients who underwent concomitant tricuspid valve repair (TVR) had significantly higher pulmonary pressures pre-operatively compared with patients who underwent only mitral valve repair (MVR) ($p < 0.001$). In patients who underwent MVR and tricuspid annuloplasty, pulmonary artery pressures improved such that at midterm follow-up, pulmonary artery pressures were as low as those in patients who underwent MVR only ($p = 0.97$). Predis = predischarge; Preop = pre-operative.

FIGURE 4 Longitudinal Change in the Proportion of Patients With RV Dysfunction



Right ventricular (RV) dysfunction initially deteriorated after surgical treatment in patients who underwent mitral valve repair (MVR) only, as well as in patients who underwent concomitant tricuspid valve repair (TVR) (both $p < 0.001$). During follow-up, recovery of RV function occurred in both groups, and by 5 years post-operatively, the proportion of patients with normal RV function was similar in both groups ($p = 0.45$). Abbreviations as in Figure 2.

TABLE 3 Determinants of RV Function Recovery During Follow-Up

	Univariate		Multivariate	
	p Value	HR	p Value	HR (95% CI)
Age	0.04	0.99	0.16	
Female	0.49	0.91		
Hypertension	0.94	0.99		
Diabetes mellitus	0.97	0.98		
Coronary artery disease	0.06	0.66	0.18	
LV ejection fraction <60%	0.82	0.97		
LV end-systolic diameter >40 mm	0.85	0.97		
Pulmonary artery systolic pressure >50 mm Hg	0.27	0.82		
Atrial fibrillation	0.01	0.64	0.02	0.68 (0.50-0.95)
Tricuspid annulus diameter	0.09	0.98	0.22	
Pre-operative RV dysfunction	0.10	0.76	0.43	
Pre-operative tricuspid regurgitation moderate or more	0.43	0.86		
Tricuspid annuloplasty	0.04	1.38	0.02	1.4 (1.06-1.96)

Abbreviations as in Tables 1 and 2.

Interactive CardioVascular and Thoracic Surgery 15 (2012) 102–108
doi:10.1093/icvts/ivs107 Advance Access publication 28 March 2012

Tricuspid regurgitation after successful mitral valve surgery

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Table 2: Major determinants of late onset TR

Study	Determinant
De Bonis *et al.* [22]	Right chamber dilatation/dysfunction
Mutlak *et al.* [8]	Higher PASPs
Wang *et al.* [19]	Longer time from onset of MV disease to surgery
Boyaci *et al.* [18]	History of rheumatic heart disease
Matsunaga and Duran [15]	Ischaemic heart disease
Song *et al.* [20]	Female gender
Song *et al.* [20]	Larger LA size
Kim *et al.* [21]	AF
Shiran and Sagie [7]	Prosthetic valve malfunction

Pathophysiological mechanisms

- TA dilatation
  - -Myocardial infarction
  - -Cardiomyopathies
  - -Valvular heart disease
- Right ventricular pressure/volume overload

Pulmonary hypertension due to
- -left-sided heart disease
- -cor pulmonae
- -idiopathic PH

ASD

Conclusions

- **The tricuspid valve shows different steps of disease**

- **Each step requires to be identified and should receive appropriate treatment**

- **Early surgery in degenerative mitral regurgitation with preserved LV/RV function without AF/PH lead to better outcomes (also in term of postoperative TR evolution/progression).**

- **Progression of less than moderate TR in rheumatic/functional mitral diseases and heart failure is progressive and have a worse prognosis.**

Conclusions

- **Tricuspid annuloplasty in patients with annular dilatation > 4 cm and mild to moderate TR is recommended (IIa)**

- **Isolated annular dilatation without TR may be keep untreated (accurate evaluation of type of mitral valve disease and RV geometry/function may be helpful in decision making)**

Conclusions

Progression of TR after MVS is present in 20% to 30% in different series.

Moderate to severe TR is associated with worse outcomes and is a hightly lethal condition for which there are no clear guidlines to decide how and when to treat. Obviously if such a situation could be avoided, it should be.

As M. Mack said in a recent editorial, the harder one looks, the more one finds.