Tricuspid Valve… the black sheep of the flock

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Is TR a common problem?

- **>30%** of patients with degenerative mitral regurgitation have TR ≥+2 grade at the time of mitral valve surgery.

Cohen et al. J Thorac Cardiovasc Surg 1987;94:488-97

- **Up to 1\3** of patients with significant mitral stenosis have moderate to severe TR.

King et al. Circulation 1984;70:I193-7

- **>30%** of patients who undergo cardiac revascularization and mitral valve surgery (ischemic mitral regurgitation) have functional TR.

Matsunaga et al. Circulation 2005;112:I453-7

*

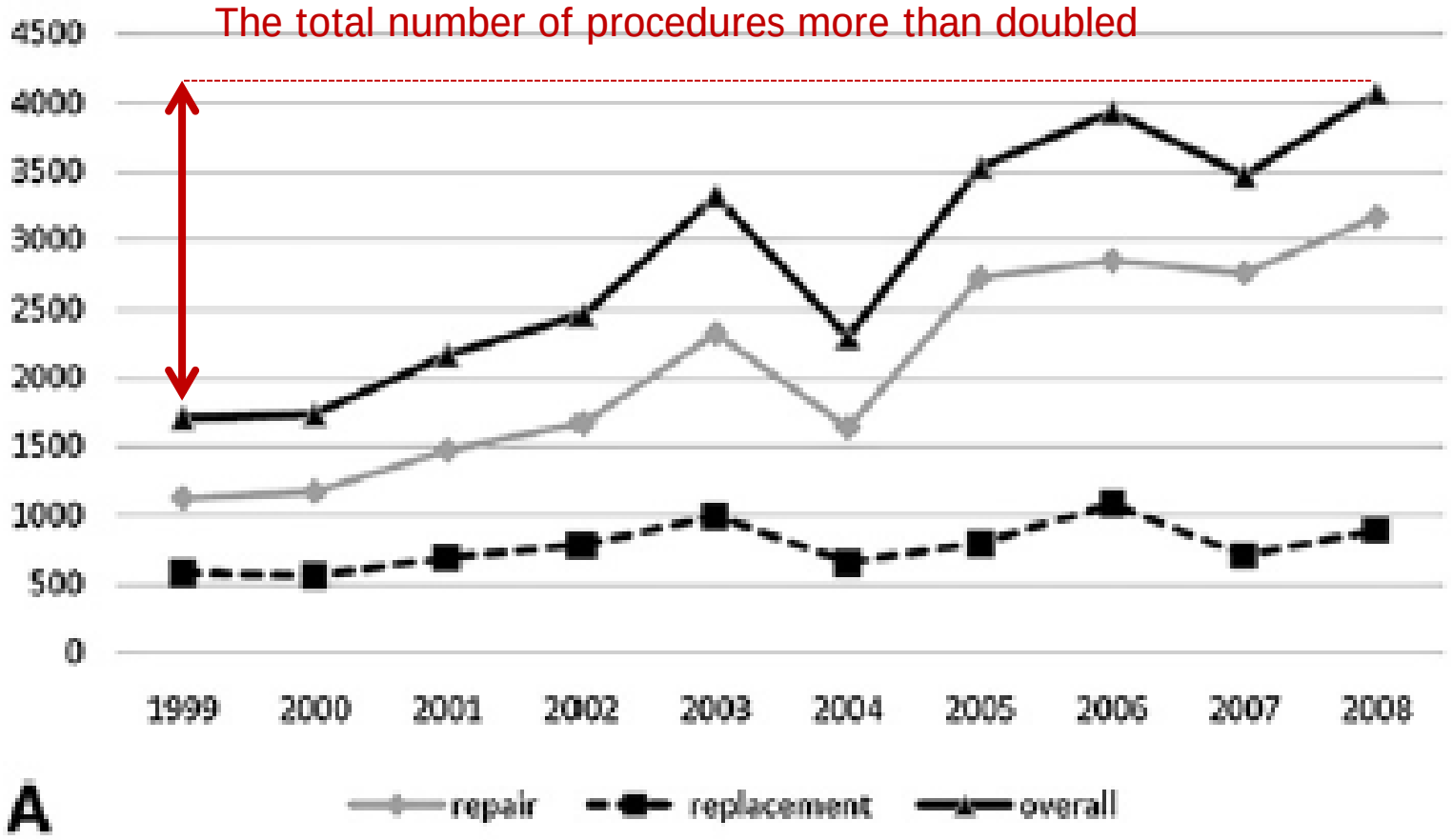
- **Up to 40%** of patients* develop significant TR after left heart surgery

Is TR a common problem?
Apparently yes!

Tricuspid valve surgery: The past 10 years from the Nationwide Inpatient Sample (NIS) database

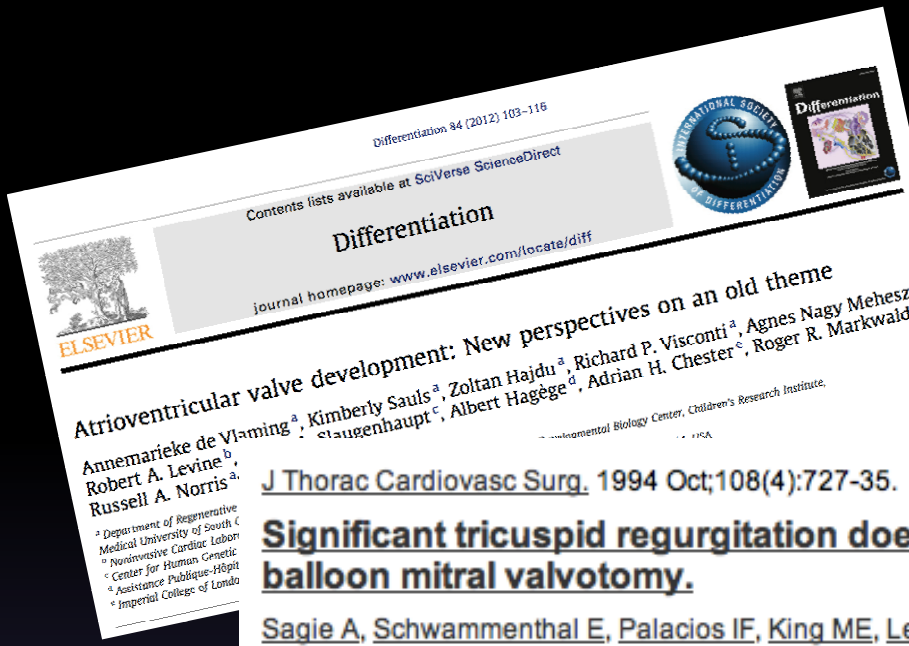
Christina M. Vassileva, MD, John Shabosky, BA, Theresa Boley, MSN, Stephen Markwell, MA, and Stephen Hazelrigg, MD

J Thorac Cardiovasc Surg 2012;143:1043-9



What has Bob Levine, the master of the mitral valve, to do with the tricuspid valve?

…apparently a lot…



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ELSEVIER

Atrioventricular valve development: New perspectives on an old theme

Annemarieke de Vlaming [a], Kimberly Sauls [a], Zoltan Hajdu [a], Richard P. Visconti [a], Agnes Nagy Mehesz [a], Robert A. Levine [b], Slaugenhaupt [c], Albert Hagège [d], Adrian H. Chester [c], Roger R. Markwald [a],

[a] Department of Regenerative
Medical University of South
[b] Noninvasive Cardiac Labor
[c] Center for Human Genetic
[d] Assistance Publique-Hôpit
[e] Imperial College of Londo

Circulation

Geometric Determinants of Functional Tricuspid Regurgitation : Insights From 3-Dimensional Echocardiography

Thanh-Thao Ton-Nu, Robert A. Levine, Mark D. H
Yosefy, Dali Fan, Lano
umacher, David J. Doser, Chaim
nd Judy Hung

American Heart Association

J Thorac Cardiovasc Surg. 1994 Oct;108(4):727-35.

Significant tricuspid regurgitation does not resolve after percutaneous balloon mitral valvotomy.

Sagie A, Schwammenthal E, Palacios IF, King ME, Leavitt M, Freitas N, Weyman AE, Levine RA.

Department of Medicine, Massachusetts General Hospital, Boston 021

J Am Coll Cardiol. 1994 Sep;24(3):696-702.

Significant tricuspid regurgitation is a marker for adverse outcome in patients undergoing percutaneous balloon mitral valvuloplasty.

Sagie A, Schwammenthal E, Newell JB, Harrell L, Jozia
diac Catheterization Laboratory, Massachusetts G

TB, Weyman AE, Levine RA, Palacios IF.
Boston 02114.

J Am Coll Cardiol. 1994 Aug;24(2):446-53.

Determinants of functional tricuspid regurgitation in incomplete tricuspid valve closure: Doppler color flow study of 109 patients.

Sagie A, Schwammenthal E, Padial LR, Vazquez de Prada JA, Weyman AE, Levine RA.

cine, Massachusetts General Hospital, Boston 02114.

J Am Coll Cardiol. 1996 Aug;28(2):472-9.

Doppler echocardiographic assessment of long-term progression of mitral stenosis in 103 patients: valve area and right heart disease.

Sagie A, Freitas N, Padial LR, Leavitt M, Morris E, Weyman AE, Levine RA.

Department of Medicine, Massachusetts General Hospital, Boston 02114, USA.

Tricuspid Valve and Mitral Valve

A Tale of 2 Valves

THE NATURAL HISTORY OF TRICUSPID REGURGITATION IN RHEUMATIC MITRAL VALVE DISEASE

- The study aimed to determine the rate of change in mitral valve area and the factors influencing the progression in a cohort of patients with mitral stenosis who did not have surgical intervention.
- RV and RA dilatation as well as increase in TR grade appeared independently of mitral valve narrowing.

Sagie et al. JACC 1996;28:472-9

Table 3. Changes in Right Heart Measurements From Entry to Follow-Up in the Groups With Progression and Nonprogression of Disease

	Progression (n = 35)			Nonprogression (n = 68)		
	No.	Entry	Follow-Up	No.	Entry	Follow-Up
RV end-systolic area (cm^2)	33	9.6 ± 3.8	10.9 ± 4.6†	63	9.3 ± 3.4	10.4 ± 5.3†
RV end-diastolic area (cm^2)	32	17.6 ± 5.9	19.6 ± 7.4*	62	16.6 ± 4.6	18.2 ± 5.3†
RV area change (%)	32	45.0 ± 9	43.1 ± 9	62	44.8 ± 9	44.1 ± 9
RA area (cm^2)	33	16.7 ± 7	18.1 ± 8*	63	16.2 ± 6	19.9 ± 8.5†
Annular diameter (cm)	33	3.4 ± 0.6	3.6 ± 0.7	63	3.4 ± 0.6	3.56 ± 0.6†
RV systolic pressure (mm Hg)	12	43.9 ± 11	51 ± 17†	31	42.1 ± 12	46 ± 14
TR jet area (cm^2)	10	5.2 ± 4.2	8.9 ± 8†	21	4.1 ± 3.2	6.0 ± 5.5†
JA/RAA ratio	10	31 ± 16%	49 ± 23%†	21	25 ± 15%	30 ± 15%†

*$p < 0.05$, †$p < 0.01$ between entry and follow-up study. Data presented are mean value ± SD or number of patients. JA = jet area; RAA = right atrial area; other abbreviations as in Table 2.

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Clinical Implication

- Bringing the tricuspid valve into focus, lowering the threshold for intervention in the valve.
- Coupling tricuspid repair to MVR in patients with rheumatic heart disease.

Do we need to adopt the same “instincts” in degenerative mitral valve disease?

The debate is ongoing in the guidelines as well as in the surgical community

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ESC guidelines

Class **IIa** indication for **moderate TR with a dilated annulus** in patients undergoing a mitral valve operation.

AHA\ACC guidelines

Class **IIb** for tricuspid annuloplasty in the presence of **annular dilatation and pulmonary hypertension**.

Yes… but TV annular dilatation should be the main consideration

Dreyfus et al. Ann Thorac Surg 2005;79:127-32

- Prospective study, recruitment over 12 yrs, f\u period 4.8±2.9 yrs
- 311 patients under went mitral valve repair (MVR).
- Tricuspid annuloplasty was performed only if the tricuspid annular diameter was greater than twice the normal size (> 70 mm) **regardless** of the grade of regurgitation.
- Patients in group 1 (163 patients; 52.4%) received MVR alone. Patients in group 2 (148 patients; 47.6%) received MVR plus tricuspid annuloplasty.

Table 2. Etiology of Mitral Valve Disease

	Group 1 (MVR)	Group 2 (MVR + TVR)	*p* Value	Total
Barlow	62 (38.0%)	50 (33.7%)	0.95	112 (36%)
Dystrophic	44 (26.9%)	47 (31.8%)	0.98	91 (29.3%)
Ischemic	21 (12.8%)	4 (2.8%)	0.08	25 (8%)
Rheumatic	18 (11.1%)	26 (17.5%)	0.73	44 (14.1%)
Endocarditis	11 (6.8%)	3 (2%)	0.54	14 (4.6%)
Cardiomyopathy	7 (4.4%)	18 (12.2%)	0.28	25 (8%)

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

Table 1. Comparison of Preoperative Demographics in Patients

	Group 1 MVR	Group 2 MVR + TVR	Test	*p* Value
n	163	148		
Female	36.8%	40.5%	χ^2	0.50
Age	61.2 ± 13.1	58.5 ± 14.1	*t*	0.11
Body surface area (kg/m²)	1.8 ± 0.2	1.8 ± 0.2	MW	0.52
Medication	1.9 ± 1.3	2.2 ± 1.2	MW	0.024
NYHA	2.5 ± 0.9	2.6 ± 0.8	MW	0.29
Atrial fibrillation	26.4%	32.4%	χ^2	0.24
TR grade	0.7 ± 0.5	0.9 ± 0.6	MW	0.027
MR grade	3.3 ± 0.6	3.4 ± 0.6	MW	0.13
LVESD (mm)	42.9 ± 7.6	45.2 ± 9.9	*t*	0.026
PAP (mm Hg)	39.2 ± 6.7	39.9 ± 6.7	*t*	0.34
EF	59.6 ± 7.7	61.4 ± 8.7	*t*	0.051

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.

Conclusion

- Remodeling annuloplasty of the tricuspid valve based on tricuspid dilation at the time of mitral valve surgery improved functional status (…*but nothing else*) irrespective of the grade of regurgitation.

Mayo Clinic challenges Dreyfus…

Retrospective study, 699 pts, recruited over 11 yrs.
f\u period 5.5±3 yrs

Yilmaz et al. J Thorac Cardiovasc Surg 2011;142:608-13

- TV annular size doesn't matter; if TR is not severe at the time of degenerative MV surgery, surgical intervention in the valve is unnecessary since it is unlikely to progress after mitral valve surgery.

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).

In patients with less than moderate preoperative TR, mean TR grade remained stable and increased only slightly after 5 years (P<0.01).

In those with at least moderate preoperative TR, mean TR grade decreased significantly from preoperative values after MV repair (P<.001 at dismissal,<1 year, and 1–3 years).

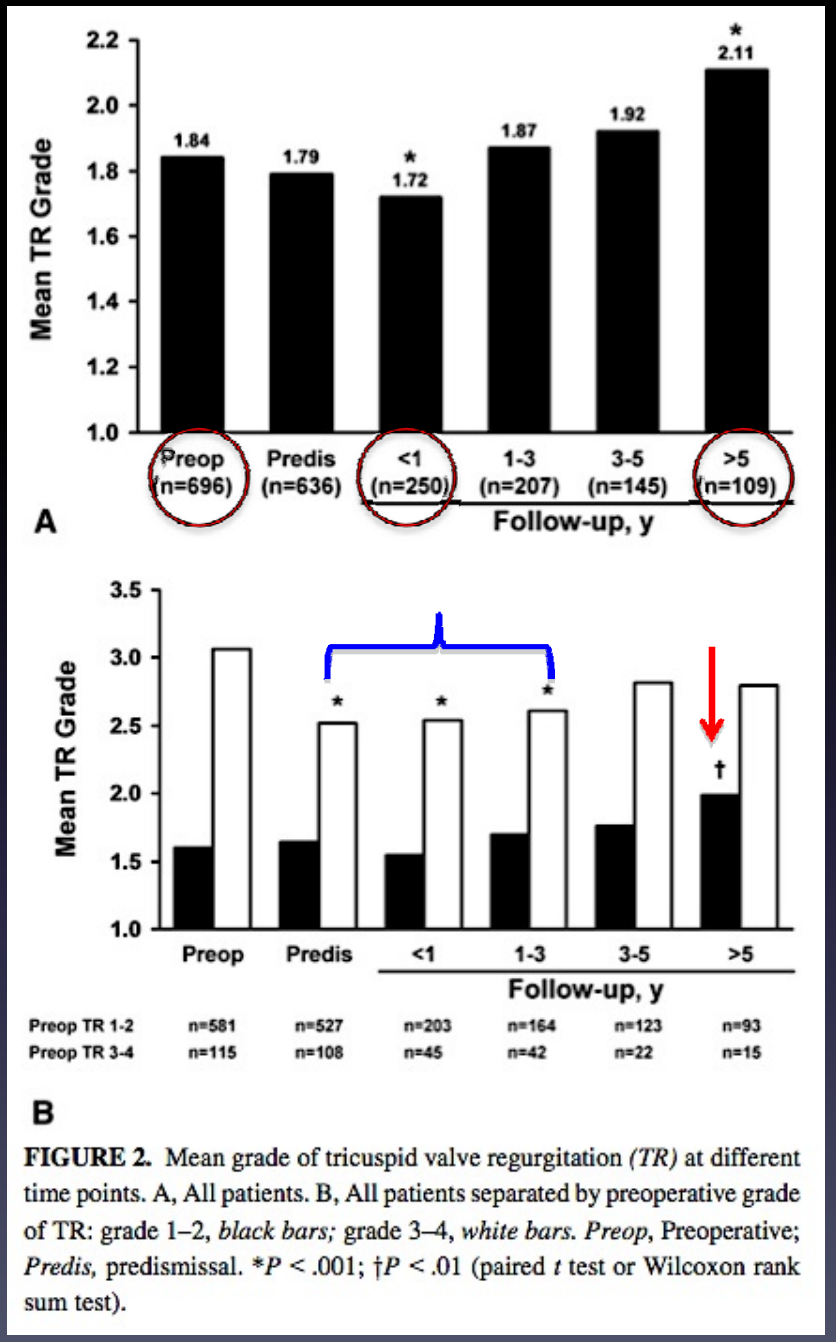

FIGURE 2. Mean grade of tricuspid valve regurgitation *(TR)* at different time points. A, All patients. B, All patients separated by preoperative grade of TR: grade 1–2, *black bars;* grade 3–4, *white bars. Preop,* Preoperative; *Predis,* predismissal. *$P < .001$; †$P < .01$ (paired *t* test or Wilcoxon rank sum test).

Exploring the mechanism of functional TR

Mechanisms of functional TR *

- Annular dilatation (the most important determinant of incomplete closure)

Sagie et al. JACC 1994;24:446-53

- Increased leaflet tethering
- Are there more?

Increased Tricuspid Regurgitation in Patients with Pulmonary Hypertension When Left Ventricular Dysfunction is Present: A New Mechanism Based on Interventricular Interaction

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*

- Hypothesis: Left ventricular remodeling may alter the tethering geometry of the tricuspid valve differently than in primary pulmonary pathology.

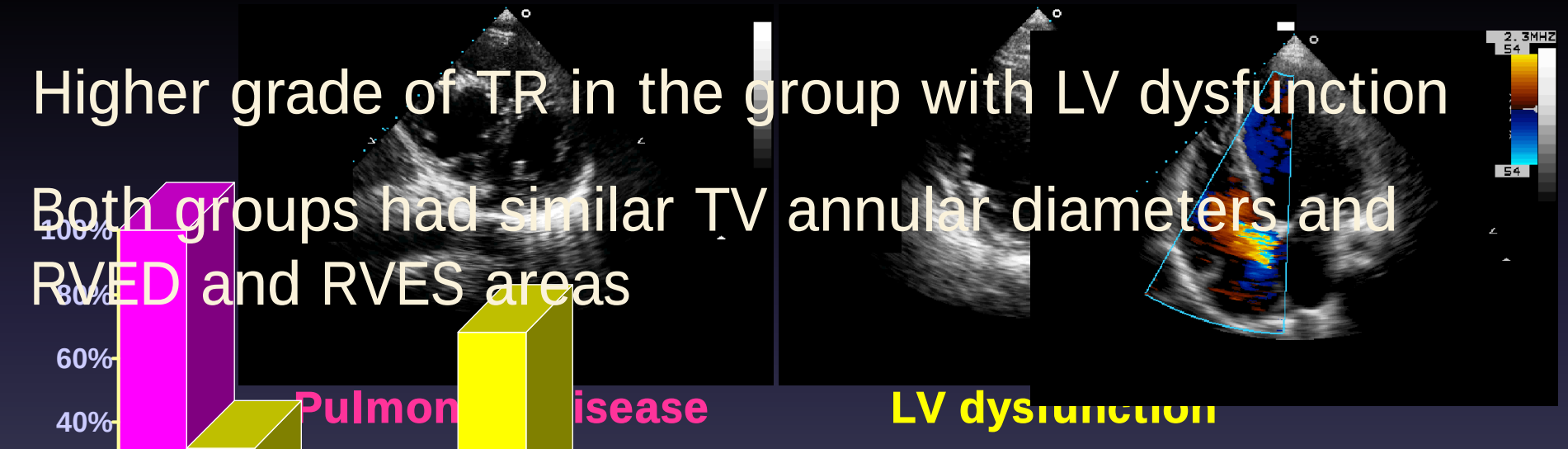
- MGH database was searched for patients with severe pulmonary hypertension (RVSP>70 mmHg). The patients were divided into two subgroups dependent upon LVEF: normal LV (EF≥50%, n=13) and LV dysfunction (EF≤30%, n=25).

Different LV shape (*septal radius of curvature*) despite comparable pulmonary pressure

Different TR jet direction indicating a possible different mechanism of TR

Higher grade of TR in the group with LV dysfunction

Both groups had similar TV annular diameters and RVED and RVES areas



LV remodeling (in particularly the change in IVS shape and function) may increase TR grade via asymmetrical deformation of the valve spatial geometry

Right Ventricular Pacing has an Immediate Effect on Tricuspid Regurgitation Grade Regardless of the Mechanical Effect of the Electrode Placement

M. Vaturi[1], J. Kuzniec[2], Y. Shapira[1], M. Perlmutter-Weiser[1], L. Glaimer[1], B. Strasberg[2], A. Sagie[1]

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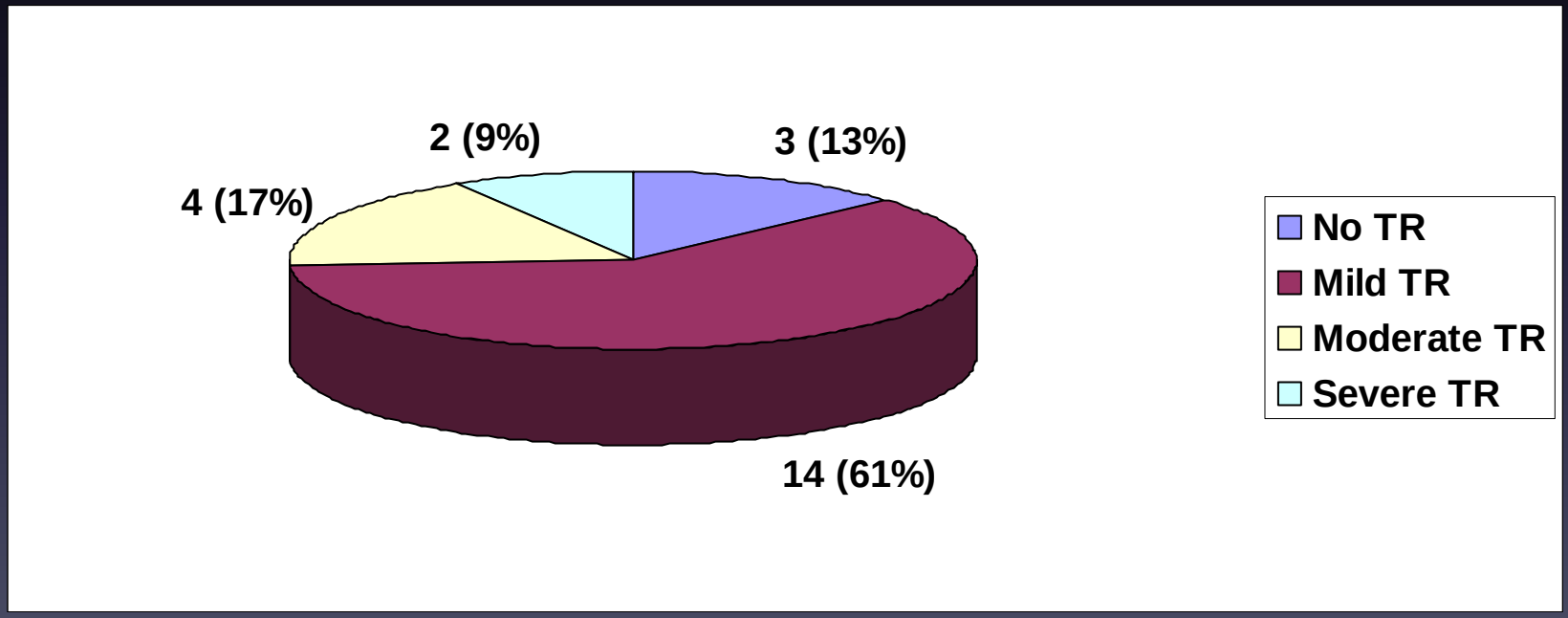
and
Sackler Faculty of Medicine, Tel Aviv University.

European Journal of Echocardiography (2010) 11, 550–553

TR in the presence of a pacemaker : is it solely related to physical interference to the leaflets by the electrode or does pacing itself have an impact on aggravating TR ?

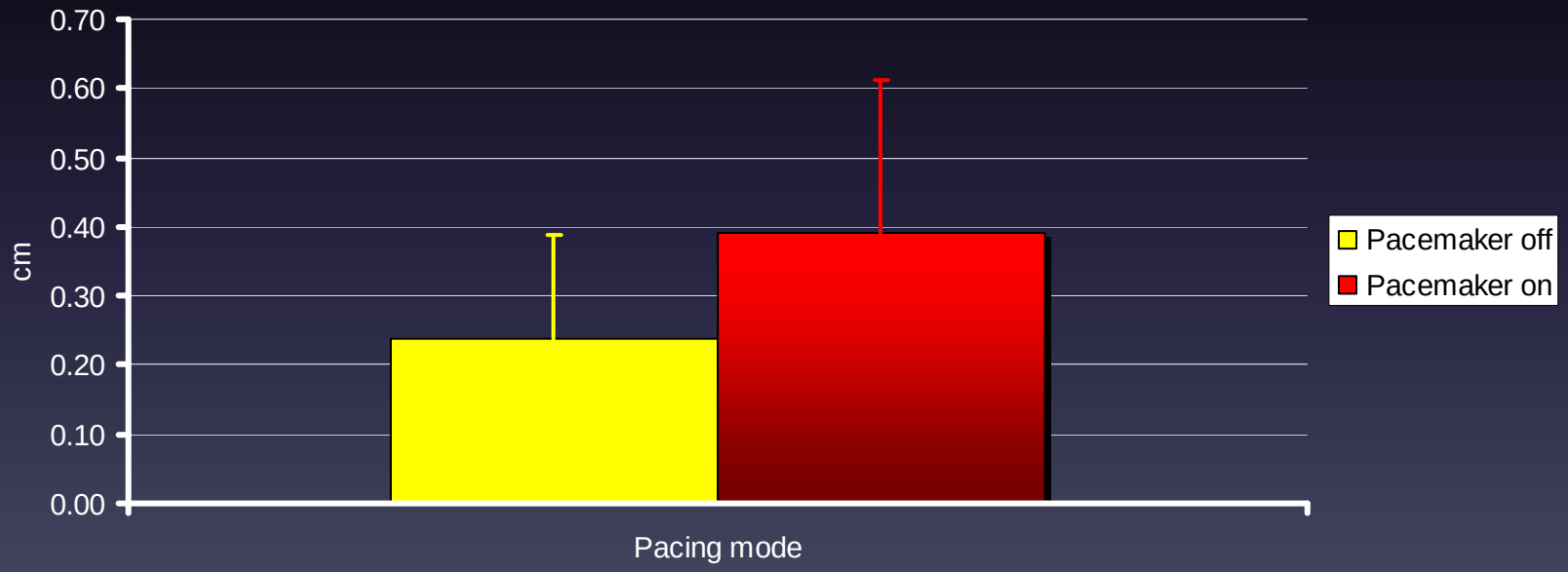
RESULTS (I)

The majority of the study patients (74%) had non significant TR at baseline.



RESULTS (II)

TR grade increased with pacing (p<0.0001)



CONCLUSIONS

- RV pacing was associated with acute increase in TR grade in patients with normal LV function. This effect was irrespective of the presence of an electrode at the plane of the leaflets.
- Active pacing may induce functional TR (possibly due to dyssynchrony in RV contraction).

We need better solutions for TR

*

- The success of the surgical approach (mainly ring annuloplasty) is limited *(significant residual TR has been reported in 10-45% of patients after TV repair with various techniques)*.

- TV repair technique should be tailored according to the precise mechanism of TR.
- The use of TV ring annuloplasty (alone) as a "default" technique of repair should be reconsidered.

- Tricuspid valve augmentation (along with ring annuloplasty) may be a better solution when increased leaflets tethering is the predominant mechanism of TR.

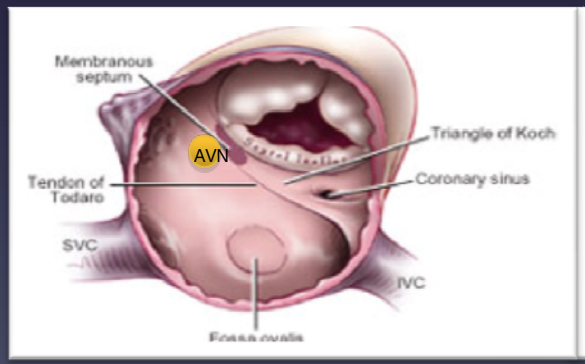
…and what about TTVI?

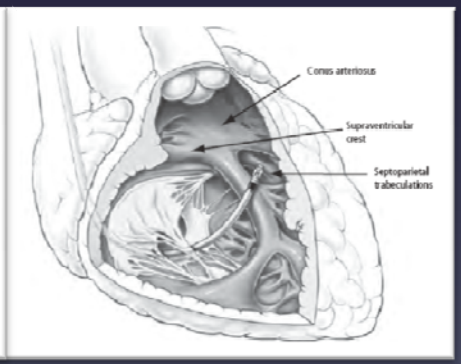
- TTVI (for native valve) is unavailable at the moment. However, the inventors may face several obstacles due to the following anatomical features of the valve:

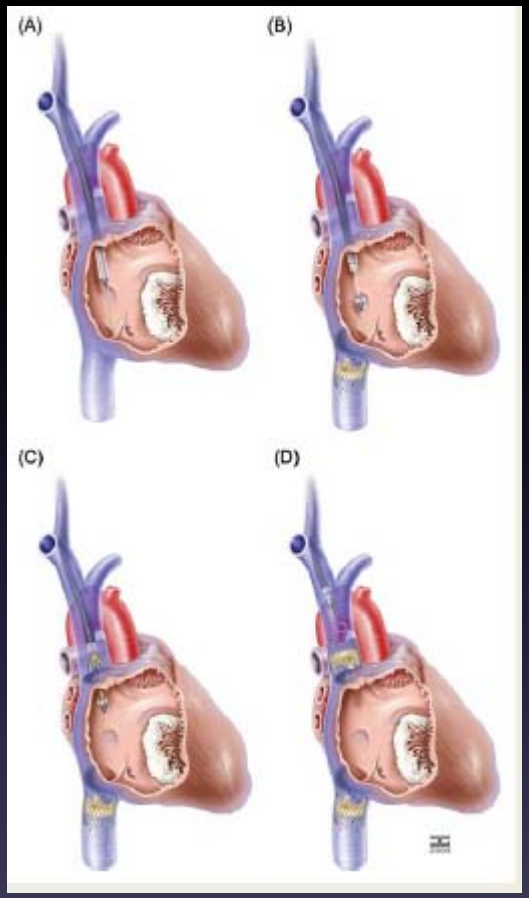
➢ Unique anatomy (triangular)

➢ A fibrous ring is not as easy to define as in the MV, although it remains identifiable.

➢ Problematic neighbor (AVN)






(A)
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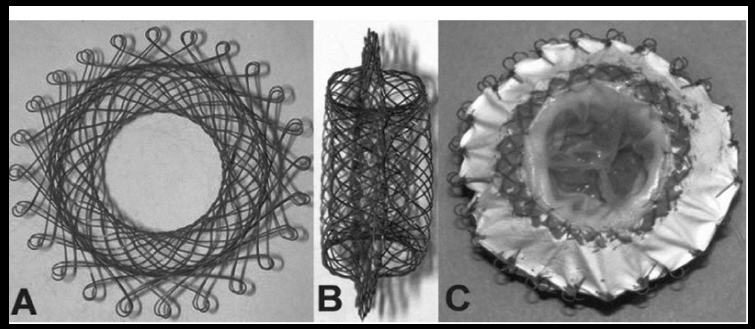
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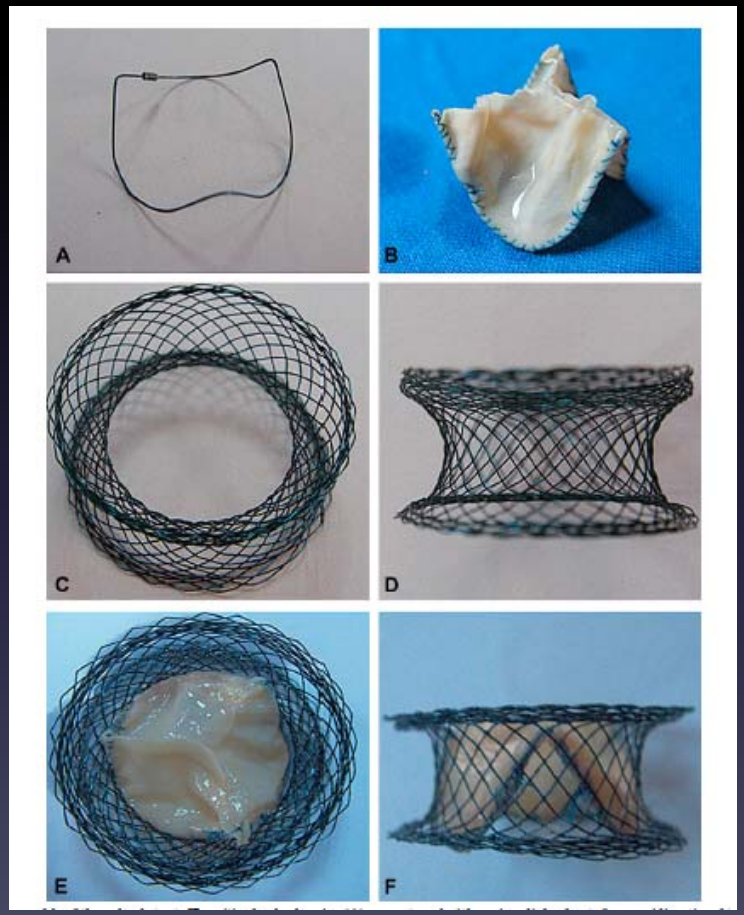
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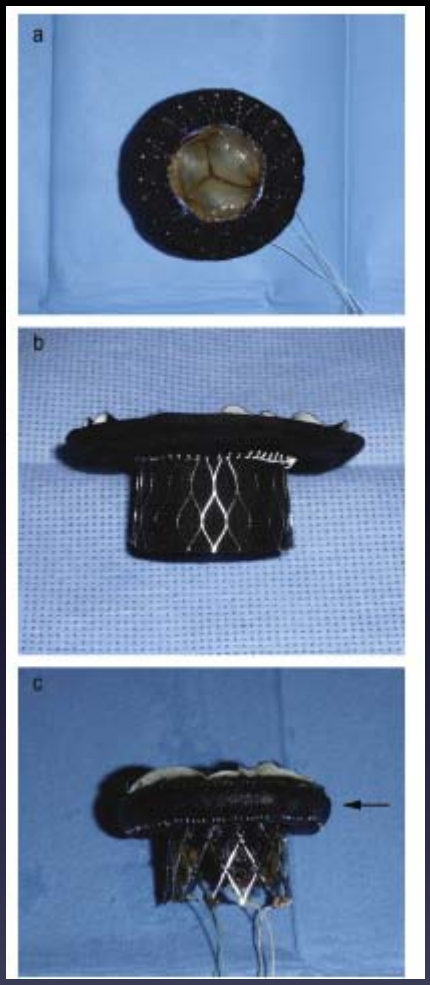
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So, what did we have so far?

- **TR is a progressive state when accompanies mitral valve disease** *(in RHD for sure, in degenerative MR – maybe?)*
- **The mechanism of functional TR is complex**.
- **Severe TR is a severe disease**. The patients are usually at the end of the scale of risk. Often, the opportunity for surgical intervention is missed *(a patient who is too sick, a cardiologist who is too conservative).*
- **The surgical repair of TR is not ideal at the present time**. Tailoring of the surgical approach to the exact mechanism may improve the surgical results.
- **TTVI is desired**.

Thank You