Tricuspid Valve Repair for Treatment and Prevention of Secondary Tricuspid Regurgitation in Patients Undergoing Mitral Valve Surgery

Dr Boris Orlov
This Presentation

“What is a problem to prepare this presentation? There is a lot of information about Tricuspid Valve!”

I met two problems:

“Don't tell fish stories where the people know you; but particularly, don't tell them where they know the fish.”

"Not that the story need be long, but it will take a long while to make it short."
Say well or be still (deflated?)
Secondary Tricuspid Regurgitation

We have entered an era of renewed interest and enthusiasm surrounding the diagnosis and treatment of valvular heart disease, driven in part by emerging percutaneous therapies for the treatment of aortic, pulmonic, and mitral valve disease.

Despite this wave of investigation, little attention has been given to the treatment of tricuspid valve disease.

Longest reported clinical follow-up (Rouen)
Mrs S….88 y-old: > 8 years with THV

No valve dysfunction
AVA: 1.68 cm², mean gradient 12 mm Hg
Secondary Tricuspid Regurgitation

Because significant tricuspid regurgitation appears to be a marker for late-stage myocardial and valvular heart disease, reoperations for recurrent TR are especially high-risk surgical procedures (up to 37% in-hospital mortality).

TR does not resolve after successful mitral valve surgery.

If untreated at the time of mitral valve surgery, significant residual TR negatively impacts perioperative outcomes, functional class, and survival.
Forgotten and Neglected Valve
Volumes are clearly a small fraction of the total MV operations yearly, which exceed 40,000.
<table>
<thead>
<tr>
<th>Valve lesion</th>
<th>Population</th>
<th>Currently treated</th>
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</thead>
<tbody>
<tr>
<td>Mitral regurgitation</td>
<td>2,520,000</td>
<td>48,000 (2%)</td>
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<tr>
<td>Aortic stenosis</td>
<td>749,000</td>
<td>79,000 (10%)</td>
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<tr>
<td>Tricuspid regurgitation</td>
<td>1,600,000</td>
<td>&lt; 8,000</td>
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</tbody>
</table>

* Moderate to severe & severe valvular lesions

Less than 0.5% of cases

“The Forgotten Valve”
Tricuspid Regurgitation

Etiology

TR is only rarely caused by primary abnormalities of the tricuspid leaflets. In most cases it is “functional” in nature.

- **Primary causes (25%)**
  - Rheumatic
  - Myxomatous
  - Ebstein anomaly
  - Endomyocardial fibrosis
  - Endocarditis
  - Carcinoid disease
  - Traumatic (blunt chest injury, laceration)
  - Iatrogenic (pacemaker/defibrillator lead, RV biopsy)

- **Secondary causes (75%) “Functional”**
  - Left heart disease (LV dysfunction or valve disease) resulting in pulmonary hypertension
  - Pulmonary hypertension (chronic lung disease, pulmonary thromboembolism, left to right shunt)
  - RV dysfunction (myocardial disease, RV ischemia/infarction)
Ventricular interdependence
Pathophysiology of Functional MR

The mitral valve (anatomically normal) is caught in a “tug-of-war” between the dilated and distorted annulus and the displaced papillary muscles.
Pathophysiology of Functional TR

The tricuspid valve (anatomically normal) is caught in a “tug-of-war” between the dilated and distorted annulus and the displaced papillary muscles.
Mitral valve is a Marionette pulled by its Masters, papillary muscles

The Problem is not with the Marionette, but with its Masters

Pathophysiology of Functional TR

- Tricuspid valve is a Marionette pulled by its Masters, papillary muscles
- The Problem is not with the Marionette, but with its Masters
Ischemic MR
Prognostic Implications

One-year mortality after MI:

No IMR 6%
Mild IMR 10%
Moderate IMR 17%
Severe IMR 40%

Lamas GA, Braunwald E et al.,
Clinical significance of mitral regurgitation after acute MI.
*Circulation.* 1997; 96: 827–833
Secondary TR
Prognostic Implications

Impact of TR on Long Term Survival

N=5223

Worse Survival Independent of
• Age
• Ventricular Function
• PAP

P < .0001

Nath J, JACC 2004; 43: 405-9
Ventricular interdependence

- Plays an important role in right ventricular function

- In addition to a shared interventricular septum, there is continuity between the muscle fibers of the left and right ventricles, resulting in a mechanical union whereby left ventricular contraction augments right ventricular free wall contraction

- Experimental models have shown that 20% to 40% of RV systolic pressure and volume outflow results from left ventricular contraction

(This mechanism is responsible for RV Failure after LVAD Implantation, that why IABP improves RV Failure)

Ho SY, Nihoyannopoulos P. Heart. 2006;92(suppl):i2–i13..
Left and Right Ventricles are together forever
Secondary Tricuspid Regurgitation

Historical Excursus

In the 1960s with the advent of valve replacement, as surgery’s role in managing valvular heart disease expanded rapidly, the thinking at that time was that if regurgitation was “functional,” then it should not require surgical treatment as, by definition, it should improve when the left-sided valve is replaced.

Reduction in severity of tricuspid regurgitation was sometimes observed after mitral valve replacement, prompting Braunwald et al. in 1967 to recommend conservative management of functional tricuspid regurgitation.

Secondary Tricuspid Regurgitation

**Historical Excursus**

However, in 1974, Carpentier et al. reported excellent results with tricuspid valve repair and argued for systematic repair of functional tricuspid regurgitation during mitral valve surgery.


It was later observed in the 1980s that some patients who had undergone successful mitral surgery returned years later with severe symptomatic tricuspid regurgitation, and when these patients were reoperated on, mortality was very high.

Secondary Tricuspid Regurgitation

Pathophysiological objectives

- Pulmonary Hypertension
- Papillary Muscle Displacement
- Tricuspid Annular Dysfunction
Secondary Tricuspid Regurgitation

Pulmonary hypertension

- In patients with left-sided valvular disease a rising left atrial pressure, transmitted through the lungs as pulmonary arterial hypertension, resulting in RV pressure overload and:
  
  • can directly result in tricuspid regurgitation
  
  OR
  
  • more typically causes right ventricular dilatation, which leads to dilatation and distortion of the tricuspid valve annulus (Carpentier type I regurgitation) or/and by tethering of the tricuspid valve leaflets (Carpentier type IIIb regurgitation)

- At least in theory, reduction in degree of pulmonary hypertension (by mitral valve repair) could result in less tricuspid regurgitation, but this would first require reverse remodeling of the previously dilated and deformated right ventricle, which may not be instantaneous.
Secondary Tricuspid Regurgitation

Pulmonary hypertension

In practice, complete reverse right ventricular remodeling practically not occur, and normalization of pulmonary artery pressures alone will not eliminate tricuspid regurgitation in many patients. (This is well demonstrated in the pulmonary thromboendarterectomy literature, in which moderate to severe secondary tricuspid regurgitation is reported postoperatively in 30% to 45% of patients despite successful reduction in pulmonary arterial pressure).
Papillary Muscle Displacement

Mascherbauer J, Maurer G. Eur Heart J 2010;31:2841-2843
The anterior leaflet is the largest, whereas the posterior leaflet is notable for the presence of multiple scallops. The septal leaflet is the smallest and arises medially directly from the tricuspid annulus above the interventricular septum.

The anterior papillary muscle provides chordae to the anterior and posterior leaflets, and the medial papillary muscle provides chordae to the posterior and septal leaflets. The septal wall gives chordae to the anterior and septal leaflets. These multiple chordal attachments are important mediators of TR, as they impair proper leaflet coaptation in the setting of right ventricular dysfunction and dilation.
Secondary Tricuspid Regurgitation
Papillary Muscle Displacement

Modern echocardiographic imaging (particularly real-time 3-D) have observed septal leaflet tethering in patients with secondary tricuspid regurgitation who have normal pulmonary artery pressures.

Because the two ventricles are interdependent at the septum, left ventricular septal dysfunction also causes dysfunction of the right septal wall, the area of origin of the small septal papillary muscles (chords) to the septal and anterior leaflets of the tricuspid valve (antero-septal comissural gap).
Secondary Tricuspid Regurgitation

Such regurgitation can occur irrespective of the size and function of the right ventricle and explains why left ventricular dysfunction is an independent risk factor for secondary tricuspid regurgitation (independent of the effect of pulmonary hypertension).


Ventricular Interdependence

Lt & Rt Ventricles are together forever
Secondary Tricuspid Regurgitation

Tricuspid Annular Dysfunction

- Tricuspid annular dilatation has long been recognized as a constant feature of secondary tricuspid regurgitation.

- Recently, other abnormalities in the annulus have been discovered:
  - Unlike the saddle-shaped annulus in normal subjects, valves with secondary tricuspid regurgitation are dilated, flattened, and circular.
  - An asymmetric reduction in tricuspid annular contraction.
The tricuspid annulus has a complex 3-dimensional structure, which differs from the more symmetric “saddle-shaped” mitral annulus.

Rationale for Surgical Correction of Secondary Tricuspid Valve Disease at the Time of Mitral Valve Surgery
Secondary Tricuspid Regurgitation
Prognostic Implications

• **TR After MVR**: Independent Predictor of:
  - NYHA III or IV
  - Heart Failure Death
  - All-Cause Mortality
  - Reduced Exercise Capacity

• **After PBM Valvuloplasty**: TR Do Not Improve in 50-80%
Nonregression or progression of tricuspid regurgitation after MV surgery

- Tricuspid regurgitation is frequently present months or years after isolated mitral valve surgery.

- Although repair of left-sided valve dysfunction may reduce the severity of tricuspid regurgitation, a substantial proportion of patients will go on to develop moderate or severe regurgitation.

  In one series, 43% of patients had severe tricuspid regurgitation at a mean follow-up of 11 years after isolated mitral valve replacement


- Although in some patients, significant tricuspid regurgitation will resolve with correction of the left-sided lesion, there is no means of accurately predicting this at the time of mitral surgery.
Mortality and morbidity associated with tricuspid regurgitation occurring after MV surgery

The early mortality, long-term survival, freedom from heart failure, and functional outcome are all significantly worse for patients with severe tricuspid regurgitation compared to those without severe regurgitation.

Moderate tricuspid regurgitation, is also associated with inferior survival, but to a lesser degree than for severe regurgitation (79% 1-year survival for moderate, compared to 64% for severe and 90% to 92% for patients with mild or none, respectively).

Mortality and morbidity associated with tricuspid regurgitation occurring after MV surgery

Although Re-do surgery can be offered to these patients, it may not improve survival and quality of life at this late stage!

Despite resolution of tricuspid regurgitation; the 5-year event-free survival in one series was reported to be 42%, and in another, the 3-year patient survival was 19%.


The mortality of reoperative tricuspid valve surgery is about 20% to 40% or substantially higher

Limited (no chance?) effectiveness for second ball
Annular Dilatation

Indicator of functional and structural abnormality of the tricuspid valve and right ventricle, representing the early stages of secondary tricuspid regurgitation.
Using echocardiographic analysis of 109 patients, Sagie et al. demonstrated that pulmonary hypertension and right ventricular dilatation per se were not prerequisites for developing functional tricuspid regurgitation.

The most consistent feature they found was tricuspid annular dilatation

Progression of tricuspid valve dysfunction

Dilated annulus


- A dilated annulus is an Indicator of functional and structural abnormality of the tricuspid valve and right ventricle.

- Annular dilatation represents the early stages of secondary tricuspid regurgitation.
There is a good correlation in both patients with VHD (r=0.87) and patients with ASD (r=0.88). The correlation lines cross the X-axis at a TAD value of 33-34 mm, which is the threshold for TR.
Secondary Tricuspid Regurgitation or Dilatation: Which Should Be the Criteria for Surgical Repair?

N = 311

- **Tricuspid annuloplasty if TA diameter > 2x Normal (70 mm)** regardless of the grade of regurgitation.

- Group 1 (163 patients, 52.4%): Mitral Valve Repair.
- **Group 2** (148 patients, 47.6%): MVR + Tricuspid Annuloplasty.

- Tricuspid regurgitation increased > 2 grades:
  - 48% group 1
  - 2% group 2 ($p < .001$).

- **NYHA:** group 1 = 1.6 vs group 2 = 1.1 ($p=0.01$)
When Should We Operate?

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

70mm Surgical = 40 mm Echo

• 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.

Secondary Tricuspid Regurgitation

Irrational & Rational

Despite these observations, only a minority of cardiologists and surgeons embraced using tricuspid valve repair for functional tricuspid regurgitation, and surgical abstention continues in many centers to the present day.

This strategy has been increasingly scrutinized since Dreyfus et al. reported that patients having tricuspid valve repair at the time of mitral valve surgery did better in the long term compared with patients who did not.

Indications for Surgery
When Should We Operate?

- No consensus to guide decision making
- TV repair is often dictated by team or surgeon predisposition
- Lack of a clear guideline on TV repair indications
Indications for Intervention in TV Disease

Table 2. 2006 ACC/AHA Guidelines Pertaining to the Surgical Management of Tricuspid Valve Disease/Regurgitation

Class I

Tricuspid valve repair is beneficial for severe TR in patients with MV disease requiring MV surgery. *(Level of Evidence: B)*

Class IIa

1. Tricuspid valve replacement or annuloplasty is reasonable for severe primary TR when symptomatic. *(Level of Evidence: C)*

2. Tricuspid valve replacement is reasonable for severe TR secondary to disease/abnormal tricuspid valve leaflets not amenable to annuloplasty or repair. *(Level of Evidence: C)*

Class IIb

Tricuspid annuloplasty may be considered for less than severe TR in patients undergoing MV surgery when there is pulmonary hypertension or tricuspid annular dilatation. *(Level of Evidence: C)*

Class III

1. Tricuspid valve replacement or annuloplasty is not indicated in asymptomatic patients with TR whose pulmonary artery systolic pressure is less than 60 mm Hg in the presence of a normal MV. *(Level of Evidence: C)*

2. Tricuspid valve replacement or annuloplasty is not indicated in patients with mild primary TR. *(Level of Evidence: C)*

ACC indicates American College of Cardiology; AHA, American Heart Association; TR, tricuspid regurgitation; and MV, mitral valve.
## Indications for Intervention in TV Disease

<table>
<thead>
<tr>
<th>Indications</th>
<th>Class</th>
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<tbody>
<tr>
<td>Severe TR in a patient undergoing left sided valve surgery</td>
<td>IC</td>
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<tr>
<td>Severe primary TR and symptoms despite medical therapy without severe right ventricular dysfunction</td>
<td>IC</td>
</tr>
<tr>
<td>Severe TS (± TR), with symptoms despite medical therapy*</td>
<td>IC</td>
</tr>
<tr>
<td>Severe TS (± TR) in a patient undergoing left sided valve intervention*</td>
<td>IC</td>
</tr>
<tr>
<td>Moderate organic TR in a patient undergoing left-sided valve surgery</td>
<td>IIaC</td>
</tr>
<tr>
<td><strong>Moderate secondary TR with dilated annulus (&gt; 40 mm) in a patient undergoing left sided valve surgery</strong></td>
<td>IIaC</td>
</tr>
<tr>
<td>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 &gt; 60 mmHg)</td>
<td>IIaC</td>
</tr>
<tr>
<td>Severe isolated TR with mild or no symptoms and progressive dilation or deterioration of right ventricular function</td>
<td>IIbC</td>
</tr>
</tbody>
</table>

* Percutaneous technique can be attempted as a first approach if TS is isolated

TR: tricuspid regurgitation
TS: tricuspid stenosis

VHD Guidelines ESC 2007

[European Society of Cardiology](https://www.cardio.org)
When Should We Operate?
Surgical Armamentarium
Secondary Tricuspid Regurgitation

Implications for Surgical Therapy

Based on current understanding of pathophysiology, principles of surgical therapy for secondary tricuspid regurgitation include the following:

• Elimination of increased afterload to the right ventricle by correction of left-sided valve dysfunctions and optimization of left ventricular function

• Maximization of right ventricular remodeling by reducing pulmonary hypertension. Correction of left-sided lesions often suffices, but in cases in which pulmonary hypertension persists, oral pulmonary vasodilators such as sildenafil and bosentan may be helpful in promoting reverse remodeling of the right ventricle


• Correct tricuspid annular dilatation and dysfunction - a tricuspid valve annuloplasty to restore annular size and geometry
Surgical Techniques for Tricuspid Valve Repair

- Two principal surgical methods are used to treat or prevent secondary tricuspid regurgitation: the ring annuloplasty method introduced by Carpentier and the suture annuloplasty method described by De Vega.

- With the ring annuloplasty technique, the annulus is permanently fixed in a systolic position by suturing in a rigid or semirigid ring.
Because the small septal wall leaflet is fairly fixed, there is little room for movement if the free wall of right ventricular/tricuspid annulus should dilate.

Dilatation of the tricuspid annulus occurs primarily in its anterior/posterior (mural) aspect, which can result in significant functional TR as a result of leaflet malcoaptation.

The septal aspect of the tricuspid annulus is considered to be analogous to the intertrigonal portion of the mitral annulus in that it is relatively spared from annular dilation.
Because of this property, tricuspid annular sizing algorithms have been based on the dimension of the base of the septal leaflet.

The ring size must be at least one size smaller than the distance between the antero-septal and septo-posterior commissures, or at least one size smaller than the surface area of the anterior leaflet.
Conceptual Classification of TV Annuloplasty

- Suture Annuloplasty
- Flexible Band
- Undersized Ring Annuloplasty
- Remodeling 3-D Ring Annuloplasty
Surgical Techniques for Tricuspid Valve Repair

Annular remodeling strategies should be tailored in the setting of mechanism and severity of Secondary TR.

Probably, patients with extensive leaflet tethering (>1.0 cm) required additional maneuvers to ensure valve competence.

E. M. Spinner, D. H. Adams, and A. P. Yoganathan
In Vitro Characterization of the Mechanisms Responsible for Functional Tricuspid Regurgitation
<table>
<thead>
<tr>
<th>Tricuspid Valve</th>
<th>Medtronic</th>
<th>Edwards</th>
<th>St Jude</th>
<th>Sorin</th>
<th>Peters Surgical</th>
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<td><strong>Rigid Rings</strong></td>
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<td><strong>Flexible Rings/ Bands</strong></td>
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</table>
Carpentier-Edwards Classic Ring
Cosgrove-Edwards Annuloplasty Band
Remodeling 3-D Ring Annuloplasty
Types of TV repair rings
Edwards MC3

- The MC3 TV annuloplasty ring (Edwards Lifesciences, Irvine, CA, USA) is the first TV annuloplasty ring anatomically designed to conform to the three-dimensional shape of the normal TV and minimize stress on sutures.

- Progressive flexibility is created from the unique processing of the titanium band.

- The Edwards MC3 annuloplasty ring is covered with material that encourages host tissue ingrowth.
Contour 3D™ Ring

- Remodeling annuloplasty ring (rigid)
  - Unique asymmetrical 3D ring design (nonplanar)
  - Ring design based upon scientific evidence on normal tricuspid annular geometry
- Launched in 2010
- Developed with Drs. Aubrey Galloway, Eugene Grossi, Rüdiger Lange and Hugo Vanermen
- Polyester knit covering with titanium/silicone core
- Six sizes, 26 – 36 mm
- Tricuspid
Tri-Ad™ Ring

- Remodeling annuloplasty ring (semi-rigid)
  - Targeted remodeling with semi-rigid stiffener and flexible segments that adapt to the nonplanar annular geometry
  - Large suture free area to avoid the conduction area
- Launched in 2010
- Developed with David Adams, MD
- Braided polyester covering and MP-35N/silicone core
  - Closed-coil spring
- 6 sizes, 26 – 32mm
- Tricuspid
Surgical Techniques for Tricuspid Valve Repair

- Recent long-term studies suggest that ring annuloplasty repairs are more durable than suture annuloplasty repairs
  

- More than 85% of patients having a ring annuloplasty will be free from moderate or severe tricuspid regurgitation 10 years after the surgery
  
Echocardiographic Follow-up of Tricuspid Annuloplasty with a New Three-Dimensional Ring in Patients with Functional TR

• The TV annuloplasty with the new physiologic MC3 ring is effective for the management of TR and may be superior to conventional techniques.
• However, patients with extensive leaflet tethering (>1.0 cm) require additional maneuvers to ensure valve competence.

Tricuspid Valve Repair With Various Annuloplasty Rings

Department of Cardiac Surgery, The Leviev Heart Center, Sheba Medical Center, ISRAEL

Dan Spiegelstein, Prabal Ghosh, Leonid Sternik, Rafael Koperstein, Micha S. Feinberg, Ehud Raanani

We compared clinical outcomes for different tricuspid valve (TV) annuloplasty ring types, in patients requiring surgical intervention for TV disease with or without concomitant disease of the mitral valve.

<table>
<thead>
<tr>
<th>Early Results</th>
<th>Flexible n=134</th>
<th>Classic n=46</th>
<th>3rd n=104</th>
<th>p value</th>
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<tr>
<td>Mortality</td>
<td>7(5%)</td>
<td>4(9%)</td>
<td>6(5%)</td>
<td>0.61</td>
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<tr>
<td>CVA</td>
<td>2(2%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0.32</td>
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<td>TIA</td>
<td>3(2%)</td>
<td>1(2%)</td>
<td>3(3%)</td>
<td>0.94</td>
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<td>Low C.O.</td>
<td>2(2%)</td>
<td>8(17%)</td>
<td>6(6%)</td>
<td>&lt;0.01</td>
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<td>ARF/Dias</td>
<td>12(9%)</td>
<td>7(15%)</td>
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<td>New Dialysis</td>
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<td>3(7%)</td>
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<td>Pacemaker</td>
<td>7(5%)</td>
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<td>Length of stay</td>
<td>10±2.8</td>
<td>10±8</td>
<td>11±7</td>
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<table>
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<td>Mean TR</td>
<td>1.6±0.7</td>
<td>1.9±0.7</td>
<td>1.7±0.6</td>
<td>0.05</td>
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<tr>
<td>TR None/Trival</td>
<td>60(53%)</td>
<td>10(26%)</td>
<td>30(33%)</td>
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<tr>
<td>TR Mild</td>
<td>44(39%)</td>
<td>24(63%)</td>
<td>63(69%)</td>
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<td>6(8%)</td>
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<tr>
<td>TR Severe</td>
<td>4(4%)</td>
<td>1(3%)</td>
<td>0(0%)</td>
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</tr>
<tr>
<td>Freedom from Mild TR</td>
<td>60(53%)</td>
<td>10(26%)</td>
<td>30(33%)</td>
<td>0.002</td>
</tr>
<tr>
<td>Freedom from Moderate+ TR</td>
<td>104(92%)</td>
<td>34(89%)</td>
<td>83(92%)</td>
<td>0.86</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Late Results</th>
<th>Flexible n=127</th>
<th>Classic n=42</th>
<th>3rd n=99</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Follow up (month)</td>
<td>23±19</td>
<td>34±22</td>
<td>9±8</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Late Death</td>
<td>9(7%)</td>
<td>8(19%)</td>
<td>2(2%)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Re-operation on TV</td>
<td>3(2.4%)</td>
<td>0(0%)</td>
<td>0(0%)</td>
<td>0.18</td>
</tr>
<tr>
<td>Mean NYHA FC</td>
<td>1.6±0.8</td>
<td>1.8±0.9</td>
<td>1.7±0.8</td>
<td>0.50</td>
</tr>
<tr>
<td>NYHA I</td>
<td>54(59%)</td>
<td>15(52%)</td>
<td>41(51%)</td>
<td>0.49</td>
</tr>
<tr>
<td>NYHA II-IV</td>
<td>37(40%)</td>
<td>14(48%)</td>
<td>40(49%)</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Summary and Conclusions

Early results are similar between rigid and flexible rings. Flexible ring may have less rate of recurrent TR. TV intervention should be more liberal and early. Selection of the “suitable” ring is still unknown.
Our strategy

The **systematic and consistent** performing TV Annuloplasty for all patients undergoing any open heart surgery and having TV dilatation (> 38 mm) or moderate to severe TR!

Consistency

Sheba Medical Center
Tel Hashomer
Advanced thinking
Patients with moderate degrees of tricuspid regurgitation require careful consideration, because of the possibility that the severity may have been underestimated. (vasodilators, diuretics, inotropes, fasting, and general anesthesia may result in downgrading of severe tricuspid regurgitation)

Any patient who has any prior documentation of severe regurgitation should undergo tricuspid valve repair, as severe regurgitation at any point infers an abnormally functioning valve.

Coexisting pulmonary hypertension is an indication for tricuspid valve repair, and if present in the setting of moderate regurgitation, it should alert the clinician to the possibility that regurgitation severity is being underestimated.
Moderate tricuspid regurgitation
Rationale for Surgical Correction

- Because of the secondary tricuspid regurgitation’s dynamic nature, patients with mild or moderate degrees of tricuspid regurgitation may still have severe valvular dysfunction.

- Regardless of severity, any degree of tricuspid regurgitation other than trivial is undesirable.


- Evidence from surgical series suggests that the severity of mild to moderate tricuspid regurgitation occurring after mitral valve surgery increases over time and is associated with poorer long-term survival and higher reoperation rates.
Tricuspid Annular Dilatation
Assessment

- Measurement of the annular diameter should be part of pre-/intraoperative transesophageal echocardiographic assessment.

- An abnormal intercommissural annular diameter recorded on any view of more than 35 mm likely represents a dilated annulus.

- Currently in Mount Sinai Hospital, 70% of mitral valve repair patients receive concurrent tricuspid valve repair for annular dilatation or valve regurgitation.

In the present era, the risk of tricuspid valve repair at the time of mitral valve surgery is probably negligible, as patients usually do not have associated end-organ dysfunction, which increases perioperative risk as was historically seen in patients having tricuspid valve surgery.

Two groups who liberally applied tricuspid valve repair for annular dilatation at the time of mitral valve repair reported an operative mortality of 0.7% and 2%.


Secondary Tricuspid Regurgitation

Tricuspid Annuloplasty

Let’s do this!

It is fast, simple, effective and beneficial
Secondary Tricuspid Regurgitation

Conclusions

Secondary tricuspid regurgitation commonly occurs in combination with left-sided valvular heart disease and will often not improve despite correction of the left-sided valve dysfunction.

Because tricuspid regurgitation occurring after prior mitral surgery carries a poor prognosis, surgical repair of the tricuspid valve at the time of mitral valve surgery is recommended for treating and preventing secondary tricuspid regurgitation.

Assessing the tricuspid valve annular dimensions must be a part of all mitral valve operations, and annuloplasty strongly considered in patients with tricuspid annular dilatation or moderate to severe tricuspid regurgitation.

Future randomized trials will determine whether there is a role for prophylactic tricuspid valve repair in all patients undergoing mitral valve surgery.
Our message is:

To be liberal in the indications for Tricuspid Annuloplasty
TV Replacement

- Although repair is preferred, valve replacement is necessary when the valve leaflets themselves are diseased, abnormal, or destroyed. Thrombosis with mechanical tricuspid valves is rare (1% per year).
- Overall survival has been shown to be equivalent between bioprosthetic and mechanical valves in a recent large metaanalysis.

TV Replacement

- TV repair appears to result in improved mid-term survival (up to 10 years after surgery, primarily as a result of higher perioperative mortality with replacement) as compared with tricuspid valve replacement.
- Higher perioperative mortality with replacement may have been due to a rigid object (tricuspid valve), that leads to loss of tricuspid annular contraction which finally impedes right ventricular function.
- **TV supra-annular implantation** avoids this phenomenon.
Collaboration - Heart Team

If you want to go fast, go alone; If you want to go far, go together

old African proverb
Secondary Tricuspid Regurgitation

Thank You
SURGEON’S VIEW

Secondary TR

Patients

We operate on Everybody!
Secondary TR
Different Mechanisms

- Pulmonary arterial hypertension, resulting in pressure overload on the right ventricle and can directly result in tricuspid regurgitation.

- Left ventricular septal dysfunction also causes dysfunction of the right septal wall, the area of origin of the papillary muscles (chords) to the septal leaflet of the tricuspid valve.

- Geometric change of the RV, characterized or by homogenous, or by heterogenous dilatation in the septal-lateral direction, has much effect on coaptation of the TV leaflets as a result of displacement of the papillary muscles.

- A stretched RV wall and subsequent loss of RV contraction surrounding the TV annulus (dilated, flattened, and circular annulus).

- Combination of mechanisms
רפואת – זה אומנות
לעבוד על ה télécharg בדמנ קطحن עשה את שלה
TV Percutaneous
To date, there have been few reports describing percutaneous approaches to tricuspid valve disease.

In 2005, Boudjemline et al. described a novel percutaneous tricuspid valve consisting of a bovine jugular venous valve mounted to a self-expanding nitinol frame consisting of 2 disks.

The device was implanted in seven normal sheep, but no further work has been done with this device.
Nitinol stent with a self-expandable super-absorbent polymer (SAP), composed of right atrial anchoring elements, a right ventricular tubular stent, and a trileaflet bovine pericardial valve. The stent is coated with a waterproof material, and a pouch containing SAP for minimizing paravalvular leakage.

Twin valve caval stent for functional replacement.
Unanswered Questions
Is Functional MR/TR just a marker of poor LV/RV function or this is a major contributor to decreased survival rates?
Restrictive Ring Annuloplasty

- Addresses only the annular end & does not addresses tethering
- Exacerbates papillary muscle displacement by increasing distance from the papillary muscle to the mitral annulus
- Converts the valve into unicuspid valve with rigid posterior and restricted anterior leaflet
Restrictive Ring Annuloplasty
Extremely poor candidates

Posterior leaflet angle $\geq 45^\circ$
Tenting area $\geq 2.5$ cm$^2$
Coaptation distance $\geq 1$ cm

Those are patients with advanced Ischemic MR
required an advanced MV Repair

Magne J. at all.: Circulation 2007, 115: 782-791
Advanced surgical approaches for Advance Ischemic MR patients

- Mitral valve leaflets augmentation

- Mitral valve leaflets relocation
Indications for TV Surgery

- TR does not simply “go away” after mitral valve surgery
- Tricuspid valve repair currently appears underutilized
Indications for TV Surgery

- Given the adverse consequences of allowing TR to progress to severe (such as worsening symptoms of right heart failure), it would seem logical that earlier intervention for TR, especially in the presence of ongoing right atrial and right ventricular enlargement, would be beneficial.
Postulates

- Reduction in degree of pulmonary hypertension (by mitral valve repair) could result in less tricuspid regurgitation, but **this would first require reverse remodeling of the previously dilated right ventricle**, which may not be instantaneous.

- **Two ventricles are interdependent** at the septum, left ventricular septal dysfunction also causes dysfunction of the right septal wall, the area of origin of the papillary muscles to the septal leaflet of the tricuspid valve.

- Patients having tricuspid valve repair at the time of mitral valve surgery did better in the long term compared with patients who did not.

- Although in some patients, significant tricuspid regurgitation will resolve with correction of the left-sided lesion, there is no means of accurately predicting this at the time of mitral surgery.

- For survivors of reoperative surgery because of a high rate of persistent or recurrent heart failure and continued elevated risk of death despite resolution of tricuspid regurgitation.

- The poor prognosis for tricuspid regurgitation occurring after mitral valve surgery.

- Limited effectiveness of surgical therapy at this late stage.

- Annular dilatation represents the early stages of secondary tricuspid regurgitation.
CUT BY ME 27.10.11
I met two problems:

- "Don't tell fish stories where the people know you; but particularly, don't tell them where they know the fish."

- "Not that the story need be long, but it will take a long while to make it short."
Ventricular Interdependence
Secondary Tricuspid Regurgitation

Pathophysiology

- The mechanism of this regurgitation is complex, and it is unlikely the valve is truly “normal”

- Recent echocardiographic studies have demonstrated abnormal geometry and function of the tricuspid valve in patients with functional regurgitation


Functional TV incompetence
“A normal valve with dilated annulus”
Secondary Tricuspid Regurgitation

Geometrical alteration

Geometrical alteration of the tricuspid apparatus are caused by interaction between:

- altered tricuspid annulus size and shape,
- right ventricular remodeling, and
- displacement of papillary muscles,

which lead to leaflet tethering
Secondary Tricuspid Regurgitation
Tricuspid Annular Dysfunction

Kim et al. support this theory in an echocardiographic study of 75 patients with right ventricular dilatation.

Predictive of the severity of secondary tricuspid regurgitation were:
- eccentricity of the right ventricle
- tricuspid valve tethering (tenting) area
- end-diastolic tricuspid annular diameter

Non significant predictive factors of the severity of secondary tricuspid regurgitation were:
- the right ventricular dimensions
- right ventricular function
- pulmonary artery pressures

All these suggesting that change in geometry of the right ventricle and the consequent papillary muscle displacement, is the critical factor in the pathophysiology of tricuspid regurgitation.

Whereas such eccentric displacement of the ventricle is more likely to occur in the globally dilated ventricle, it can also occur in normal-sized ventricles.

Systematic Tricuspid Valve Repair Consistency
Heart Team
Severe tricuspid regurgitation

The American College of Cardiology and American Heart Association guidelines recommend repair of all valves with severe tricuspid regurgitation in patients undergoing mitral valve surgery.


Despite this

Most authorities would now recommend repairing the tricuspid valve in any patient with a less than severe tricuspid regurgitation undergoing any heart operation.

But this postulate is not completely correct too. Why?
The tricuspid annulus has a complex 3-dimensional structure, which differs from the more symmetric “saddle-shaped” mitral annulus.

This distinct shape has implications for the design and application of currently available annuloplasty rings in the tricuspid position (most currently available rings are essentially planar). The novel approaches or rings tailored to the unique tricuspid annular shape might improve ventricular function and reduce leaflet stress.

Pathophysiology of Ischemic MR

3-D Shape

MV

TV
Secondary Tricuspid Regurgitation

Figure 2: Event-Free Survival After Balloon Mitral Valvotomy by TR Severity

Events were defined as death, New York Heart Association functional class III or IV, MV surgery, or repeat mitral valve balloon valvotomy (n = 318). Patients with severe tricuspid regurgitation (TR) had significantly worse event-free survival compared with patients with mild TR.

• (A) Dilated tricuspid annulus with abnormal circular shape, failure of leaflet coaptation, and resultant TR. Dilation occurs primarily along the mural portion of the tricuspid annulus, above the right ventricular free wall
• (B) Rigid or flexible annular bands are used to restore a more normal annular size and shape (ovoid), thereby reducing or eliminating TR
• (C) DeVega–style suture annuloplasty in which a purse-string suture technique is used to partially plicate the annulus and reduce annular circumference and diameter
• (D) Suture bicuspidalization is performed by placement of a mattress suture from the anteroposterior to the posteroseptal commissures along the posterior annulus
Surgical Techniques for Tricuspid Valve Repair

Edwards MC3 annuloplasty system

Intraoperative and two-chamber TEE views of the Edwards MC3 annuloplasty system (Edwards LifeSciences, Irvine, CA).
Systematic Tricuspid Valve Repair
Rationale for Surgical Correction

Lower long-term incidence of significant tricuspid regurgitation and better symptom status in patients having concomitant tricuspid valve repair at the time of mitral valve repair, and also the late occurrence of significant regurgitation in some patients who had a nondilated annulus at initial surgery, raises the question as to whether all patients should have a tricuspid repair at the time of mitral surgery.

Systematic Tricuspid Valve Repair
Rationale for Surgical Correction

The low risk of tricuspid repair, high prevalence of late secondary tricuspid regurgitation, the inability to reliably predict which patients will develop secondary regurgitation, and the high mortality and morbidity associated with severe tricuspid regurgitation, it may ultimately prove beneficial to perform prophylactic tricuspid repair in most patients having mitral valve surgery regardless of the presence of annular dilatation or regurgitation.