Conflict of Interests

- Echo-Insight
  - Research Grants
- Tomtec
  - Research Grants
- Philips Medical Imaging
  - Research Grants
  - Speakers bureau
  - Advisory bureau
The Tricuspid Valve on M-mode

The Tricuspid Valve on 2D TTE
The Tricuspid Valve on 3D TTE

How many leaflets does the TV have?
THE TRICUSPID VALVE…now

Did anyone say TRICUSPID valve?

TV in Pulmonary Hypertension
Tricuspid valve complex

- 3 leaflets:
  - Anterior
  - Posterior
  - Septal
- Chordae tendinae
- 2/3 papillary mus
- Fibrous tricuspid annulus
- RA myocardium
- RV myocardium

TRICUSPID VALVE

Three leaflets
1. Anterior
   - From the annulus along RV free wall
2. Posterior
   - From the annulus along RV free wall
3. Septal
   - From the tricuspid annulus above the membranous septum

The anterior leaflet is the largest.
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.
In comparison with MV, PMs are smaller, widely separated and carrying chordae to a single leaflet, allowing a greater leaflet separation if annulus and RV cavity dilate.

TRICUSPID VALVE

RV vs. LV pap muscles:
- Smaller
- More widely separated
- Carry chordae to a single leaflet
  - Allowing greater leaflet separation
  - Tricuspid valve malcoaptation

In the setting of TA and RV cavity dilatation.
Comprehensive Two-Dimensional Interrogation of the Tricuspid Valve Using Knowledge Derived from Three-Dimensional Echocardiography

Karina Addetia, MD, Megan Yamat, RDCLS, Amuj Mediratta, MD, Diego Medvedofsky, MD, Mira Patel, MD, Preston Ferrara, RDCLS, Victor Mor-Avi, PhD, and Roberto M. Lang, MD, Chicago, Illinois

RVIF + septum  |  SAX + 1 leaflet  |  SAX + 2 leaflets
---|---|---
(1) S | (2) A | (3) A
Aorta  |  Aorta

RVF  |  A4C + LVOT  |  A4C + CS
(4) P | (5) S | (6) CS
Aorta | LVOT


3D for TV Anatomy

Courtesy of Stankovic I, EuroEcho abstract 2012
Which leaflet are we seeing in each view?

A4C

<table>
<thead>
<tr>
<th></th>
<th>AL 81%</th>
<th>SL 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL 9%</td>
<td>PL 19%</td>
<td>SL 100%</td>
</tr>
<tr>
<td>PL 91%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PSAX

<table>
<thead>
<tr>
<th></th>
<th>AL 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL 62%</td>
<td>SL 38%</td>
</tr>
<tr>
<td>AL 4%</td>
<td>AL 21%</td>
</tr>
<tr>
<td>PL 66%</td>
<td>SL 19%</td>
</tr>
<tr>
<td>ANT 13%</td>
<td></td>
</tr>
<tr>
<td>P-A-S 12%</td>
<td></td>
</tr>
</tbody>
</table>

RVIF + Sept

<table>
<thead>
<tr>
<th></th>
<th>SL 100%</th>
<th>AL 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL 100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AL 100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RVIF - Sept

<table>
<thead>
<tr>
<th></th>
<th>PL 77%</th>
<th>AL 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL 23%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PL 25%</td>
<td>AL 100%</td>
<td></td>
</tr>
<tr>
<td>SL 75%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stankovic J Am Soc Echocardiogr 2014
Addetia K J Am Soc Echocardiogr 2015
Impact of TR

- KM survival curves for patients with TR
- Survival worse in moderate and severe TR

Patients with TR and LVEF <50%

Patients with TR and LVEF ≥50%

NOW

Increasing size of tricuspid valve malcoaptation

Why do we need to know more about the tricuspid valve?

TV Malcoaptation

All 3 leaflets: Anterior, posterior and septal

Two leaflets: Anterior and posterior

RA perspective
Basal SAX view

Aorta and single leaflet

Aorta and two leaflets

LVOT/septum and two leaflets

Comprehensive Two-Dimensional Interrogation of the Tricuspid Valve Using Knowledge Derived from Three-Dimensional Echocardiography


RVIF view

2D view with septum

2D view without septum
Tricuspid valve disorders

Tricuspid Stenosis

1. Rheumatic #1
2. Tricuspid atresia
3. RA tumors
4. Carcinoid
5. RV inflow obstruction
6. Endomyocardial fibrosis
7. TV vegetations
8. Pacemaker
9. Extracardiac tumors

Tricuspid Regurgitation

Primary (or “Organic”) TR

- Intrinsic abnormality of the valve apparatus
- 15-30%* of TR

Secondary (or “Functional”) TR

- TR due to RV and/or TV annular dilation
- 70-85%* of TR

Antunes MJ, Barlow JB, Heart 2007

Primary (Organic) TR – Abnormal Tricuspid valve

Carcinoid disease

Rheumatic

Ebstein

Prolapse

Endocarditis
Primary (Organic) TR – Pacemaker/ICD

- Challenging diagnosis
- Course of pacemaker wire can only be seen in 15% of cases on 2D echocardiography
- Lin et al. (JACC 2005) reported that the tricuspid regurgitation induced by device leads was diagnosed using 2D echocardiography in only five of 41 patients (12%) who underwent surgery for pacemaker-related tricuspid regurgitation

P-S Commissure: Correct Position

A:
Pacemaker Lead Impingement

Pacemaker Adherence
• Primary (Organic) TR – Pacemaker/ICD

89 year-old man with right heart failure
Past medical history: CAD, MV repair, TAVI in 2009
• Permanent pacemaker implantation post TAVI for bradycardia
Primary/Organic TR – PPM/ICD Device Location

26 year-old with dilated cardiomyopathy on the transplant list

ICD inserted and echo performed 8 days later
Primary/Organic TR – PPM/ICD Device Location


Impact of Implantable Transvenous Device Lead Location on Severity of Tricuspid Regurgitation

- Karima Addetia, MD, Francesco Maffessanti, PhD, Anuj Mediratta, MD, Megan Yamat, RDCS, Lynn Weinert, BS, Joshua D. Moss, MD, Hemal M. Nayak, MD, Martin C. Burke, MD, Amit R. Patel, MD, Eric Kruse, RDCS, Valluvan Jeevanandam, MD, Victor Mor-Avi, PhD, and Roberto M. Lang, MD, FASE, Chicago, Illinois

- J Am Soc Echocardiogr 2014;27:1164-75

- 45/100 had TV leaflet interference
- Septal Leaflet (23)
- Bivariate analysis: pre-implantation VC, RA size, TAD, and lead-leaflet interference were associated with post-device TR
- Multivariate analysis: pre-implantation VC width and interfering leads were independently associated with post-device TR
TRICUSPID ANNULUS

- Saddle-shaped
  - High points antero-posterior
  - Low points medial-lateral
- Ellipsoid shape

THE ACC/AHA 2014 GUIDELINES

ESC/EACTS Guidelines for management of VHD EHJ 2012
ACC/AHA Guidelines for management of VHD JACC 2014
Tricuspid valve disorders

Tricuspid Stenosis
1. Rheumatic #1
2. Tricuspid atresia
3. RA tumors
4. Carcinoid
5. RV inflow obstruction
6. Endomyocardial fibrosis
7. TV vegetations
8. Pacemaker
9. Extracardiac tumors

Tricuspid Regurgitation

Primary (or “Organic”)
Intrinsic abnormality of the valve apparatus
15-30%* of TR

Secondary (or “Functional”)
TR due to RV and/or TV annular dilation
70-85%* of TR

Antunes MJ, Barlow JB, Heart 2007

Presentation Title Here | 41

Tricuspid valve disorders

Tricuspid Stenosis
1. Rheumatic #1
2. Tricuspid atresia
3. RA tumors
4. Carcinoid
5. RV inflow obstruction
6. Endomyocardial fibrosis
7. TV vegetations
8. Pacemaker
9. Extracardiac tumors

Tricuspid Regurgitation

Primary (or “Organic”)
Intrinsic abnormality of the valve apparatus
15-30%* of TR

Secondary (or “Functional”)
TR due to RV and/or TV annular dilation
70-85%* of TR

Antunes MJ, Barlow JB, Heart 2007

Presentation Title Here | 42
Functional Tricuspid Regurgitation

70-85% of TR

RV and/or TV annular dilatation, leaflet tethering with RV remodeling due to pressure/volume overload

- Left heart disease (↓LV function, valve disease) + PH
- Any cause of PH
- RV dysfunction

FACTORS ASSOCIATED WITH TRICUSPID ANNULAR ENLARGEMENT

AFib

RA↑

PH

RV↑

Tricuspid annular dilatation ↓fractional shortening

Left-sided heart disease or other isolated RV disease
Functional TR

- Tricuspid annulus dilatation may be a more reliable indicator of TV pathology than degree of regurgitation
- Good correlation between TA diameter and TR regurgitant volume

TR varies depending on preload, afterload, RV function

Currently Available Quantitative Techniques for TR Assessment are not good enough

TR is load dependent

LVEF – 20%

64 year-old man with a NICM

9 months ago - CHF

Now - No CHF
TR is load dependent

TA dimension = 52 mm
 TA dimension = 46 mm

CHF
Now - No CHF

TR is load dependent

Inspiration
Expiration

2D Apical-4 CH2D RV Inflow3D VC Area
Tricuspid valve dilatation

- TA dilatation occurs mostly along the RV Free Wall
- Septal portion of the tricuspid annulus relatively fixed

TRICUSPID ANNULUS ENLARGEMENT

Normal  
Non-planarity angle = 158°

Functional TR  
Non-planarity angle = 173°

Annulus becomes larger, rounder and flatter with worsening TR

Taramasso M et al. J Am Coll Cardiol 2012
RV free-wall dilatation and TV morphology

Importance of the TA

2002: 80 had MV repair

13 TAP with ≥3+TR

21 TAP with ≥3+TR

43 TAP with TA ≥40mm on TTE

2004: 102 MV repair

Worsened RV parameters in those with dilated TA who did not have annuloplasty

RV reverse remodeling

Van de Veire et al. JTCS 2011

2y FU

RV short-axis
Importance of the TA

- Performing tricuspid annuloplasty based on TA dilatation rather than TR degree results in improved surgical outcome

<table>
<thead>
<tr>
<th></th>
<th>MV + TV repair</th>
<th>MV repair only</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival @ 10 years</td>
<td>90.3%</td>
<td>85.5%</td>
<td>p=NS</td>
</tr>
<tr>
<td>Grade III-IV TR</td>
<td>1%</td>
<td>34%</td>
<td>p&lt;0.001</td>
</tr>
<tr>
<td>Class III-IV CHF</td>
<td>0%</td>
<td>14%</td>
<td>P &lt; 0.01</td>
</tr>
</tbody>
</table>


TRICUSPID VALVE TENTING

- TV tenting volume by 3DE (accounting for both enlarged annulus area and leaflet tenting) is the major determinant of residual functional TR after annuloplasty

The major goal of TV repair is an reduction of TV tenting volume; however, current annuloplasty techniques worsen leaflet tethering and actually increase TV tenting volume

Min SY et al. Eur Heart J 2010
Functional TR and annular dilatation

The annulus is dilated if it measures

1. **> 40 mm** or **> 21 mm/m^2** on 2D transthoracic echocardiography
   - Apical 4-chamber view
   - In diastole
2. **> 70 mm** on direct intraoperative measurement
MEASURING THE TRICUSPID ANNULUS – THE ‘BEST’ 2D ECHOCARDIOGRAPHIC VIEW

Miglioranza JASE 2014

Feasibility of the measurement

THE DYNAMIC ANNULUS

Multiple 2D planes from RV inflow view were used to reconstruct area of tricuspid annulus

Tei et al. Circulation 1982
Role for 3D echocardiography

• Better approximation of septal-lateral dimension
• Also allows measurement of antero-posterior dimension

Addetia K, Muraru D, Veronisi F, Badano LP, Lang RM et al. work in progress
On the horizon…

Muraru D...Addetia K...Lang RM, Badano LP et. al.

Thank you
Questions?