Tricuspid and Pulmonary Valve Disease

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Tricuspid Regurgitation
So What?

• Right Sided Failure
  – Edema
  – Gut congestion
  – Atrial fibrillation
  – DEATH – associated with increased risk of death

Dyspnea!!!

Little TR – OK (useful for us, in fact)
Lots of TR - BAD
TR predicts survival (n=5,223)

Nath et al (VA, Palo Alto), JACC 2004
“Complex” Anatomy (literally)

- Leaflet(s) – One continuous leaflet with indentations into Anterior, Septal, Posterior
- Annulus – D-shaped, with flatter portion along the central fibrous body - contractile
- Chordae
- Papillary muscles – usually 3
- Underlying Right Ventricular Myocardium
Echocardiographic Assessment of Tricuspid Valve

- Is the TR Physiological or Pathologic
- Is the Morphology of TV Leaflets Normal
  \[ \text{VERSUS} \]
- Is the TR functional?
  - Annulus dilatation, leaflet tethering, sPAP
- Is there a hemodynamically significant consequence from the TR

### Tricuspid Valve Anatomy - TTE
Incremental Value of the En Face View of the Tricuspid Valve by Two-Dimensional and Three-Dimensional Echocardiography for Accurate Identification of Tricuspid Valve Leaflets

Ivan Stankovic, MD, Ana Maria Darzba, MD, Ruta Jasienyte, MD, Aleksandar N. Neskov, MD, PhD, Petar Claus, PhD, and Jens-Uwe Vogt, MD, PhD, Zecevo, Belgrade, Serbia

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

Karima Addetta, MD, Megan Yamat, RDMS, Anuj Mediratta, MD, Diego Medvedofsky, MD, Mita Patel, MD, Preston Ferrara, RDMS, Victor Mor-Avi, PhD, and Roberto M. Lang, MD, Chicago, Illinois

JASE 2015
Proposed views of the TV targeted to interrogate specific leaflets

Why is this important?
What Can Go Wrong?

• Leaky
  – Stretched
  – Infected, with long-term sequelae
  – Perforated
  – Skewered
  – Ripped

• Narrowed
  – Rheumatic
  – Evil Humors

Carpentier I - Normal Leaflet
Mobility/Annular Dilatation
Carpentier II- Excessive leaflet mobility

- Billowing leaflets or valve prolapse
- Chordal rupture
- Chordal or papillary muscle elongation

Carpentier III – Restricted Leaflet Mobility
Etiologies of TR

- **Functional TR**
  - PAH
  - Vol. Overload e.g. ASD
  - Cor Pulmonale
  - Left heart Disease
  - RV myocardial Disease
    - RV dysplasia
    - RV ischemia
    - Post-transplant

- **Primary TR**
  - Rheumatic
  - Myxomatous
  - Ebstein’s Anomaly
  - Endocarditis
  - Carcinoid/Infiltrative
  - Traumatic – anterior structure-MVA
  - Iatrogenic
    - Pacer/ICD wires
    - RV biopsy

No reason why Carpentier’s Classification can’t apply

**Functional TR**

**RV Remodeling**
- RV dysfunction and dilatation
- Papilary Muscle Displacement
- Leaflet tethering and resultant tenting
- Annular Dilatation

**RA Remodeling**
- Atrial Fibrillation
- LA-RA enlargement
- Annular and Ventricular Base Dilatation

*Surkova et al – Abstract EACVI 2016*
Primary TR

- Tricuspid Valve Prolapse
- Associated with MVP, Diseases of Aorta and aortic valve
- Septal leaflet 93%
- Anterior 86%
- Posterior 43%

Leaflets
Pacemaker Lead Impingement

- (a) Valve obstruction caused by lead placed in between leaflets.
- (b) Lead adherence due to fibrosis and scar formation to valve causing incomplete closure.
- (c) Lead entrapment in the tricuspid valve apparatus
- (d) Valve perforation or laceration.
- (e) Annular dilatation.

R. Al-Bawardy et al: TR in patients with pacemakers and ICDs
Secondary TR

- Functional Lesion of the Tricuspid Apparatus
- Primary Alteration of the Right Heart

- Etiologies
  - Left-sided valve disease or LV disease
  - Chronic Atrial Fibrillation
  - Shunt – ASD
  - PH/PAH (> 50-55 mmHg)
  - RV infarction

\[\text{FTR} \neq \text{FTR}\]

Clinical Context and Mechanism of Functional Tricuspid Regurgitation in Patients With and Without Pulmonary Hypertension

Yan Topilsky, MD; Amber Khanna, MD; Thierry Le Toureaur, MD; Soon Park, MD; Hector Micheletta, MD; Rakesh Suri, MD, DPhil; Douglas W. Mahoney, MS; Maurice Enriquez-Sarano, MD

(Circ Cardiovasc Imaging, 2012;5:314-323.)
Annular Dimension


Annulus Diameter

40 mm or 21 mm/m²
Factors Predicting Persistent TR

- Tenting Area and Height: > 1.6 cm² or 8 mm predicts residual TR after surgery
- Clinical Parameters: Age, Female Atrial Fibrillation, Delay from Dx to Sx, Rheumatic, RTx, Redo-mitral valve surgery, MV replacement, ischemic MR
- RV enlargement and Dysfunction
- LVEF
- PH

Matsuyama K, ATS 2003:75:1826-8
Benedetto U, JTCVS 2012:143:632-8

Tricuspid Valve Assessment

- Leaflets
  - Thickening, doming, restriction
  - Coaptation
  - Flail
- Annulus diameter
- Mean gradient
- TR severity
- RA + RV dilatation, septal flattening
- RV systolic function
- PA pressure
Quantitation?

Quantification of TR by Color Doppler

- Simplest and quickest way to evaluate TR severity but limitations and uncertainties

**Analogous to MR Assessment by color Doppler**

- A large color jet represents more significant tricuspid regurgitation than a small jet
- Visualisation of the color jet depends on:
  - Hemodynamic/Loading Conditions
    - Hyper/Hypotension
    - RA Pressure and pressure gradient between RV-RA
    - RA size and capacitance
    - **Phase of respiration**
  - Cause of regurgitation
    - Excentric Jet (Coanda effect)-use multiple views
    - Vs. Central Jet
  - Technical Limitations
    - Sub-optimal views
    - Gain settings
Quantitation – Vena Contracta

Severe: VC > 0.7 cm
Nyquist 50-60 cm/s
EOA = 2\pi R^2 \times \frac{V_{\text{alias}}}{V_{\text{max}}}

- Set Nyquist Limit to aliasing velocity of 28 cm/s
- A Radius of > 9mm correlates with severe TR
- 6-9mm moderate TR
- < 5mm, usually with mild TR

<table>
<thead>
<tr>
<th>Nyquist – Radius</th>
<th>cm/sec</th>
<th>cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 – 0.9cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 – 1.0cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31 – 0.8cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37 – 0.68cm</td>
<td></td>
<td></td>
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<tr>
<td>43 – 0.59cm</td>
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Hepatic Vein Reversal
TR signal – density and shape

Paradoxical Septum – D-Diastole
### RA Size

![Echocardiogram Images]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tricuspid valve</td>
<td>Usually normal</td>
<td>Normal or abnormal</td>
<td>Abnormal/ flail leaflet/ poor coaptation</td>
</tr>
<tr>
<td>RV/RA/IVC size</td>
<td>Normal</td>
<td>Normal or dilated</td>
<td>Usually dilated</td>
</tr>
<tr>
<td>Jet area-central jets (cm²)*</td>
<td>&lt;5</td>
<td>5-10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>VC width (cm)*</td>
<td>Not defined</td>
<td>&lt; 0.7</td>
<td>&gt; 0.7</td>
</tr>
<tr>
<td>PISA radius (cm)**</td>
<td>&lt;0.5</td>
<td>0.6-0.9</td>
<td>&gt;0.9 *</td>
</tr>
<tr>
<td>Jet density and contour-CW</td>
<td>Soft and parabolic</td>
<td>Dense, variable and contour</td>
<td>Triangular with early peaking</td>
</tr>
<tr>
<td>Hepatic vein flow</td>
<td>Systolic dominance</td>
<td>Systolic blunting</td>
<td>Systolic reversal</td>
</tr>
</tbody>
</table>

*IVC - inferior vena cava; RA - right atrium; RV - right ventricle; VC - vena contracta width; PISA - Proximal isovelocity surface area.
Tricuspid Stenosis

Rheumatic
Infiltration – Carcinoid
Compression – Rare – external (clot/tumor)/aorta

VTI 63-74 cm

\[ A_2 = \frac{A_1 \cdot v_1}{v_2} \]

- TVA cm$^2$ = 190/PHT
- \( A_1 = \text{LVOT CSA or RVOT CSA} \)
- \( V_1 = \text{LVOT V1 or RVOT V1 (PW)} \)
- \( V_2 = \text{Vmax of Tricuspid Inflow by CW Doppler} \)

Lesser Degree: TR>TS
Pulmonic Valve << Tricuspid Valve

- Stenosis – Valvar, Sub-, Supra
  - Congenital
  - Infiltrative
  - Iatrogenic – post Ross e.g.

- Regurgitation
  - PH
  - Congenital Surgery – Repaired Tetralogy
  - Endocarditis
  - Infiltrative
Normal PV

PS
Pulmonic Valve Disease-Carcinoid

Table 11 Grading of pulmonary stenosis

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak velocity (m/s)</td>
<td>&lt; 3</td>
<td>3–4</td>
<td>&gt; 4</td>
</tr>
<tr>
<td>Peak gradient (mmHg)</td>
<td>&lt; 36</td>
<td>36–64</td>
<td>&gt; 64</td>
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PR Severity

Table 9 Echocardiographic and Doppler parameters used in the evaluation of pulmonary regurgitation severity: Utility, advantages, and limitations

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Utility/Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV size</td>
<td>RV enlargement sensitive for chronic significant PR. Normal size virtually excludes significant PR. Simple signs of severe PR.</td>
<td>Enlargement seen in other conditions. Not specific for PR.</td>
</tr>
<tr>
<td>Paradoxical septal motion (volume overload pattern)</td>
<td>Jet length - Color flow Vena contracta width</td>
<td>Simple quantitative method that works well for other valves Poor correlation with severity of PR. More difficult to perform, requires good images of pulmonary valve; lacks published validation.</td>
</tr>
<tr>
<td>Jet deceleration rate - CW</td>
<td>Simple</td>
<td>Quantitative regurgitant flow and fraction Steep deceleration not specific for severe PR. Subject to significant errors due to difficulties of measurement of pulmonary annulus and a dynamic RVOJ; not well validated.</td>
</tr>
<tr>
<td>Flow quantitation - PW</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Impact

• Same as for TR
  – Assess RV size, RA size, RV function
  – PAP Calculation Caveat – Subtract the PS Gradient**
  – SPAP = (TR gradient + RAP) – PV PG
    = (43 + 15) – 32 = 26 mmHg

Take Home Messages TR

• Look at the patient – R = L
• Remember- it’s not jus the valve
  – RV, RA, IVC
• The World is 3D – 2D has limitations – awareness of these can allow us to overcome them
• Functional vs Tricuspid will guide therapy - and TA size matters
Summary

More than eyeball of color jet

• Tricuspid
  – Morphology, Degree of dysfunction, Impact on cardiac size and function

• Pulmonic
  – Same as above

• Implications for Clinical therapy
  – When to intervene in primary and secondary TR, PR
  – When to intervene for TS and PS

CMR – So 1990’s

Watch RAP!

Echo, echocardiography; RAP, right atrial pressure; TR, tricuspid regurgitation.