Tricuspid and Pulmonary Valve Disease

Lawrence Rudski MD FRCP C FACC FASE
Professor of Medicine
Director, Division of Cardiology
Jewish General Hospital
McGill University
Question 1

• All of the following are compatible with severe Tricuspid Regurgitation except:
  • A  RV basal dimension measuring 50mm
  • B  Flow reversal in the hepatic veins after the P wave
  • C  PISA radius of 10 mm at an aliasing velocity of 30 cm/s
  • D  Non-parabolic TR CW Doppler signal with an early peak
All of the following are true except:

A) The simplified Bernoulli equation is not valid
B) The septum is D-shaped in diastole
C) The PAP may be overestimated due to the presence of laminar flow
D) The RA pressure is likely > 15 mmHg
Which of the following is least likely

- A) A diastolic rumble will be heard over the apex
- B) The IVC will be markedly dilated
- C) Mitral inflow pulsed Doppler will demonstrate E:A reversal
- D) The RV systolic pressure will be significantly elevated
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
View from Above

Pulmonic valve

Aortic valve

Mitral valve

Septal

Anterior

Posterior

Tricuspid valve
Tricuspid Valve Anatomy - TTE
Tricuspid Valve Anatomy - TEE
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 Daraban, MD, Ruta Jasaityte, MD, Aleksandar N. Neskovic, MD, PhD, Piet Claus, PhD, and Jens-Uwe Voigt, MD, PhD, Leuven, Belgium; Belgrade, Serbia

Journal of the American Society of Echocardiography
Volume 27 Number 4
Why is this important?
What Can Go Wrong?

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

• Narrowed
  – Rheumatic
  – Evil Humors
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
Primary or Secondary?
PA Pressure - As a general rule...

- In setting of severe TR, PAPs > 55 mmHg is often associated with anatomically normal tricuspid valves, while PAPs < 55 mmHg usually associated with an abnormality of the tricuspid valve apparatus.
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
Leaflets
Bicuspid TV Valve

Courtesy of Dr. Roberto Lang
Pacemaker Lead Impingement

Courtesy of Dr. Roberto Lang
Not TV Dinner, but TV Kebab

- (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.

Annular Dimension

70 mm

Annulus Diameter

40 mm or 21 mm/m²
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
TR by PISA

- 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
EOA = \(2\pi R^2 \times \frac{V_{\text{alias}}}{V_{\text{max}}\}}\)}
Hepatic Vein Reversal
TR signal – density and shape
Effect on RV (and vice versa)

**Chamber Quantification**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. RV Basal (RVD1)</td>
<td>&gt; 4.2 cm</td>
</tr>
<tr>
<td>RV Mid (RVD2)</td>
<td>&gt; 3.5 cm</td>
</tr>
<tr>
<td>RV Longitudinal (RVD3)</td>
<td>&gt; 8.6 cm</td>
</tr>
<tr>
<td>B. RVOT PLAX proximal</td>
<td>&gt; 3.3 cm</td>
</tr>
<tr>
<td>C. RVOT PSAX distal</td>
<td>&gt; 2.7 cm</td>
</tr>
</tbody>
</table>
Paradoxical Septum – D-Diastole
RA Size
<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 contour</td>
<td>Dense, 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

Etiology

Rheumatic

Infiltration – Carcinoid

Compression – Rare – external (clot/tumor)/aorta
TS Gradients and TV Area

VTI 63-74 cm

• TVA cm² = 190/PHT
Calculation of TVA

- $A_1 = \text{LVOT CSA or RVOT CSA}$
- $V_1 = \text{LVOT V1 or RVOT V1 (PW)}$
- $V_2 = \text{Vmax of Tricuspid Inflow by CW Doppler}$

\[
A_2 = \frac{A_1 \cdot V_1}{V_2}
\]
CW Doppler

![Doppler Image]

TVI = 60 cm; mean grad = 9 mmHg
\[ P_{1/2} = 173 \text{ ms} \]

**Table 10** Findings indicative of haemodynamically significant tricuspid stenosis

<table>
<thead>
<tr>
<th>Specific findings</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean pressure gradient</td>
<td>≥ 5 mmHg</td>
</tr>
<tr>
<td>Inflow time-velocity integral</td>
<td>&gt; 60 cm</td>
</tr>
<tr>
<td>( T_{1/2} )</td>
<td>≥ 190 ms</td>
</tr>
<tr>
<td>Valve area by continuity equation(^a)</td>
<td>≤ 1 cm(^2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supportive findings</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Enlarged right atrium ( ≥ ) moderate</td>
<td></td>
</tr>
<tr>
<td>Dilated inferior vena cava</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Stroke volume derived from left or right ventricular outflow. In the presence of more than mild TR, the derived valve area will be underestimated. Nevertheless, a value ≤ 1 cm\(^2\) implies a significant haemodynamic burden imposed by the combined lesion.
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
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>
</tr>
</tbody>
</table>

![Echocardiogram](image)
PR Severity
<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</td>
<td>Enlargement seen in other conditions.</td>
</tr>
<tr>
<td>Paradoxical septal motion (volume overload pattern)</td>
<td>Simple sign of severe PR</td>
<td>Not specific for PR</td>
</tr>
<tr>
<td>Jet length – Color flow</td>
<td>Simple</td>
<td>Poor correlation with severity of PR</td>
</tr>
<tr>
<td>Vena contracta width</td>
<td>Simple quantitative method that works well for other valves</td>
<td>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>Steep deceleration not specific for severe PR</td>
</tr>
<tr>
<td>Flow quantitation – PW</td>
<td>Quantitates regurgitant flow and fraction</td>
<td>Subject to significant errors due to difficulties of measurement of pulmonic annulus and a dynamic RVOT; not well validated</td>
</tr>
</tbody>
</table>

CW, Continuous wave; RV, right ventricle; PR, pulmonic regurgitation; RVOT, right ventricular outflow tract.
Not many numbers
RV enlargement with PR jet and not much else
Very broad vena contracta
Short PHT
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
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

Echo, echocardiography; RAP, right atrial pressure; TR, tricuspid regurgitation.
Images can be deceptive! – Integrate detail with the BIG PICTURE
Question 1

All of the following are compatible with severe Tricuspid Regurgitation except:

- A. RV basal dimension measuring 50mm
- B. Flow reversal in the hepatic veins after the P wave
- C. PISA radius of 10 mm at an aliasing velocity of 30 cm/s
- D. Non-parabolic TR CW Doppler signal with an early peak
Answer - B

- The flow reversal representing severe TR is after the QRS – i.e. in systole
All of the following are true except:

A) The simplified Bernoulli equation is not valid
B) The septum is D-shaped in diastole
C) The PAP may be overestimated due to the presence of laminar flow
D) The RA pressure is likely > 15 mmHg
Answer - C

• Laminar flow is likely to underestimate severity of TR. The Simplified Bernoulli equation is predicated on turbulent flow
Which of the following is least likely

- A) A diastolic rumble will be heard over the apex
- B) The IVC will be markedly dilated
- C) Mitral inflow pulsed Doppler will demonstrate E:A reversal
- D) The RV systolic pressure will be significantly elevated
Answer - C

• This patient has rheumatic TS, and therefore likely also has rheumatic mitral valve disease
• There is severe RA enlargement and therefore likely marked elevation of RA pressure
• The patient is in atrial fibrillation, so there will not be much of an A wave present