Echocardiographic Evaluation of Tricuspid Valve

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Disclosures

Speakers Bureau (Philips, Medtronic)
Advisory Board (Siemens)
Anatomy of Tricuspid Valve

Anatomic Specimen Drawing of Tricuspid Valve

Probably the first drawing of a dissected tricuspid valve was done by Leonardo da Vinci.

Leonardo probably drew an ox heart.

Leonardo did not use the term ‘tricuspid valve’ as it has not been invented yet.

He referred to valves as ‘heart sieves’.

Leonardo da Vinci
(1452 – 1519)
Self-portrait c. 1512

Drawn circa 1512-13
British Royal Collection
Who Named Mitral & Tricuspid Valves

Andreas Vesalius
Flemish Anatomist
(1514 – 1564)

Gaspard Bauhin
(Bauhinus)
Swiss Physician
(1560 - 1624)

Terms ‘mitral’ and ‘tricuspid’ valves have been in continuous use for more than 500 years!

Tricuspid Valve Anatomy

Image source: University of Toronto

3 LEAFLETS (anterior, septal & posterior)

TRICUSPID ANNULUS

CHORDAE TENDINEAE

RIGHT VENTRICULAR MYOCARDIUM

3 PAPILLARY MUSCLES
**Variability in Tricuspid Valve Anatomy**

<table>
<thead>
<tr>
<th>NUMBER OF LEAFLETS</th>
<th>BETWEEN 2 AND 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cusps of tricuspid valve in 50 hearts</td>
<td></td>
</tr>
<tr>
<td>Number of cusps</td>
<td>Absolute no.</td>
</tr>
<tr>
<td>2 Cups</td>
<td>2</td>
</tr>
<tr>
<td>3 Cups</td>
<td>14</td>
</tr>
<tr>
<td>4 Cups</td>
<td>26</td>
</tr>
<tr>
<td>5 Cups</td>
<td>7</td>
</tr>
<tr>
<td>6 Cups</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
</tr>
</tbody>
</table>

Tricuspid valve is most commonly a 4-leaflet valve.

*Table 6. Number of cusps of tricuspid valve in 50 hearts*  
*Surg Radiol Anat 1990;12:37-41*

**NUMBER OF PAPILLARY MUSCLES**  
Between 2 and 9

Only in a minority of humans the tricuspid valve is truly trileaflet.

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**Tricuspid Valve: Autopsy Specimen**

*Van Mierop Archive, University of Florida*
Tricuspid Valve Videography

Intracardiac video recordings performed after the blood is replaced with a transparent, oxygen-carrying fluid.

3D TEE: Tricuspid Valve

Right Atrial Side

Right Ventricular Side
Tricuspid Valve Guidelines

Echo Assessment of Tricuspid Valve

Tricuspid valve should be evaluated based on national and international guidelines.

<table>
<thead>
<tr>
<th>Year</th>
<th>MV + AV</th>
<th>TV + PV</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003 – ASE Native Valve Regurgitation</td>
<td>11</td>
<td>5½</td>
<td>2:1</td>
</tr>
<tr>
<td>2008 – ASE Native Valve Stenosis</td>
<td>15</td>
<td>4</td>
<td>4:1</td>
</tr>
<tr>
<td>2009 – ASE Prosthetic Valves</td>
<td>10½</td>
<td>5½</td>
<td>2:1</td>
</tr>
<tr>
<td>2014 – ACC/AHA Valve Disease</td>
<td>36</td>
<td>6</td>
<td>6:1</td>
</tr>
</tbody>
</table>

This reflects the fact that echocardiographic methods for evaluation of right-sided valves are less validated than those for the left-sided valves.
Prevalence of Tricuspid Regurgitation

![Graph showing prevalence of valvular disease opportunity in the US (2006 estimate)]

Valvular Disease Opportunity in US (2006 Estimate)

Echocardiographic View of Tricuspid Valve
Echocardiographic Evaluation of Tricuspid Valve

1. Tricuspid Valve Anatomy
2. Primary ways of quantification
3. Ancillary Methods

Tricuspid Valve: 2D TTE Views

Short-Axis View at Aortic Valve Level
Tricuspid Valve: Short-Axis View

Posterior leaflet in most cases

50/50 chance of either septal or anterior leaflet

Int J Cardiovasc Imaging 2007;23:717-724

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Tricuspid Valve: TTE Views

Right Ventricular Inflow View
Tricuspid Valve: RV Inflow View

Either posterior or septal leaflet

Anterior leaflet in most cases


Tricuspid Valve: TTE Views

Apical 4-Chamber View
Tricuspid Valve: A4C View

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

Karina A. DeCeulaer, MD, Megan Yamat, RDCS, Anuj Mediratta, MD, Diego Medvedovsky, MD, Mia Patel, MD, Preston Ferrara, RDCS, Victor Mor-Avi, PhD, and Roberto M. Lang, MD, Chicago, Illinois

Background: Accurate identification of tricuspid valve (TV) leaflets by two-dimensional (2D) transthoracic echocardiography is difficult because of variability in the intersection between the imaging plane and leaflets. Using information obtained from multiphase reconstruction (MPR) of three-dimensional (3D) data sets, the investigators sought to define “novel” 2D views that would allow targeted interrogation of TV leaflets using 2D transthoracic echocardiography.

Methods: Images of the TV in the standard 2D views (apical four chamber, right ventricular focused, right ventricular inflow, and parasternal short axis) and 3D data sets were acquired from the same probe position in 106 adults. Three-dimensional MPR was used to determine which leaflet combination was seen in the 2D image: anterior and septal, anterior and posterior, anterior alone, or posterior and septal. Using this analysis, 2D landmarks were identified to define nonstandard TV views tailored to depict specific leaflets. Two-dimensional images in these views and 3D data sets were then prospectively collected in 54 additional patients. Three independent readers analyzed these 2D views to determine TV leaflet compositions, and their interpretation was compared with 3D MPR–derived reference.

Results: Three-dimensional MPR views made it possible to define six nonstandard 2D views on the basis of anatomic clues and landmarks, which consistently depicted all the aforementioned leaflet combinations. When these six views were prospectively tested, the agreement of TV leaflet identification against 3D MPR was excellent ($\kappa = 0.96$, $\kappa = 0.93$, and $\kappa = 0.98$).

Conclusion: The nonstandard 2D views defined in this study allow accurate TV leaflet identification and may thus be useful when localization of TV leaflet pathology is clinically important.
Tricuspid Valve: 2D TEE

Transgastric Tricuspid Valve Short-Axis View

Tricuspid Valve: 2D TEE

Transgastric Tricuspid Valve Short-Axis View
Tricuspid Regurgitation

Tricuspid Regurgitation | Etiology

SECONDARY (FUNCTIONAL) (80%)

PRIMARY (20%)
- Ebstein’s
- Carcinoid
- Rheumatic
- Traumatic
- PPM/ICD lead
Primary Tricuspid Regurgitation | Endocarditis

*Staphylococcus aureus* vegetation in an IVDA

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Primary Tricuspid Regurgitation | Trauma

17-year-old male with a gun-shot wound
Primary Tricuspid Regurgitation | Carcinoid Disease

Carcinoid Disease | 3D TTE – LV Perspective
Primary TR: Rheumatic Heart Disease

Woman with mechanical MV & AV for rheumatic heart disease; residual native TV disease

Primary TR: Ebstein’s Anomaly
Primary TR: Ebstein’s Anomaly

Secondary Tricuspid Regurgitation
Quantification of Tricuspid Regurgitation

Primary ways of quantification

Color Doppler is the primary means for quantifying tricuspid regurgitation.

<table>
<thead>
<tr>
<th>Method</th>
<th>SEVERE TR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Size at Nyquist limit 50-60 cm/s</td>
</tr>
<tr>
<td>Jet Area</td>
<td>&gt; 10 cm²</td>
</tr>
<tr>
<td>PISA Radius</td>
<td>&gt; 0.9 cm</td>
</tr>
<tr>
<td>Vena Contracta</td>
<td>&gt; 0.7 cm</td>
</tr>
</tbody>
</table>

Evaluate TR in Multiple Views

Apical 4-Chamber View
Evaluate TR in Multiple Views

RV Inflow View

Evaluate TR in Multiple Views

Hepatic Vein View
Primary Means of Quantifying TR

Semiquantitative assessment of TR severity using regurgitant jet size in the right atrium.

**ASE Guidelines**

<table>
<thead>
<tr>
<th>Absolute TR Jet Area</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MILD TR</strong></td>
</tr>
<tr>
<td>Jet area &lt; 5 cm²</td>
</tr>
<tr>
<td><strong>MODERATE TR</strong></td>
</tr>
<tr>
<td>Jet area 5 - 10 cm²</td>
</tr>
<tr>
<td><strong>SEVERE TR</strong></td>
</tr>
<tr>
<td>Jet area &gt; 10 cm²</td>
</tr>
</tbody>
</table>

**Framingham**

<table>
<thead>
<tr>
<th>Relative TR Jet Area (Jet Area / RA Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JA/RA Area &lt; 20%</td>
</tr>
<tr>
<td>JA/RA Area 20 - 40%</td>
</tr>
<tr>
<td>JA/RA Area &gt; 40%</td>
</tr>
</tbody>
</table>

All these values apply primarily to central (non-Coanda) jets.

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TV Regurgitation: PISA & Vena Contracta

**PISA Radius**

0.7 cm

**Vena Contracta**

0.5 cm

**Nyquist**

50 to 60 cm/s

**Conclusion**

Tricuspid regurgitation is less than severe.

TR is severe when $PISA \ r > 0.9 \ cm$ and $VC > 0.7 \ cm$. 

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Ancillary Methods for Assessing Tricuspid Regurgitation

1. Right Heart Size
   - Big RA & RV & IVC in chronic TR
   - Normal RA & RV size in acute TR

2. E Wave Velocity
   - Native tricuspid valve $E_{max} > 1.0 \text{ m/s}$ suggests severe TR

3. Hepatic Veins
   - S wave reversal is sign of severe TR.

Shapes of Spectral TR Jet

- **Parabolic Shape**
  - Broad-based, symmetric TR jet.
  - Such jets are turbulent on color Doppler.
  - Seen e.g. in less than severe TR or in severe TR when RA pressure is not very high.

- **Triangular Shape**
  - Early peaking, rapidly decelerating TR jet.
  - Such jets are often laminar on color Doppler.
  - Seen e.g. in severe TR when RA pressure is very high (as in acute TR).
Shapes of Spectral TR Jet

Forward and reverse flow signals across TV are almost mirror images of each other.

Note the laminar nature of TR jet.

Seen e.g. in severe TR with normal RV systolic pressure

Tricuspid Stenosis
Normal Valve Areas

Normal MITRAL valve area in adult humans is roughly the size of a US quarter.

\[4.2 \, \text{cm}^2\]

Normal AORTIC valve in adult humans is roughly the size of a US nickel or dime.

\[2-4 \, \text{cm}^2\]

Normal TRICUSPID valve in adult humans is roughly the size of a US half-dollar coin.

\[6-8 \, \text{cm}^2\]

Echocardiographic Evaluation of Tricuspid Valve

1. Tricuspid Valve Anatomy
2. Primary ways of quantification
3. Ancillary Methods
Quantification of Tricuspid Stenosis

Continuous Wave Doppler is the primary means for quantifying tricuspid stenosis.

Because of normally significant respiratory variations in tricuspid inflow, either average several beats or use end-expiratory apnea beats.

<table>
<thead>
<tr>
<th>Method</th>
<th>Hemodynamically Significant Tricuspid Stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean gradient (at HR 70-80 bpm)</td>
<td>≥ 5 mm Hg</td>
</tr>
<tr>
<td>Inflow VTI</td>
<td>&gt; 60 cm</td>
</tr>
<tr>
<td>Pressure Half-time</td>
<td>&gt; 190 msec</td>
</tr>
<tr>
<td>Valve area (by continuity equation)</td>
<td>≤ 1 cm²</td>
</tr>
</tbody>
</table>

3D TTE
Tricuspid Valve Planimetry
TVA < 1 cm²

Carcinoid Heart Disease
Suie N. Hong, MD, Muhamed Suric, MD, PhD, Izhak Kronzon, MD
New York, New York

Images in Cardiology

Ancillary Methods for Assessing Tricuspid Stenosis

1. **Right Atrial Size**
   - Moderate or severe RA enlargement supports the diagnosis of significant tricuspid stenosis.

2. **Right Atrial Pressure**
   - Dilated inferior vena cava and other signs of elevated RA pressure

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Tricuspid Stenosis | Anatomy

- **Carcinoid Disease**
- **Right Atrial Lymphoma**
Tricuspid Stenosis | Anatomy

Right Atrial Lymphoma

Tricuspid Stenosis | Hemodynamics

1. High antegrade velocity across TV
2. High diastolic VTI and mean gradient
3. Respiratory variations in tricuspid inflow
4. Difficulty of measuring P½ at high heart rate

Mean $\Delta P = 7$-12 mm Hg
Tricuspid Stenosis | Ancillary Signs

Dilated & noncollapsing IVC (high RA pressure)

Thank You!

New York University Langone Medical Center