Morpho-Anatomy of Tricuspid Valve

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TRICUSPID VALVE: OBJECTIVES

- Anatomy of the TV
- Ambiguity of Leaflets Imaged on 2D
- Mechanisms of Tricuspid Regurgitation
- Value of TV 3D imaging for Pacemakers
- Functional Tricuspid Regurgitation
- TV and Structural Heart Disease
Impact of TR

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

Emerging TV

Bi-caval valve implantation

Forma Concept

Transatrial Intrapericardic tricuspid annuloplasty concept


Figure 3. Transcatheter techniques targeting functional TR. Transcatheter devices in early clinical testing can be grouped according to their mechanism of action into annuloplasty devices, coaptation devices and heterotopic caval valve implantation.
2D Echocardiography

THE TV ON 3D ECHO

RV perspective

RA perspective
THE TRICUSPID VALVE: ADDED VALUE OF 3D IMAGING

2D ➔ 3D

< 5% of pts

~ 85% of pts

THE NORMAL TRICUSPID VALVE COMPLEX

1. Three leaflets
   - Anterior
   - Septal
   - Posterior
2. Fibrous annulus
3. Chordae tendinae
4. Papillary muscles
5. RA myocardium
6. RV myocardium

Courtesy Dr. Stephen P. Sanders, Professor of Pediatrics (Cardiology), Harvard Medical School
How many leaflets does the TV have?

TV in Pulmonary Hypertension
AMBIGUITY OF LEAFLET IMAGED ON 2D
Ambiguity of leaflets imaged on 2D

Post LVAD study

RV inflow view

RV inflow view 2

Presentation Title Here
MECHANISMS OF TRICUSPID REGURGITATION

**Primary (or “Organic”)**

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

**Secondary (or “Functional”)**

- TV annular dilatation, RV dilatation and papillary muscle displacement
- 70-85%* of TR

Antunes MJ, Barlow JB, Heart 2007

LEAFLETS: PRIMARY “ORGANIC” TR

- Traumatic Ruptured TV Leaflet
- History of trauma - healed rib fracture
Carcinoid heart disease

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
P-S COMMISSURE: CORRECT POSITION

A:

<table>
<thead>
<tr>
<th>Postero-septal</th>
<th>Antero-posterior</th>
<th>Middle</th>
<th>Antero-septal</th>
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• **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
POSTERIOR TV LEAFLET PERFORATION

PACEMAKER ADHERENCE
FUNCTIONAL TRICUSPID REGURGITATION

- Chronic PE, Lung disease
- RV ischemia, VOL, CM
- Left-sided valve disease
- Atrial fibrillation
- L-R shunt

70-85%* of TR

- TA dilatation
- RV enlargement
- PM displacement
- TV tethering

FTR

TRICUSPID VALVE ≠ MITRAL VALVE

- Different valve orifices
- Different subvalvular apparatuses
- Different ventricles

Yet TR and MR are assessed in similar ways

Dreyfus G. J Am Coll Cardiol 2015;65:2331–6
TRICUSPID VALVE ≠ MITRAL VALVE

64 year-old man with a NICM

LVEF – 20%

9 months ago - CHF

Now - No CHF

TR IS LOAD DEPENDENT
MECHANISMS OF TRICUSPID REGURGITATION

<table>
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<th>Group (N)</th>
<th>Controls (99)</th>
<th>Id FTR (141)</th>
<th>PHTN FTR (140)</th>
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<tr>
<td>TR</td>
<td>None</td>
<td>Matched for ERO</td>
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<tr>
<td>sPAP</td>
<td>Normal Controls</td>
<td>&lt;50 mmHg Aging, Afib</td>
<td>≥ 50 mm Hg</td>
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<td>Associations:</td>
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<tr>
<td>TA</td>
<td>Normal</td>
<td>↑↑↑↑</td>
<td>↑↑↑</td>
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<tr>
<td>Tenting</td>
<td>Normal</td>
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<tr>
<td>RV Base</td>
<td>Normal</td>
<td>↑↑↑↑</td>
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<td>RV Length</td>
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<td>Remodeling</td>
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TRICUSPID ANNULUS

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

Courtesy F. Veronesi, PhD.
Ton Nu Circulation. 2006

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

Functional TR and annular dilatation

The annulus is dilated if it measures
1. > 40 mm or > 21 mm/m² on 2D transthoracic echocardiography
   – Apical 4-chamber view
   – In diastole
2. > 70 mm on direct intraoperative measurement

ESC/EACTS Guidelines for management of VHD EHJ 2012
ACC/AHA Guidelines for management of VHD JACC 2014
FUNCTIONAL TRICUSPID REGURGITATION

Normal

Non-planarity angle = 158°

Non-planarity angle = 173°

With worsening TR, the annulus becomes larger, rounder and flatter

Taramasso M et al. J Am Coll Cardiol 2012

FUNCTIONAL TRICUSPID REGURGITATION

TA dilatation occurs mostly along the RV free-wall

Septal portion of the tricuspid annulus relatively fixed

Dreyfus et al. ATS 2005
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

MECHANISMS OF TRICUSPID REGURGITATION

TR is highly dependent on annular dilatation, with significant TR occurring with only 40% dilatation, whereas it was seen at 75% dilatation in vitro MV studies. i.e. the TV leaks earlier than the MV

Spinner EM. Circulation 2011
Software-generated annulus

**On the horizon...**

**3D Echo**

![Graph showing tricuspid annular dimensions](image)

- Long axis
- Traditional 4-chamber
- RV-focused view
- Short-axis


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**MECHANISMS OF TRICUSPID REGURGITATION**

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

![Image of 3DE view](image)

*Min SY et al. Eur Heart J 2010*
THE ACC/AHA 2014 GUIDELINES

TA dilated if >40 mm in apical 4-chamber view

TRICUSPID VALVE MODELING FROM ECHO IMAGES

Pre-procedural planning

MitraClip implantation in Diastolic model

MitraClip implantation in Systolic model

Clinical MitraClip implantation

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

Avenatti et al, Eur Heart Journal: Card. Imag, 2017
TRICUSPID VALVE CLIP

Avenati et al. Eur Heart Journal Card. Imag. 2017

Valve in Valve
Conclusions

• The TV should be imaged in 3D using TT
• The anatomy of the TV is variable
• TR that occurs after a pacemaker implantation may be due to TY leaflet impingement
• The measurement of the TA annulus is clinically relevant
• The advent of TV interventions will lead to advances in cardiac imaging of the forgotten valve”

Thank you!

BEWARE... THE ULTRASOUND BEAM OFTEN ELICITS FINDINGS THE HISTORY AND PHYSICAL EXAM CANNOT...