ASSESSMENT OF THE RIGHT VENTRICLE BY ECHOCARDIOGRAPHY
Anatomy of the Right Ventricle
- RIGHT VENTRICULAR ANATOMY

- PV
- Infundibulum
- Membranous septum
- TV
- Inflow tract
- Apex
• 3 MUSCULAR BANDS

• THE PARIETAL BAND
• SEPTOMARGINAL BAND
• MODERATOR BAND (DEFINES ANATOMIC RIGHT VENTRICLE FROM LEFT)
**RV OUTFLOW ANATOMY**

**TTE: Parasternal Long Axis View**

- **RV Outflow Tract**
  - Linear densities in RVOT are usually catheters rather than PPM or ICD wires.

- **Tricuspid Valve**
  - Should not be mistaken for an abnormal structure.

**TTE: RV Inflow (Tilt) View**

- **Posterior Tricuspid Leaflet**
  - If you over-rotate the probe, you will transition from inferior RV wall to interventricular septum. Then posterior leaflet becomes septal leaflet.

- **Anterior Tricuspid Leaflet**
  - Happens to have papillary fibroelastoma in this patient.

- **Coronary Sinus**

- **Superior Vena Cava**

- **Inferior Vena Cava**
RV WALL SEGMENTS

Ant RVOT

ANT RVOT

LAT

ANT RV

infr

Infundibular Septum

Membranous Septum

Inlet Septum

Trabecular Septum

lateral wall of the RV

anterior wall of the RV

anterior wall of the RVOT

inferior wall of RV
• RV WALL THICKNESS AND CHAMBER SIZE

RV INFERIOR WALL

SUBCOSTAL VIEW

N=<0.5cm Measured at peak r wave
2D and M-mode: Thickness of RV Free Wall

- Normal: less than 0.5 cm
- Measure at the level of TV chordae and at the peak of R wave of ECG on subcostal view
- Well correlated with peak RV systolic pressure
RV DIMENSIONS

DIAMETERS ABOVE THE TRICUSPID VALVE ANNULUS

MID RV CAVITY

DISTANCE FROM THE TV ANNULUS TO RV APEX
RV DIMENSIONS
2D and M-mode: RV Dimension

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Reference</th>
<th>Mildly Abnormal</th>
<th>Moderately Abnormal</th>
<th>Severely Abnormal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal RV diameter (RVD1), cm</td>
<td>2.0-2.8</td>
<td>2.9-3.3</td>
<td>3.4-3.8</td>
<td>≥ 3.9</td>
</tr>
<tr>
<td>Mid-RV diameter (RVD2), cm</td>
<td>2.7-3.3</td>
<td>3.4-3.7</td>
<td>3.8-4.1</td>
<td>≥ 4.2</td>
</tr>
<tr>
<td>Base–to-apex (RVD3), cm</td>
<td>7.1-7.9</td>
<td>8.0-8.5</td>
<td>8.6-9.1</td>
<td>≥ 9.2</td>
</tr>
</tbody>
</table>
2D and M-mode: RVOT and PA Size
## 2D and M-mode: RVOT and PA Size

<table>
<thead>
<tr>
<th></th>
<th>Reference Mildly</th>
<th>Moderately</th>
<th>Severely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>range</td>
<td>abnormal</td>
<td>abnormal</td>
</tr>
<tr>
<td>RVOT diameters, cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above aortic valve (RVOT1)</td>
<td>2.5-2.9</td>
<td>3.0-3.2</td>
<td>3.3-3.5</td>
</tr>
<tr>
<td>Above pulmonic valve (RVOT2)</td>
<td>1.7-2.3</td>
<td>2.4-2.7</td>
<td>2.8-3.1</td>
</tr>
<tr>
<td>PA diameter, cm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below pulmonic valve (PA1)</td>
<td>1.5-2.1</td>
<td>2.2-2.5</td>
<td>2.6-2.9</td>
</tr>
</tbody>
</table>
2D and M-mode: RV Size

▶ Normal RV is approximately 2/3 of the size of the LV
▶ RV Dilatation
  : appears similar or larger than LV size
  : shares the apex
Limitations of Echocardiography in The Evaluations of RV Function

- Difficulties in the estimation of RV volume
  - crescentic shape of RV
  - separation between RV inflow and outflow
    - no uniform geometric assumption for measuring volume
- Difficulties in the delineation of endocardial border owing to well developed trabeculation
- Difficulties in the adequate image acquisition owing to the location just behind the sternum
Limitations of Echocardiography in The Evaluations of RV Function

- Difficult to standardize the evaluation method of RV function
  - Variations in the direction or location of the RV are common
  - Easily affected by preload, afterload, or LV function
- Different complex contraction-relaxation mechanism among the segments of the RV
- Cannot image the entire RV in a single view
Why should we measure RV function?

- RV is not just a conduit of blood flow: has its unique function
- Prognostic significance in various clinical settings
- Risk stratification or guide to optimal therapy
Function of the Right Ventricle

- Conduit of blood flow
- Maintain adequate pulmonary artery perfusion pressure to improve gas exchange
- Maintain low systemic venous pressure to prevent congestion of tissues or organs
- Affect LV function
  - limit LV preload in RV dysfunction
  - Ventricular interdependence
- Prognostic significance in various clinical settings
RV Function and Prognosis

▶ RV ejection fraction: an indicator of increased mortality in patients with CHF associated with CAD
  
  (Polak et al. J Am Coll Cardiol 1983)

▶ RV function predicts exercise capacity and survival in advanced heart failure
  
  (Di Salvo et al. J Am Coll Cardiol 1983)

▶ RV function is a crucial determinant of short-term prognosis in severe chronic heart failure
  
  (Gavazzi et al. J Heart Lung Transplant 1997)
RV Function and Prognosis

- RV ejection fraction: independent predictor of survival in patients with moderate heart failure
  (De Groote et al. J Am Coll Cardiol 1998)

- RV function predicts prognosis in patients with chronic pulmonary disease

- RV contractile reserve is associated with one year mortality in patients with DCMP
Measurements of RV Function

- 2 D and M-mode echocardiography
  - chamber size or wall thickness
  - RV area or fractional area change
  - RV volume or EF
  - Tricuspid annular systolic plane excursion (TAPSE)

- Doppler echocardiography

- 3 Dimensional Echocardiography
The ratio of two orthogonal minor axis left ventricular chordae, measured from short axis view

- Reflects the degree of septal flattening resulting in abnormal LV shape
- Normal: approximately 1.0 in both diastole and systole
2D and M-mode: Eccentricity Index
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- Eccentricity Index
- RV volume overload
- RV pressure overload
2D and M-mode: Fractional Area Change (FAC)

\[
\frac{(\text{End-diastolic area}) - (\text{end-systolic area})}{(\text{end-systolic area})} \times 100
\]
2D and M-mode: RV Area and FAC in A4C

<table>
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<tr>
<th>Reference Mildly</th>
<th>Moderately</th>
<th>Severely</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV diastolic area (cm²)</td>
<td>11-28</td>
<td>29-32</td>
</tr>
<tr>
<td>RV systolic area (cm²)</td>
<td>7.5-16</td>
<td>17-19</td>
</tr>
<tr>
<td>RV FAC (%)</td>
<td>32-60</td>
<td>25-31</td>
</tr>
</tbody>
</table>

- Well correlated with RV function measured by radionuclide ventriculography or MRI
- Good predictor of prognosis
- Limitations: fail to measure FAC due to inadequate RV tracing
Remains problematic given the complex geometry of the RV and the lack of standard methods for assessing RV volumes

\[ \text{RVEF (\%)} = \left\{ \frac{(\text{EDV} - \text{ESV})}{\text{EDV}} \right\} \times 100 \ (\%) \]

<table>
<thead>
<tr>
<th>Normal Range Ellipsoidal model</th>
<th>LV</th>
<th>RV</th>
<th>LV</th>
<th>RV</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDVI (ml/m²)</td>
<td>52-87</td>
<td>63-103</td>
<td>59.17</td>
<td>70.0</td>
</tr>
<tr>
<td>ESVI (ml/m²)</td>
<td>14-35</td>
<td>22-56</td>
<td>22.64</td>
<td>32.6</td>
</tr>
<tr>
<td>SV (ml/m²)</td>
<td>18-52</td>
<td>40-41</td>
<td>36.42</td>
<td>37.31</td>
</tr>
<tr>
<td>EF (%)</td>
<td>59-74</td>
<td>43-65</td>
<td>61.20</td>
<td>53.91</td>
</tr>
</tbody>
</table>

PVR = \( \frac{TRV}{TVI_{RVOT}} \times 10 + 0.16 \) (NI value is 1.5-2.5)
Tricuspid Annular Plane Systolic Excursion

- Degree of systolic excursion of TV lateral annulus on A4C
  - 1.5-2.0 cm in normal
  - Value less than 1.5 cm is considered as abnormal

- Well correlated with RVEF measured by RVG
- Reproducible
- Strong predictor of prognosis in patients with CHF
Tricuspid Annular Plane Systolic Excursion

※ TAPSE and RV ejection fraction

- TAPSE 2cm = RVEF 50%
- TAPSE 1.5cm = RVEF 40%
- TAPSE 1cm = RVEF 30%
- TAPSE 0.5cm = RVEF 20%

Event free survival according to TAPSE in patients with CHF
Doppler Echocardiography: Tissue Doppler Imaging

Peak systolic velocity (PSV)
Normal <11.5 cm/sec

Tricuspid lateral annular velocities

V1 = -0.122m/s
PG1 = 0.1mmHg

V2 = -0.164m/s
PG2 = 0.1mmHg

V = 0.134m/s
PG = 0.1mmHg

Al = 10 cm/sec
Doppler Echocardiography: Tissue Doppler Imaging

- Allows quantitative assessment of RV systolic and diastolic function by measurement of myocardial velocities

- Peak systolic velocity (PSV)
  - PSV < 11.5 cm/s identifies the presence of RV dysfunction
  - Sensitivity of 90%, specificity of 85%
  - Less affected by HR, loading condition, and degree of TR

- Tricuspid lateral annular velocities
  - Reduced in patients with inferior MI and RV involvement
  - Associated with the severity of RV dysfunction in patients with heart failure
Doppler Echocardiography: Strain Rate Imaging
Doppler Echocardiography: Strain Rate Imaging

▶ RV longitudinal strain in apical view
  : Feasible in clinical setting
  : Baso-apical gradient with higher velocities at the base
  : RV velocities are consistently higher as compared to LV
▶ Strain and strain rate values
  : More inhomogeneously distributed in the RV
  : Reverse baso-apical gradient, reaching the highest values in the apical segments and outflow tract
▶ Acute increase in RV afterload
  : Increase in RV myocardial strain rate
  : Decrease in peak systolic strain, indicating a decrease in SV
Doppler Echocardiography: 3D Echocardiography

Advantages of RT3DE

- Volume analysis does not rely on geometric assumptions
- Little artifacts associated with motion or respiration
- Multiple slices may be obtained from the base to the apex of the heart as in the method of discs
  - Measure entire RV volume
  - Well correlated with RV volume measured by MRI
RV Function: 3D Echocardiography
RV Function: 3D Echocardiography

EDV 99.80 ml
ESV 38.17 ml
SV 61.63 ml
EF 61.76 %
SDI16 10.2 %
Conclusion

▶ RV function is an important parameter in cardiac disease

▶ 2DE is a relatively feasible method to assess RV dysfunction in clinical practice

▶ Several new echocardiographic techniques such as TDI, SRI, RT3DE may give us further information in assessing RV function