Moving Right Ventricular Assessment
Beyond the Eyeball

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No disclosure
The Right Ventricle Anatomy

COMPLEX GEOMETRY!

• Asymmetrical, crescentic shape, wrapped around LV

• Consists of 3 components:
  1. *Inlet,*
  2. *Apical trabecular,* and
  3. *Outlet conus (infundibulum)*

• Different structures compare to LV;
  1. *Relative apical displacement of TV,*
  2. *Band & coarse apical trabeculation,*
  3. *> 3 papillary muscles,*
  4. *A 3 leaflet TV with septal papillary muscle attachment*

*Ho SY, et al. Heart 2006; 92 (Suppl I) : i2 – i3*
The Right Ventricle; location in the thorax

- Placed retro-sternally
- Most anterior cardiac structure
- Near field of the ultrasound beam
  + complex geometry

- Limiting optimal echo windows and resolution
- A single 2D echo view → Incomplete visualization of the RV
- Needs more than one projection for a comprehensive evaluation of RV structure and function.

→ Assessment of dimension and function: very challenging
Eye balling ?
Eye balling?

Assessment as

**ordinal categories** [normal, mild, moderate, severe]

**binary category** (normal vs abnormal)

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**Accuracy and Interobserver Concordance of Echocardiographic Assessment of Right Ventricular Size and Systolic Function: A Quality Control Exercise**

Lee Fong Ling, MBBS, Nancy A. Obuchowski, PhD, Leonardo Rodriguez, MD, Zoran Popovic, MD, Deborah Kwon, MD, and Thomas H. Marwick, MBBS, PhD, MPH, Cleveland, Ohio

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**Visual assessment**
- RVS and RVSF

**Quantitative assessment**
- RVS (basal and mid, & longitudinal φ)
- RVSF (FAC, TAPSE, s’, RVIMP)

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1. Quantitation of RV size & function is critical and reduces inter-reader variability

2. Additional definitions for grading RV function are needed.

- Visual assessment $\rightarrow$ inaccurate and shows considerable variability
- Quantitative assessment $\rightarrow$ improved accuracy and decreased variability, [defining the normality of the right ventricle]
- The reliability of grading mild and moderate abnormalities remains inadequate

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**defining the cases as normal or abnormal**
The Right Ventricle Quantitative Measurements

**Linear Measurements**

→ Distance & Area dimension

2 D measurements → challenging because:

• the complex geometry of the right ventricle

• lack of specific right-sided anatomic landmarks (as reference points)

→ routinely assessed using multiple acoustic windows

**Volumetric Measurements**

• 3 D measurements → overcome the limitation of orientation and reference point

• Could be challenging in: suboptimal image quality, severely enlarge RV

• Important!
  
  • correct timing (end diastolic – end systolic)
  
  • correct tracing
Echo Windows to View the Right Ventricle

Needs ≥ 1 projections for a comprehensive evaluation of RV structure and function
The Right Ventricle Dimension: RVOT

- **RVOT prox**: from the anterior RV wall to the interventricular septal-aortic junction (PLAX) or to the aortic valve (PSAX)
- **RVOT distal**: just proximal to the pulmonary valve

- RVOT prox is less reproducible than RVOT distal
- Risk of underestimation or overestimation if the RV view is obliquely oriented with respect to RV outflow tract
- Endocardial definition of the RV anterior wall is often suboptimal
- Regional measure; may not reflect global RV size

**Images:**
- Image A: RVOT Prox, Normal Ø < 30 mm
- Image B: RVOT-Prox, Normal Ø < 35 mm
- Image C: RVOT Distal, PA, Normal Ø < 27 mm

**end-diastole!**

**Inner edge to inner edge method**

The Right Ventricle Dimension

Caution: different angulation → different measurement, despite similar size

- **Basal RV linear dimension (RVD1)**
  - Max transversal dimension in the basal 1/3 of RV inflow (abN > 41 mm)

- **Mid-cavity RV linear dimension (RVD2)**
  - Approximately halfway between the max basal diameter and the apex, at the level of papillary muscles (abN > 35 mm)

- **Longitudinal diameter** (abN > 83 mm)

Inner edge to inner edge method

The Right Ventricle Area

- Manual tracing of RV endocardial border: lateral tricuspid annulus → the free wall → the apex → the interventricular septum → medial tricuspid annulus
- Trabeculations, papillary muscles and moderator band are included in the cavity area

Limitation:
- Needs optimal image quality
- Challenged by coarse trabeculation
- Size underestimation if foreshortened
- Different tomographic view through cardiac cycle
- Not accurately reflect global RV size

Normal range (men) 10-24 cm²
Normal range (women) 8-20 cm²

The Right Ventricle Wall Thickness

- Useful measurement of RVH

- From the subcostal view, align the u/s beam perpendicular to the RV free wall

- Below TV annulus, at a distance + the length of open anterior TV leaflet and parallel to RV free wall

- End diastole, when it is fully open

RV Systolic Function

- Echo parameters that have the clinical utility and value demonstrated by many studies are:
  - Tricuspid Annular Plane Systolic Excursion (TAPSE)
  - Fractional area change (FAC)
  - S’ velocity of the tricuspid annulus
  - RV index of myocardial performance (RIMP)

- Another parameters:
  - RV strain and strain rate
  - RV 3 D EF

Tricuspid Annular Plane Systolic Excursion

- An useful index for evaluating RV longitudinal function.
- M-mode cursor through the lateral tricuspid annulus
- Longitudinal motion of the annulus between end-diastole and peak systole

Advantage: Simple, highly reproducible
Disadvantages:
- Affected by cardiac translation (may be over/underestimate)
- Angle dependency

abNormal < 17 mm

Fractional area change

- Defined as:
  \[
  \frac{\text{End diastolic area} - \text{End systolic area}}{\text{End-diastolic area}} \times 100\%
  \]

- Obtained by tracing RV endocardium both in systole and diastole from the annulus, along the free wall to the apex, and then back to the annulus, along the interventricular septum.

- Include trabeculations and bands inside the chamber.

- RV focused apical 4 chamber view.

Abnormal RVFAC < 35%

2D Fractional Area Change is one of the recommended methods of quantitatively estimating RV function.

Tissue Doppler Imaging S’ Velocity

- SV placed in the lateral annulus parallel to free wall
- keep the basal segment and the annulus aligned with the Doppler cursor
- Simple, reproducible → should be used in the assessment of RV function
- Angle dependent
- s’ < 9.5 cm/s is abnormal

- SV (also multiple) is placed after image acquisition (off line analysis)
- Angle dependent
- Lower absolute values and reference ranges than pulsed TDI s’ wave. Abnormal s’ < 6 cm/s

RV IMP (Tei Index)

- Global systolic and diastolic function
- Less affected by HR
- Prognostic value

\[
\text{IVCT + IVRT} \quad \text{ET} \\
\text{TCO} - \text{ET} \quad \text{ET}
\]


Pulsed Doppler: Normal ≤ 0.43

Tissue Doppler: Normal ≤ 0.54
Global Longitudinal Strain using speckle tracking imaging

- Strain: the degree of myocardial deformation compared with its original length \([L_0]\) (%) → RV free wall from base to apex
- Established prognostic value
- Angle independent, no tethering effect
- RV GLS: average of 3 segments (reproducible & recommended)
- Abnormal finding: > -20% OR -[< 20] %


- RV-focused apical four-chamber view
- Trace RV basal free wall → apex
- Don’t start from too low (anulus)
- RoI: Myocardium (exclude pericardium)
The Right Ventricle 3 Dimension Imaging

- Needs specific software and requires offline analysis with experience operator
- Includes RV outflow tract contribution to overall function
- Correlates with RV EF by CMR
- Load dependency and dependent on adequate image quality

Temporal resolution > 20–25 vol/sec

- 3D data set is acquired from a RV focused apical 4 chamber view by stitching together the subvolumes generated from 4-6 consecutive beats.
- Minimal depth and optimal sector angle (should recover entire RV)
- The RV endocardial surface is semi automatically traced (end-systole and end-diastole).
- Myocardial trabeculae and moderator band should be included in the cavity
- 3D surface model → RV EDV and ESV, stroke volume, and EF.

Conclusion

1. Assessment of RV size and function is important but **challenging** because of it’s complex geometry, location behind the sternum, at near field us the echo view, and coarse trabeculation

2. Eye balling assessment of the right ventricle is **not recommended** because it is inaccurate and shows significant variability

3. **Quantitative assessment** increase accuracy and reduce variability of the measurements

4. It will need **multiple acoustic windows** to assess the RV comprehensively because of the complex geometry

5. The are **guidelines** that recommend how to assess the RV size and function, to standardize the parameters, to improve the diagnosis accuracy and agreement
Thank you