12th Annual Multimodality Cardiovascular Imaging Conference for the Clinician

How Do You Evaluate RV Size and Function?
Is RV Strain the Best Index for RV Systolic Function?

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Disclosures

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- None

Objectives

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- Identify causes of RV dysfunction.
- Highlight the role of echocardiography in the evaluation of RV size and function.
- Review the role of CMR in RV evaluation.

Etiologies of RV Dysfunction

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Causes of RV Dysfunction

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TABLE 1 Etiologies of RV Pressure Overload, Volume Overload, and RV Cardiomyopathy

RV Pressure Overload	RV Volume Overload	RV Cardiomyopathy
Pulmonary hypertension*	Valvular regurgitation	Myocardial infarction
Pulmonary arterial hypertension	Tricuspid	ARVC
Due to left heart disease	Pulmonary	Dilated cardiomyopathy
Due to lung disease and/or hypoxia	Systemic-to-pulmonary shunt	Hypertrophic cardiomyopathy
CTEPH and other pulmonary artery obstructions	Atrial septal defect	Amyloidosis
Unclear and/or multifactorial mechanisms	Partial anomalous pulmonary vein drainage	Myocarditis
Pulmonary valve stenosis	High output states† (i.e., thyrotoxicosis)	Sarcoid
Pulmonary artery stenosis		Transplant
Pulmonary embolism		Post-surgery
		Post-LVAD
		Cardiotoxicity (i.e., chemotherapy)
		Sepsis

Sanz et al. JACC 2019

“Right Ventricular Function The Barometer of All That Lies Ahead”

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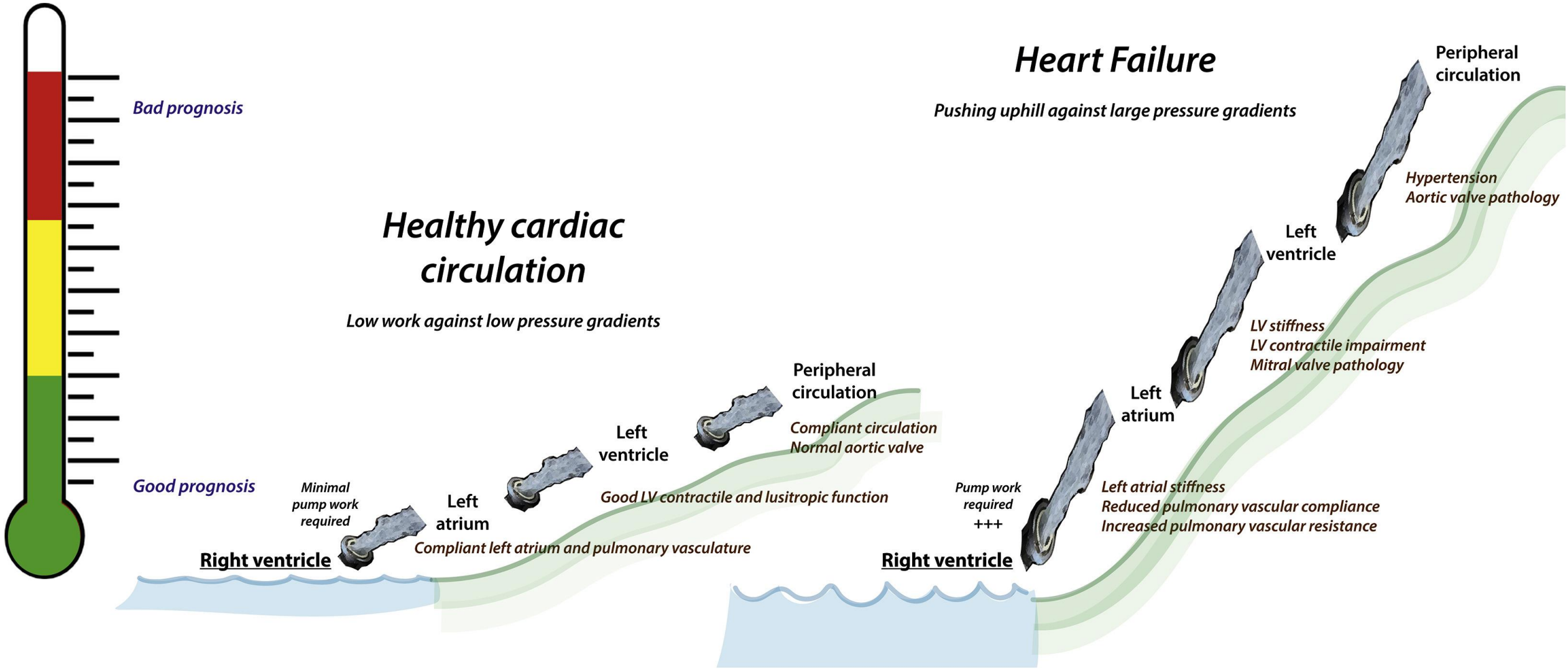

André La Gerche et al. JACC 2019

Echocardiographic Evaluation of RV Size and Function

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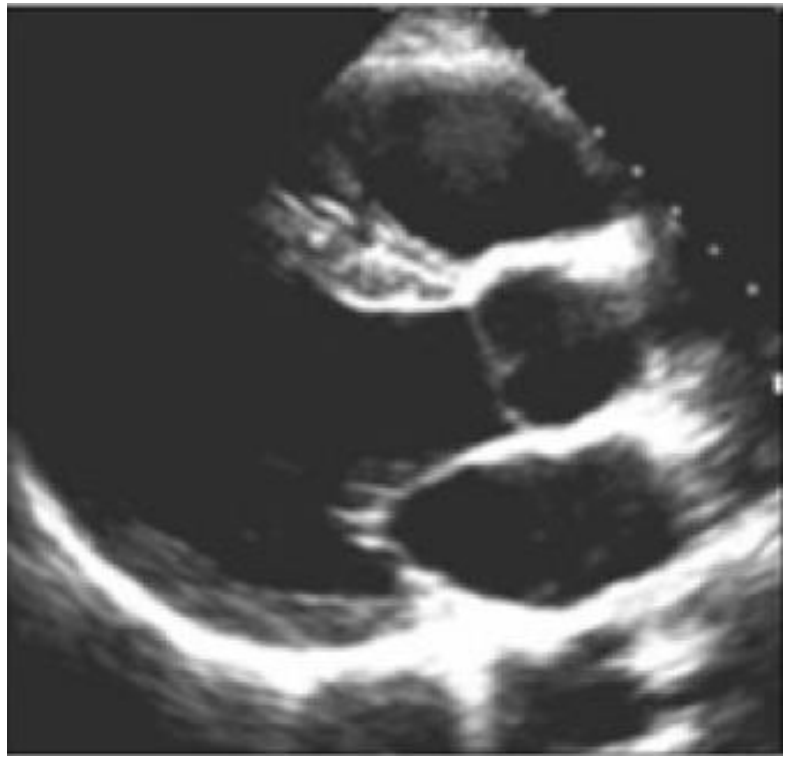
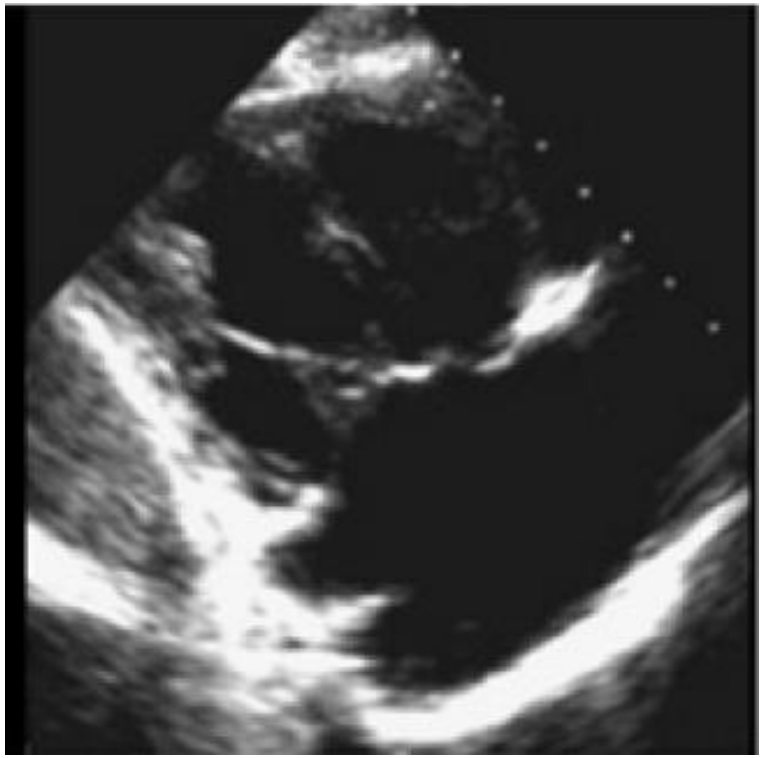
PLAX Views



Anterior RV wall

RVOT and PA



RV inflow

Rudski et al. JASE 2010

PSAX Views

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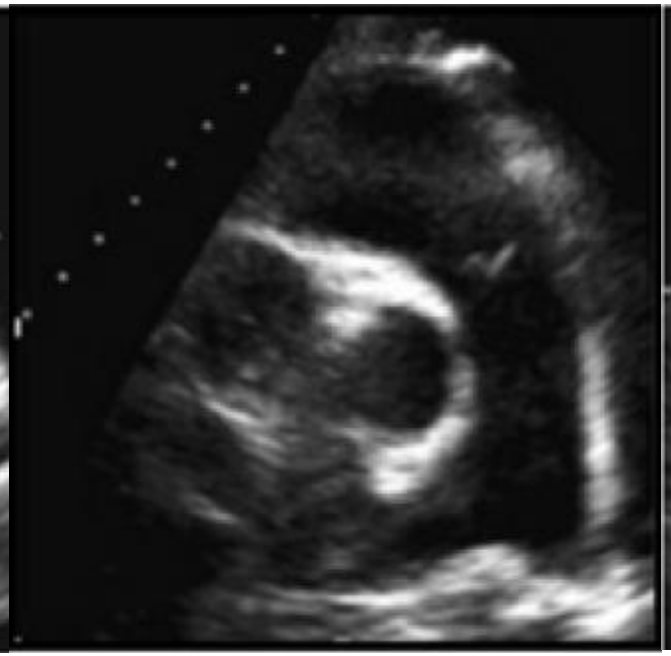
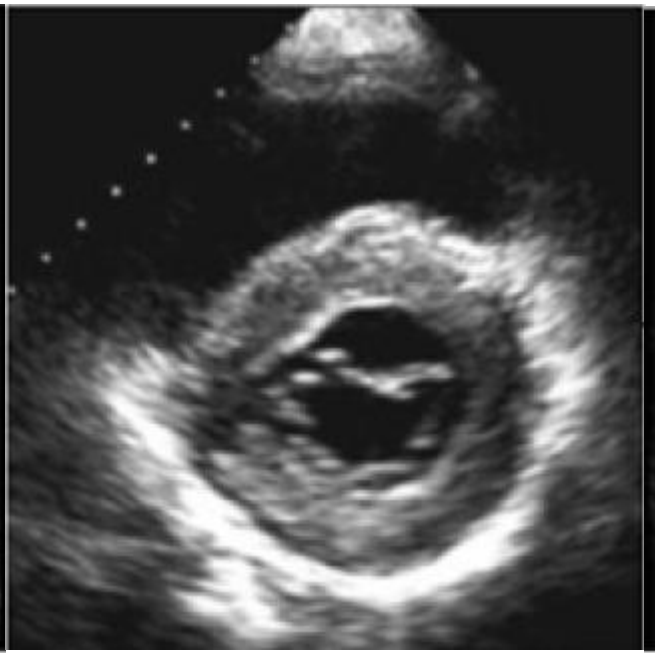
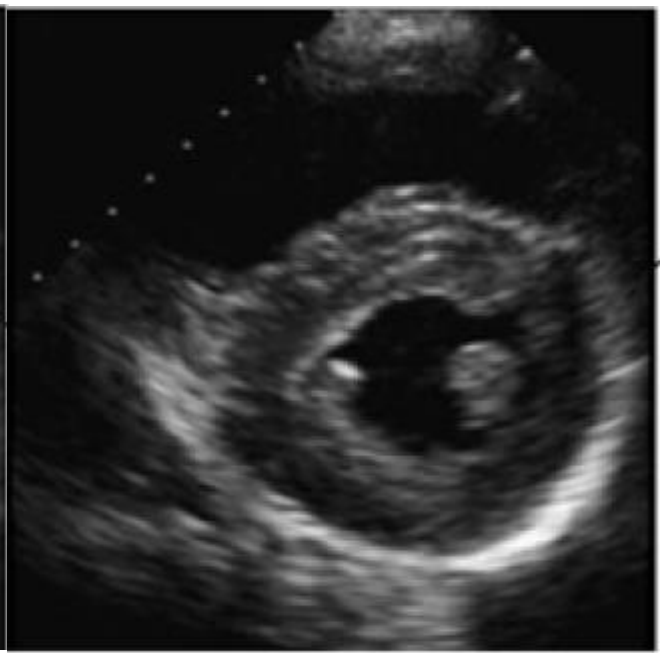
Basal RV



Bifurcation of the PA



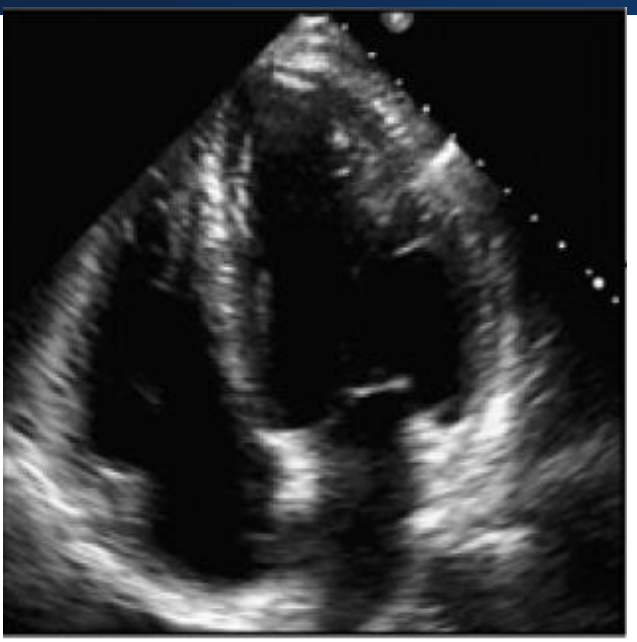
RV short-axis at MV level



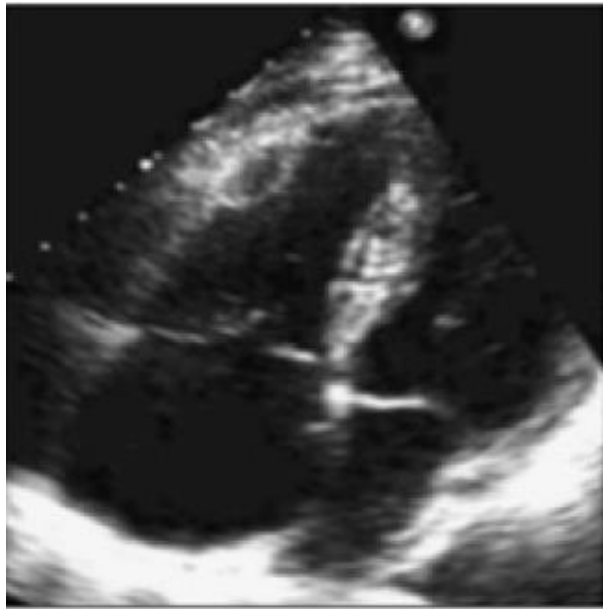
RV short-axis at PM level

Rudski et al. JASE 2010

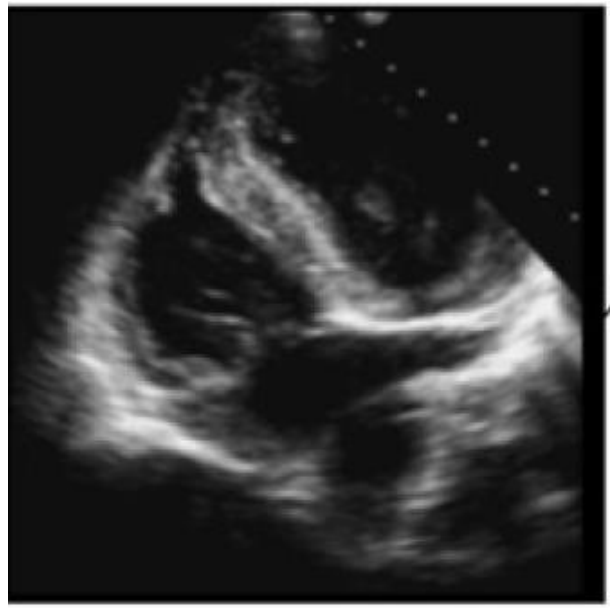
Apical Views



4-chamber view

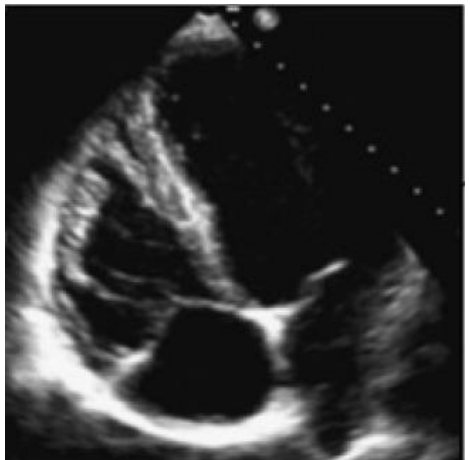


Modified 4-chamber view

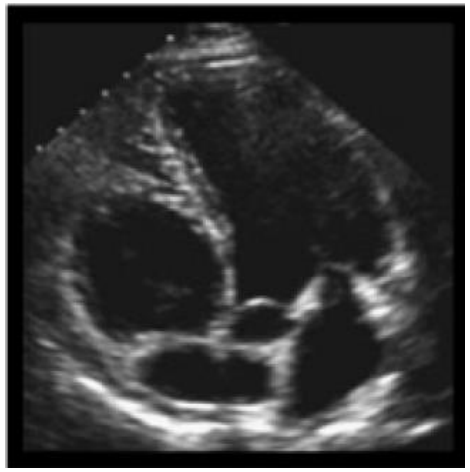


Apical coronary sinus view

RV focused view

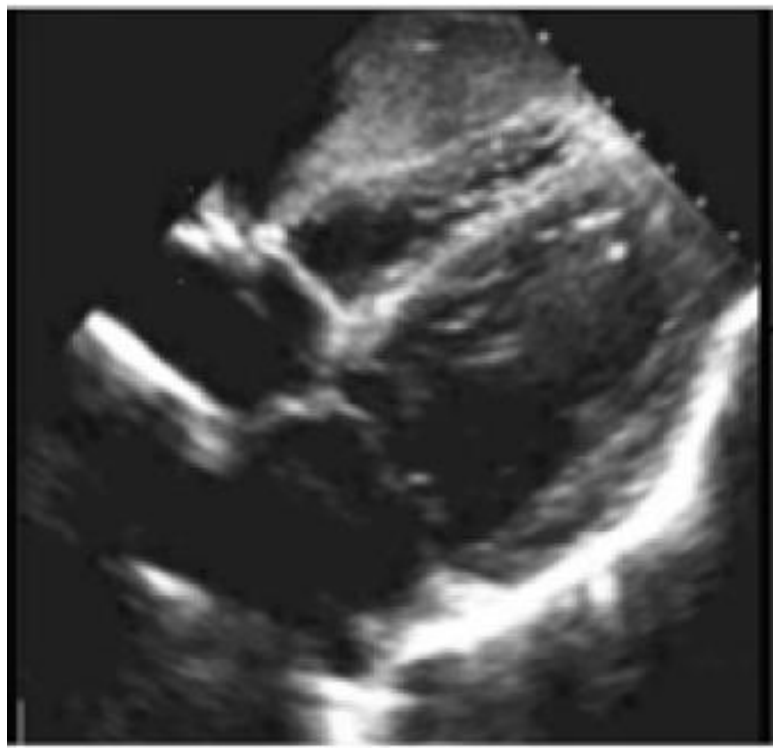


5-chamber view

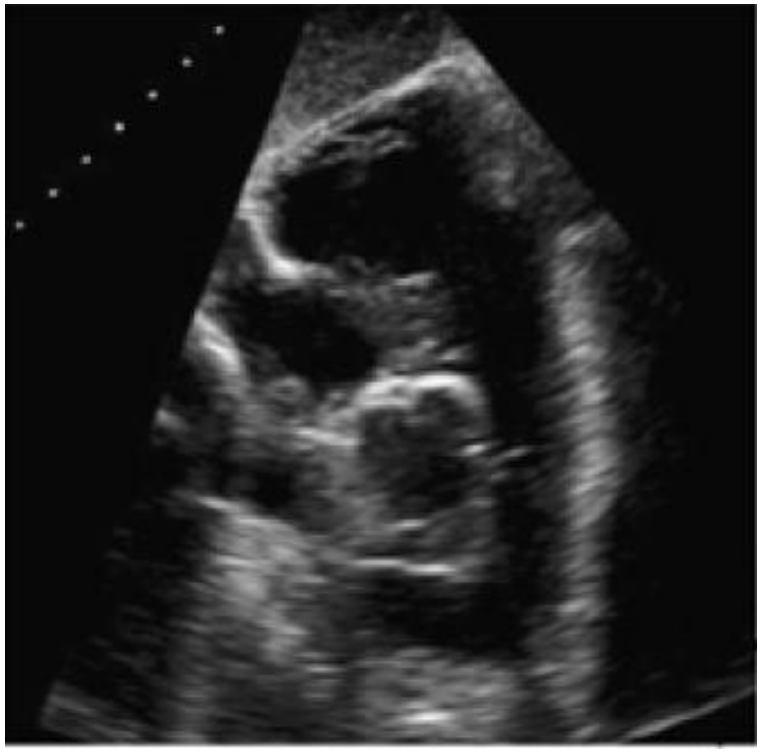


Rudski et al. JASE 2010

Subcostal Views

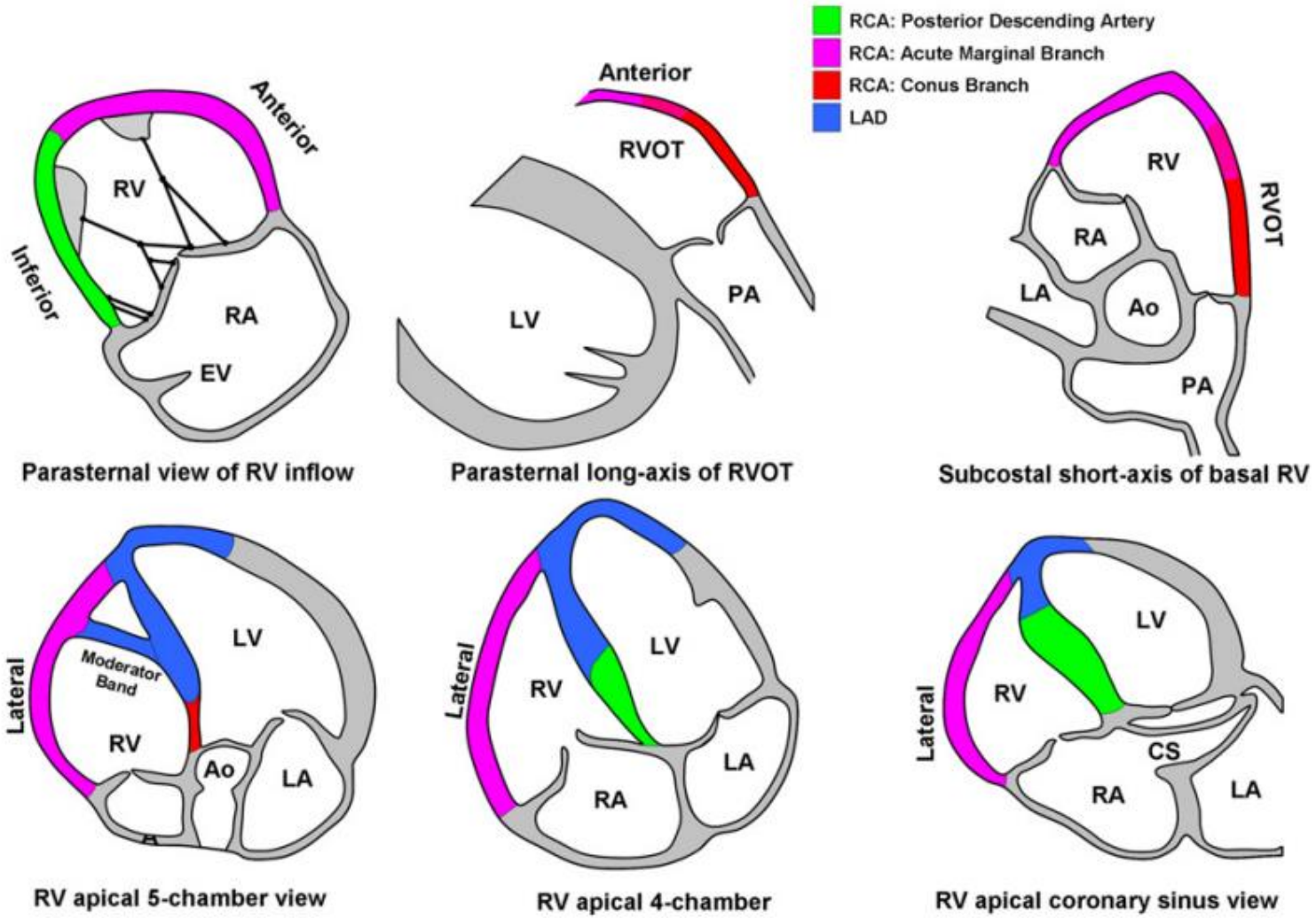


4-chamber view



Short axis view of the basal RV

Rudski et al. JASE 2010



Rudski et al. JASE 2010

Inferior MI complicated by RV infarction

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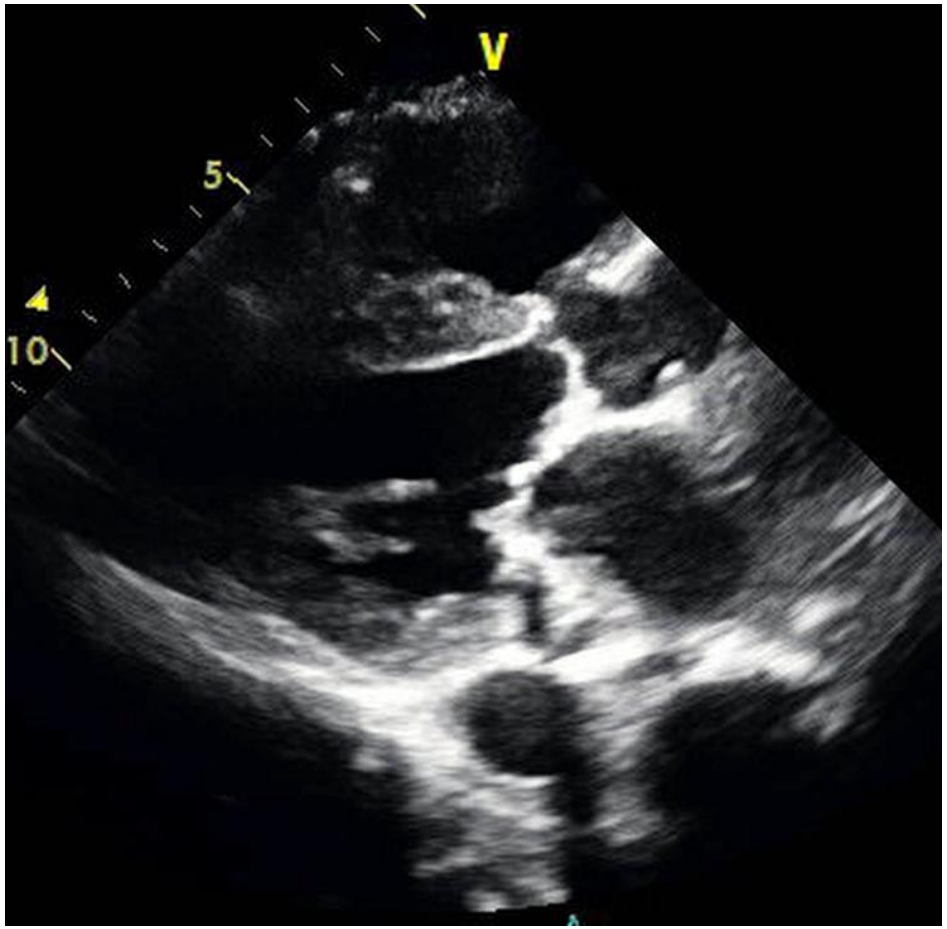

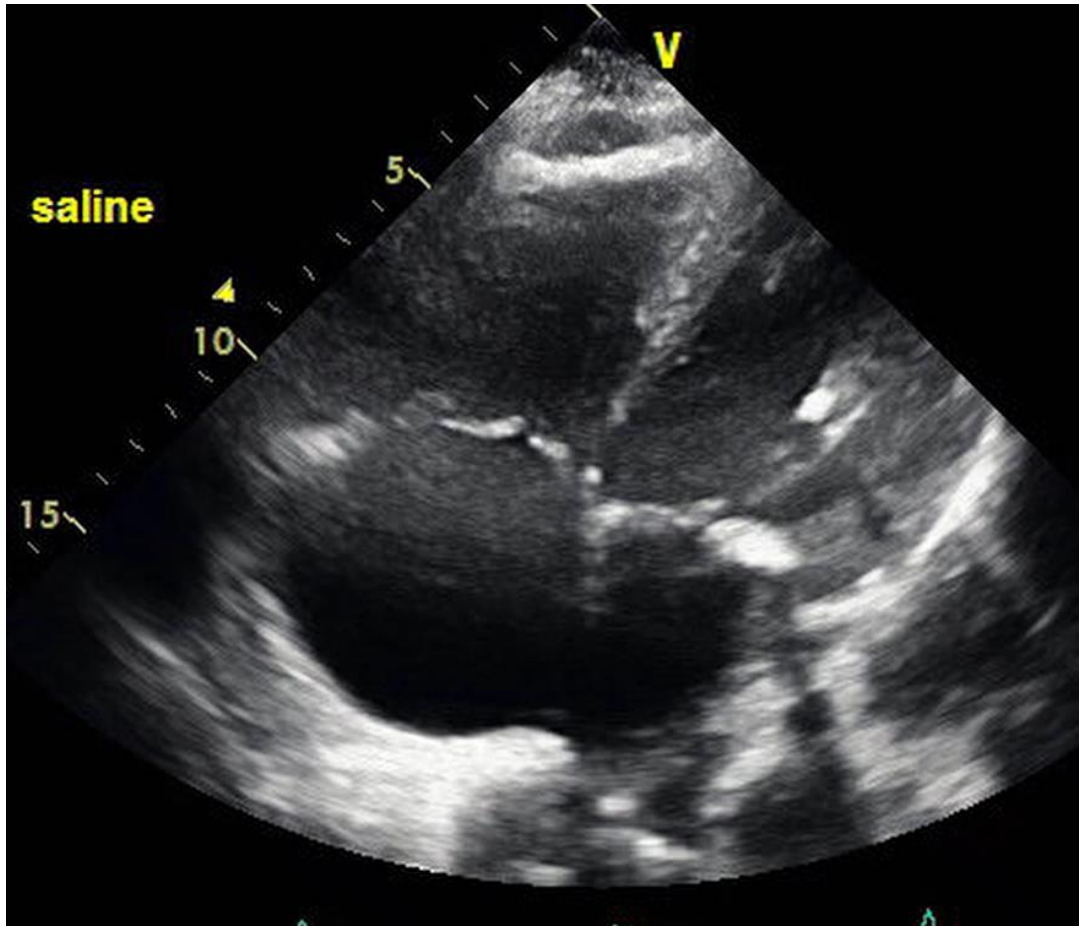

RV Size

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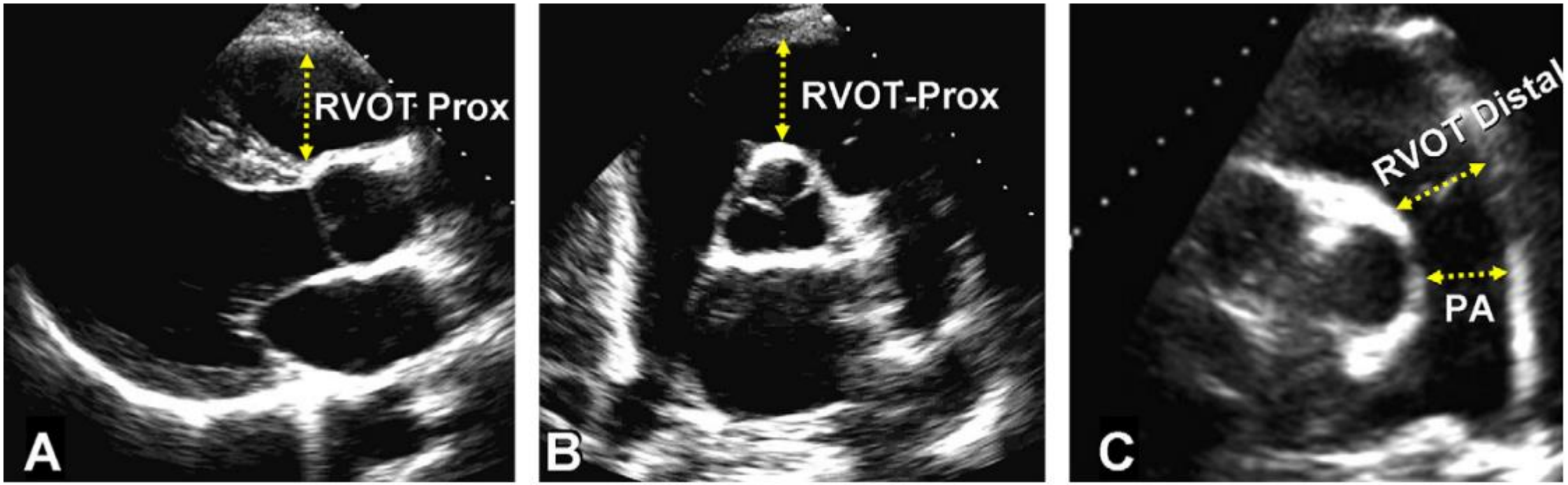
RV dilation

RVOT PLAX diameter > 30 mm **RVOT proximal diameter > 35 mm** **RVOT distal diameter > 27 mm**



Rudski et al. JASE 2010

RV Size

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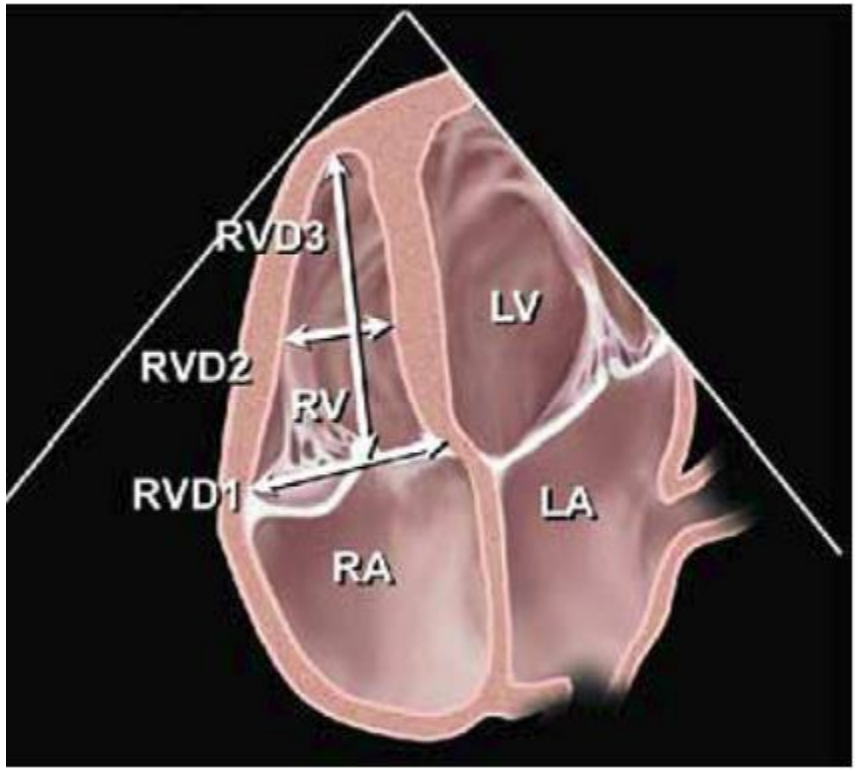
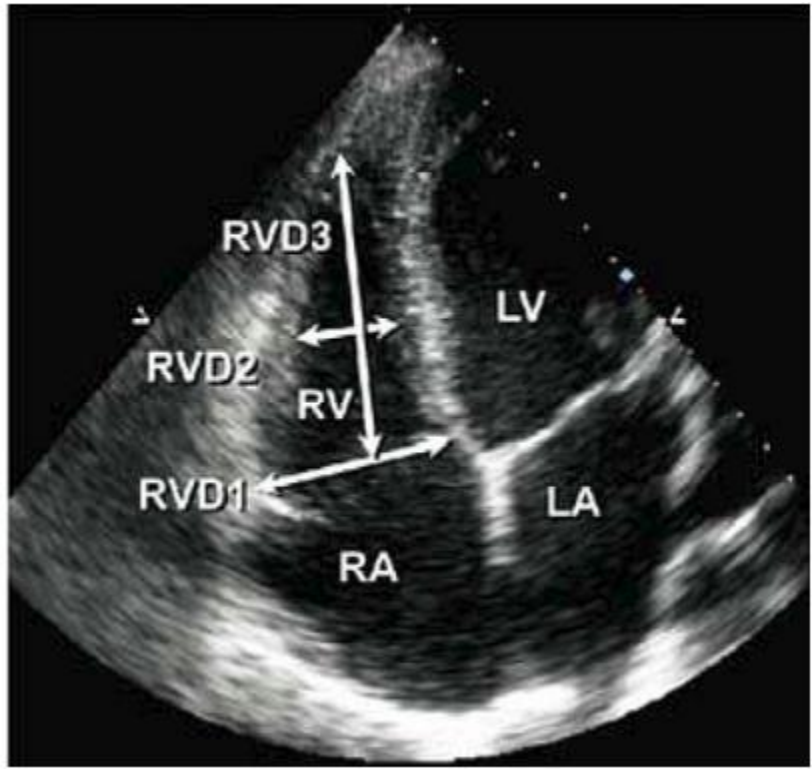
RV dilation

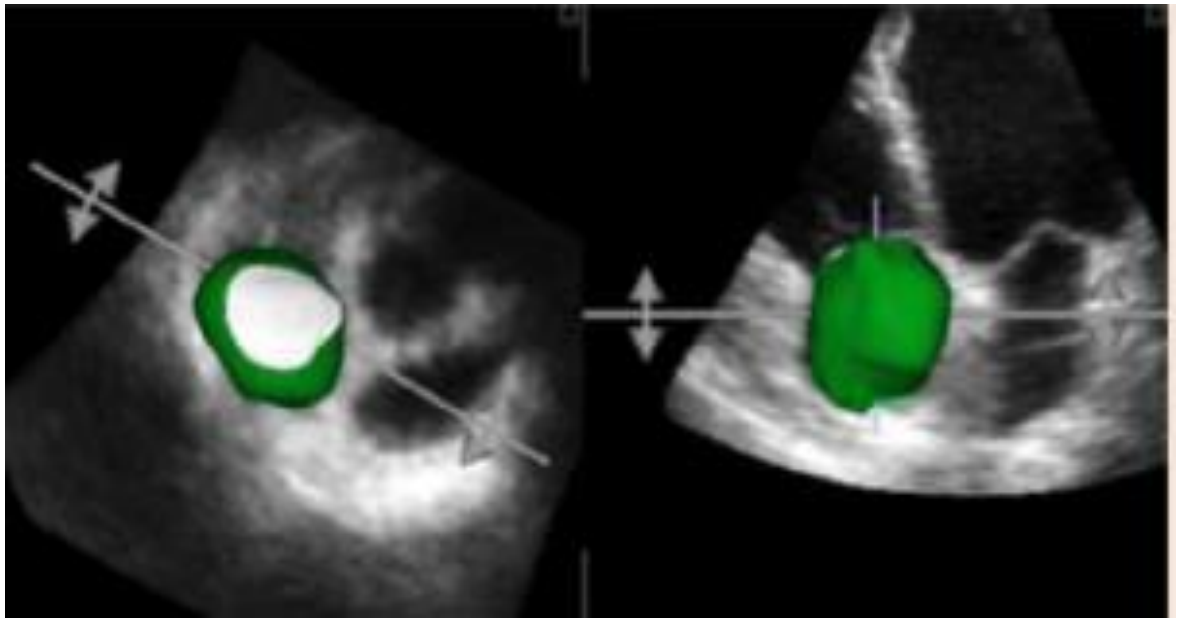
- **RV basal diameter: > 41 mm**
- **RV mid diameter: > 35 mm**
- **RV longitudinal diameter >83 mm**





Rudski et al. JASE 2010

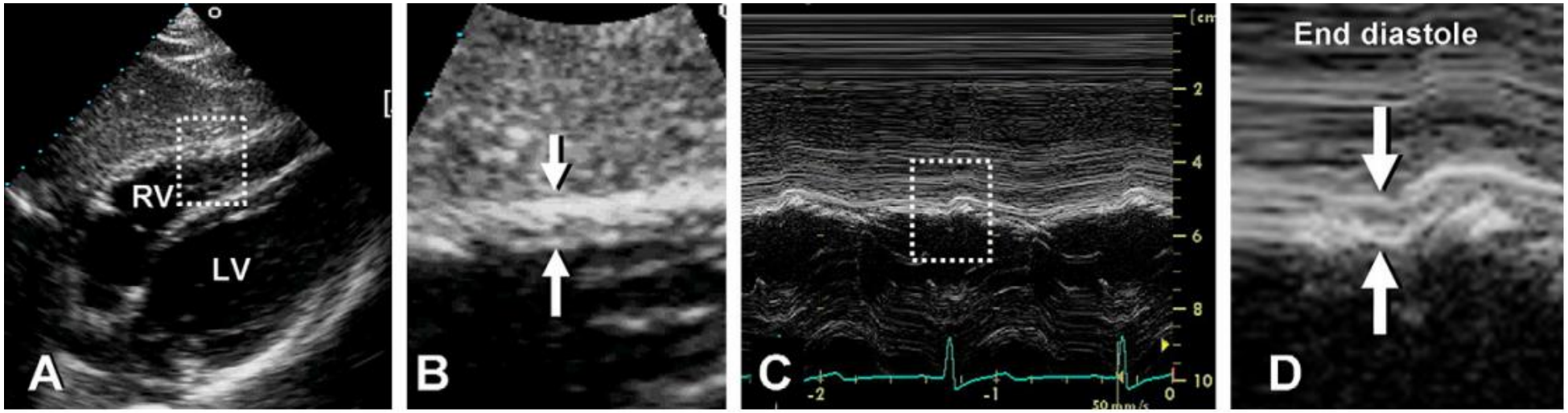
RA Volume



- **The recommended parameter to assess RA size is RA volume**
- **The normal ranges for 2D echocardiographic RA volume are**
  - **21 ±6 mL/m² in women**
  - **25 ± 7 mL/m² in men**

Lang et al. JASE 2015.

RV Thickness



RV hypertrophy: RV end diastolic wall thickness > 5 mm

Rudski et al. JASE 2020

Fractional Area Change (FAC)

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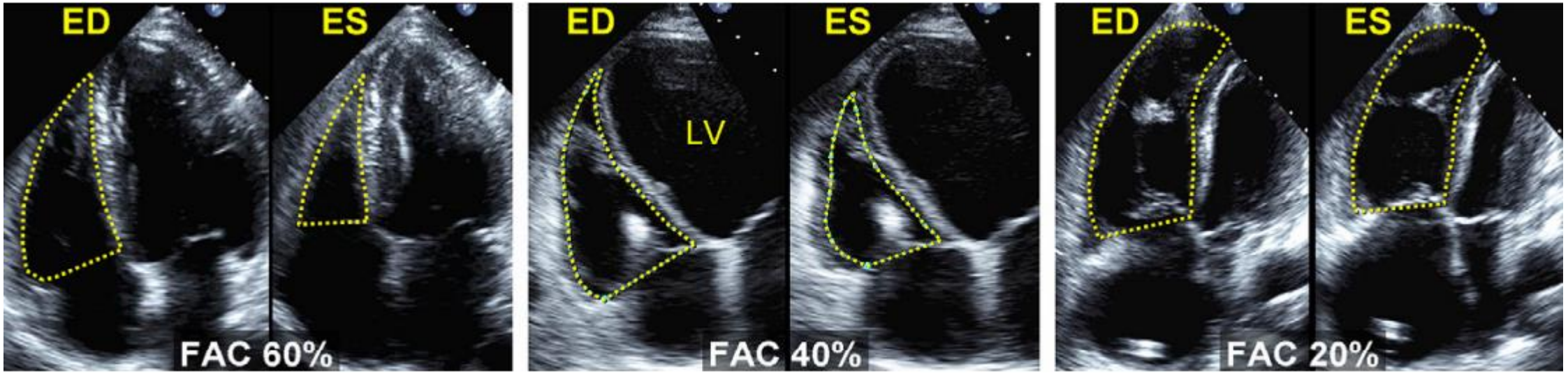
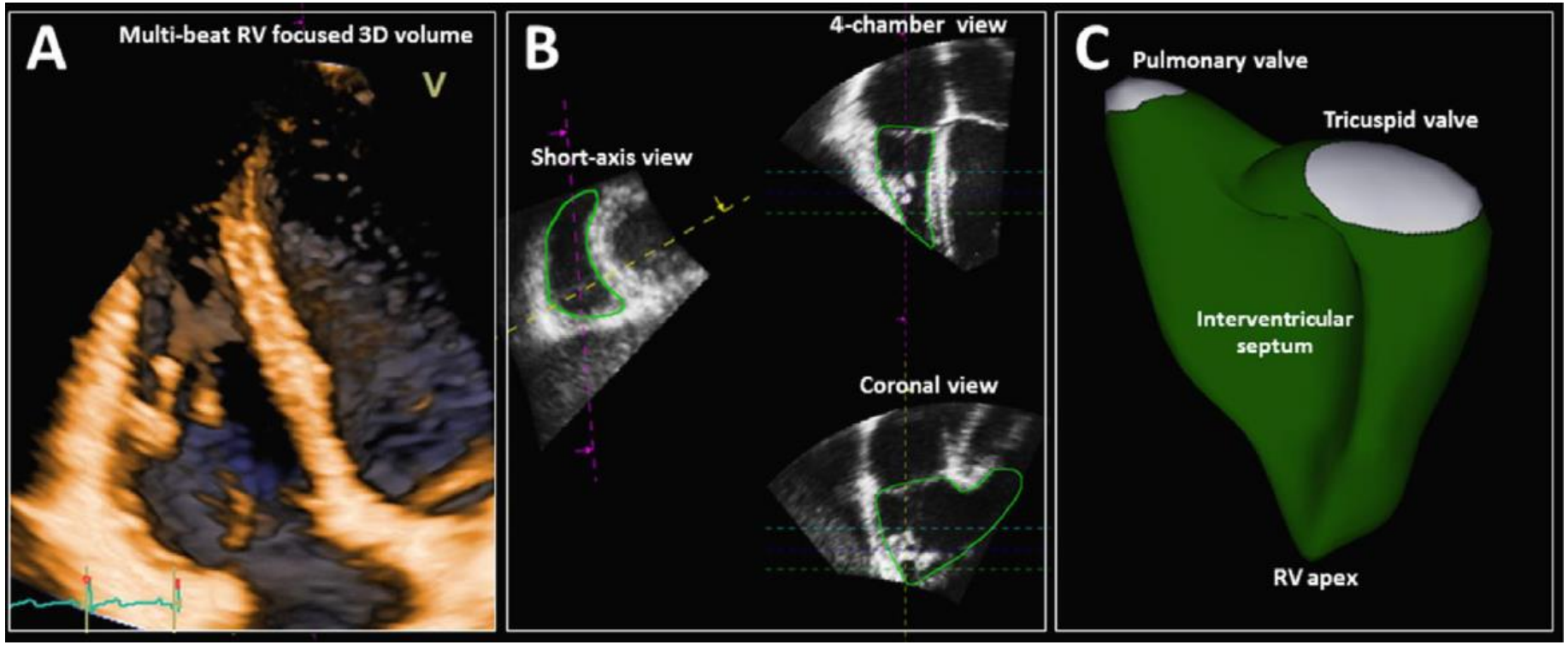
FAC = (EDA-ESA)/EDA



Abnormal RV FAC < 35

Rudski et al. JASE 2020

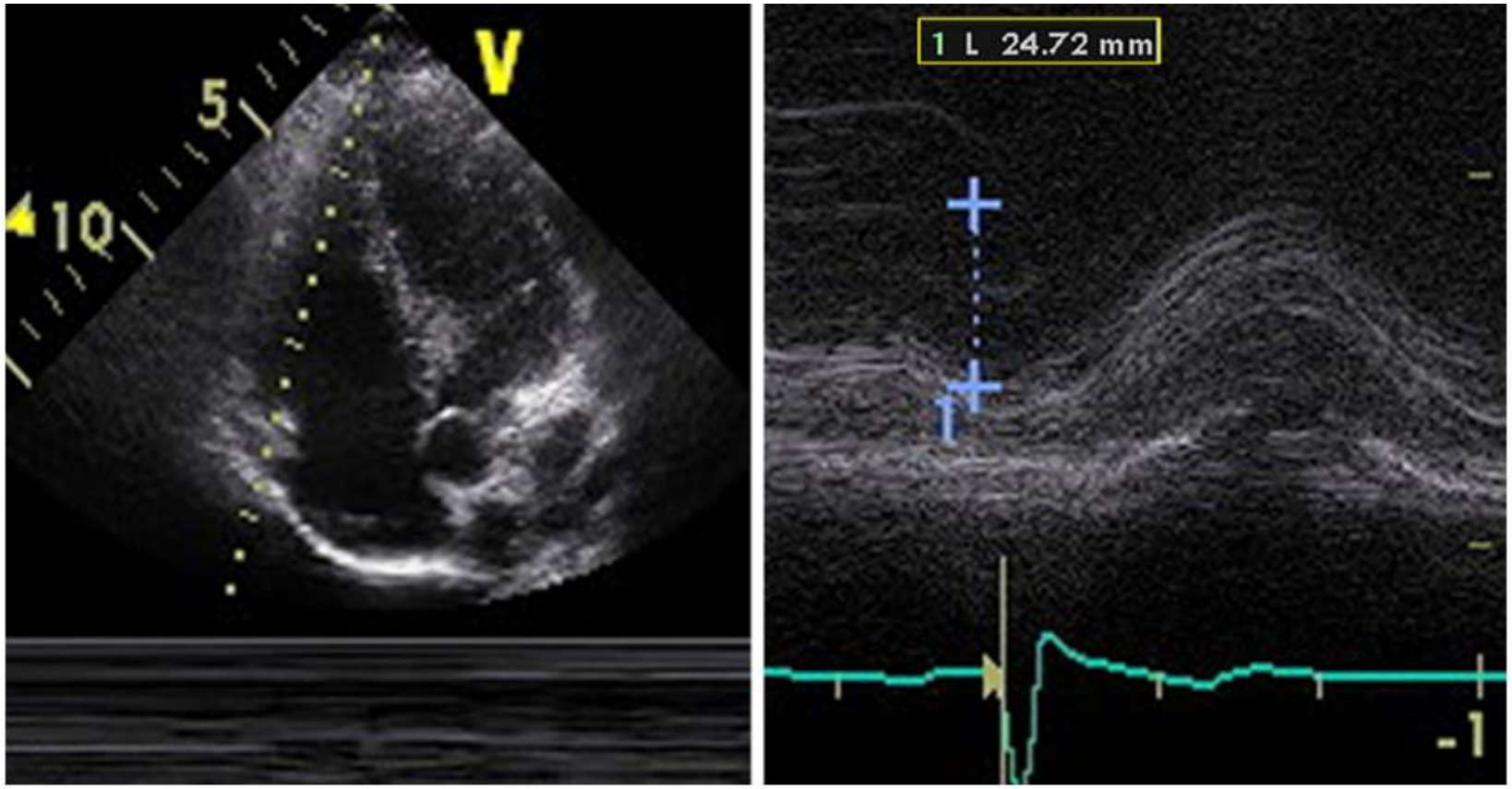
3D RV Volumes and RVEF



Abnormal RV 3D EF <45%

Lang et al. JASE 2015.

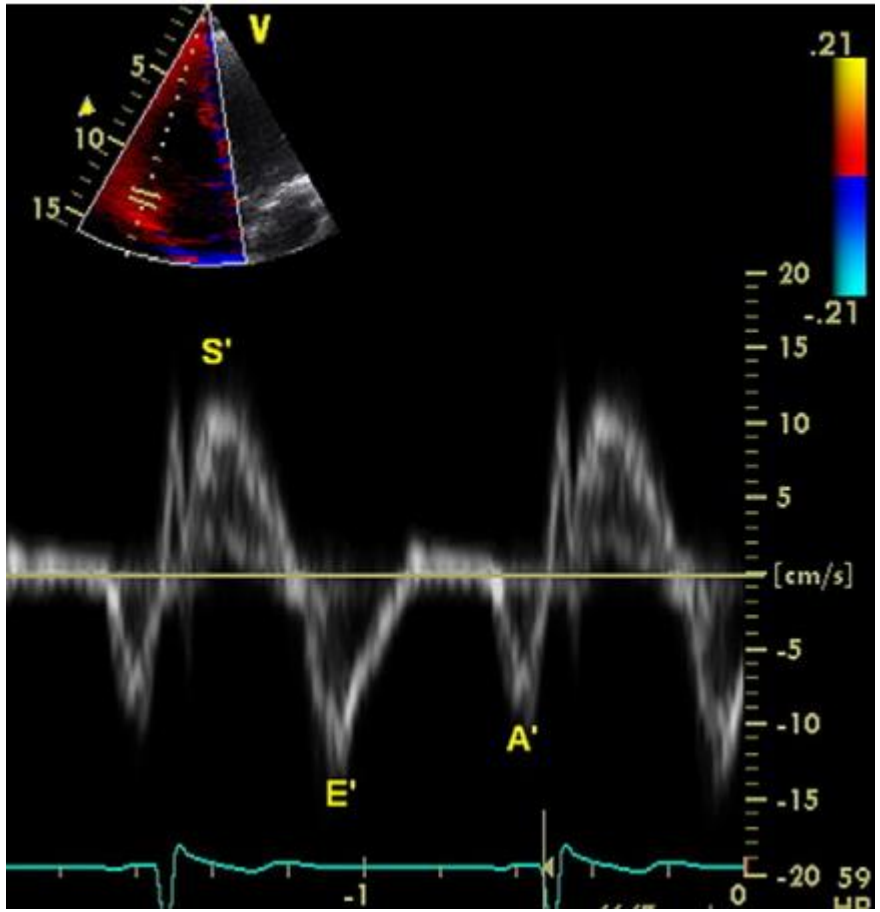
Tricuspid Annular Plane Systolic Excusion (TAPSE)



Abnormal TAPSE <17 mm

Rudski et al. JASE 2020

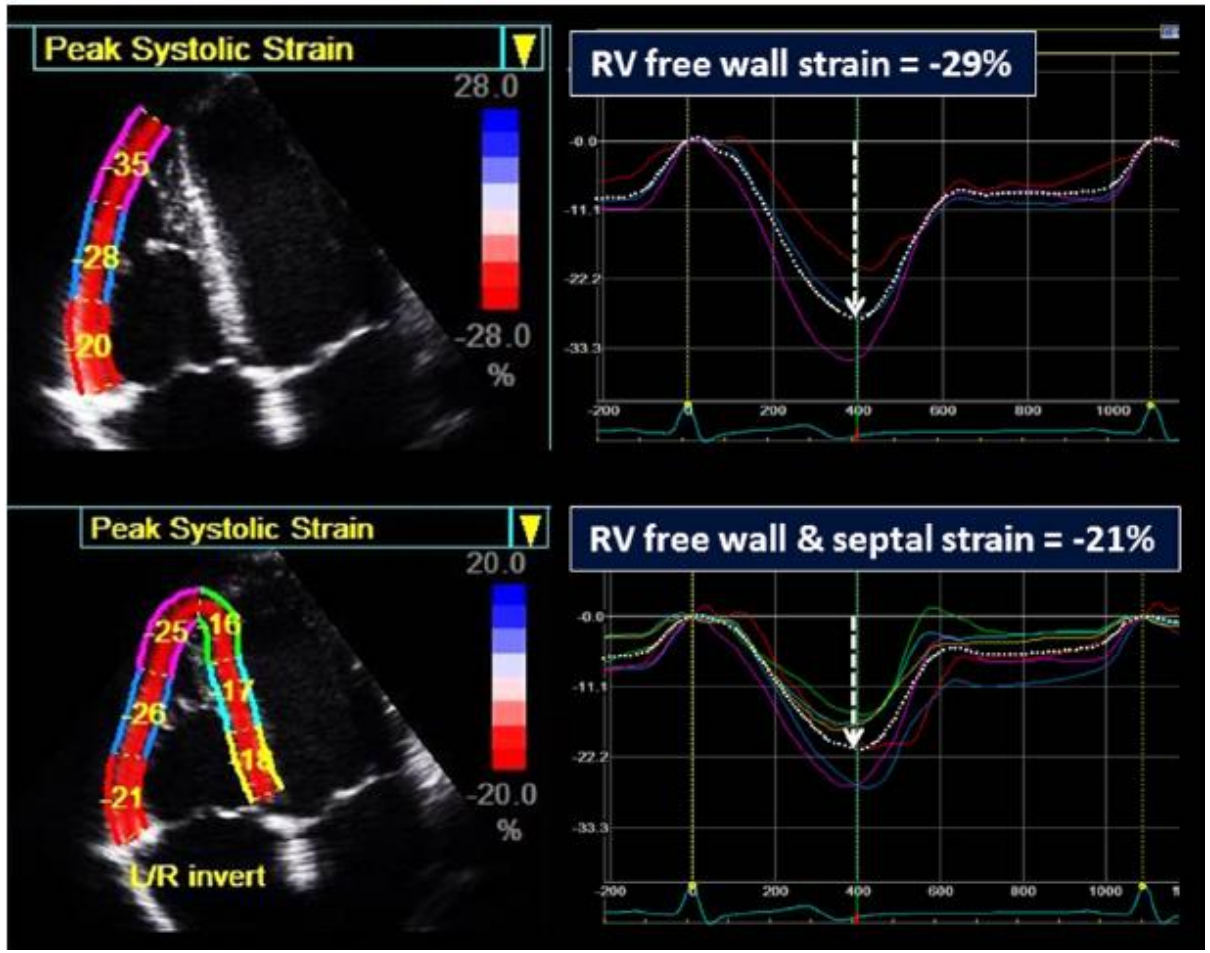
Tissue Doppler of the Tricuspid Annulus



Abnormal Pulsed Doppler S wave (<9.5 cm/sec)

Rudski et al. JASE 2020

RV Strain



Abnormal RV free wall 2D strain > -20%

Lang et al. JASE 2015.

Additive Value of RV Strain

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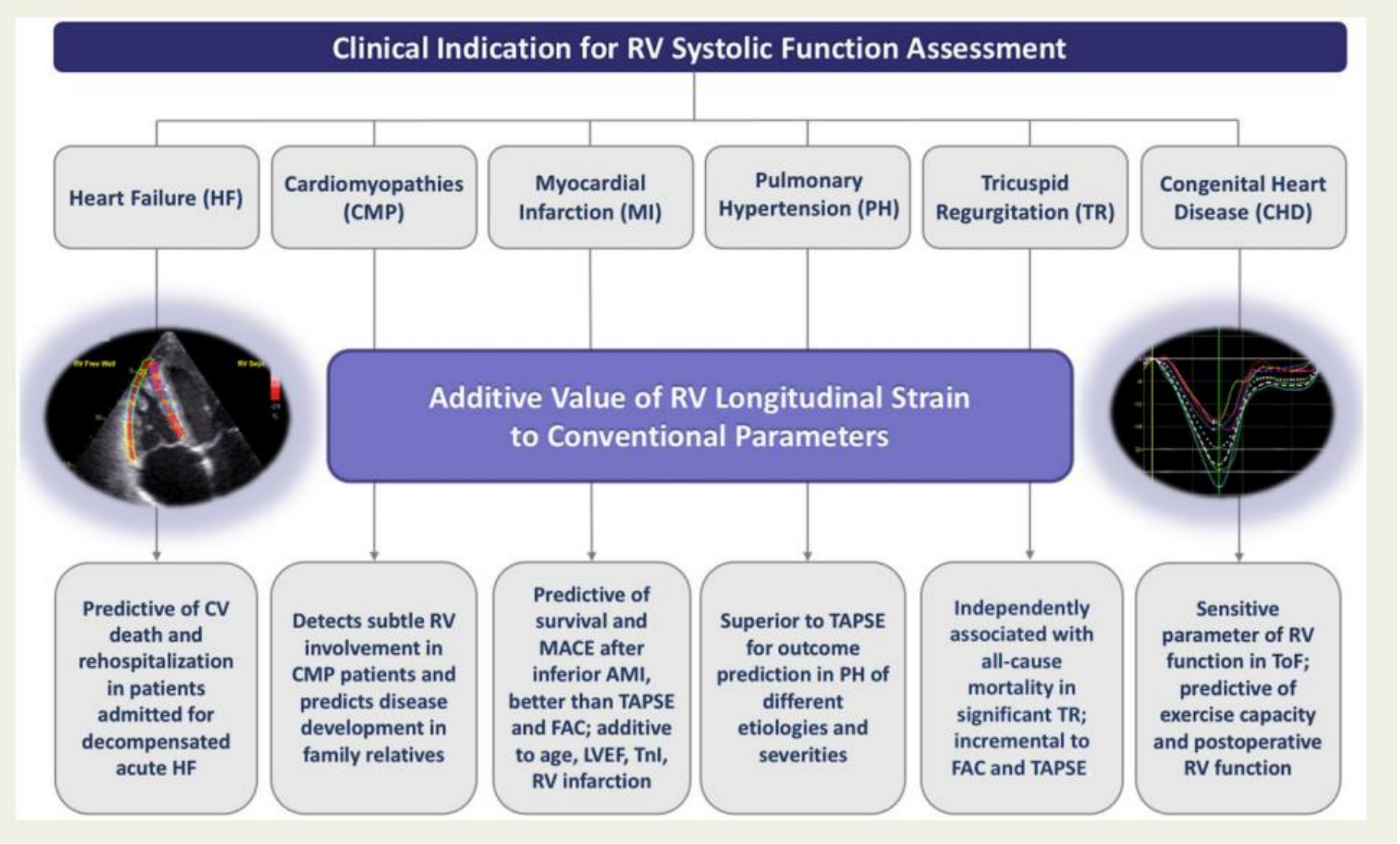
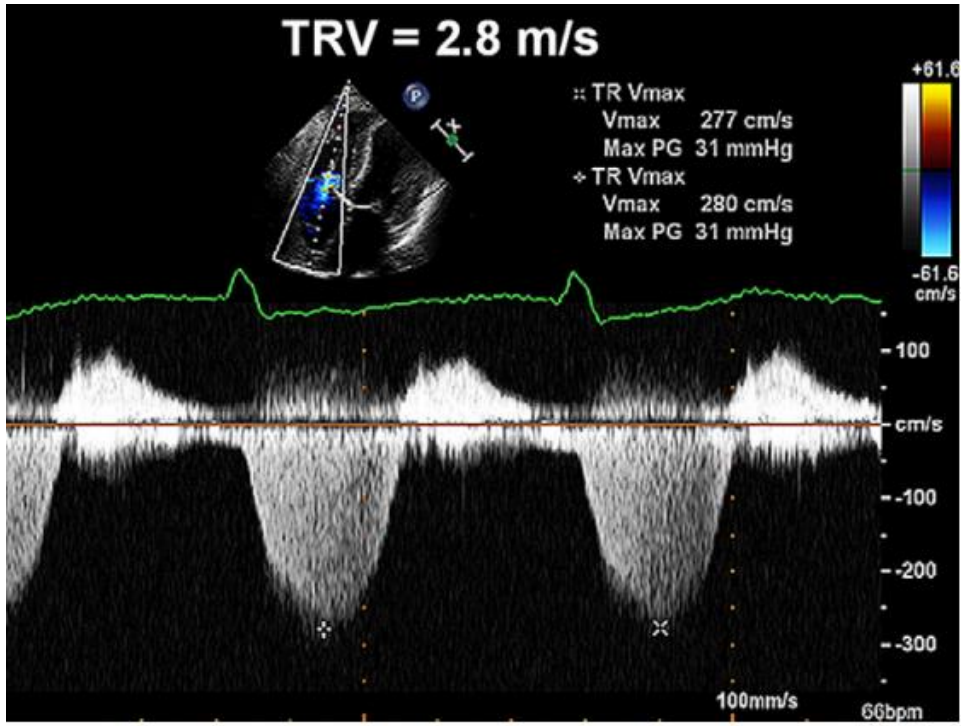
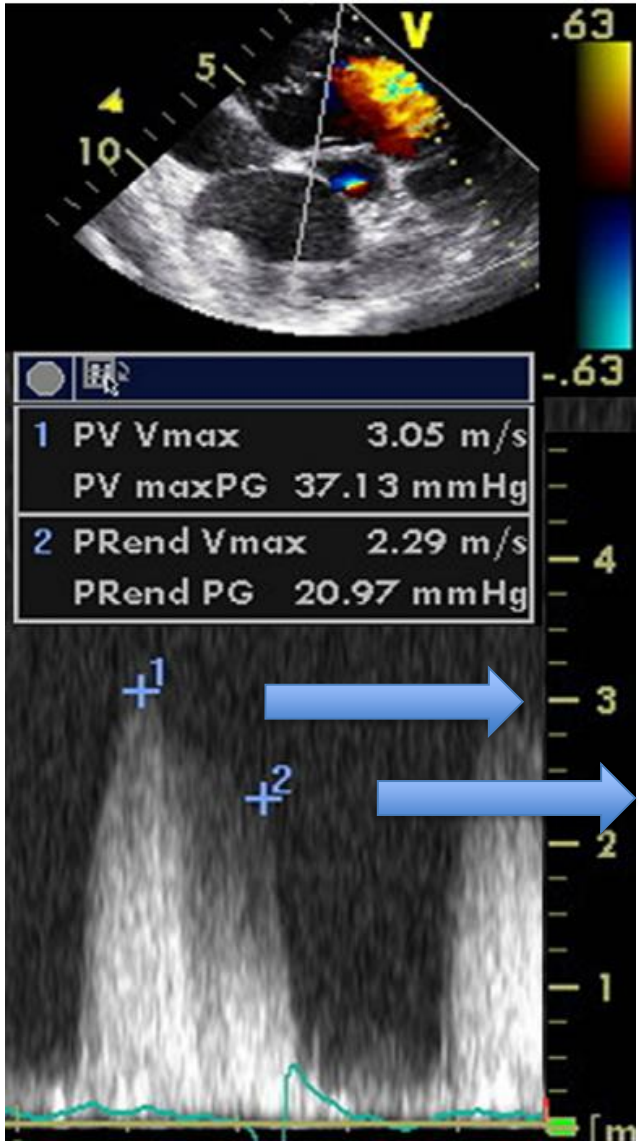


Muraru at al. European Heart Journal - Cardiovascular Imaging (2022) 23, 898–912

Estimation of PA Pressures



$$RVSP=PASP = 4v^2 + RAP$$

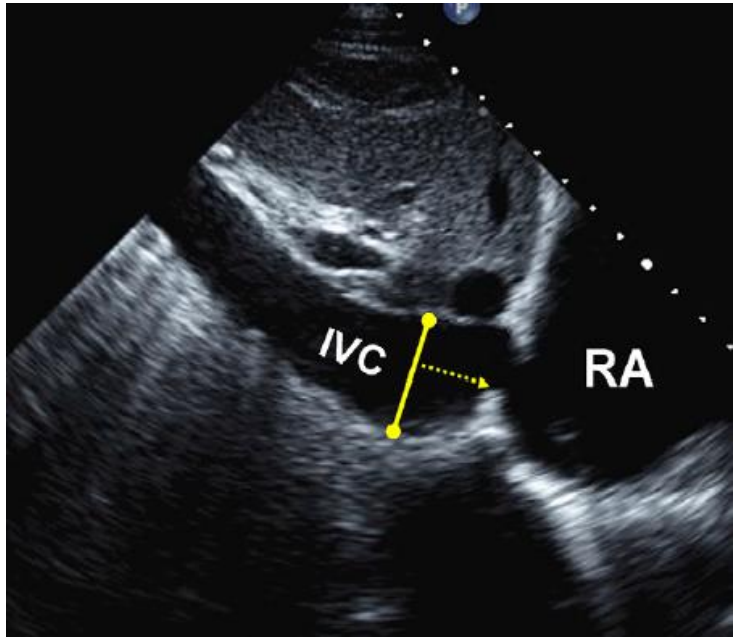


Mean PA pressure

Diastolic PA pressure

Rudski et al. JASE 2020

Estimation of RA Pressures



Variable	Normal (0-5 (3) mm Hg)	Intermediate (5-10 (8) mm Hg)		High (15 mm Hg)
IVC Diameter	≤ 2.1 cm	≤ 2.1 cm	> 2.1 cm	> 2.1 cm
Collapse with sniff	> 50%	<50%	> 50%	< 15%

Echocardiographic Features of pulmonary HTN

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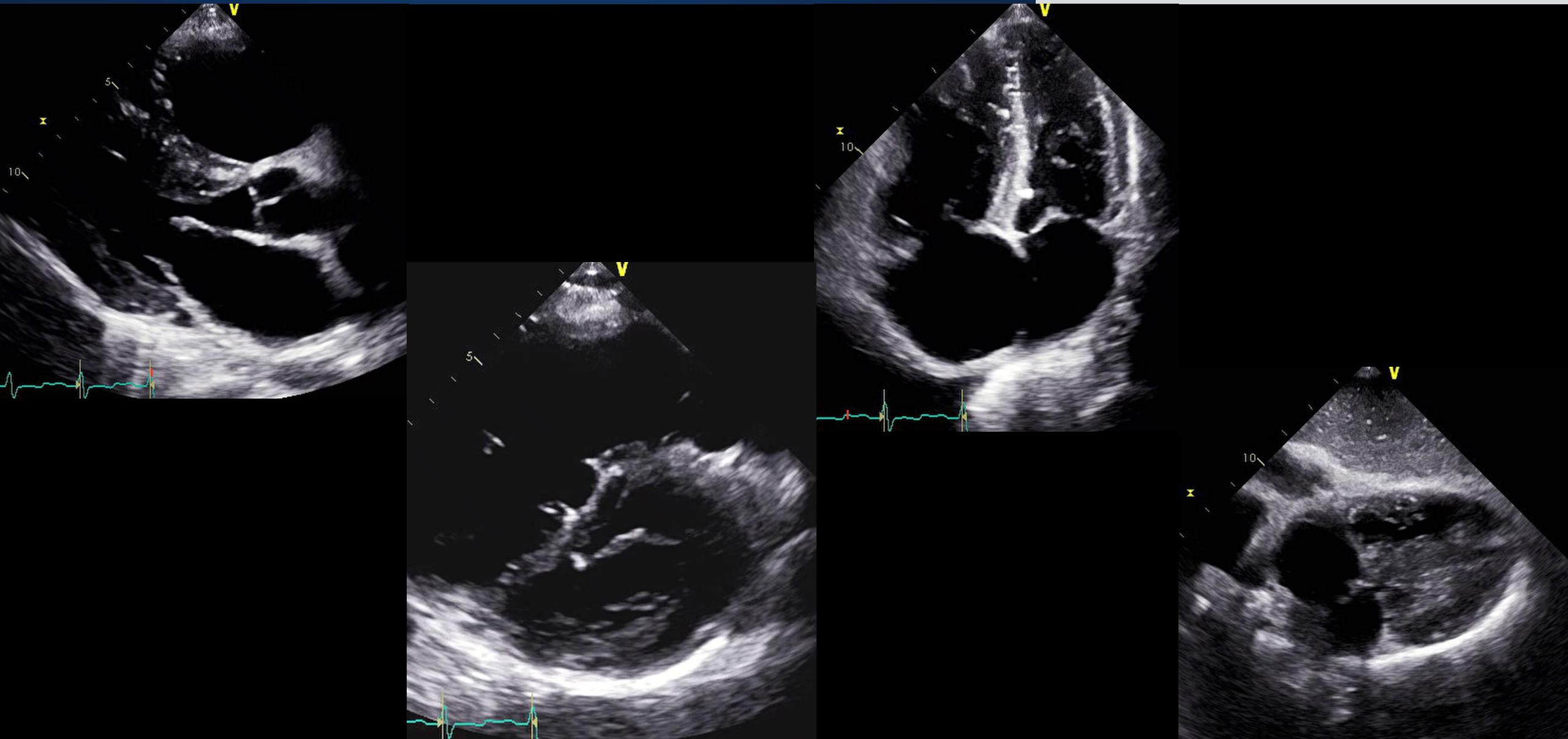
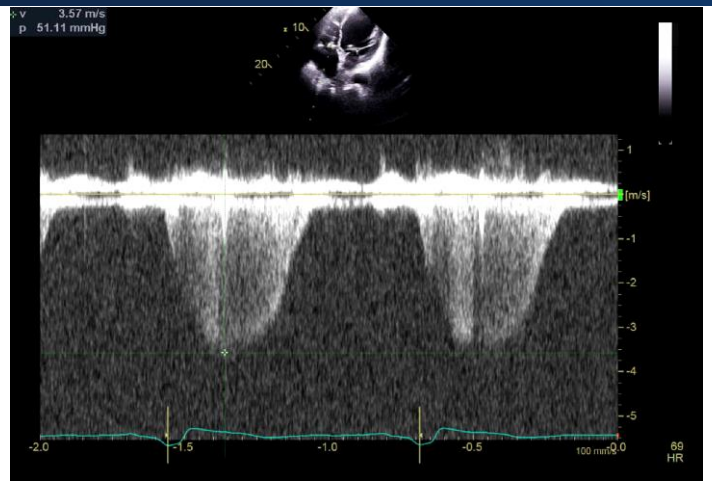
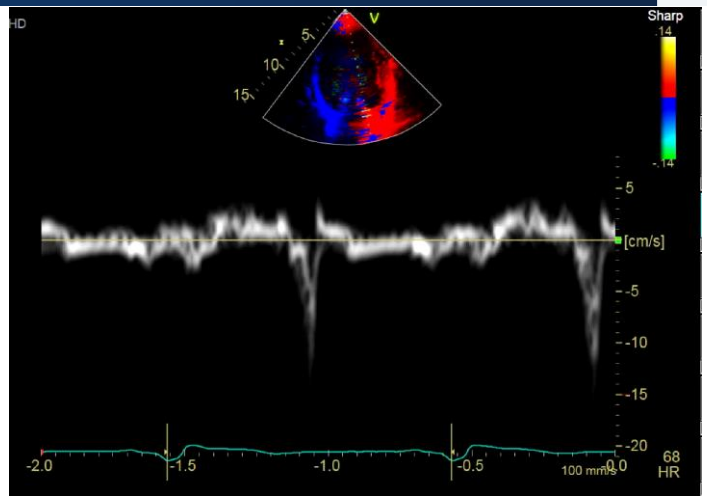


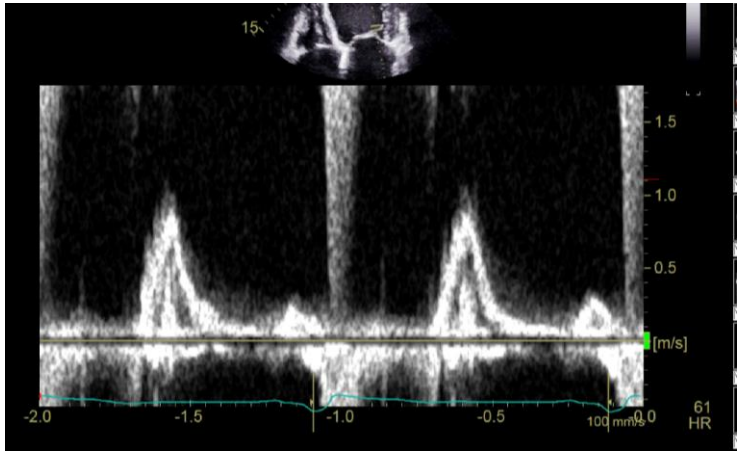
PH related to HFrEF/HFpEF



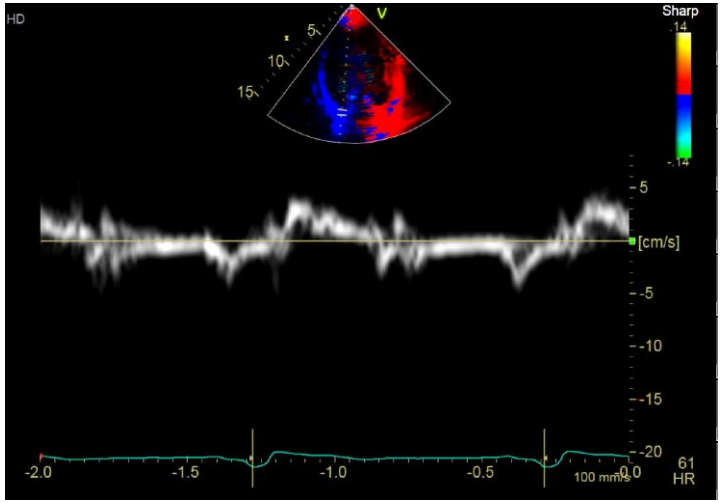
PASP 61 mm Hg

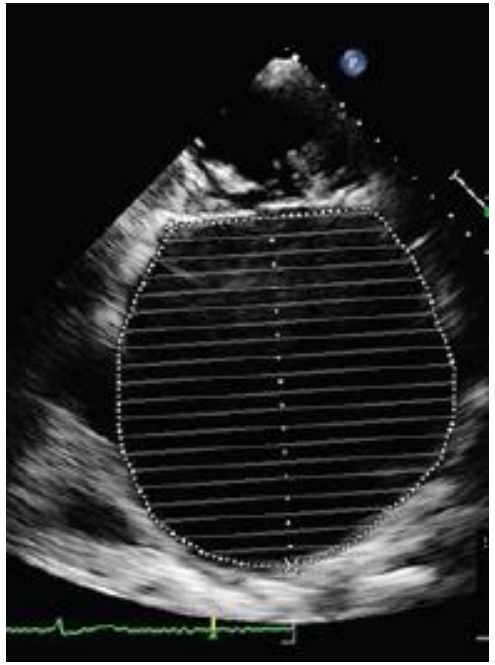


Septal and Lateral E/E' > 14



E/A ratio 2.75





LA dilation

RV Strain Secondary to a PE

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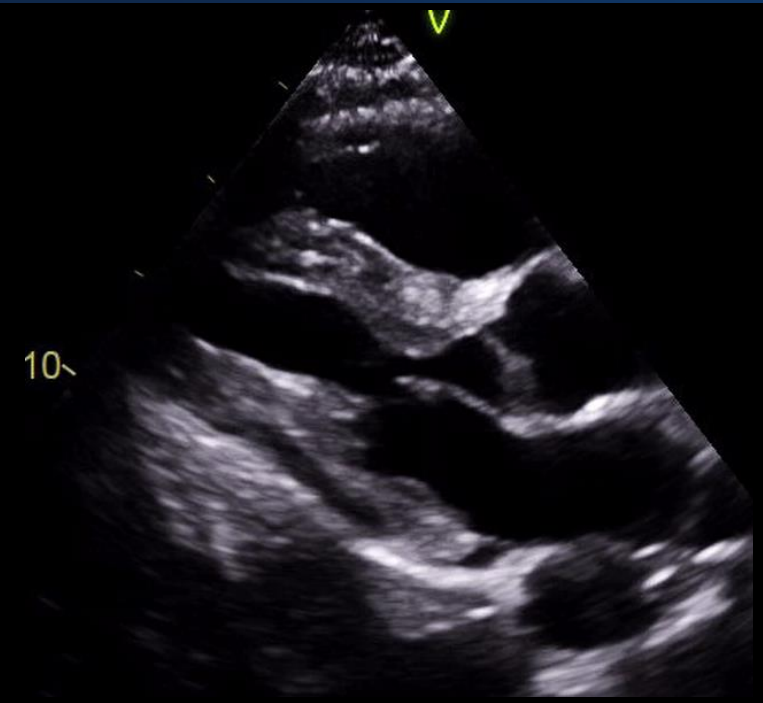

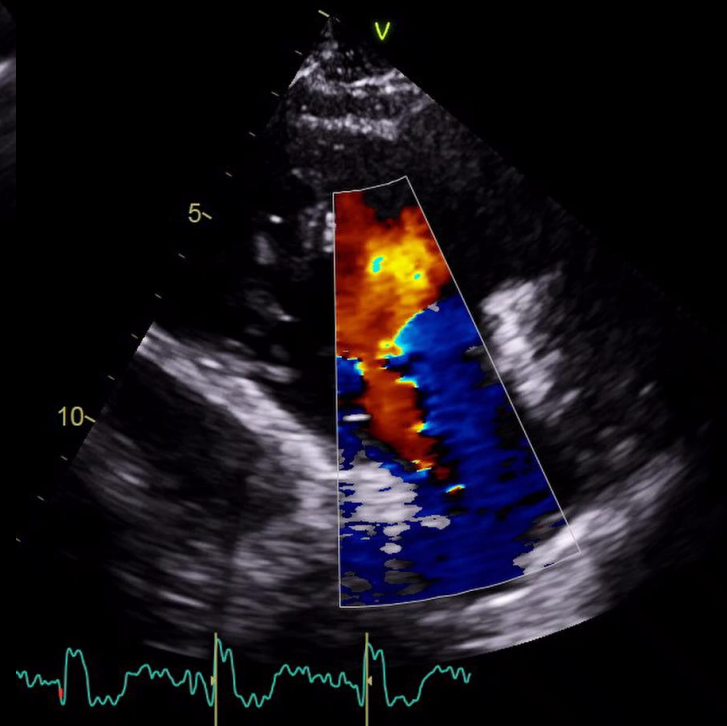

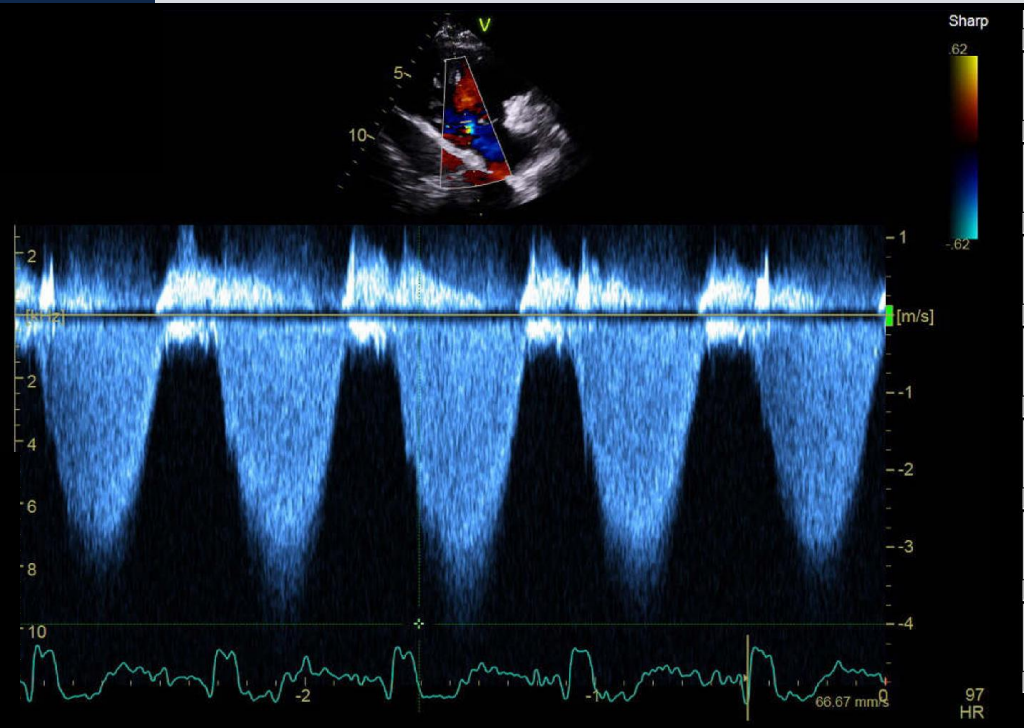

PASP 60 mm Hg

RV Strain Secondary to a PE

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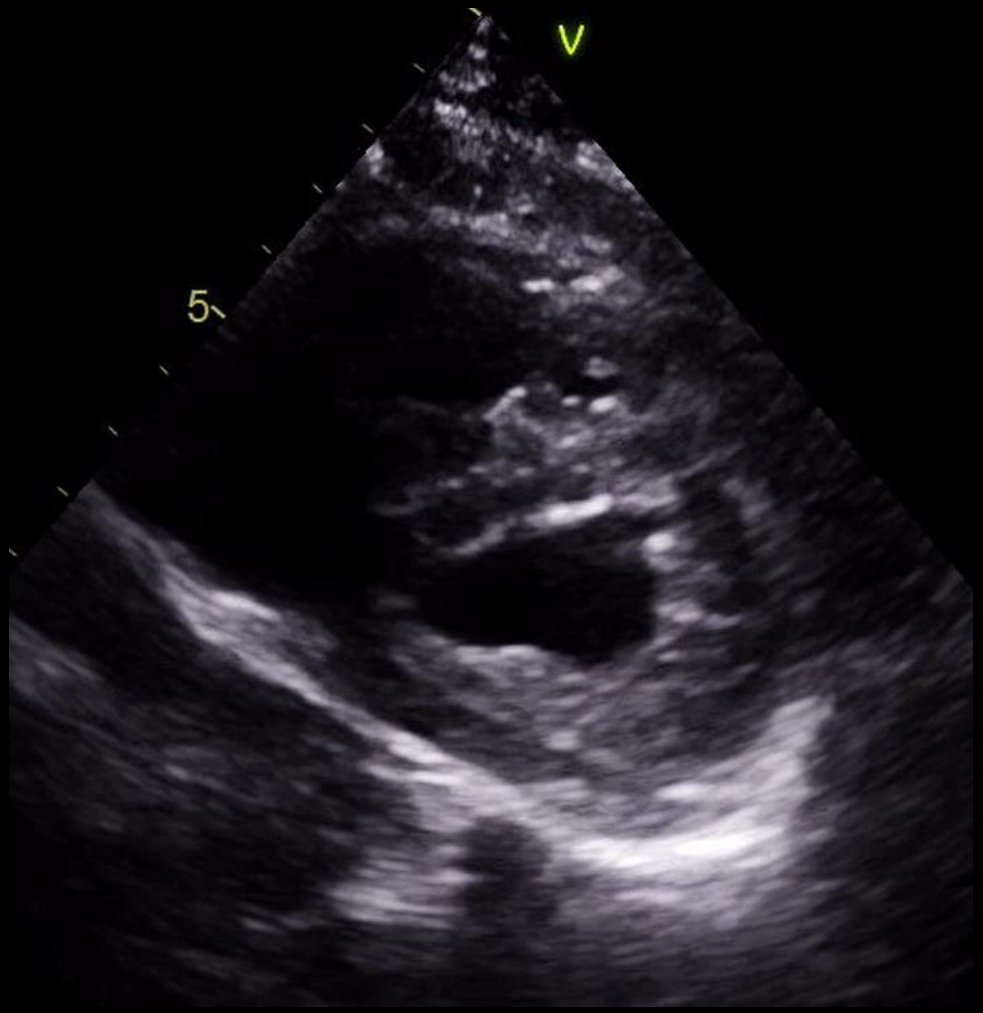
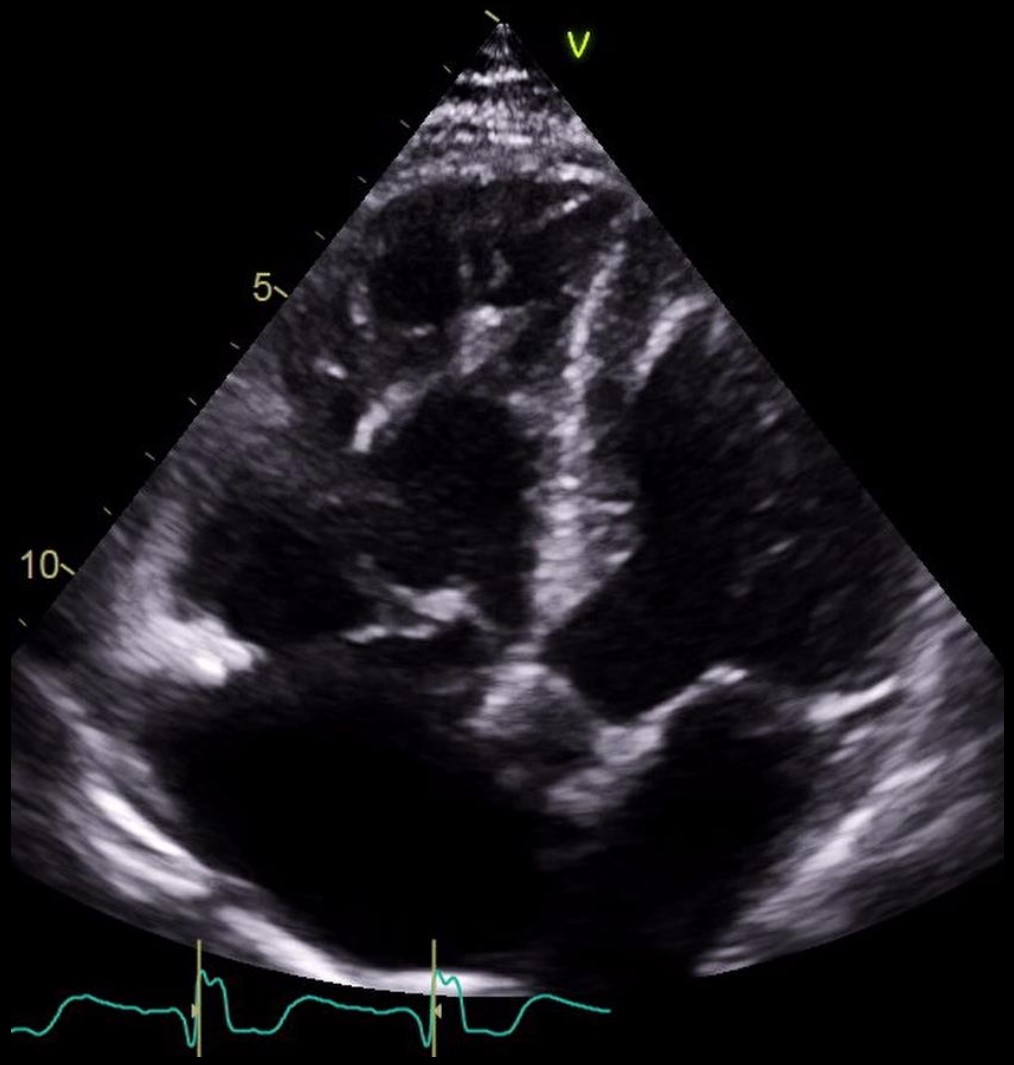


D-shaped septum



McConnell's Sign

Role of CMR in RV Assessment

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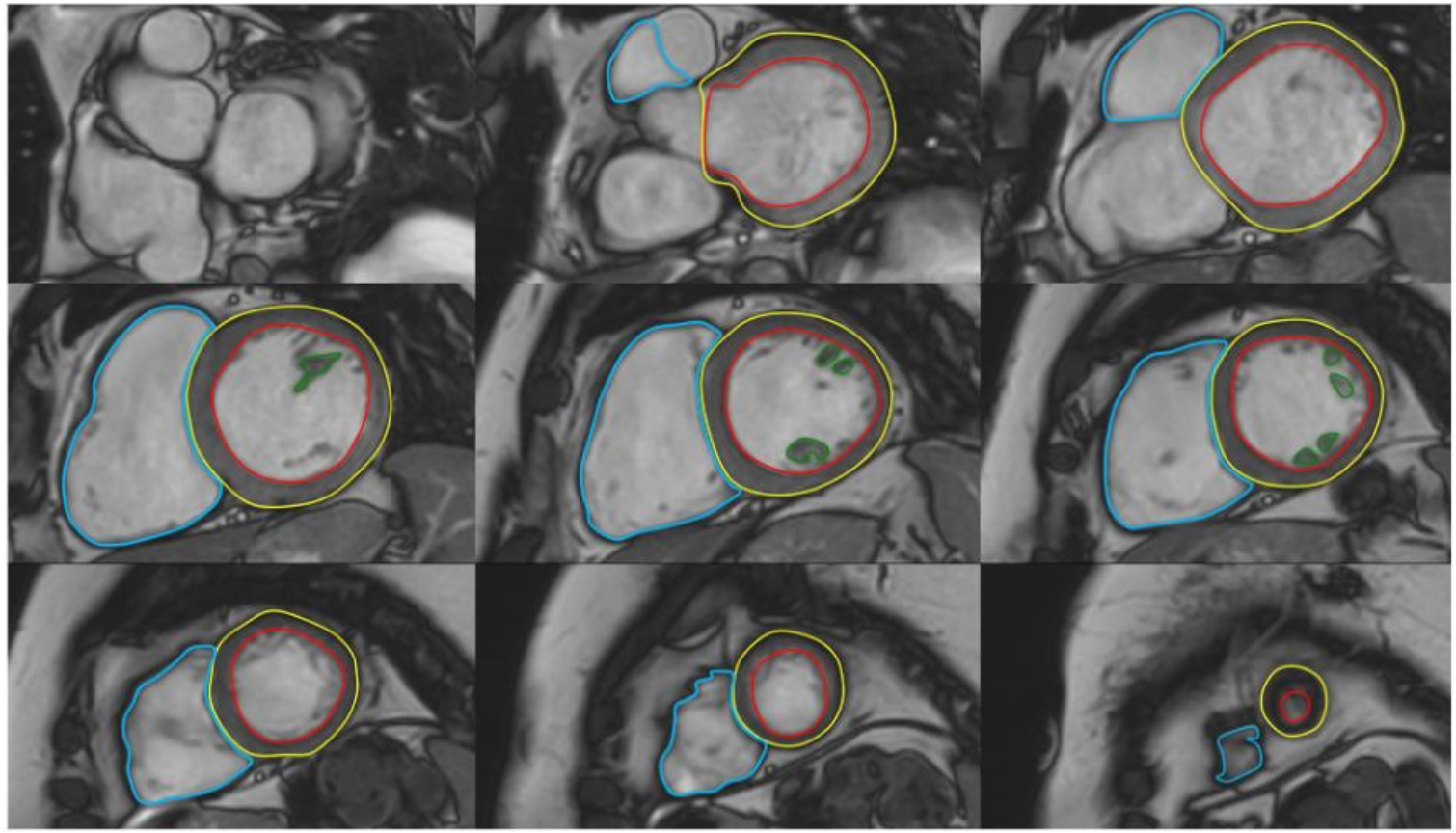
- Assessment of
  - EDV, ESV, RV SV and RV EF
  - Intracardiac shunts
  - RV mass
  - Regional wall abnormalities
  - Strain
  - Myocardial perfusion
  - Myocardial edema
  - Fibrosis/necrosis



Kawel-Boehm et al. J Cardiovasc Magn Reson (2020)

WhyCMR?

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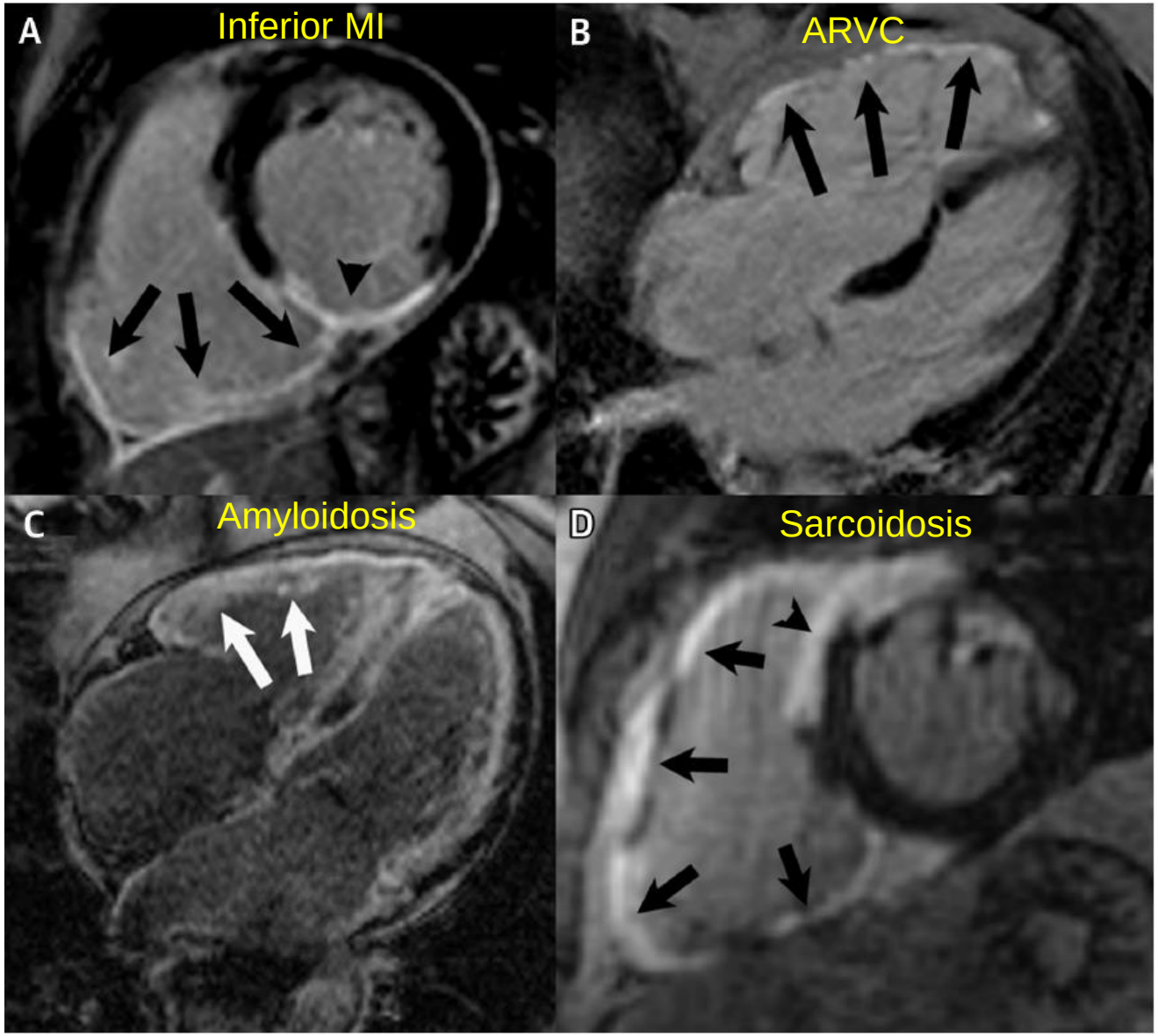

Sanz et al. JACC 2019

Arrhythmogenic Right Ventricular Cardiomyopathy

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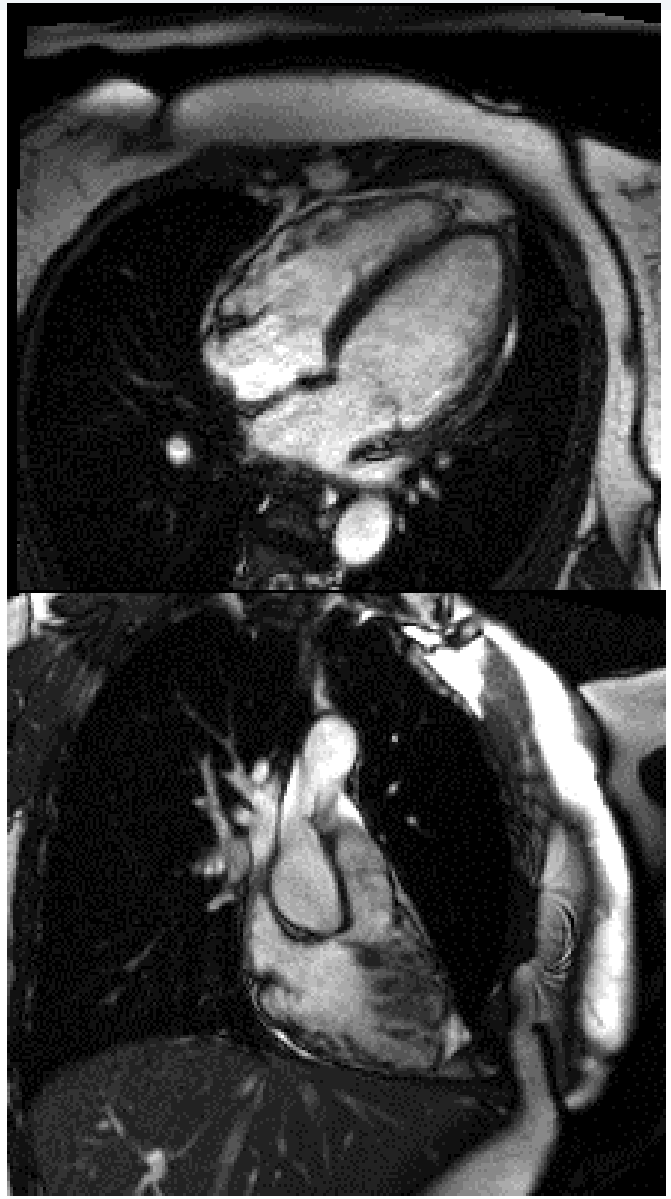
	Major Criteria	Minor Criteria
TTE	• Regional RV akinesia, dyskinesia, or aneurysm and one of the following at end diastole: ○ PLAX RVOT ≥32 mm (corrected for body size [PLAX/BSA] ≥19 mm/m^2) ○ PLAX RVOT ≥36 mm (corrected for body size [PLAX/BSA] ≥21 mm/m^2) ○ Fractional area change ≤33%	• Regional RV akinesia, dyskinesia, and one of the following at end diastole: ○ PLAX RVOT ≥32 and <36 mm (corrected for body size [PLAX/BSA] >18 and <21 mm/m^2) ○ PLAX RVOT ≥29 and <32 mm (corrected for body size [PLAX/BSA] >16 and <19 mm/m^2) ○ Fractional area change >33% and ≤40%
CMR	• Regional RV akinesia or dyskinesia or dyssynchronous RV contraction and one of the following: ○ Ratio of RV end-diastolic volume to BSA ≥110 mL/m^2 (male) or ≥100 mL/m^2 (female) ○ RV ejection fraction ≤40%	• Regional RV akinesia or dyskinesia and one of the following: ○ Ratio of RV end-diastolic volume to BSA ≥100 mL/m^2 and <110 mL/m^2 (male) or ≥90 mL/m^2 and <100 mL/m^2 (female) ○ RV ejection fraction >40% and ≤45%
	• Regional RV akinesia, dyskinesia, or aneurysm	• Regional RV akinesia, dyskinesia, or aneurysm



Summary

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- RV dysfunction can occur secondary to RV pressure overload, RV volume overload, or RV myopathy.
- Echocardiography plays an instrumental role in RV evaluation. Multiple parameters need to be taken into consideration when evaluating RV size and function.
- CMR additionally has a role in RV assessment and delineating the type of RV myopathy.

Thank You!

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