RCPS MASTERCLASS

Participant Guide

United Therapeutics CORPORATION

RCPS
MASTERCLASS

DAY 1

DAY 1 AT-A-GLANCE

GOAL

The goal of Day 1 is to ensure you can proficiently articulate key clinical details regarding echocardiogram in order to deepen your communication connections with HCPs.

LEARNING OBJECTIVES

Upon completion of Day 1 training, you will be able to:

- ✓ Confidently navigate clinical dialogue around echocardiogram.
- ✓ Apply active listening and impactful question techniques.
- ✓ Navigate conversational 'rabbit holes' with HCPs.

AGENDA

Day 1 AM Focus – Echo & Our Patients	
9:00-9:30 am	**Welcome & Icebreaker**
9:30-10:45 am	**Echo Clinical Cultivator –** Howard Castillo & Melissa McGruder
10:45-11:00 am	**BREAK**
11:00 am-12:00 pm	**Patient Identifiers –** Howard Castillo & Melissa McGruder

Day 1 PM Focus – Echo: Connection is Crucial/Application	
12:00-1:00 pm	**LUNCH**
1:00-2:00 pm	**Lead the Dialogue:** Listening/ Questioning
2:00-2:15 pm	**BREAK**
2:15-3:15 pm	**Managing Rabbit Holes**
3:15-3:45 pm	**G.R.O.W.**
3:45-5:00 pm	**Dialogue Trios**
	Closing

TWO TRUTHS AND A LIE WORKSHEET

As each participant presents their two truths and a lie, write their name and place a sticker on the statement number you think is the lie.

Name: .....

1	2	3

Name: .....

1	2	3

Name: .....

1	2	3

Name: .....

1	2	3

Name: .....

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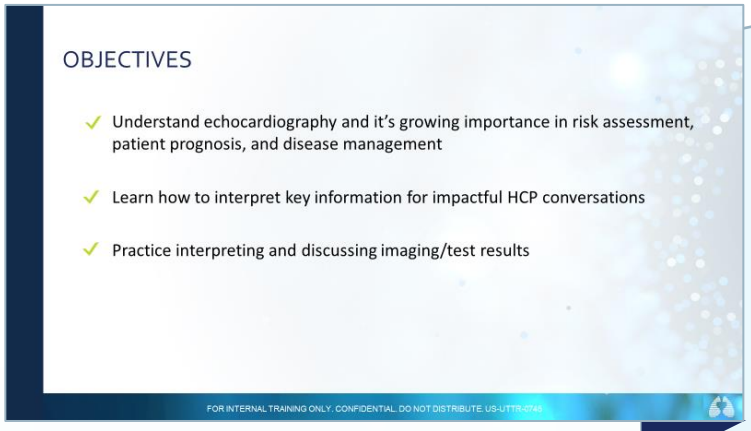
CLINICAL CULTIVATOR

NOTES



CLINICAL CULTIVATOR

ROLE OF ECHOCARDIOGRAM IN PAH

- Integral assessment—often the **first test to raise suspicion of PH**
- Evaluates cardiac **structure**, **function** and hemodynamics
- Rule out congenital heart diseases and shunts
- Provides a reasonably accurate **estimate of sPAP/RVSP**
- **Guides** diagnosis and therapy
- **Helps determine prognosis**: many echo parameters are prognostic:
  - RV size and function (e.g., **TAPSE**)
  - **Pericardial effusion**
  - Estimate **RAP** and **RVSP** (hemodynamics)

PAP=pulmonary arterial pressure; RAP=right atrial pressure; RVSP=right ventricular systolic pressure; sPAP=systolic pulmonary arterial pressure; TAPSE=tricuspid annular plane systolic excursion.

NOTES

2022 ESC/ERS ECHO DIAGNOSTIC RECOMMENDATIONS

Recommendation	Class	Level
Echocardiography is recommended as the **first-line**, non-invasive, **diagnostic** investigation in **suspected** PH	I	B
It is recommended to assign an **echocardiographic probability** of PH, based on an abnormal **TRV** and the presence of other echocardiographic signs suggestive of PH	I	B
It is recommended to maintain the current threshold of **TRV (>2.8 m/s)** for echocardiographic probability of PH according to the updated hemodynamic definition	I	C
Based on the probability of PH by echocardiography, further testing should be considered in the clinical context (i.e., **symptoms** and **risk factors** or associated conditions for PAH/CTEPH)	IIa	B
In symptomatic patients with intermediate echocardiographic probability of PH, **CPET may be considered** to further determine the likelihood of PH	IIb	C

CPET=cardiopulmonary exercise test; CTEPH=chronic thromboembolic pulmonary hypertension; TRV=tricuspid regurgitation velocity.

Reference: Humbert M, Kovacs G, Hoeper MM, et al. 2022 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension. *Eur Respir J.* 2022 Aug 30;2200879. doi: 10.1183/13993003.00879-2022. Online ahead of print.

CLINICAL CULTIVATOR

NOTES

RISK ASSESSMENT AT FOLLOW-UP[1,2]

- Suggested assessment and timing for the follow-up of patients with pulmonary arterial hypertension

Is recommended or is indicated

Should be considered

May be considered

	At baseline	3–6 months after changes in therapy[a]	Every 3–6 months in stable patients[a]	In case of clinical worsening
Medical assessment (including WHO-FC)				
6MWT				
Blood test (including NT-proBNP)[b,c]				
ECG				
Echocardiography or cMRI				
ABG or pulse oximetry[d]				
Disease-specific HR-QoL				
CPET				
RHC				

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6MWT, 6-minute walking test; ABG, arterial blood gas analysis; ALAT, alanine aminotransferase; ASAT, aspartate aminotransferase; BNP, brain natriuretic peptide; cMRI, cardiac magnetic resonance imaging; CPET, cardiopulmonary exercise testing; ECG, electrocardiogram; HR-QoL, health-related quality of life; INR, international normalized ratio; NT-proBNP, N-terminal pro-brain natriuretic peptide; PAH, pulmonary arterial hypertension; RHC, right heart catheterization; TSH, thyroid-stimulating hormone; WHO-FC, World Health Organization functional class.

Green: is indicated; yellow: should be considered; orange: may be considered.

[a] Intervals to be adjusted according to patient needs, PAH aetiology, risk category, demographics, and comorbidities.

[b] Basic laboratory tests include blood count, INR (in patients receiving vitamin K antagonists), serum creatinine, sodium, potassium, ASAT/ALAT, bilirubin, and BNP/NT-proBNP.

[c] Extended laboratory tests (e.g. TSH, troponin, uric acid, iron status, etc.) according to clinical circumstances.

[d] ABG should be performed at baseline but may be replaced by pulse oximetry in stable patients at follow-up.

References: 1. Humbert M, et al. *Eur Heart J.* 2022;ehac237. **2.** Humbert M, Kovacs G, Hoeper MM, et al. 2022 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension. *Eur Respir J.* 2022 Aug 30;2200879. doi: 10.1183/13993003.00879-2022. Online ahead of print.

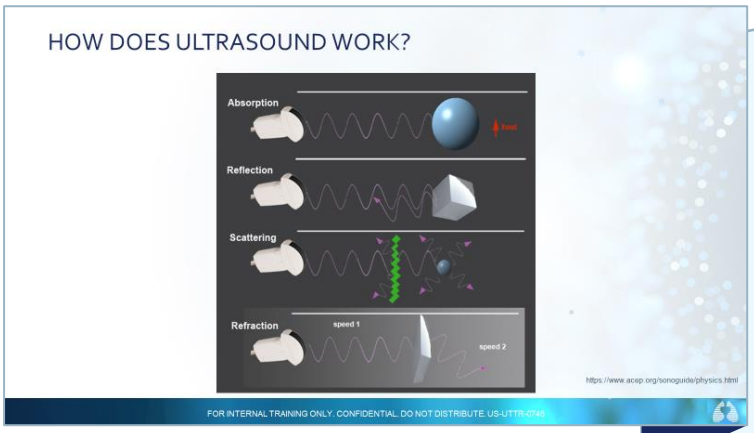
WHAT ARE WE LOOKING FOR?

Structure
- Atria (left and right)
- Ventricles (left and right)
- Septum

Function
- Eyeball method
- Tricuspid Annular Plane Systolic Excursion (TAPSE)

Pressures
- Right atrial pressure (RAP)
- Right ventricular systolic pressure (RVSP)

CLINICAL CULTIVATOR



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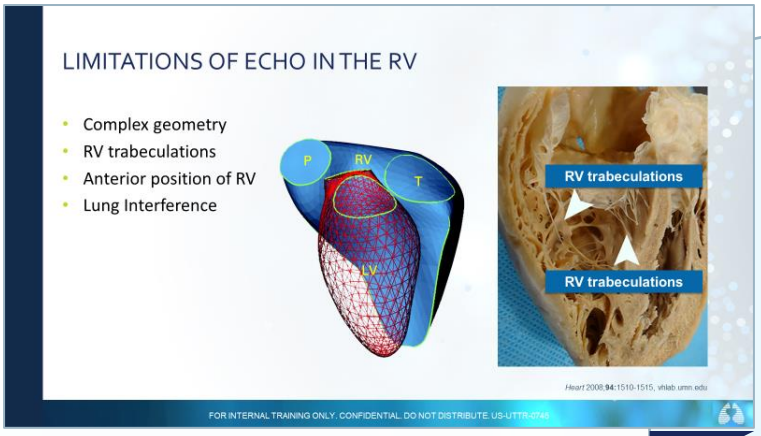

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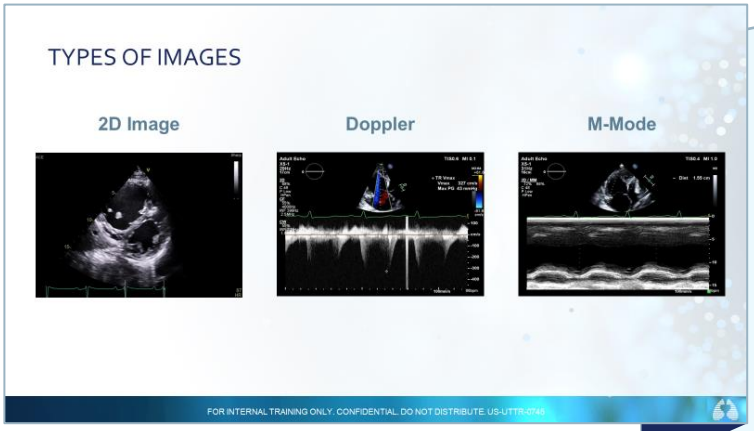

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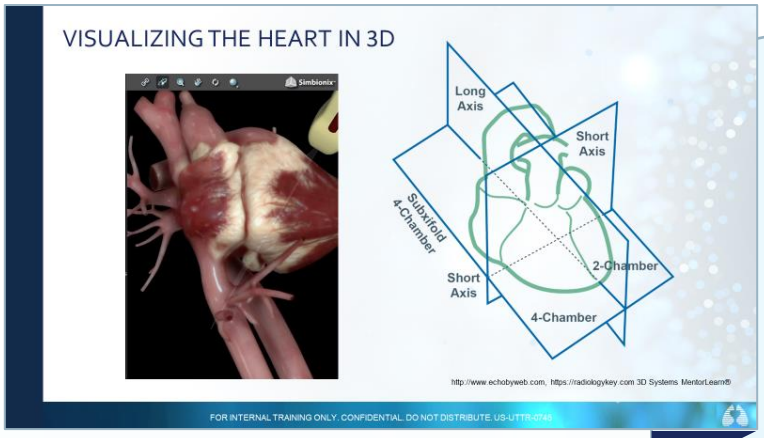

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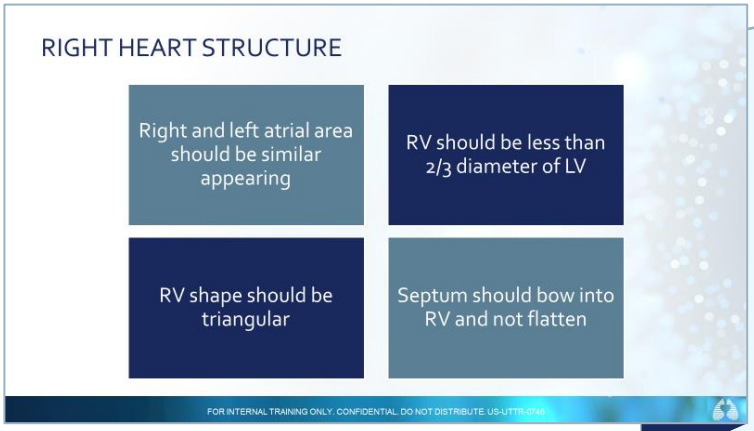

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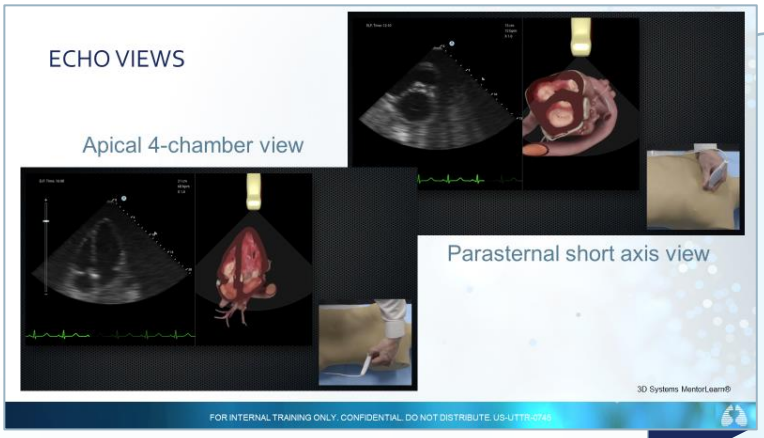

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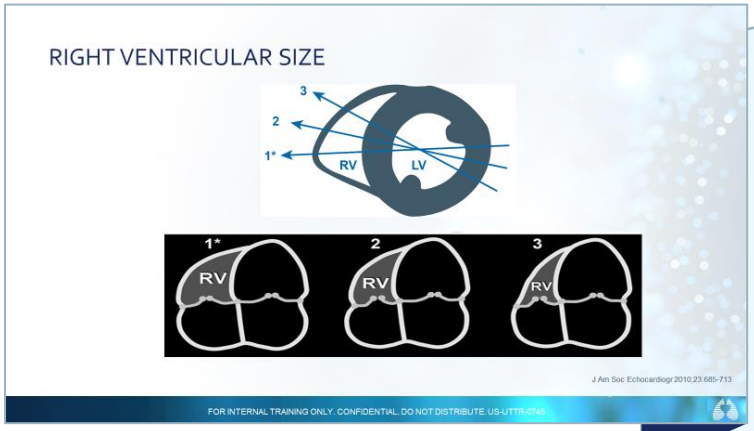

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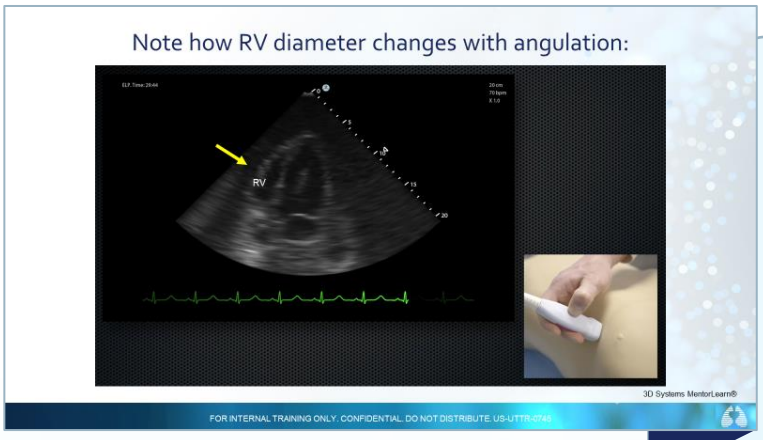

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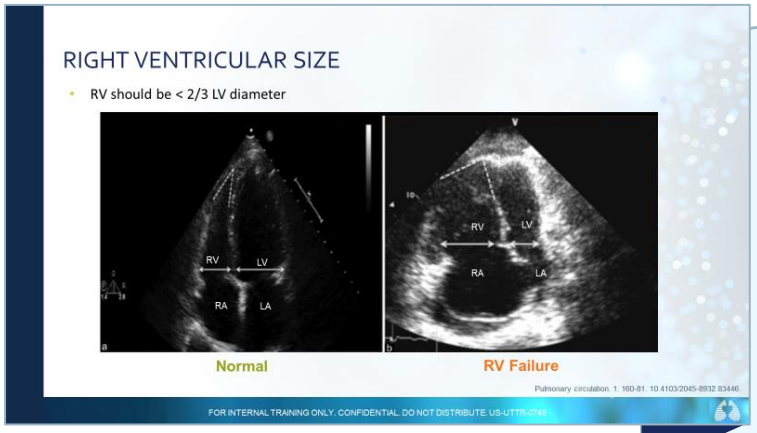

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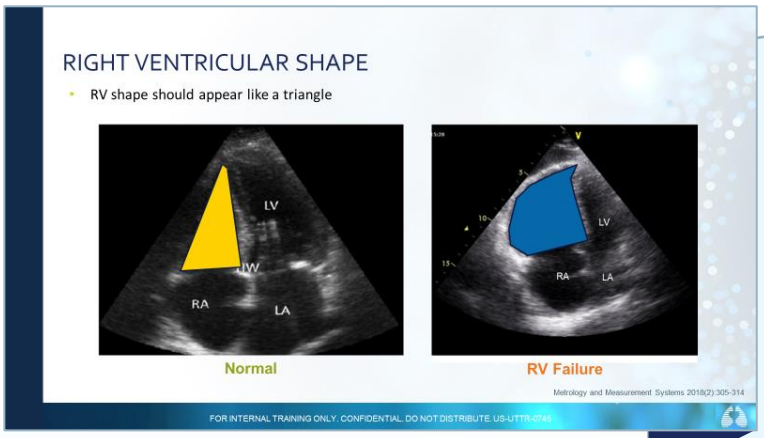

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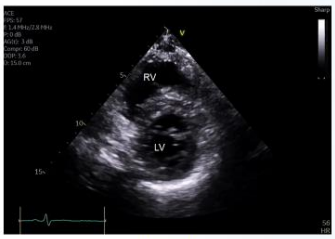
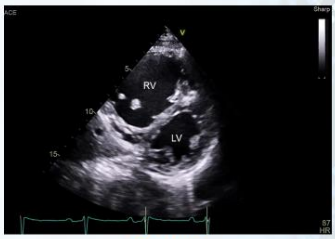
SEPTAL FLATTENING

- Septum should bow into the RV and not flatten



Normal



RV Failure

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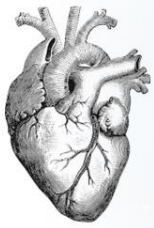
RIGHT HEART FUNCTION



- Septum should move toward the RV during systole
- RV free wall should move inward and upward during systole
- TAPSE should be > 1.8 cm

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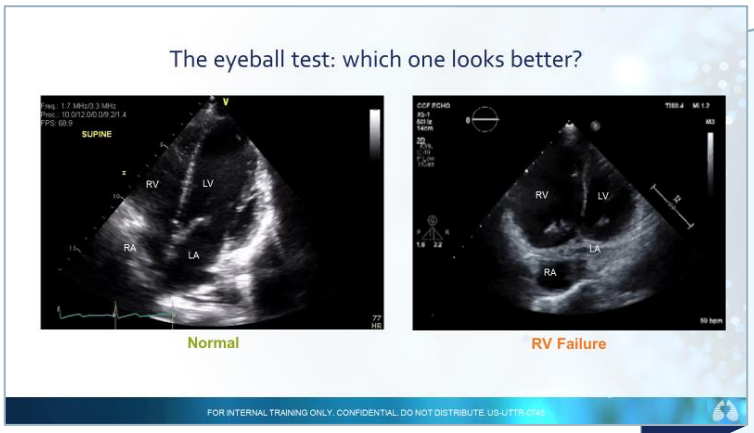
CLINICAL CULTIVATOR



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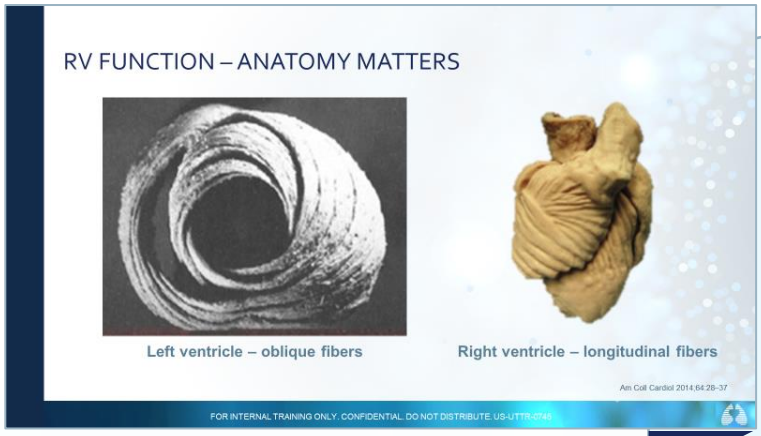

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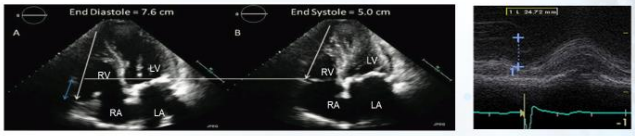
NOTES

TRICUSPID ANNULAR PLANE SYSTOLIC EXCURSION (TAPSE)

- Echo M-mode measures TAPSE
- TAPSE is the **distance** the tricuspid valve moves between the end of diastole to end of systole
- TAPSE measures RV contractility, a surrogate of **Right Ventricular Ejection Fraction**
- The annulus (a ring-shaped structure that provides support for the flaps of the tricuspid valve) moves with normal heart contractions (excursion)
- There's little movement in the overloaded/dilated RV
- **TAPSE <1.8 cm is associated with greater RV systolic dysfunction and is prognostic of poor survival among patients with PAH** (*P*=0.02)



J Am Soc Echocardiogr 2010;23:685-713, Am J Respir Crit Care Med2006;74: 1034–42. Am Heart J. 1984 Mar;107(3):526-31

TRICUSPID ANNULAR PLANE SYSTOLIC EXCURSION (TAPSE)

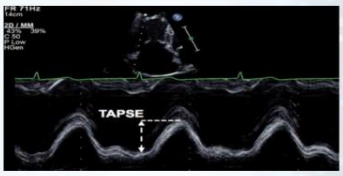
In the 2022 ESC/ERS Guidelines for the diagnosis and treatment of PH, a refined indicator of RV to pulmonary artery coupling has been introduced into risk assessment:

sPAP/TAPSE ratio

Low risk: >0.32 mm/mm Hg

Intermediate risk: 0.19–0.32 mm/mm Hg

High risk: <0.19 mm/mm Hg



RV=right ventricle or ventricular; RVEF=right ventricular ejection fraction; sPAP=systolic pulmonary arterial pressure; TAPSE=tricuspid annular plane systolic excursion.

Reference: Humbert M, Kovacs G, Hoeper MM, et al. 2022 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension. *Eur Respir J.* 2022 Aug 30;2200879. doi: 10.1183/13993003.00879-2022. Online ahead of print.

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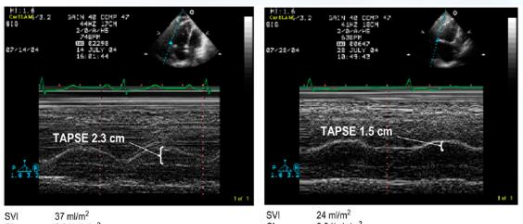
NOTES

TAPSE: NORMAL RV FUNCTION VERSUS ABNORMAL RV DYSFUNCTION



SVI	37 ml/m^2	SVI	24 ml/m^2
CI	2.9 l/min/m^2	CI	2.0 l/min/m^2
RAP	11 mmHg	RAP	10 mmHg
mPAP	44 mmHg	mPAP	50 mmHg
PVR	6.5 mmHg/l/min	PVR	11.0 mmHg/l/min

CI, cardiac index; mPAP, mean pulmonary arterial pressure; PVR, pulmonary vascular resistance; RAP, right atrial pressure; SVI, stroke volume index; TAPSE, tricuspid annular plane systolic excursion.
Forfia et al. *Am J Respir Crit Care Med.* 2006;174:1034-1041. Images used with permission of the American Thoracic Society. Copyright © American Thoracic Society.

RIGHT HEART PRESSURES

- Right atrial pressures
- Pulmonary artery pressures (Right ventricular systolic pressure)

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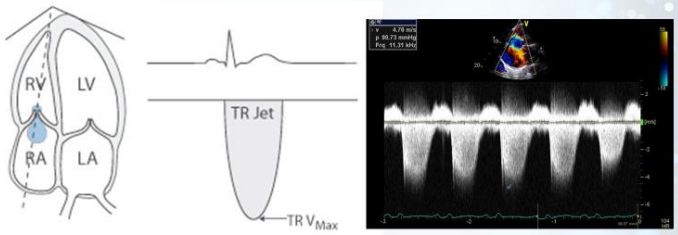
RVSP CALCULATION

RVSP = RAP + 4(TR jet velocity)^2



J Am Soc Echocardiogr. 2010 Jul;23(7):687-8, 691-2, 698-9, http://www.csecho.ca (Accessed 2/25/2018)

NOTES

Echocardiographic Features of Primary Pulmonary Hypertension

Eduardo Bossone, MD, PhD, Thanh H. Duong-Wagner, MD, Giuseppe Paciocco, MD, Hakan Oral, MD, Mark Ricciardi, MD, David S. Bach, MD, Melvyn Rubenfire, MD, and William F. Armstrong, MD, *Ann Arbor, Michigan*

Study Purpose:

- To define the echocardiographic features present at the time of Primary (idiopathic) Pulmonary Hypertension diagnosis

Patient Population:

- 51 patients, 88% Female
- Mean age 41.7 ± 12.2
- 21% FC II, 69% FC III, 10% FC IV

Methods:

- TTE and Doppler examinations were performed: specific views included the parasternal long- and short-axis views, apical 4-, 2-,and 3-chamber views, and subcostal views
- Pulsed and continuous wave Doppler interrogation was performed on all 4 cardiac valves

Bossone et al. *J Am Soc Echocardiogr.* 1999;12:655-662.

CLINICAL CULTIVATOR

RESULTS

- 98% of patients demonstrated **RV enlargement**
- 90% exhibit systolic (interventricular) **septal flattening**
- 76% had (qualitative) **RV systolic dysfunction**

Triad of right heart findings in PVD

- 92% had RA enlargement
- 70% of patients had "grade I" diastolic dysfunction (E<A)
- All patients demonstrated normal LV function
- <2% of patients had >mild mitral regurgitation

LV, left ventricular; PVD, pulmonary vascular disease; RA, right atrial; RV, right ventricular.

Bossone et al. *J Am Soc Echocardiogr.* 1999;12:655-662.

NOTES

SUMMARY

- To paint a picture of the heart
  - Assess RA/RV structure
  - Assess RV function
  - Estimate RA/PA pressures
- Also consider
  - Confirm findings in other views
  - Look at the left heart
  - Look at valves
  - Look for congenital anomalies

INTERPRETATION STATIONS WORKSHEET 1

As you visit and discuss Interpretation Stations with your station colleagues, record notes below.

Key-Data Observations and Conclusions:

HCP-to-Patient: What Information to Share and How to Verbalize It

INTERPRETATION STATIONS WORKSHEET 2

As you visit and discuss Interpretation Stations with your station colleagues, record notes below.

Key-Data Observations and Conclusions:

HCP-to-Patient: What Information to Share and How to Verbalize It

INTERPRETATION STATIONS WORKSHEET 3

As you visit and discuss Interpretation Stations with your station colleagues, record notes below.

Key-Data Observations and Conclusions:

HCP-to-Patient: What Information to Share and How to Verbalize It

PATIENT IDENTIFIERS WORKSHEET 1

Record below everything you would want to share with your attending about the patient case as if you were presenting Grand Rounds.

Patient: _____

Include:

- The 'why' for each datapoint or nonclinical detail you choose to highlight.
- Language you would utilize with an actual attending.

PATIENT IDENTIFIERS WORKSHEET 2

Record below everything you would want to share with your attending about the patient case as if you were presenting Grand Rounds.

Patient: _____

Include:

- The 'why' for each datapoint or nonclinical detail you choose to highlight.
- Language you would utilize with an actual attending.

PATIENT IDENTIFIERS WORKSHEET 3

Record below everything you would want to share with your attending about the patient case as if you were presenting Grand Rounds.

Patient: _____

Include:

- The 'why' for each datapoint or nonclinical detail you choose to highlight.
- Language you would utilize with an actual attending.

LEAD THE DIALOGUE: LISTENING & QUESTION-ASKING TECHNIQUES

NOTES

LEAD THE DIALOGUE: LISTENING & QUESTION-ASKING TECHNIQUES

NOTES

MANAGING 'RABBIT HOLES': IDENTIFY THE SPIRAL

NOTES

GROW CONVERSATION PLANNING

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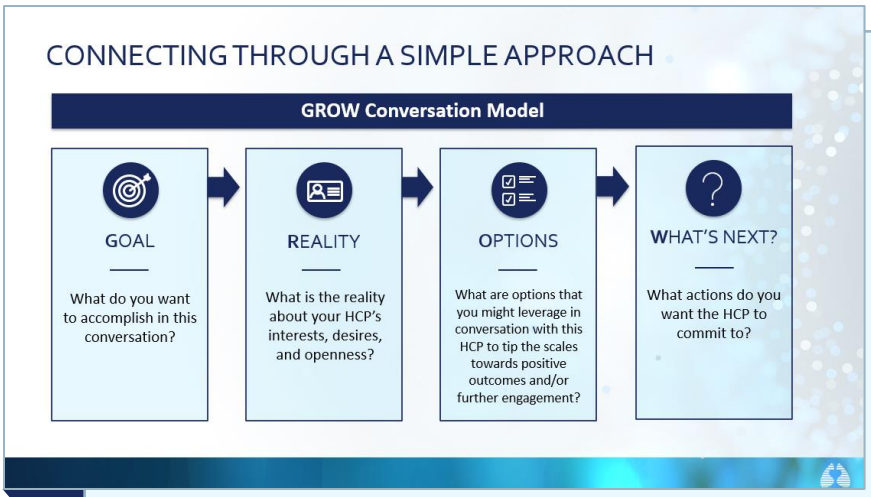

DIALOGUE DUO PRACTICE

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DAY 2

DAY 2 AT-A-GLANCE

GOAL

The goal for Day 2 is to ensure you are proficient articulating key clinical details regarding right heart catheterization in order to deepen your communication connections with HCPs.

LEARNING OBJECTIVES

Upon completion of Day 2 training, representatives will be able to:

- ✓ Confidently navigate clinical dialogue around right heart catheterization.
- ✓ Apply active listening and impactful question techniques.
- ✓ Navigate conversational 'rabbit holes' with HCPs.

AGENDA

Day 2 AM Focus – Right Heart Catheterization & Our Patients	
8:30-9:30 am	**Headshots** – Group A
9:30-10:00 am	**Ice Breaker**
10:00-11:15 am	**RHC Clinical Cultivator** – Howard Castillo & Melissa McGruder
11:15-12:00 pm	**Patient Identifiers** – Howard Castillo & Melissa McGruder

Day 2 PM Focus – Right Heart Catheterization: Connection is Crucial/Application	
12:00-1:15 pm	**LUNCH & Headshots** – Group B
1:15-2:15 pm	**Lead the Dialogue:** Listening/Questioning
2:15-2:30 pm	**BREAK**
2:30-3:45 pm	**Managing Rabbit Holes**
3:45-5:15 pm	**Dialogue Trios**
	Closing

CLINICAL CULTIVATOR

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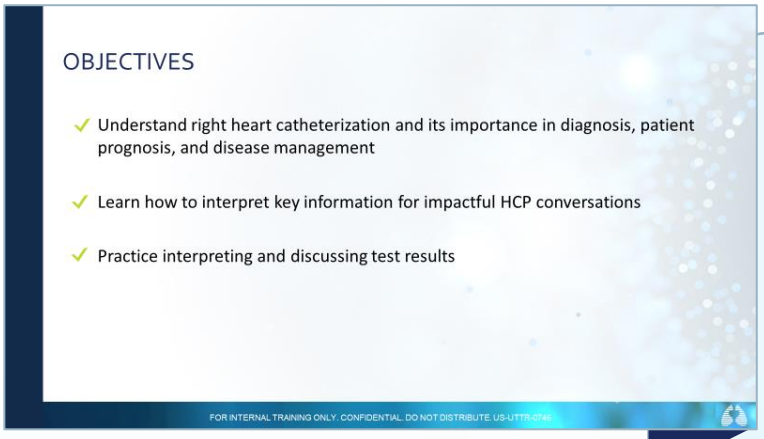

CLINICAL CULTIVATOR

ROLE OF HEMODYNAMICS IN PAH

- **PAH/PH is defined** by hemodynamic criteria[1]
- Hemodynamic **progression of PAH** is well characterized[2,3]
- Hemodynamic parameters figure prominently in **risk assessment tools**[1,4-10]
- Increased **RAP** and decreased **CI** are independent predictors of death[11]
- Hemodynamics are an **early precursor of disease worsening**[12]

RAP=right atrial pressure, CI=Cardiac Index

References: 1. Galiè et al. Eur Heart J. 2015;37:67-119. 2. Klinger. J Respir Dis. 2009;30:1-11. 3. Champion et al. Circulation. 2009;120(11):992-1007. 4. Humbert et al. Eur Respir J. 2010;36:549-555. 5. Thenappan et al. Eur Respir J. 2010;35:1079-1087. 6. Thenappan T, Glassner C, Gomberg-Maitland M. Chest. 2012;141(3):642-650. 7. Lee et al. Eur Respir J. 2012;40:604-611. 8. Benza et al. Circulation. 2010;122:164-172. 9. Benza et al. Chest. 2012;142(2):448-456. 10. D'Alonso et al. Ann Intern Med. 1991;115:343-349. 11. Thenappan T et al. Eur Respir J. 2010;35:1079-1087. 12. van de Veerdonk MC et al. Chest. 2015;147(4):1063-1071.

NOTES

2022 ESC/ERS RHC DIAGNOSTIC RECOMMENDATIONS

Recommendation	Class	Level
RHC is recommended to confirm the diagnosis of PH (especially PAH or CTEPH), and to support treatment decisions	I	B
In patients with suspected or known PH, it is recommended to perform RHC in experienced centers	I	C
It is recommended that RHC comprises a complete set of hemodynamics, and is performed following standardized protocols	I	C
Vasoreactivity testing is recommended in patients with I/H/DPAH to detect patients who can be treated with high doses of a calcium channel blocker	I	B

I=idiopathic; H=hereditary; DPAH=drug- or toxin-induced PAH; RHC=right heart catheterization.

Reference: Humbert M, Kovacs G, Hoeper MM, et al. 2022 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension. *Eur Respir J.* 2022 Aug 30;2200879. doi: 10.1183/13993003.00879-2022.

NOTES

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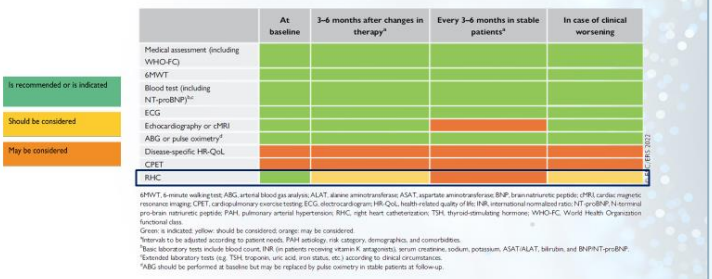
RISK ASSESSMENT AT FOLLOW-UP

- Suggested assessment and timing for the follow-up of patients with pulmonary arterial hypertension



	At baseline	3–6 months after changes in therapy[a]	Every 3–6 months in stable patients[a]	In case of clinical worsening
Medical assessment (including WHO-FC)				
6MWT				
Blood test (including NT-proBNP)[b,c]				
ECG				
Echocardiography or cMRI				
ABG or pulse oximetry[d]				
Disease-specific HR-QoL				
CPET				
RHC				

6MWT, 6-minute walking test; ABG, arterial blood gas analysis; ALAT, alanine aminotransferase; ASAT, aspartate aminotransferase; BNP, brain natriuretic peptide; cMRI, cardiac magnetic resonance imaging; CPET, cardiopulmonary exercise testing; ECG, electrocardiogram; HR-QoL, health-related quality of life; INR, international normalized ratio; NT-proBNP, N-terminal pro-brain natriuretic peptide; PAH, pulmonary arterial hypertension; RHC, right heart catheterization; TSH, thyroid-stimulating hormone; WHO-FC, World Health Organization functional class.
Green: is indicated; yellow: should be considered; orange: may be considered.
[a]Intervals to be adjusted according to patient needs, PAH aetiology, risk category, demographics, and comorbidities.
[b]Basic laboratory tests include blood count, INR (in patients receiving vitamin K antagonists), serum creatinine, sodium, potassium, ASAT/ALAT, bilirubin, and BNP/NT-proBNP.
[c]Extended laboratory tests (eg, TSH, troponin, uric acid, iron status, etc.) according to clinical circumstances.
[d]ABG should be performed at baseline but may be replaced by pulse oximetry in stable patients at follow-up.

References: Humbert M, Kovacs G, Hoeper MM, et al. 2022 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension. *Eur Respir J*. 2022 Aug 30;2200879. doi: 10.1183/13993003.00879-2022.

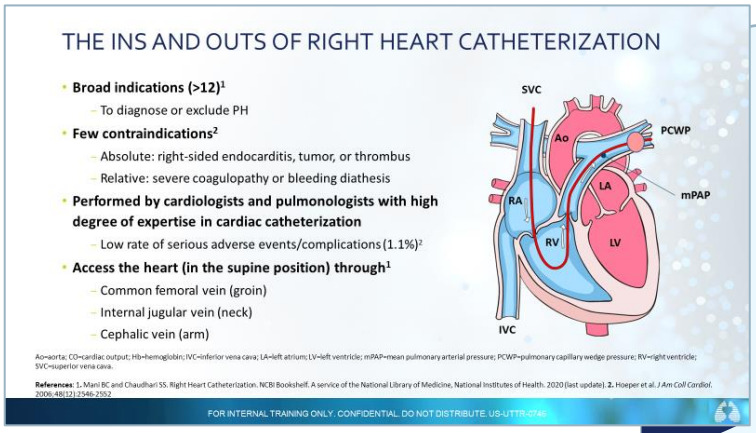
NOTES

RIGHT HEART CATHETERIZATION

Assesses	Evaluates	Excludes	Confirms
• Key hemodynamic parameters • Congenital heart defects • Response to vasodilator challenge	• Severity of PAH	• Left-sided heart disease	• Diagnosis • Gold standard (required for every patient with suspected PH)

Reference: McLaughlin et al. *Circulation*. 2009;53(17):1573-1619.

CLINICAL CULTIVATOR



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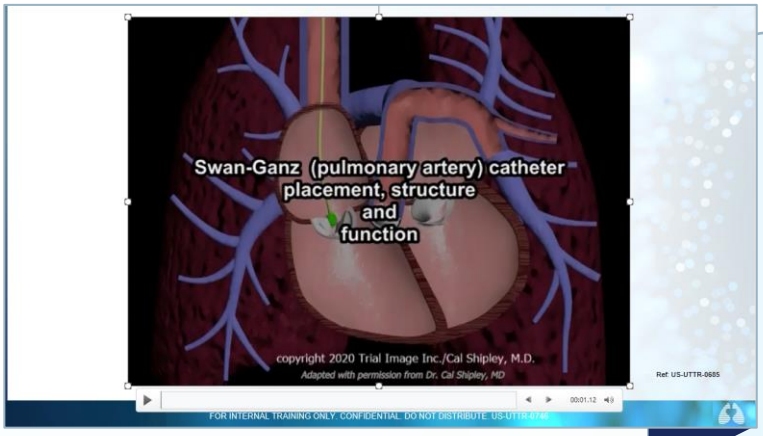

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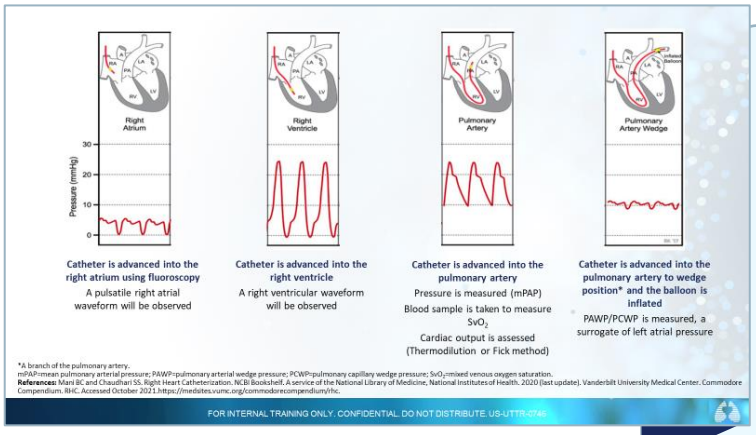

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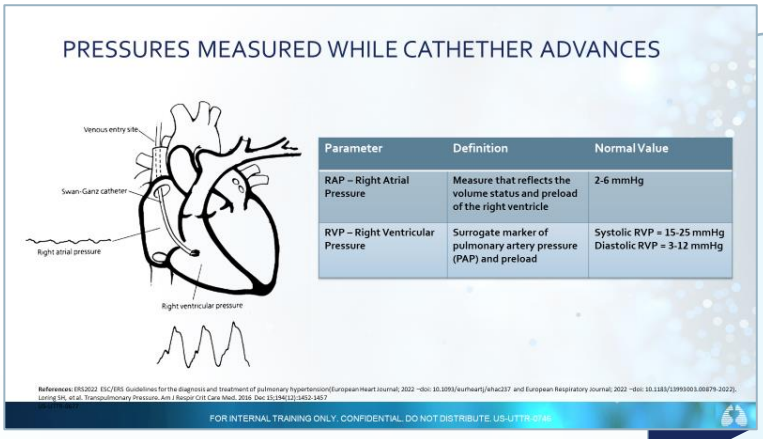

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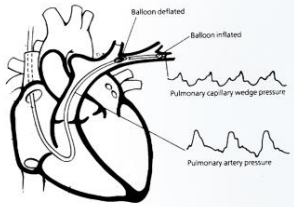
PRESSURES MEASURED WHILE CATHETHER ADVANCES



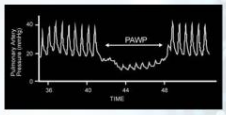
Parameter	Definition	Normal Value
PAP – Pulmonary Arterial Pressure	Measure of pulmonary arterial pressure, which can be measured as systolic, diastolic, and mean	mPAP 8-20 mmHg
PAWP – Pulmonary Arterial Wedge Pressure	Measure of pulmonary venous pressure and indirect measure of left atrial pressure	≤15 mmHg

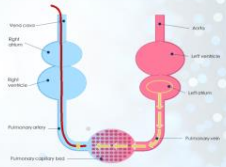
References: ERS2022. ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension(European Heart Journal; 2022 –doi: 10.1093/eurheartj/ehac237 and European Respiratory Journal; 2022 –doi: 10.1183/13993003.00879-2022).
Loring SH, et al. Transpulmonary Pressure. Am J Respir Crit Care Med. 2016 Dec 15;194(12):1452-1457

NOTES

ASSESSMENT OF PULMONARY ARTERIAL WEDGE PRESSURE

- **Accurate measurement of PAWP is critical to distinguishing the type of pulmonary vascular disease and appropriate treatment**
- PAWP under normal conditions provides accurate estimate of left-sided filling pressures
  - **LA pressure waves are transmitted retrograde**
  - During diastole (mitral valve is open), PAWP and left ventricular end-diastolic pressure (LVEDP) are approximately equal
- Elevation of PAWP
  - Pulmonary Venous Hypertension (PVH): limits treatment for PAH
- Elevation of PAWP with vasodilator
  - Pulmonary veno-occlusive disease (PVOD)
  - LV diastolic dysfunction
- **LVEDP should be measured if there is difficulty assessing PAWP** or concern for left-sided heart disease remains
  - (normal range is <12 mmHg)





Cardiopulmonary Schema

LA=left atrium, LVEDP=left ventricular end-diastolic pressure; PCWP=pulmonary capillary wedge pressure
Reference: McLaughlin et al. *J Am Coll Cardiol.* 2009;53(17):1573-1619.

CLINICAL CULTIVATOR

NOTES

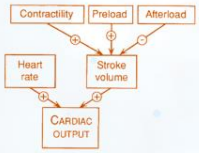
OTHER READINGS & CALCULATIONS

Parameter	Definition	Normal Value
SvO_2 – Mixed Venous Oxygen Saturation	Oxygen content of the blood that returns to the heart after meeting tissue needs	65-80%
PVR – Pulmonary Vascular Resistance	Resistance to blood flow within the pulmonary vasculature $PVR = \frac{mPAP - PAWP}{CO}$	0.3-2.0 WU
TPG – Transpulmonary Pressure Gradient	Pressure difference across the lung, from the opening of the pulmonary airway to the pleural surface TPG = mPAP – PAWP	≤12 mmHg
CO – Cardiac Output	Amount of blood pumped out of each ventricle in 1 minute (L/min)	4.0-8.0 L/min
CI – Cardiac Index	Turns CO into a normalized value that accounts for the body size of a patient CI = CO / Body Surface Area	2.5-4.0 L/min/m²

References: ERS2022. ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension(European Heart Journal; 2022 –doi: 10.1093/eurheartj/ehac237 and European Respiratory Journal; 2022 –doi: 10.1183/13993003.00879-2022). Loring SH, et al. Transpulmonary Pressure. Am J Respir Crit Care Med. 2016 Dec 15;194(12):1452-1457

CARDIAC OUTPUT (CO)

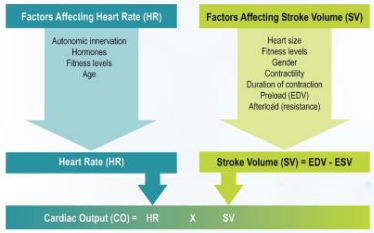
- One of the most important parameters for monitoring cardiac function
  - Measured in Liters per minute (entire blood supply is pumped every minute)
    - Product of stroke volume (SV) x heart rate (HR)
  - Normal range, 4.0–8.0 L/min
- Cardiac output can be obtained invasively by thermodilution, indirect Fick or direct Fick method
  - Thermodilution more widely used and considered gold standard
  - If Fick is used, the direct method is preferred



References: Lavdaniti M. *Int J Caring Sci.* 2008;1(3):112-117.

CLINICAL CULTIVATOR

- Sufficient cardiac output (HR x SV) is needed to provide an adequate and continuous supply of blood throughout the body tissues based on the needs of the body
- Conditions that affect heart rate and stroke volume directly affect CO
- CO is a measure of ventricular output and a clinical indicator of ventricular function



References: US-UTTR-0677

NOTES

PRELOAD & AFTERLOAD

PRELOAD

- **Preload** is the stretch on the ventricles prior to contraction
  - Can be measured by echo and cardiac MRI - known as Ejection Fraction (EF)
  - Right Atrial Pressure is a measure that reflects the volume status and preload of the right ventricle
  - Right Ventricle Pressure is a surrogate marker of preload
- **PAWP** is a measure of preload of the left side of the heart

AFTERLOAD

- **Afterload** is the force the ventricles must generate to pump against resistance in the vessels
  - Systemic Vascular Resistance evaluates RV afterload
- **Right Ventricle Afterload (RVA)** is the force against which blood is ejected from the right ventricle into the pulmonary artery

References: US-UTTR-0677.

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CARDIAC INDEX

- Cardiac index (CI) is the ratio of CO to the surface area of the body
- Cardiac index is calculated by dividing CO by body surface area
- It is measured in liters per minute per square meter ($L/min/m^2$)
- It is a measure of ventricular output and a clinical indicator of ventricular function
- Low CI points to heart failure, RV failure, and pulmonary hypertension

References: US-UTTR-0677

NOTES

VASOREACTIVITY TESTING OVERVIEW

- In patients with idiopathic, hereditary, and drug/toxin induced PAH, acute vasodilator testing during RHC is strongly recommended based on current guidelines[1]
- Acute vasodilator testing may identify patients who might respond favorably to calcium channel blockers (CCB)
- During RHC, acute pulmonary vasodilator testing assesses the ability of the pulmonary arteries to relax acutely in response to medications such as:
  - IV epoprostenol
  - Inhaled iloprost
  - Inhaled nitric oxide
- Guidelines consider a positive response to vasoreactivity testing by a reduction of mPAP ≥10 mmHg to reach an absolute value of mPAP ≤40 mmHg with an increased or unchanged cardiac output
  - Note that patients should have normal oxygen saturation prior to starting inhaled NO so that one can assess the true response on pulmonary vascular tone and not response to improved oxygenation
- While patients with a sustained long-term response to CCB therapy are rare, ~ 6-8%[2], a positive response predicts a better clinical outcome and prognosis[3]

References: 1. Humbert M, Kovacs G, Hoeper MM, et al. 2022 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension. *Eur Respir J.* 2022 Aug 30;2200879. doi: 10.1183/13993003.00879-2022. 2. Sitbon O, Humbert M, Jais X, et al. Long-term response to calcium channel blockers in idiopathic pulmonary arterial hypertension. 2005;111:3105-3111. 3. Raffy O, Azarian R, Brenot F, et al. Clinical significance of the pulmonary vasodilator response during short-term infusion of prostacyclin in primary pulmonary hypertension. Circulation. 1996;93:484-488.

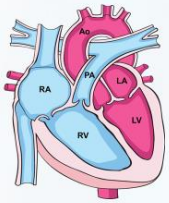
NOTES

CLINICAL CULTIVATOR

NOTES

GOLD STANDARD FOR DIAGNOSIS

1. PVR >2 WU
   Normal: 0.3-2.0 WU
2. PAWP ≤15 mm Hg
   Normal: 8.0 ±2.9 mmHg
3. mPAP >20 mm Hg
   Normal: 8-20 mmHg

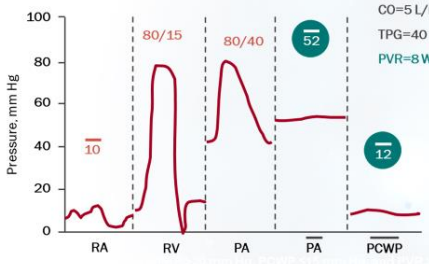


- Group 1 (**PAH**) and Group 3 **PH-ILD** are **precapillary** forms of pulmonary hypertension (occurs in pulmonary arterioles) that share the **same** hemodynamic criteria
- Group 2 PH due to **left heart disease** is a **post-capillary** form of PH (occurs in pulmonary venules)

Ao=aorta; CI=cardiac index; CLD=chronic lung disease; ILD=interstitial lung disease; LA=left atrium; LV=left ventricle; mPAP=mean pulmonary arterial pressure; PA=pulmonary artery; PAWP=pulmonary arterial wedge pressure; PVR=pulmonary vascular resistance; RA=right atrium; RHC=right heart catheterization; RV=right ventricle; WHO=World Health Organization; WSPH=World Symposium on Pulmonary Hypertension; WU=Wood units.

References: Humbert M, Kovacs G, Hoeper MM, et al. 2022 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension. *Eur Respir J.* 2022 Aug 30;2200879. doi: 10.1183/13993003.00879-2022.

CARDIOPULMONARY PRESSURE PROFILE IN PAH



CO=5 L/min
TPG=40 mm Hg
PVR=8 WU

Does the patient have PAH?

Is the disease compensated or decompensated?

What PAH-specific therapy or therapies would you initiate?

CO=cardiac output; PA=pulmonary artery; PAH=pulmonary arterial hypertension; PCWP=pulmonary capillary wedge pressure; PVR=pulmonary vascular resistance; RA=right atrium; RV=right ventricle; TPG=transpulmonary pressure gradient; WU=Wood units.
Tracing courtesy of Michael A. Mathier, MD, FACC, University of Pittsburgh School of Medicine.

CLINICAL CULTIVATOR

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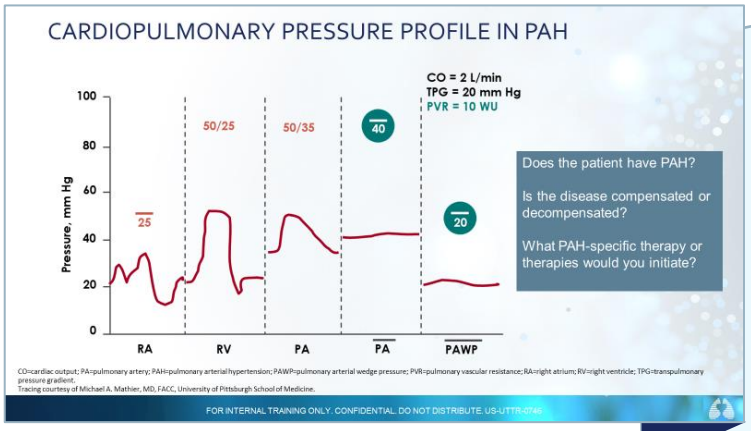
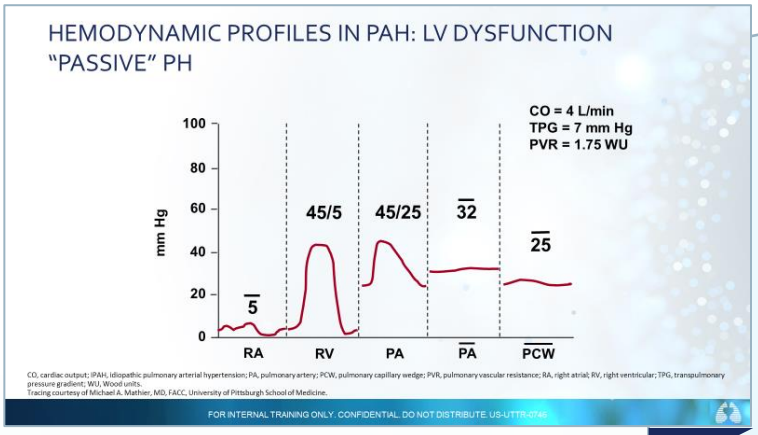




CLINICAL CULTIVATOR

SUMMARY

- Remains "gold standard" for diagnosis of PAH
- Required for every patient with suspected PAH
- Allows assessment of key hemodynamic parameters (RAP, PAP, PAWP, and CO) as well as calculation of CI and PVR
- Allows assessment of response to vasodilator challenge
- Allows determination of disease severity and appropriate selection of PAH therapy

NOTES

PATIENT IDENTIFIERS WORKSHEET 1

Record below everything you would want to share with your attending about the patient case as if you were presenting Grand Rounds.

Patient: _____

Include:

- The 'why' for each datapoint or nonclinical detail you choose to highlight.
- Language you would utilize with an actual attending.

PATIENT IDENTIFIERS WORKSHEET 2

Record below everything you would want to share with your attending about the patient case as if you were presenting Grand Rounds.

Patient: _____

Include:

- The 'why' for each datapoint or nonclinical detail you choose to highlight.
- Language you would utilize with an actual attending.

PATIENT IDENTIFIERS WORKSHEET 3

Record below everything you would want to share with your attending about the patient case as if you were presenting Grand Rounds.

Patient: _____

Include:

- The 'why' for each datapoint or nonclinical detail you choose to highlight.
- Language you would utilize with an actual attending.

LEAD THE DIALOGUE: LISTENING & QUESTION-ASKING TECHNIQUES

NOTES

LEAD THE DIALOGUE: LISTENING & QUESTION-ASKING TECHNIQUES

NOTES

MANAGING 'RABBIT HOLES': MANAGING THE SPIRAL

NOTES

DIALOGUE DUO PRACTICE

NOTES

RCPS
MASTERCLASS

DAY 3

DAY 3 AT-A-GLANCE

GOAL

The goal of Day 3 is for you to apply key insights previously learned from SMEs and colleagues to work through a challenging problem with a real-life HCP.

LEARNING OBJECTIVES

Upon completion of Day 3 training, you will be able to:

- ✓ Apply solutions to overcome challenges with real-life HCPs.
- ✓ Demonstrate skills learned during Masterclass to hold successful HCP conversations.

AGENDA

Day 3	
9:00-11:30 am	Solve MY Problem
11:30 am- 12:00 pm	Program Close

GROW WORKSHEET

Directions:
Complete the information below for the specific HCP you identified as the hardest to connect with.

GOAL: What do you want to accomplish in this conversation?

REALITY: What is the reality about your HCP's interests, desires, and openness?

OPTIONS: What are options that you might leverage in conversation with this HCP to tip the scales towards positive outcomes and/or further engagement?

WHAT'S NEXT?: What actions do you want the HCP to commit to?

PART 3: PAIR & SHARE

NOTES

OBSERVATION EVALUATION

Directions:
While observing each HCP conversation, use the rubric below to help guide your oral feedback.

Demonstrated Clinical Knowledge				
5	4	3	2	1
Can teach a course with this level of effortless expertise	Anticipates potential question, and addresses them before asked	Provides responses to every question asked	Demonstrates subject matter expertise	Baseline generalist knowledge

Level of Active Listening				
5	4	3	2	1
Is globally listening, with an applied balance of logic and emotion, and utilizes selective silence	Acknowledges, mirrors, and actively listens in a way that demonstrates interpersonal acumen	Appears to listen to the meaning behind the words	Appears to listen to the words	Appears to listen with the intent to speak

Use of Impactful Questions				
5	4	3	2	1
Uses questions that stimulate the HCP's sense of responsibility and takes ownership of the process	Uses questions that develop the HCP's awareness and focus	Gathers all the relevant information	Uses primarily open questions	Uses primarily closed questions

Avoidance of Rabbit Holes				
5	4	3	2	1
Maintains a positive attitude and body language, all while redirecting from the potential rabbit hole	Redirects from potential rabbit hole/s by describing what they're hearing, finding common ground, and moving forward	Manages to close the conversation within the allotted time and includes some follow-up dialogue	Active, somewhat forceful steering of the conversation	Passive, polite approach to steering the conversation

RCPS

MASTERCLASS

Resources

PAH Diagnostic FAQs

Echocardiogram

What is an echocardiogram? How is it performed? Do patients need to be sedated? Is this an in-patient procedure? Where do they go for it?

Several echo imaging approaches are used to evaluate right heart anatomy and function, and findings may vary based on a patient's position, body build, and technician techniques. Transthoracic echocardiography (TTE) is a tool to image the effects of PAH on the heart and is used in conjunction with continuous wave Doppler measurements to assess blood flow.

Patients do not need to be sedated for TTE and it only takes 10-20 minutes. TTE is the most common type of echocardiogram and is an outpatient, noninvasive procedure, taking place entirely outside the body. Gel is applied to the chest and a handheld transducer scans the heart. An echo can be performed at a doctor's office or a hospital.

What is the role of an echocardiogram in PAH?

It is an integral assessment tool, and often the first to detect PAH by evaluating cardiac structure, function, and hemodynamics. It is also used to rule out left heart disease and shunts. Many echo parameters are prognostic, such as RV/RA size and function, pericardial effusion, and estimates of PAP, RAP and CO/CI.

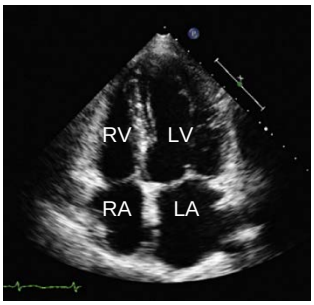
RA diameter and pericardial effusion are variables of risk assessment in the 2015 ESC/ERS guidelines, and pericardial effusion is a variable in the REVEAL 2.0 calculator.

What are the limitations in using an echocardiogram to identify PAH?

Most limitations are based on the over/underestimation of RV pressure. These findings don't tend to match those of right heart catheterization. The ability of echo to determine peak TR jet velocity to estimate right ventricular systolic pressure (RVSP) is limited. TR jet can also over/underestimate RVSP in individual patients and can be hard to visualize in patients with chronic lung disease. Potential challenges also include angle variances during an echo and chest cavity abnormalities.

What can an echocardiogram measure?

- *TAPSE*
- *RV/RA Diameter*
- *RA Area*
- *LV/LA Diameter*
- *TRV*
- *PA Diameter*
- *Pericardial Effusion*
- *RV Hypertrophy*
- *IVC Diameter*

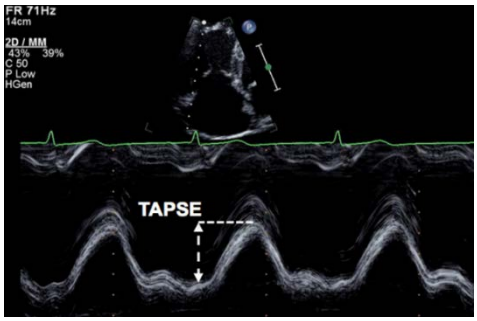


Normal Echocardiogram

What is TAPSE (Tricuspid Annular Plane Systolic Excursion)?

TAPSE is the distance the tricuspid valve moves between the end of diastole to end of systole (M-mode echo); <1.7 cm = RV dysfunction.

TAPSE is a surrogate for the ejection fraction of the RV. TAPSE measures the excursion (contractility) of the RV when the heart pumps based on the movement of the annulus of the tricuspid valve. The annulus (a ring-shaped structure that provides support for the flaps of the tricuspid valve) moves with normal heart contractions (excursion). When the RV is overloaded, there's little movement of the tricuspid annulus because the RV is so full or dilated. The position of the echo at the right angle of the annulus is vital to get an accurate measurement.



What is RVSP (Right Ventricular Systolic Pressure)?

RVSP and TAPSE are terms incorrectly used interchangeably, but RVSP is different than TAPSE. RVSP is calculated from TR jet velocity and RAP and can be used to estimate the systolic pressure of the PA. If miscalculated, RVSP can be over/underestimated.

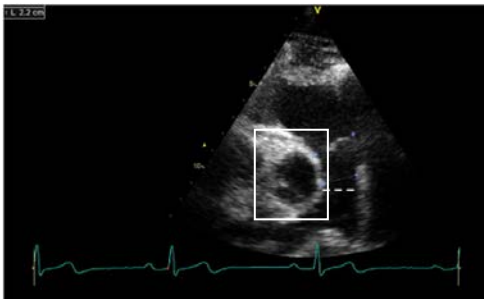
Is RVSP the same as mPAP?

RVSP is not the same as mPAP. RVSP is an estimation of the systolic pressure of the RV whereas mPAP is measured by RHC and is a true measured value from the pulmonary artery. The systolic pressure of the PA is used to calculate mPAP.

How is PA diameter measured? How is it used?

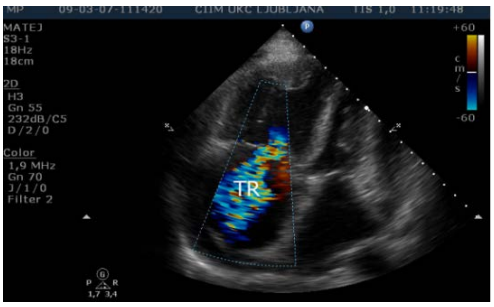
Pulmonary artery diameter is measured in end diastole halfway between the pulmonary valve and bifurcation of the main pulmonary artery.

PA diameter >25 mm is considered abnormal.



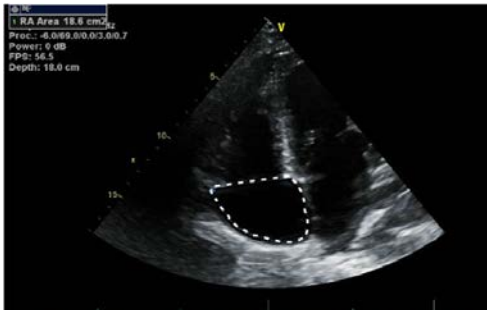
What is TRV (Tricuspid Regurgitant Jet Velocity)?

The tricuspid valve sits between the RA and RV. When the RV pumps blood into the pulmonary artery (a process known as systole), the tricuspid valve is supposed to be closed to avoid back-flow of blood into the RA (regurgitation). Under high pressure the RV becomes dilated, the valve stretches, and regurgitation occurs. Blood regurgitation will increase under higher pressure, increasing the velocity of blood movement into the right atrium. In an echo, TR jet velocity is measured, which is used to calculate the RVSP. A TRV <2.8 m/s is considered normal.



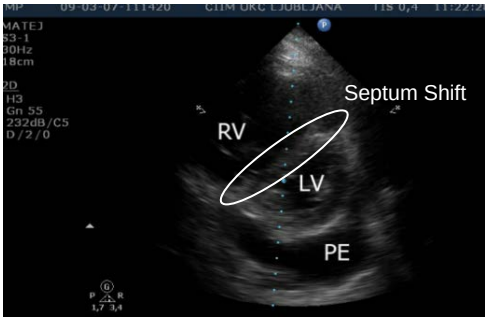
How is RA area measured? How is it used?

Right atrial area is measured at end ventricular systole on the frame just prior to tricuspid valve opening. Depending on TR jet velocity, finding RA area >18cm^2 along with other echo measures increases the probability of PAH. RA area is a component of risk assessment in the 2015 ESC/ERS guidelines.



What is Interventricular Septal (IVS) flattening?

In an echo, there is a view which looks at the heart from the bottom up. The RV and LV are next to each other, but the LV is bigger than the RV, and the septum is between them. When the RV gets bigger, it pushes the septum into the LV. Overload of the RV will cause a shift of the septum or flattening of the septum.

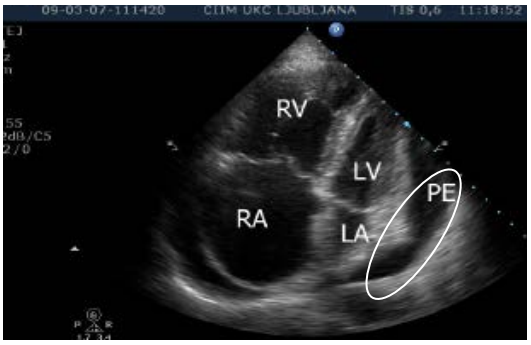


What does RV dilation mean and how is it related to NT-proBNP?

The RV dilates in response to increased pressure, which can lead to the RV becoming thinner and eventually failing. RV dilation will lead to a release of NT-proBNP. Monitoring NT-proBNP can reveal signs of strain in the RV sooner than physical findings.

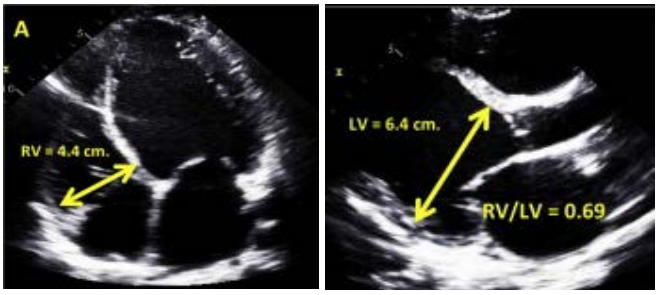
What is pericardial effusion?

Pericardial effusion is the buildup of extra fluid in the pericardium (fibrous sac) around the heart. Fluid buildup puts pressure on the heart, preventing it from pumping normally. Pericardial effusion is a component of risk assessment in the 2015 ESC/ERS guidelines and REVEAL 2.0.



What is RV/LV diameter ratio?

This is measured from the standard A4C view. Measurement is taken at end diastole. A ratio of >1 measured at end diastole suggests RV dilation.



What echocardiogram readings suggest PAH? How often should they be assessed?

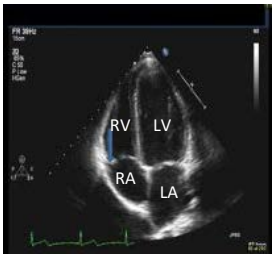
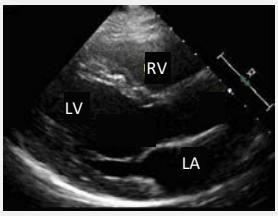
- *RV/LV diameter ratio >1.0*
- *Flattening of the IVS*
- *RA area >18cm^2*
- *RV hypertrophy*
- *Elevated sPAP (>50 mmHG)*
- *TRV >3.4 m/s*

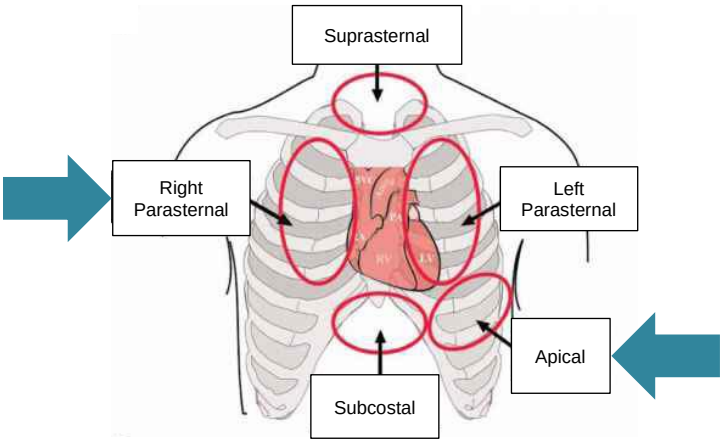
After baseline, an echo should be performed every 6-12 months, 3-6 months after changes in therapy, and in case of clinical worsening, according to the 2015 ESC/ERS guidelines.

ECHOCARDIOGRAM TYPES

Type	Description
Transthoracic echocardiogram (TTE)	**Most common type of echocardiogram** and is noninvasive, taking place entirely outside the body **(in about 20 minutes)**. Gel is applied to the chest, and a handheld transducer scans the heart.
Transesophageal echocardiogram (TEE)	Provides **better images** because the esophagus and heart sit close together, and the sound waves do not need to pass through skin, muscle, or bone. TEE is a better choice for some conditions. Additionally, **obesity and lung disease can interfere with standard echocardiography.** This is more invasive than TTE and requires mild sedation (patient cannot drive for 24 hours).
Doppler echocardiogram	Assesses the **flow of blood through the heart's chambers and valves**. The amount of blood pumped out with each beat is an indication of the heart's functioning. Also, Doppler can detect abnormal blood flow within the heart, which can indicate a problem with one or more of the heart's four valves, or with the heart's walls.
M-Mode (motion-mode) echo	This, the simplest type of echocardiography, produces an image that is similar to a tracing rather than an **actual picture of heart structures**. M-mode echo is useful for measuring heart structures, such as the heart's pumping chambers, the size of the heart itself, and the thickness of the heart walls; also, M-mode for TAPSE.
3-D echo	Echocardiography typically shows a flat picture, but the machines can also create 3-D imaging. This technology is **particularly helpful for identifying problems with heart valves**, replacement heart valves, and the heart’s lower left chamber (left ventricle). Additional ways to use 3-D echo are under investigation.
Stress echo	Stress test that deliberately increases heart rate and blood pressure. Two sets of images are taken: one at rest, and another after working out on a treadmill or stationary bike. If poor health prevents such physical activity, medication is injected that mimics the effect of exercise. This test is called a pharmacologic stress echocardiogram.

ECHOCARDIOGRAM VIEWS

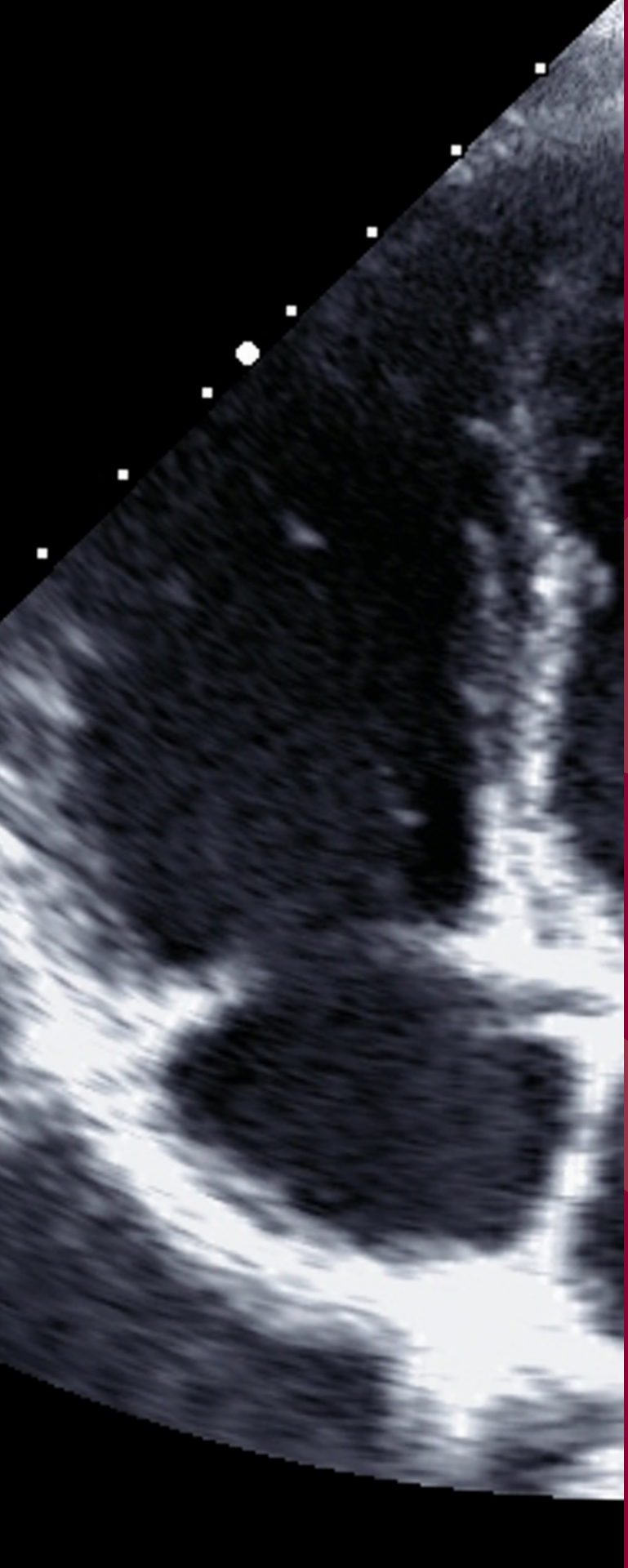
View	Transducer Position	Structures Seen
Apical 4-chamber 	Over the **apex** of the heart (fifth intercostal space)	• Right Ventricle • Left Ventricle • Right Atrium • Left Atrium • Interventricular Septum • Interatrial Septum • Tricuspid leaflets • Lateral wall of LV
Right Parasternal 	Over the third or fourth left intercostal space adjacent to sternum	• RV outflow tract • Pulmonary artery • Pulmonary valve



The **apex** (the most inferior, anterior, and lateral part as the heart lies in situ) is located on the midclavicular line, in **the fifth intercostal space**. It is formed by the **left ventricle.**

GLOSSARY/ABBREVIATIONS

A4C	Apical four-chamber view of an echocardiogram.
Annulus	Ring-shaped structure that provides support for the flaps of a valve.
Bifurcation	A division into two branches.
CI	Cardiac Index
CO	Cardiac Output
Diastole	Dilatory-relaxation phase of the cardiac cycle during which the heart's chambers fill with blood.
Dilation	The state of being expanded or enlarged.
Doppler	Used to measure and assess the flow of blood through the heart's chambers and valves.
Effusion	The escape of fluid from the blood vessels or lymphatics into the tissues or a cavity.
ESC/ERS	European Society of Cardiology/European Respiratory Society
Hypertrophy	Enlargement of an organ or a tissue as a result of an increase in size.
Intercostal Space	An interval between the ribs, occupied by intercostal muscles, veins, arteries, and nerves.
IVC	Inferior Vena Cava
IVS	Interventricular Septum
LA	Left Atrium/Atrial
LV	Left Ventricle
M-mode	Simplest type of echocardiography, produces an image that is similar to a tracing.
mPAP	Mean Pulmonary Arterial Pressure
NT-proBNP	N-Terminal pro B-type Natriuretic Peptide
PA	Pulmonary Artery
PAH	Pulmonary Arterial Hypertension
PAP	Pulmonary Arterial Pressure
Pericardial	Pertaining to the area around the heart.
PV	Pulmonary Valve
RA	Right Atrium/Atrial
RAP	Right Atrial Pressure
RHC	Right Heart Catheterization
RV	Right Ventricle
RVSP	Right Ventricular Systolic Pressure
Septum	A thin wall dividing two cavities.
sPAP	Systolic Pulmonary Arterial Pressure
Systole	The period during which the chambers of the heart (the atria and the ventricles) contract.
TAPSE	Tricuspid Annular Plane Systolic Excursion
TRV	Tricuspid Regurgitant Jet Velocity
TTE	Transthoracic Echocardiography



The Echo in PAH

State of the Art in Right Heart Assessment

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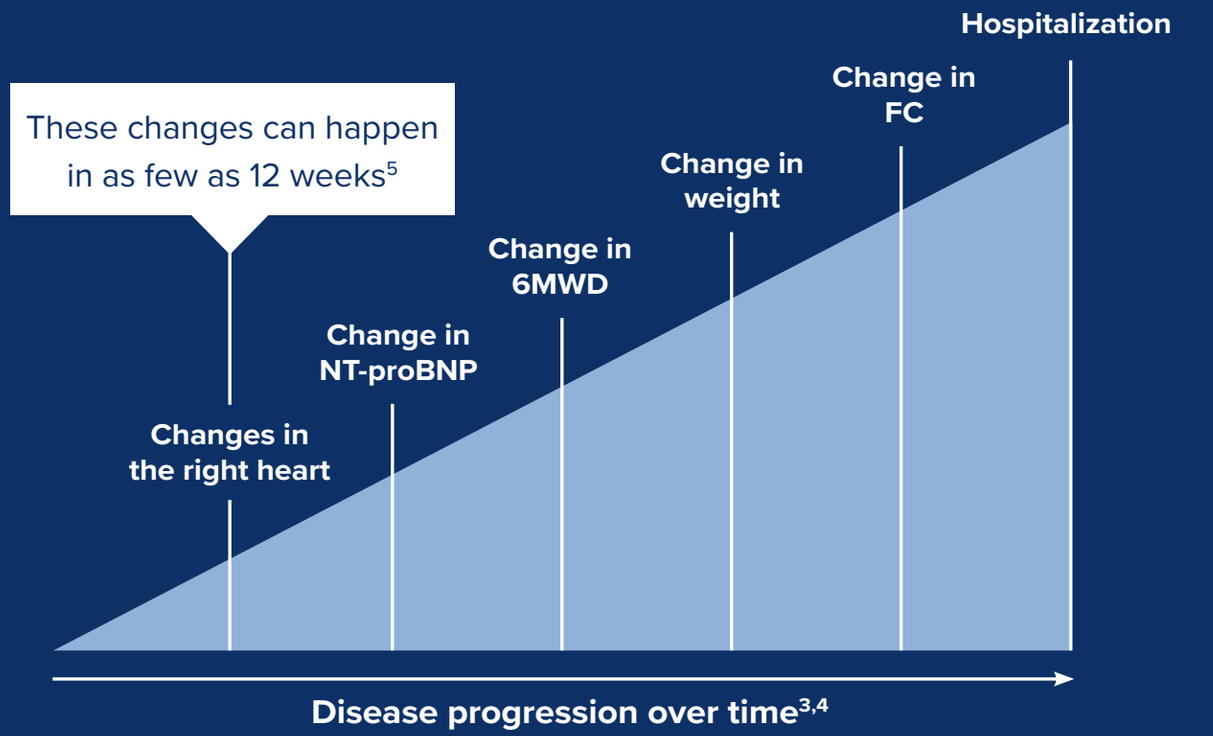
Echocardiography Is a Critical Component of Patient Care in PAH

Regular, ongoing evaluation of the RH is essential in screening for PAH and early detection of its progression over time.[1,2]

Detrimental changes to RH structure and function are leading indicators of PAH progression.[1]



Adapted from Milks MW, et al. *J Heart Lung Transplant*. 2021;40(3):172-182.

Echo provides a noninvasive assessment of the hemodynamic burden of the RV at diagnosis and throughout treatment[1]

Echo as a Diagnostic Screening Tool[6]

- Assesses parameters that are closely related to hemodynamic variables
- Can be used to evaluate the probability of PH*

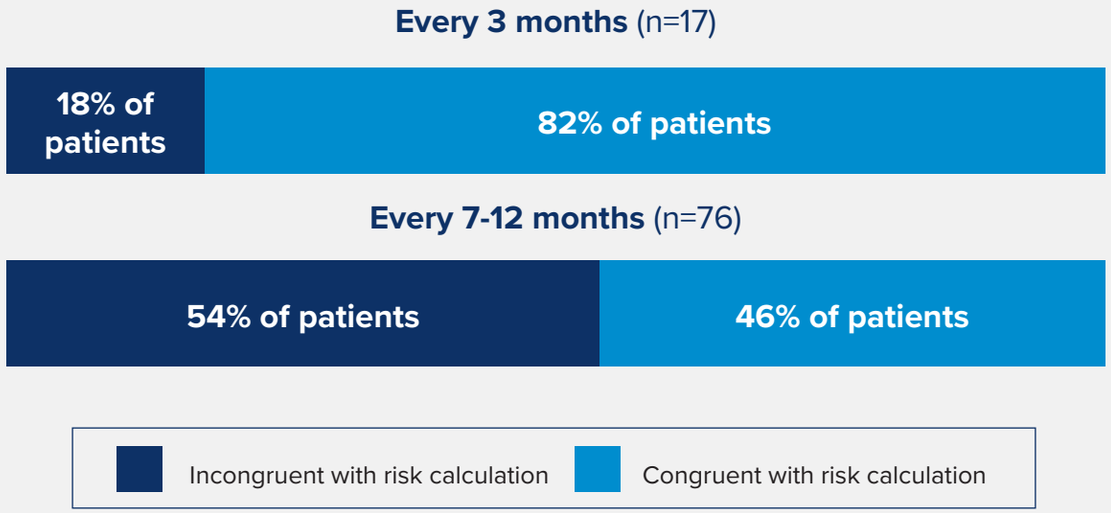
Echo as a Treatment Monitoring Tool[1,3,4,7]

- Gives insight into disease progression before symptoms worsen
- Can be used to inform treatment approaches
- May provide important prognostic information

Echos are recommended at baseline and as often as every 3 to 6 months in patients with PAH[2,6]

In a retrospective study of 153 FC II patients, physicians who ordered Echos more frequently (every 3 months) were more likely to accurately assess their patient's risk status.[2]

Congruence of gestalt and formal risk calculation based on Echo frequency (*P*=0.01)†



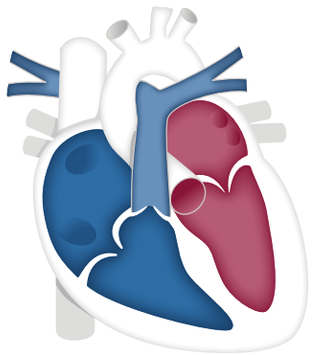
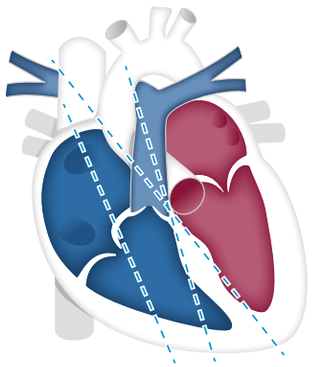
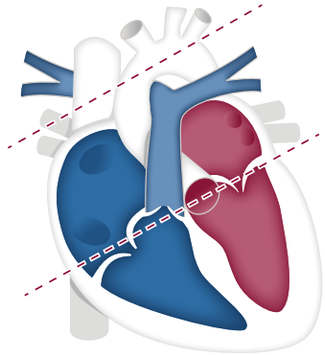
*An RHC is required for definitive diagnosis of PAH.[2]
†No statistically significant difference in incongruency between an Echo frequency of every 3 months compared with every 4 to 6 months (*P*=0.069).[2]

Echo Provides a Detailed Assessment of RH Structure and Function

To conduct a comprehensive Echo examination of changes in the RH, it is important to perform a multiparameter assessment that includes measurements of RV size, the relative proportion of the RV to the LV, and RV systolic function.[8]

Views

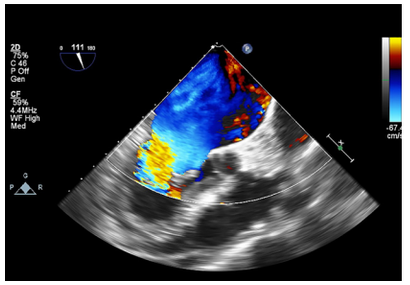
Echo assessments should capture views along each axis of the heart at various levels to cover the structures relevant to PAH.[9-11]

Window	Apical	Parasternal long-axis	Parasternal short-axis
Views	4-chamber	• Standard • RV inflow • RV outflow	• Aortic valve • Mid-cavity
Structures	• Left ventricle (inferior septum and anterior lateral segments) • Right ventricle • Left atrium • Right atrium • Mitral valve	• Right atrium • Tricuspid valve • Pulmonary valve • Pulmonary artery	• Pulmonary valve • Pulmonary artery • Mitral valve • Interventricular septum • Right ventricle
			

Echo Also Evaluates the Velocity of Blood Flow

Modalities

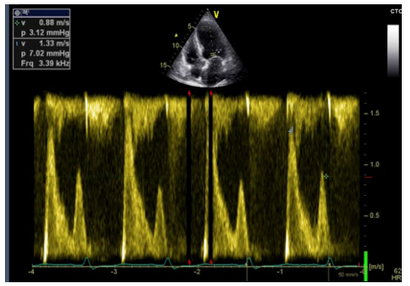
To assess the RH in PAH, the Echo sequence should include a Doppler examination, which generates images of the heart while also evaluating blood flow. Different types of Doppler are useful for capturing specific parameters.[11]



Color Doppler

Definition: In color Doppler, the colors represent the speed and direction of blood flow in real time[12]

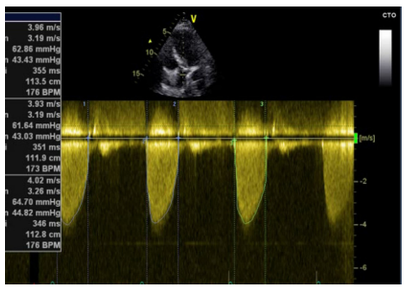
Use in PAH: All apical and parasternal views should be captured using color Doppler[11]



Pulsed-wave Doppler

Definition: Pulsed-wave Doppler uses short pulses of sound to measure blood flow[12]

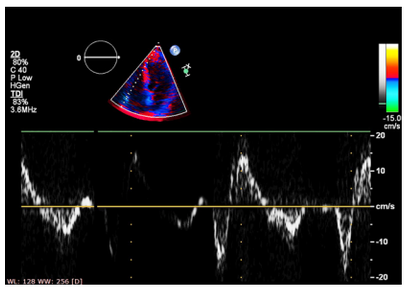
Use in PAH: Pulsed-wave Doppler is used to determine transmitral velocities, LV outflow tract, tricuspid inflow, and RVOT[11]



Continuous-wave Doppler

Definition: Instead of pulses, continuous-wave Doppler uses constant sound waves to permit measurement of faster blood flows[12]

Use in PAH: Continuous-wave Doppler can be used to assess the LV outflow aortic valve, the tricuspid valve, and the pulmonary valve[11]



Tissue Doppler

Definition: Tissue Doppler assesses the lower velocity, higher amplitude motion of the myocardium[12]

Use in PAH: It is useful in evaluating the velocity of RV contraction in the longitudinal axis[11]

Pulsed-wave and continuous-wave Doppler images from Ahmed I, Sasikumar N. StatPearls [Internet]. Accessed May 24, 2022. https://www.ncbi.nlm.nih.gov/books/NBK572130/ Republished under CC BY 4.0 license.

Echo Measures Dimensions and Functional Parameters Relevant to the Management of PAH

Parameters	Definition/Purpose	View	Significance in PAH
Dimensions			
LA AP dimension[13,14]	Simple-to-measure indicator of LA size	Parasternal long-axis	Left atrial AP dimension <3.2 cm is indicative of PH when other abnormal parameters are present
Pulmonary artery diameter[15]	Evaluation of pulmonary artery size	Parasternal short-axis	Diameters of >25 mm are considered abnormal and may indicate increased RV afterload
RA area[15]	Indicator of RA size	Apical 4-chamber	RA area >18 cm^2 is indicative of dilation
RV:LV dimension[8]	Comparison of RV to LV size provides an indirect measure of RV systolic dysfunction	Apical 4-chamber	RV:LV ratio >1.0 is suggestive of RV dilation
Functional parameters			
E/e' [13,16]	Estimation of LH filling pressures	Tissue Doppler imaging	E/e' >10 with an abnormal RVOT Doppler is indicative of PH
RV fractional area change[8,11,17]	Total area change of the RV during systole; direct indicator of RV systolic function	Apical 4-chamber	Associated with survival in PAH
Septal flattening[8,15,16]	Indicator of possible afterload-dependent RV dysfunction	Parasternal short-axis	Early sign of underlying PH; even mild septal flattening is abnormal
TAPSE[11,17,18]	Displacement of the tricuspid annulus toward RV apex; direct indicator of RV systolic function	Apical 4- chamber	TAPSE of <1.8 cm is associated with greater RV systolic dysfunction; correlates with RV ejection fraction
TRV[8,15]	Estimate of the pressure difference between the RV and the RA	Multiple views (apical 4-chamber, parasternal long-axis, parasternal short-axis)	Peak TRV >3.4 m/s suggests a high probability of PH

Important Echo Parameters in PAH

Views

Apical 4-chamber

Parasternal long axis

Standard, RV inflow, and RV outflow

Parasternal short axis

Mid-cavity level, aortic valve level

Modalities

Color Doppler

Pulsed-wave Doppler

Continuous-wave Doppler

Tissue Doppler

Measurements

Dimensions

- LA AP dimension
- Pulmonary artery diameter
- RA area
- RV:LV dimension

Functional parameters

- E/e'
- RV fractional area change
- Septal flattening
- TAPSE
- TRV

Notes

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