6th iHEF iCARD
The 6th Indonesian
Symposium on Heart Failure and
Cardiometabolic Disease

Beyond the Ejection Fraction : A practical Guide to Assessing Diastolic Function & Filling Pressure

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Why diastolic still matters

Dyspnea is common. Filling pressure is the bridge.

The practical question is rarely "does relaxation exist?"
It is: "are pressures normal now, or will they rise with stress?"

Relaxation
active, time-dependent

Elastic recoil
early suction

Compliance
volume at low pressure

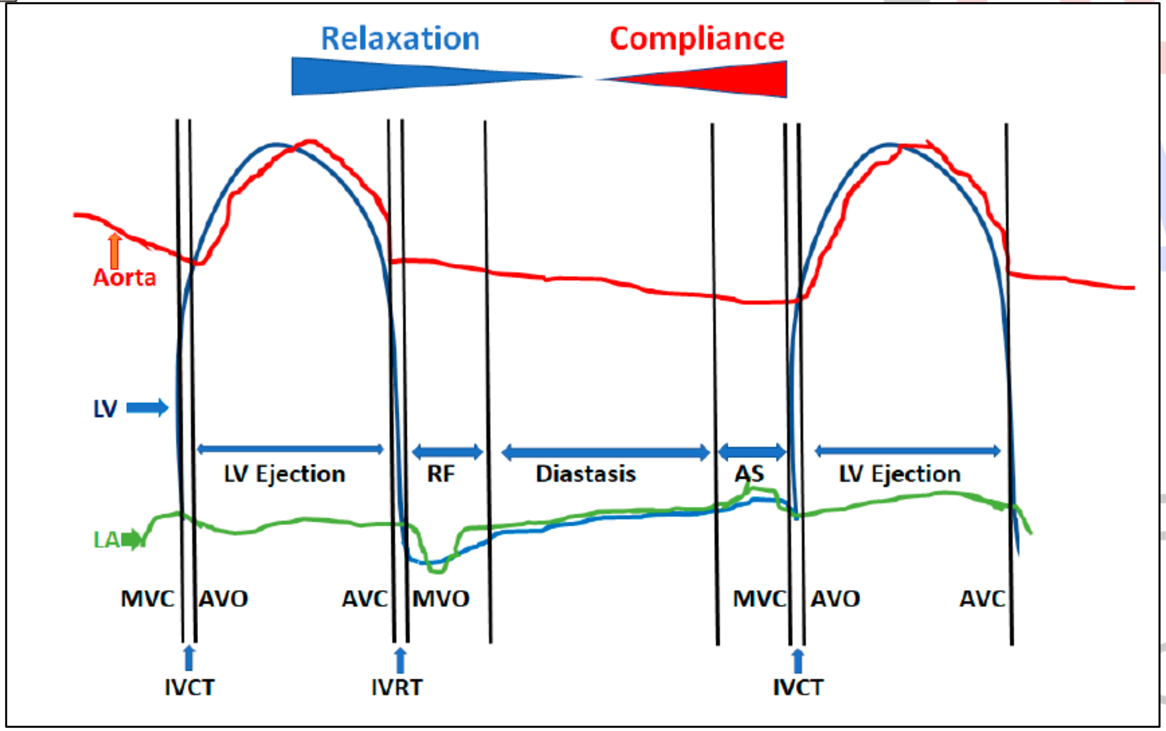
HFpEF diagnosis requires symptoms, phenotype, natriuretic peptides, and echo context — not a single Doppler number.

Elevated LAP explains exertional dyspnea, pulmonary venous congestion, and prognosis.

Reports should answer normal vs abnormal diastolic function, grade, and estimated filling pressure when possible.

Sources: ASE 2016, ASE 2025

Diastolic is a pressure-gradient relation



Normal filling

Rapid LV pressure fall creates suction
Adequate compliance allows volume at low pressure
LA pressure remains low at rest and exercise

Diastolic dysfunction

Relaxation delay blunts early filling
Stiffer LV shifts pressure–volume relation upward
LAP rises first with stress, then at rest

Sources: BSE 2024; Pai & Varadarajan, 2024; ASE 2025;

“Filling pressure” is not one number

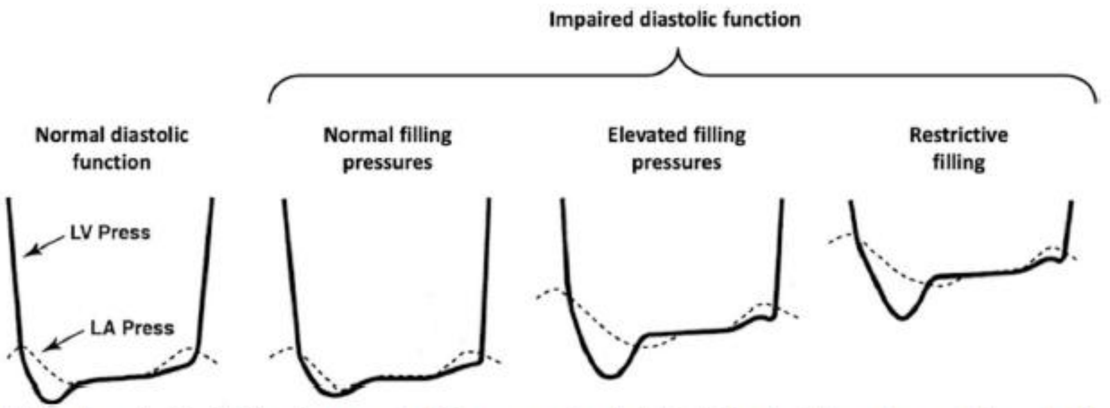


Fig. 9 Relative changes in LA and LV diastolic pressures in different stages of impaired diastolic function. LAP remains normal when relaxation is impaired but becomes elevated when LV compliance is decreased. [42] Adapted from Panesar, Dilveer and Burch

LVEDP

End-diastolic LV pressure

Can be isolated early in disease
Reflects chamber stiffness at end-diastole
May rise **before** mean LAP

Sources: ASE 2025

Mean LAP / PCWP

Mean left atrial / wedge pressure

Closest to pulmonary congestion
Often what echo algorithms estimate
Invasive abnormal at rest: PCWP >15 mmHg

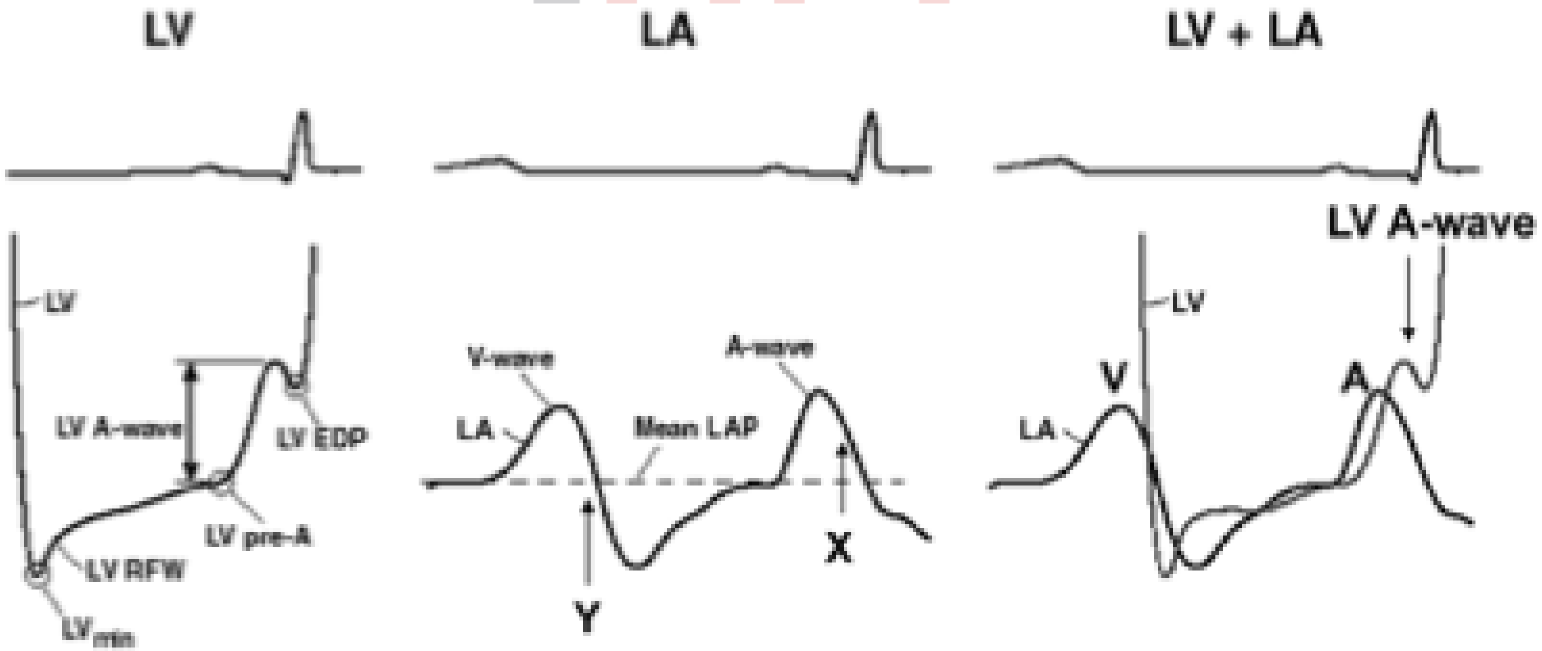


Figure 1 *(Left)* LV diastolic pressure recording. *Arrows* point to LV minimal pressure (min), LV rapid filling wave (RFW), LV pre-A pressure (pre-A), A-wave rise with atrial contraction, and end-diastolic pressure (EDP). *(Middle)* LA pressure recording showing "V" and "A" waves marked along with Y and X descent. *(Right)* Simultaneous LV pressure and LAP recording showing early and late transmitral pressure gradients. Notice that LA "A-wave" pressure precedes the late diastolic rise (LV A wave) in LV pressure.

GUIDELINES AND STANDARDS

Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography and for Heart Failure With Preserved Ejection Fraction Diagnosis: An Update From the American Society of Echocardiography

Check for updates

Sherif F. Nagueh, MD, FASE (Chair), Danita Y. Sanborn, MD, FASE (Co-Chair), Jae K. Oh, MD, FASE, Bonita Anderson, MApplSc, DMU, ACS, FASE, FASA, Kristen Billick, BS, ACS, RCS, RDCS, FASE, Genevieve Derumeaux, MD, PhD, Allan Klein, MD, FASE, Konstantinos Koulogiannis, MD, FASE, Carol Mitchell, PhD, ACS, RDMS, RDCS, RVT, RT(R), FASE, Amil Shah, MD, Kavita Sharma, MD, Otto A. Smiseth, MD, PhD, Honorary FASE, and Teresa S. M. Tsang, MD, FASE, *Houston and Dallas, Texas; Boston, Massachusetts; Rochester, Minnesota; Brisbane, Australia; San Diego, California; Creteil, France; Cleveland, Ohio; Morristown, New Jersey; Madison, Wisconsin; Baltimore, Maryland; Oslo, Norway; and Vancouver, British Columbia, Canada*

Nagueh et al Journal of the American Society of Echocardiography, July 2025

Simplified from ASE 2025 Figure 3; exceptions and supplemental parameters should be checked in the guideline.

Echocardiographic correlates with mean PCWP and with LVEDP

PCWP, mean LAP, LV pre-A, and mean LV diastolic pressure correlates	LVEDP correlates
1. Mitral peak E velocity	1. Mitral peak A velocity at tips level
2. Mitral E/A ratio	2. A-wave duration at the annulus
3. Mitral E velocity deceleration time	3. Mitral A velocity (tips level) deceleration time
4. Mitral E/e′ ratio	4. Pulmonary vein peak Ar velocity
5. Pulmonary vein systolic-to-diastolic velocity ratio	5. Pulmonary vein Ar duration – mitral A duration
6. Peak TR velocity and PASP	6. LA minimum volume
7. End-diastolic velocity of PR and PADP	7. Tissue Doppler–derived mitral annular a′ velocity
8. LARS	8. LA pump (or contractile) strain

- The term LV filling pressure refers to mean LAP or its correlates (mean PCWP, LV pre-A pressure).
- LVEDP and LAP are not the same.
- Elevated LAP is always associated with elevated LVEDP in patients with diastolic dysfunction, elevated LVEDP may be present when LAP is normal.

Nagueh et al Journal of the American Society of Echocardiography, July 2025

2025 ASE: diagnosing LV diastolic dysfunction

STEP 1
Assess e’ as marker of impaired LV relaxation

- *e’ septal ≤6 cm/s or*
- *lateral ≤ 7 or*
- *Average ≤ 6.5**

STEP 2
Assess markers of LA/LV remodeling and elevated LAP

- Average E/e’ > 14
- LARS ≤ 18%
- E/A≤0.8*, or ≥2
- LAVI > 34 ml/m² ¶

Diastolic dysfunction present if:

- e’ reduced & 1 or more markers in Step 2 present or
- e’ preserved, but 2 or more markers in Step 2 present

* : can also consider age specific cutoff values to identify abnormally reduced e’ velocity or abnormally reduced E/A ratio
: after excluding LA enlargement in athletes, or due to anemia, atrial fibrillation or flutter, and mitral valve disease
¶ : another finding consistent with diastolic dysfunction: LV mass index >95 g/m² in women or 115 g/m² in men, after exclusion of increased LV mass in athletes

Simplified from ASE 2025 Figure 3; exceptions and supplemental parameters should be checked in the guideline.

Nagueh et al Journal of the American Society of Echocardiography, July 2025

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ALGORITHM IN PRACTICE

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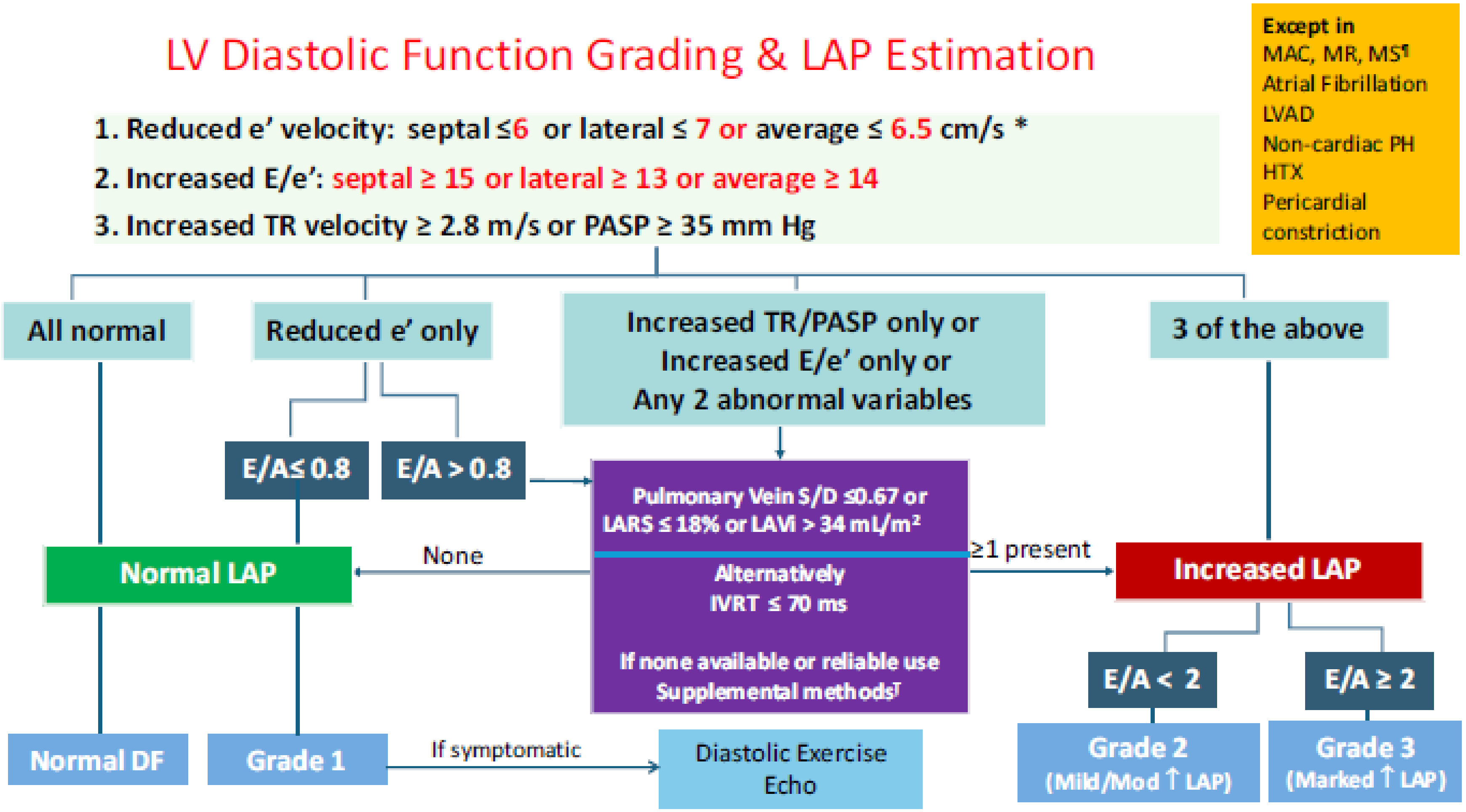
2025 ASE: diagnosing LV diastolic dysfunction

LV Diastolic Function Grading & LAP Estimation



Simplified from ASE 2025 Figure 3; exceptions and supplemental parameters should be checked in the guideline.

Nagueh et al Journal of the American Society of Echocardiography, July 2025

2025 ASE: estimating mean LAP and grading

Three primary signals

- Reduced e′ velocity
- Average E/e′ ≥14
- TR Vmax ≥2.8 m/s or PASP ≥35

How many are abnormal?

0/3	Reduced e' only	2/3 or 3/3	Discordant
Normal LAP	**Normal LAP**	**Elevated LAP**	**Use supplemental parameters or stress echo**
Normal DF	Grade 1	Grade 2 if E/A <2 Grade 3 if E/A ≥2	LAVi, LARS, PV flow, IVRT, Valsalva

Do not apply the general algorithm uncritically in severe primary MR, mitral stenosis, moderate/severe MAC, AF, LVAD, non-cardiac PH, transplant, or constriction.

Source from ASE 2025

Transmitral inflow

E wave early LA-to-LV pressure gradient and recoil/suction.

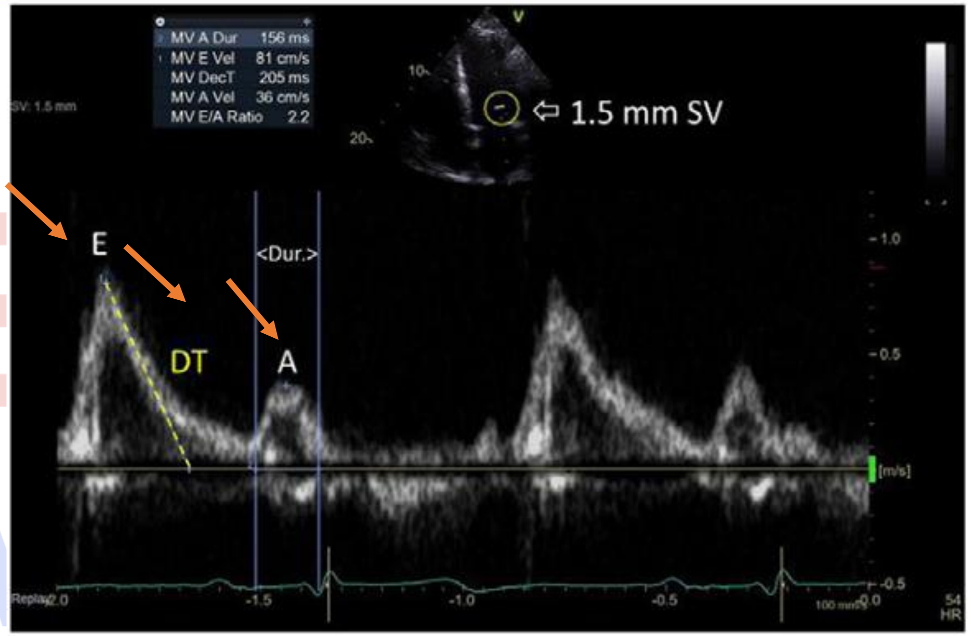
A wave atrial contribution to LV filling.

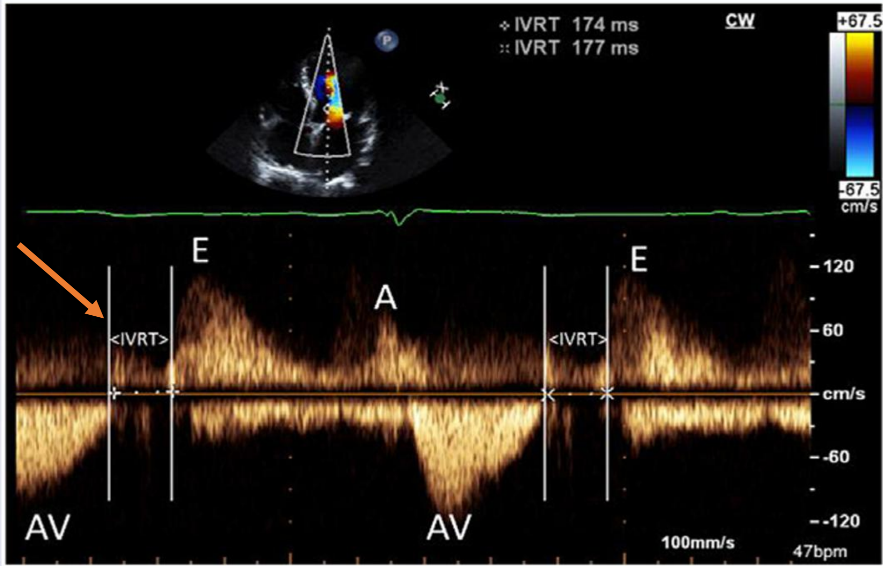
DT rate of early pressure equalization; short with high pressure/stiffness.

IVRT time from aortic valve closure to mitral opening; shortens with high LAP.

Limitation Mitral inflow is load- and age-dependent. Pseudonormal patterns are the classic trap.

Sources: ASE 2025





Tissue Doppler e'

e'

Mitral annular early diastolic velocity

A practical marker of LV relaxation that is less load-dependent than transmitral flow, but not load-independent.

2025 ASE age-independent trigger for impaired relaxation

Septal e'	**≤ 6 cm/s**
Lateral e'	**≤ 7 cm/s**
Average e'	**≤ 6.5 cm/s**

Caveats: annular calcification, prosthetic rings, regional wall motion abnormality, constriction, pacing/LBBB, and mitral valve disease.

Sources: ASE 2025

E/e' Ratio

E/e'

Approximate relation: transmitral pressure gradient / annular relaxation velocity

Average E/e' ≥ 14

supports elevated LAP in the general algorithm

When E/e' can mislead

Heavy MAC
Prosthetic mitral rings
Mitral stenosis
Primary MR and severe secondary MR
Constrictive physiology
HCM
pacing/LBBB
Young healthy patients and marked preload shifts

Sources: ASE 2025

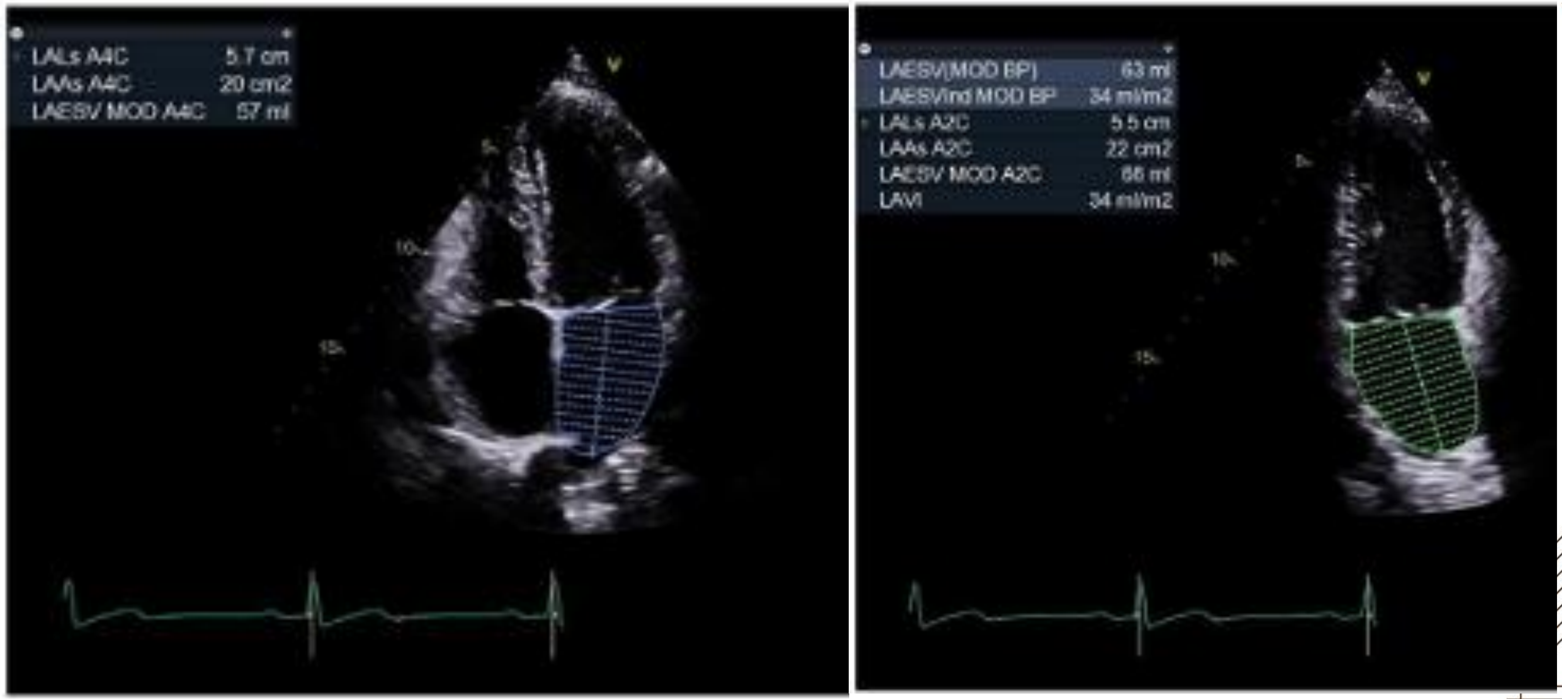
The left atrium: pressure memory and reservoir function

LAVi

Left atrial volume index

>34 mL/m²

Chronic exposure to elevated filling pressures but enlarged LA can reflect AF, MR, anemia, athletic remodeling, high-output states.



Sources: ASE 2025

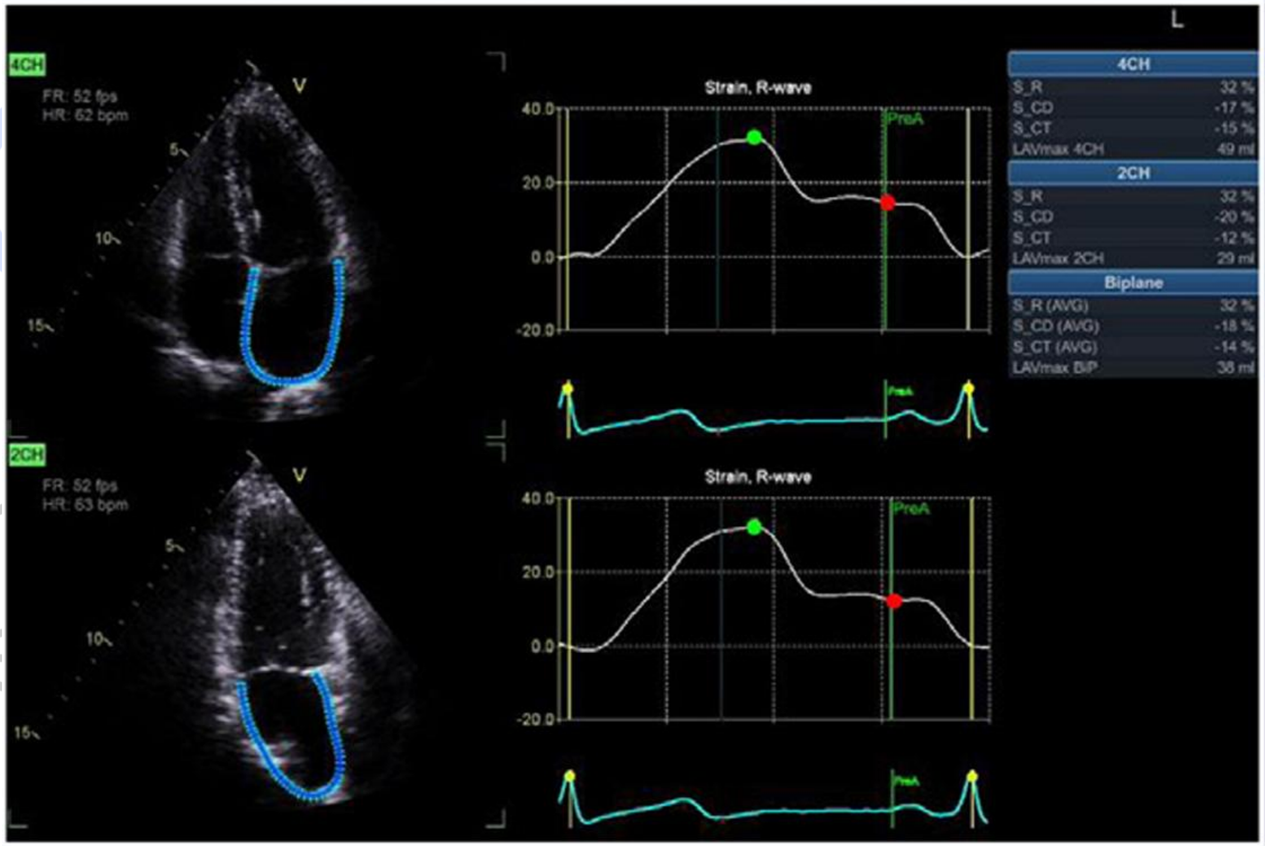
The left atrium: pressure memory and reservoir function

LARS

LA reservoir strain

≤18%

Dynamic functional marker increasingly incorporated in contemporary algorithms; high specificity for elevated LAP but vendor/training quality matters.



Sources: ASE 2025

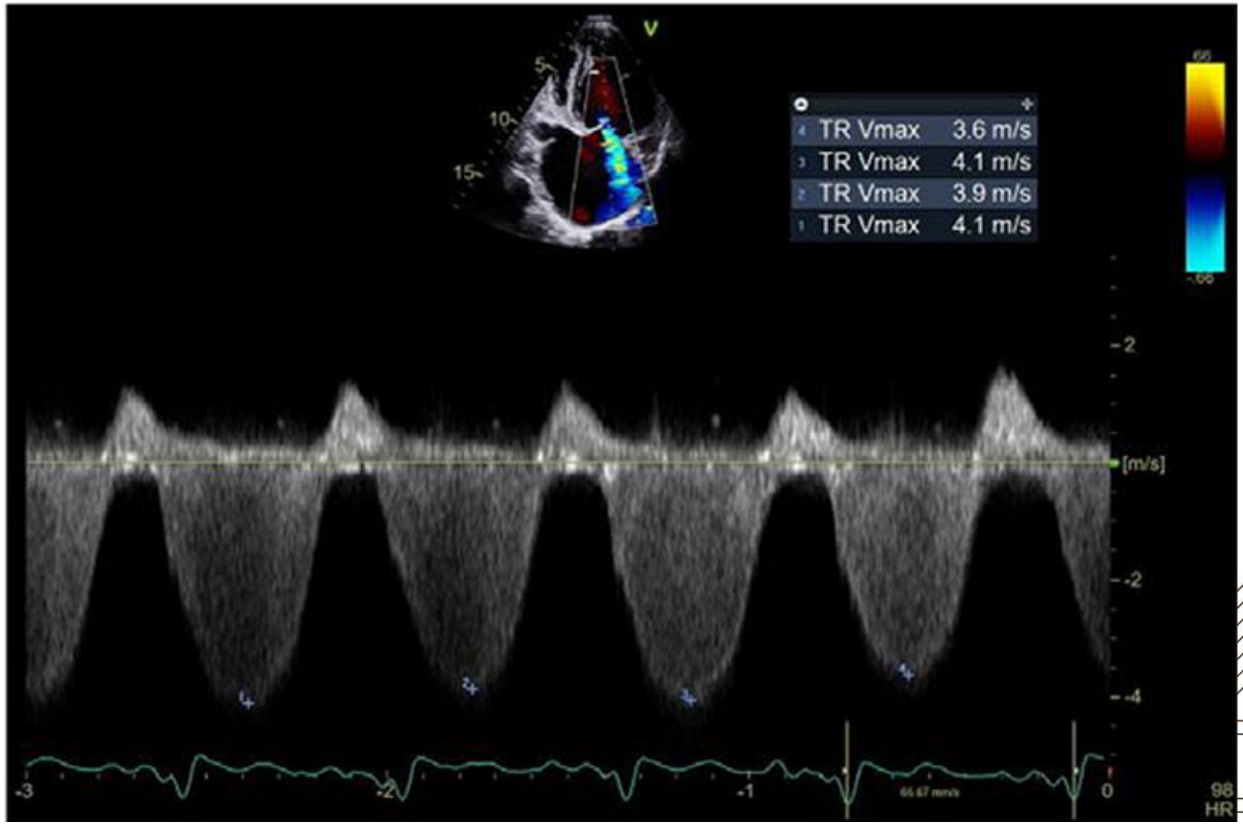
TR velocity and pulmonary venous flow

TR velocity / PASP

Elevated LAP can transmit to pulmonary circulation, but TR velocity also **reflects pulmonary vascular and RV disease.**

TR Vmax ≥2.8 m/s or PASP ≥35 mmHg

Use with RAP estimate and clinical context.

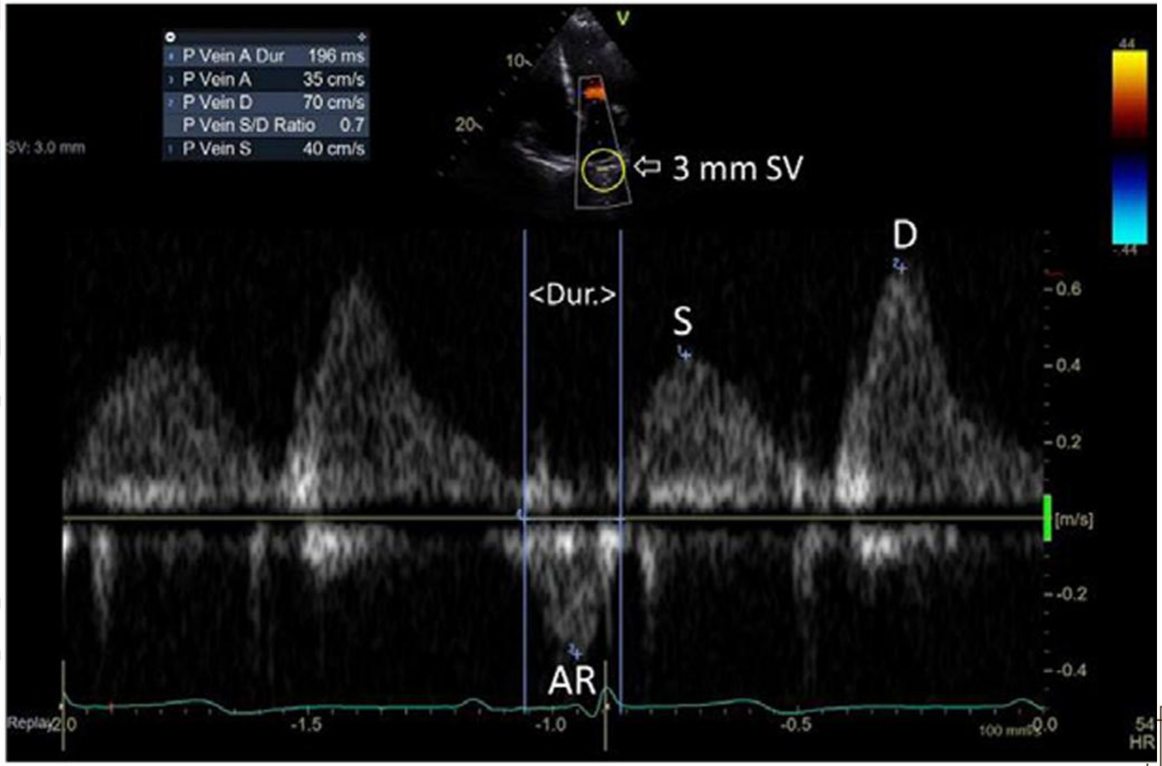


TR velocity and pulmonary venous flow

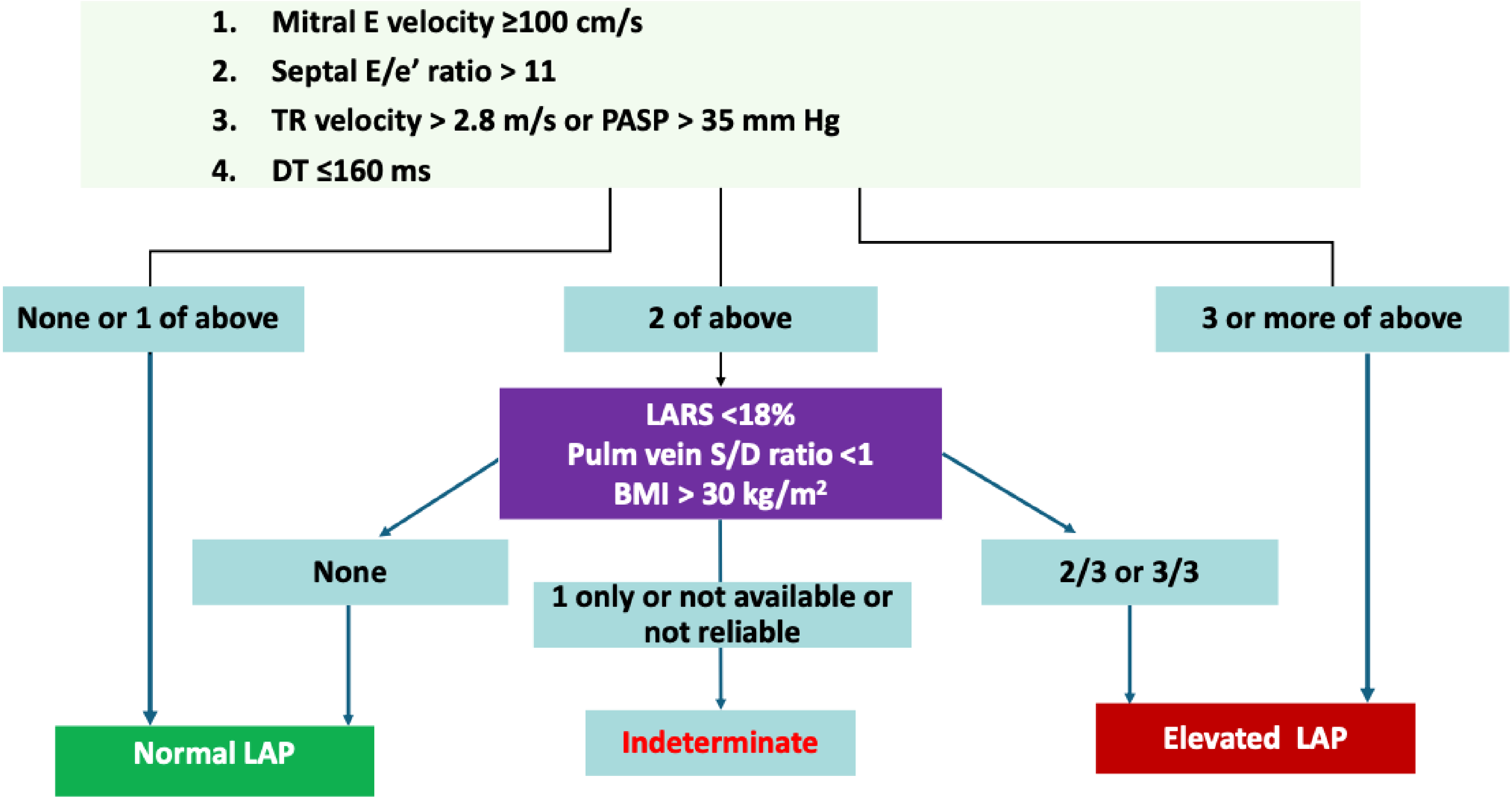
Pulmonary venous flow

S/D ratio reduced systolic dominance can support elevated LAP.
Ar–A duration >30 ms suggests elevated LVEDP.
Best use as supplemental evidence when primary parameters conflict or are missing.

Practical caveat PV flow is technically demanding and rhythm/mitral disease sensitive.



2025 ASE: LAP estimation in Atrial Fibrillation



Source from ASE 2025 Figure 8

2025 ASE: LAP estimation in Moderate-Severe MAC

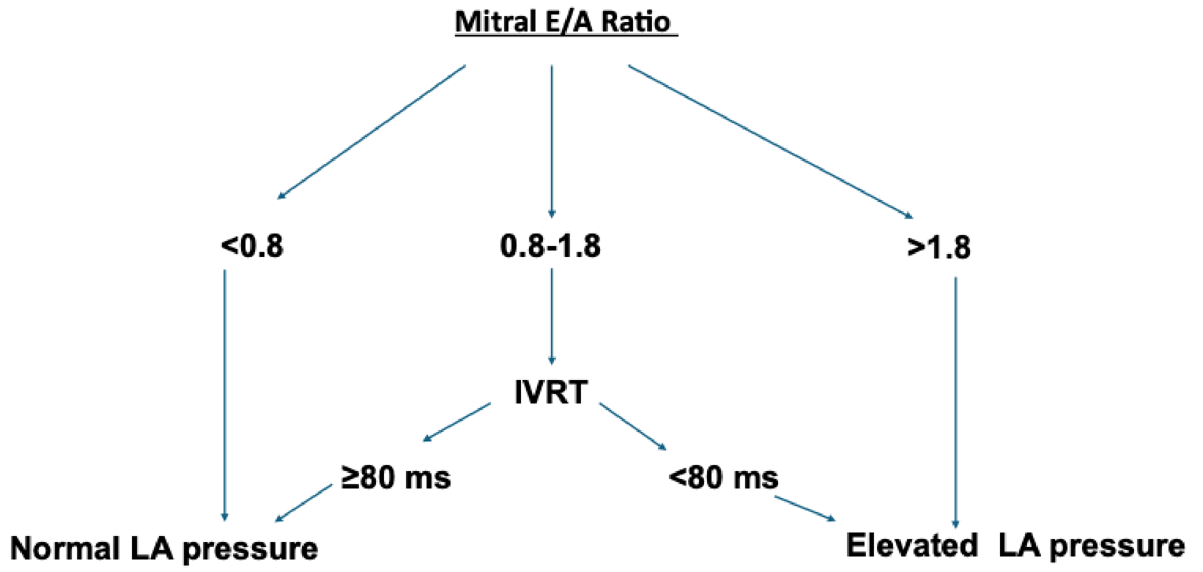


Figure 4 Algorithm for estimation of mean LAP in patients with moderate or severe MAC.

Source from ASE 2025 Figure 4

2025 ASE: LAP estimation in Pulmonary Hypertension

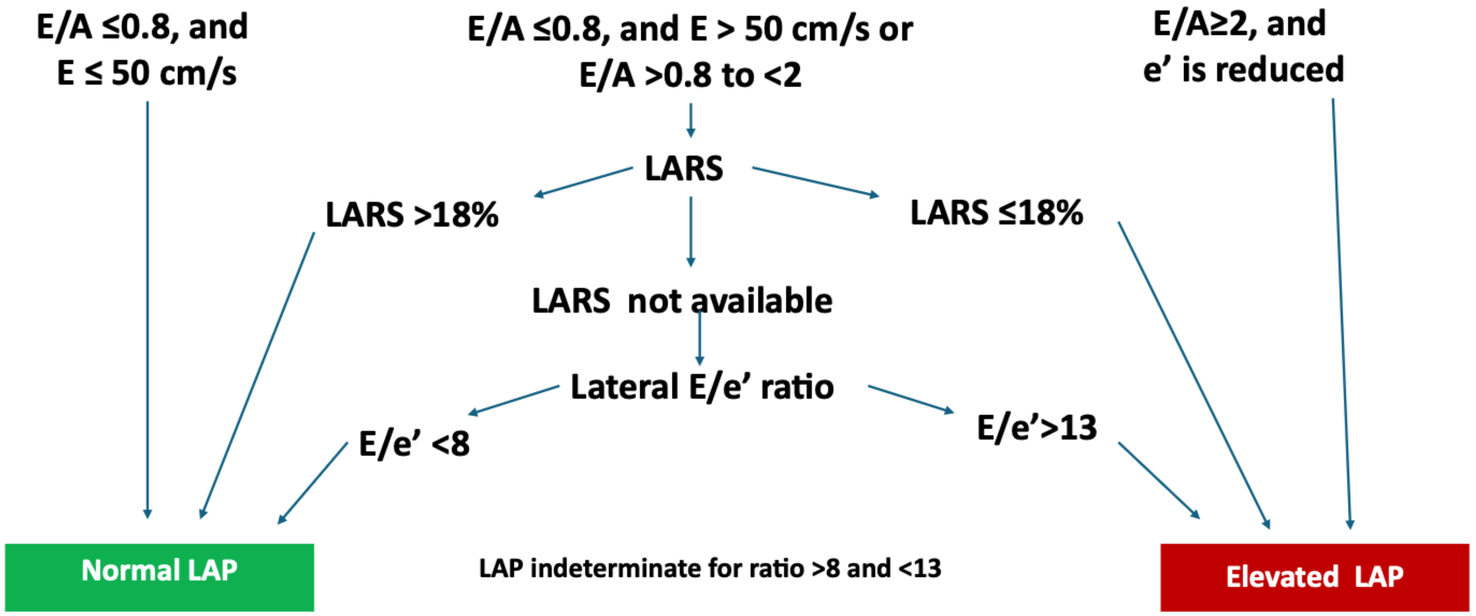
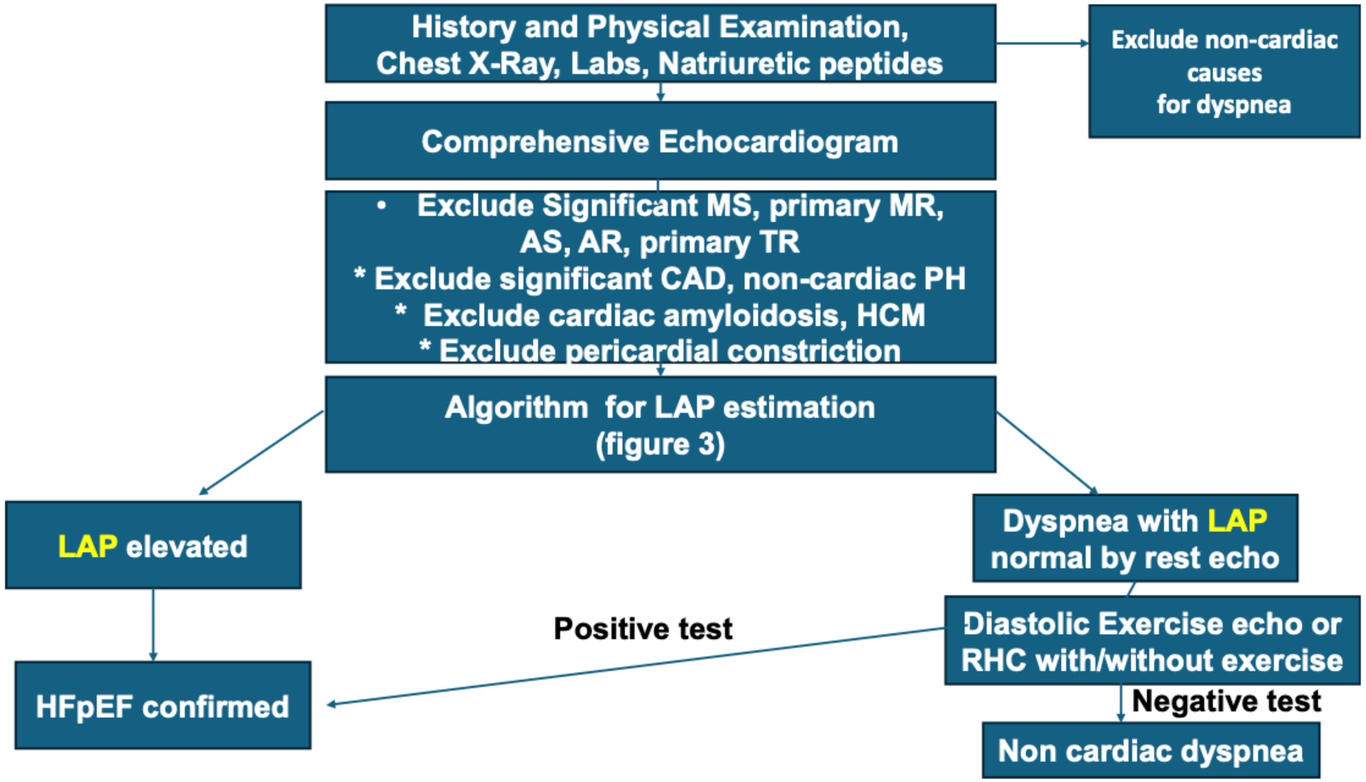


Figure 6 Algorithm for estimation of mean LAP in patients with PH.

Source from ASE 2025 Figure 6

Algorithm for HFpEF diagnosis

Multimodality imaging and cardiac catheterization should be used as needed to establish the presence of alternative diagnoses to HFpEF



Source from ASE 2025 Figure 9

HFpEF: The Algorithm

The HFA-PEFF Algorithm for the Diagnosis of HFpEF

P	Initial Workup (Step 1 (P) : Pretest Assessment)	• Symptoms and/or Signs of HF • Comorbidities / Risk factors • ECG • Standard Echocardiography • Natriuretic Peptides • Ergometry / 6 min walking test or Cardiopulmonary Exercise Testing
E	Diagnostic Workup (Step 2 (E) : Echocardiographic and Natriuretic Peptide Score)	• Comprehensive Echocardiography • Natriuretic Peptides, if not measured in Step 1
F1	Advanced Workup (Step 3 (F1) : Functional testing in Case of Uncertainty)	• Diastolic Stress Test: Exercise Stress Echocardiography • Invasive Haemodynamic Measurements
F2	Aetiological Workup (Step 4 (F2) : Final Aetiology)	• Cardiovascular Magnetic Resonance • Cardiac or Non-Cardiac Biopsies • Scintigraphy / CT / PET • Genetic testing • Specific Laboratory Tests

	Functional	Morphological	Biomarker (SR)	Biomarker (AF)
Major	septal e' < 7 cm/s or lateral e' < 10 cm/s or Average E/e' ≥ 15 or TR velocity > 2.8 m/s (PASP > 35 mmHg)	LAVI > 34 ml/m² or LVMI ≥ 149/122 g/m² (m/w) and RWT > 0,42 #	NT-proBNP > 220 pg/ml or BNP > 80 pg/ml	NT-proBNP > 660 pg/ml or BNP > 240 pg/ml
Minor	Average E/e' 9 -14 or GLS < 16 %	LAVI 29-34 ml/m² or LVMI > 115/95 g/m² (m/w) or RWT > 0,42 or LV wall thickness ≥ 12 mm	NT-proBNP 125-220 pg/ml or BNP 35-80 pg/ml	NT-proBNP 365-660 pg/ml or BNP 105-240 pg/ml

Major Criteria: 2 points	≥ 5 points: HFpEF
Minor Criteria: 1 point	2-4 points: Diastolic Stress Test or Invasive Haemodynamic Measurements

Sources: HFA–PEFF consensus 2019; ASE 2025 HFpEF section; ACC summary of HFA–PEFF.

HFpEF: The Algorithm

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Major	septal e' < 7 cm/s or lateral e' < 10 cm/s or Average E/e' ≥ 15 or TR velocity > 2.8 m/s (PASP > 35 mmHg)	LAVI > 34 ml/m² or LVMI ≥ 149/122 g/m² (m/w) and RWT > 0,42 #	NT-proBNP > 220 pg/ml or BNP > 80 pg/ml	NT-proBNP > 660 pg/ml or BNP > 240 pg/ml
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Major Criteria: 2 points	≥ 5 points: HFpEF
Minor Criteria: 1 point	2-4 points: Diastolic Stress Test or Invasive Haemodynamic Measurements

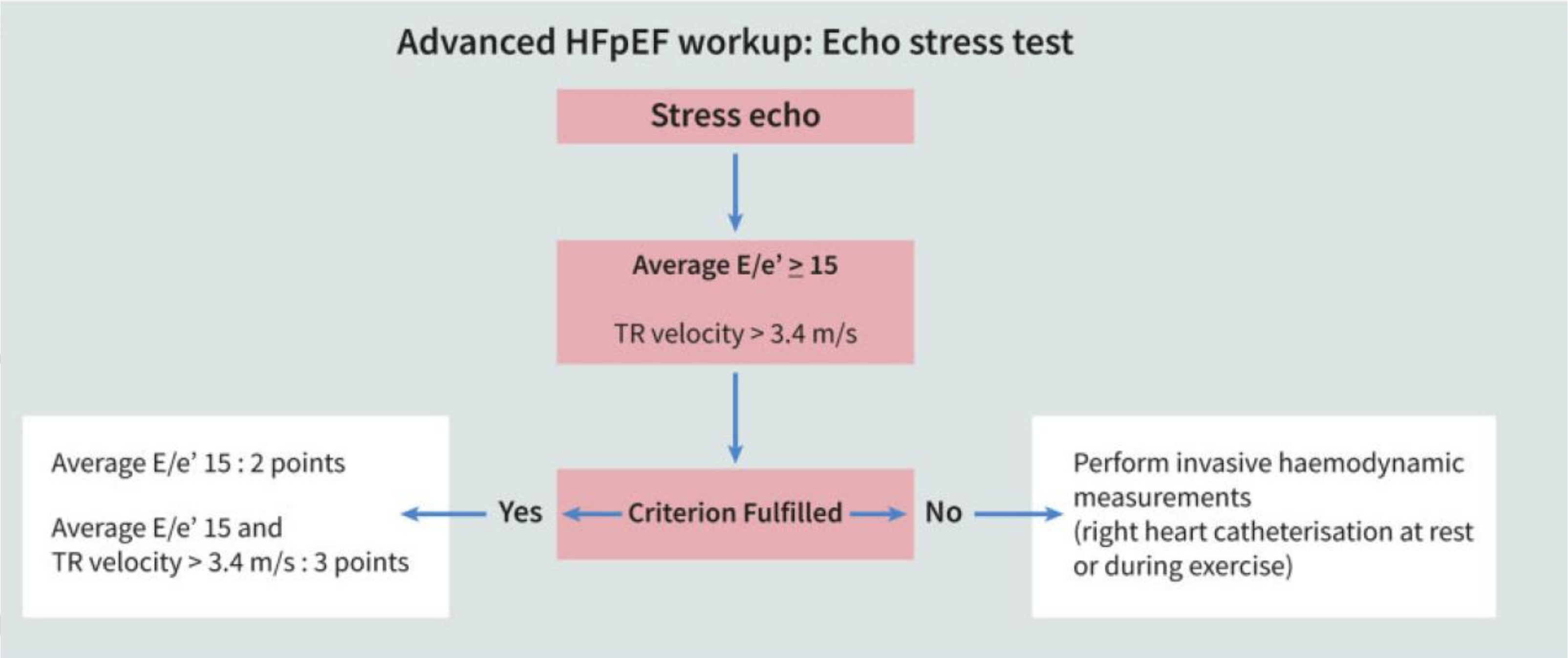
Sources: HFA–PEFF consensus 2019; ASE 2025 HFpEF section; ACC summary of HFA–PEFF.

Diastolic stress echo

Indication

Unexplained exertional dyspnea with nondiagnostic or normal resting filling pressure assessment, especially when HFpEF remains clinically plausible.

The physiology:
stiff LV → disproportionate pressure rise during exercise.



HFA–PEFF consensus 2019

Special populations

Table 7 Indicators of elevated LV filling pressures in special populations

Disease	Echocardiographic measurements indicative of elevated LV filling pressure
1. Atrial fibrillation[40-42]	1. DT < 160 ms in patients with depressed LVEF 2. Peak acceleration rate of mitral E velocity (≥1,900 cm/s^2) 3. IVRT (≤65 ms) 4. DT of pulmonary venous diastolic velocity (≤220 ms) 5. E/Vp ratio (≥1.4) 6. Septal E/e′ ratio (≥11) 7. Peak TR velocity > 2.8 m/s
2. Sinus tachycardia[43,44]	1. Predominant early LV filling pattern with depressed LVEF 2. IVRT ≤ 70 ms is specific (79%) 3. Pulmonary vein systolic filling fraction ≤40% is specific (88%) 4. Average E/e′ ratio > 14 (high specificity but low sensitivity) 5. When E and A velocities are partially or completely fused, the presence of a compensatory period after premature beats often leads to separation of E and A velocities which can be used for assessment of diastolic function
3. HCM[45]	1. Average E/e′ (>14) 2. Ar-A (≥30 ms) 3. Peak TR velocity (>2.8 m/s) 4. LA maximum volume index (>34 mL/m^2)

Source from ASE 2025 Table 7

Special populations

Table 7 Indicators of elevated LV filling pressures in special populations

Disease	Echocardiographic measurements indicative of elevated LV filling pressure
4. Restrictive cardiomyopathy[46-49]	1. Average E/e′ (>14) 2. DT < 140 ms* 3. E/A ratio > 2.5* 4. IVRT < 50 ms*
5. PH[50,51]	1. E/A ≥ 2 favors postcapillary PH 2. E/A ≤ 0.8 favors precapillary PH 3. When E/A ratio is >0.8 but <2, lateral E/e′ ratio > 13, LA maximum volume index > 34 mL/m^2, and LARS < 18% favor the diagnosis of postcapillary PH.
6. Mitral stenosis[52]	1. IVRT < 60 ms* 2. Mitral A peak velocity > 1.5 m/s 3. IVRT/$T_{E\text{-}e'}$ ratio < 4.2
7. MR[52-54]	1. IVRT < 60 ms* 2. Ar-A (≥30 ms) 3. IVRT/$T_{E\text{-}e'}$ ratio < 5.6 4. Average E/e′ ratio > 14 in patients with depressed EF

Source from ASE 2025 Table 7

Special populations

Table 7 Indicators of elevated LV filling pressures in special populations

Disease	Echocardiographic measurements indicative of elevated LV filling pressure
8. Moderate/severe MAC[55]	1. LV filling pressure normal when mitral E/A ratio is <0.8 2. LV filling pressure elevated when mitral E/A ratio is >1.8 3. E/A ratio >0.8 but <1.8, IVRT should be measured. LV filling pressure normal when IVRT is ≥80 ms, whereas it is elevated if IVRT <80 ms.
9. LV assist device[56,57]	1. E/A ratio > 2 2. RAP > 10 mm Hg 3. PASP > 40 mm Hg 4. Average E/e′ ratio > 14 or septal E/e′ ratio ≥ 15 5. LA maximum volume index > 33 mL/m^2 6. Interatrial septum position†
10. Cardiac transplant recipients[58]	1. Average E/e′ ratio < 7 denotes normal LV filling pressures 2. Average E/e′ ratio > 14 denotes elevated LV filling pressures 3. For E/e′ ratio > 7 and <14, SR_{IVR}, from all three apical views, is measured, and the ratio of mitral E velocity to SR_{IVR} is derived. A ratio ≤ 200 cm is consistent with normal LV filling pressure, but >200 cm denotes elevated LV filling pressure. 4. In patients in whom SR_{IVR} cannot be measured, peak TR velocity is relied on. Peak TR velocity ≤ 2.8 m/s is consistent with normal LV filling pressures, but >2.8 m/s denotes elevated LV filling pressures.

*Specific but not sensitive indicators of elevated LV filling pressure.
†LAP = RAP if the interatrial septum position is neutral. If septum bulges to right, then LAP is 5 mm Hg higher than RAP. If septum bulges to left, then LAP is 5 mm Hg lower than RAP.

Key Messages

- **Diastolic** is pressure-gradient physiology
- **LV filling pressure** refers to mean LAP or its correlates (mean PCWP, LV pre-A pressure).
- Elevated LAP is always associated with elevated LVEDP in patients with diastolic dysfunction, elevated LVEDP may be present when LAP is normal
- LVEDP and LAP are not the same.
- The 2025 ASE approach is more structured and incorporates LA strain, reflecting **filling pressure** → used to diagnosing **HFpEF**

References

Nagueh SF, Sanborn DY, Oh JK, et al. Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography and for HFpEF Diagnosis: An Update From ASE. J Am Soc Echocardiogr. 2025;38:537–569. doi:10.1016/j.echo.2025.03.011

Robinson S, Ring L, Oxborough D, et al. The assessment of left ventricular diastolic function: guidance and recommendations from the British Society of Echocardiography. Echo Res Pract. 2024;11:16. doi:10.1186/s44156-024-00051-2

Nagueh SF, Smiseth OA, Appleton CP, et al. Recommendations for the evaluation of LV diastolic function by echocardiography: ASE/EACVI update. J Am Soc Echocardiogr. 2016;29:277–314. doi:10.1016/j.echo.2016.01.011

Pieske B, Tschöpe C, de Boer RA, et al. How to diagnose HFpEF: the HFA–PEFF diagnostic algorithm. Eur Heart J. 2019;40:3297–3317. doi:10.1093/eurheartj/ehz641

Reddy YNV, Carter RE, Obokata M, Redfield MM, Borlaug BA. A Simple, Evidence-Based Approach to Help Guide Diagnosis of HFpEF. Circulation. 2018;138:861–870. doi:10.1161/CIRCULATIONAHA.118.034646

Pai, R. G., & Varadarajan, P. (2024). Diastolic Heart Failure Mechanisms and Assessment Revisited. In *Journal of Clinical Medicine* (Vol. 13, Number 11). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/jcm13113043

Alhamdulillah

THANK YOU

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