COMMON CAUSE

- In day to day clinical practice, the main cause of increased left sided filling pressures is **systemic hypertension**.

BEST WAY!

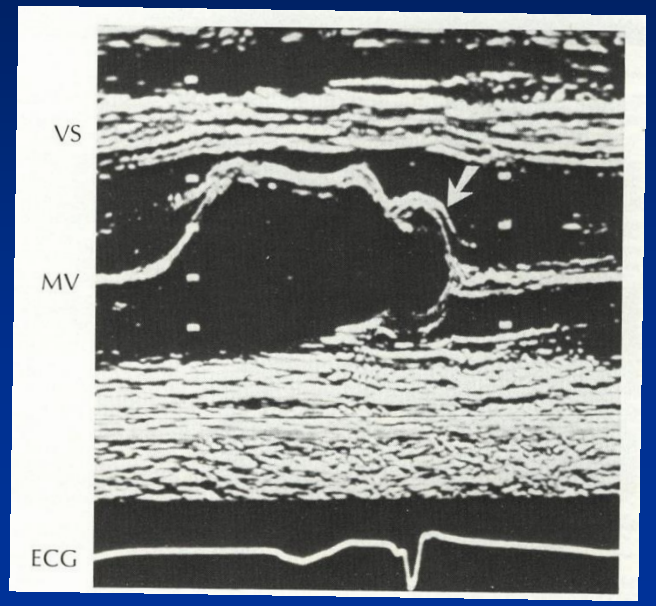
- In a patient with normal (LV ejection fraction ≥ 55%) or near normal (LVEF 45-54%) systolic ventricular function by 2DTTE, the presence of clinical signs of heart failure indicates that the heart failure is on the basis of diastolic dysfunction. In our opinion, this is the best way to diagnose this entity.

WHAT ABOUT IVC?

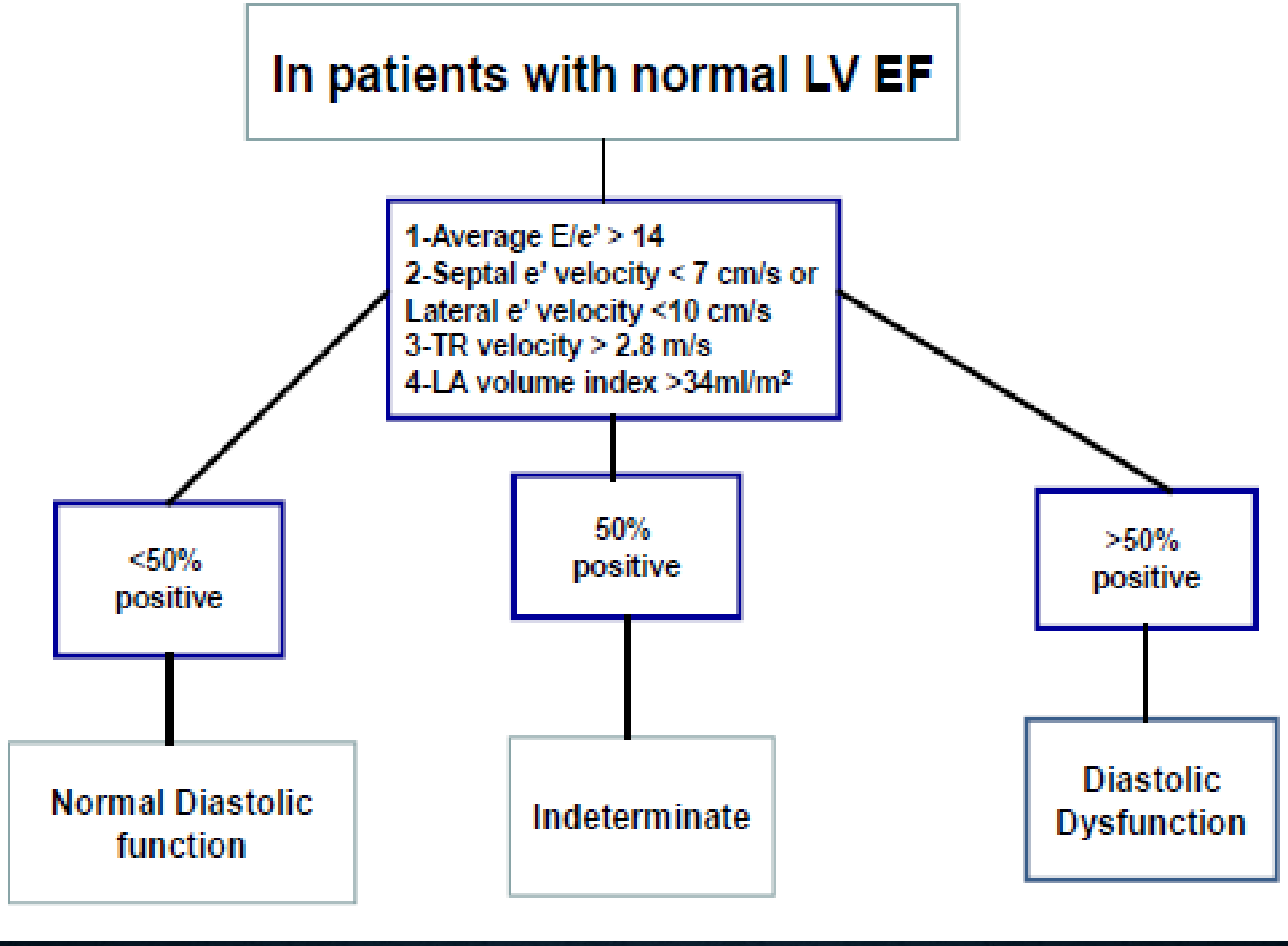
- A dilated IVC or SVC especially with minimal or no collapse on 2DTTE suggests **increased right atrial pressure** and therefore most likely **right sided heart failure** if other causes of a dilated vena cava can be excluded.[3] **A common cause of right sided heart failure is left sided heart failure** and therefore, a dilated vena cava may be a helpful finding in assessing this entity.[4]

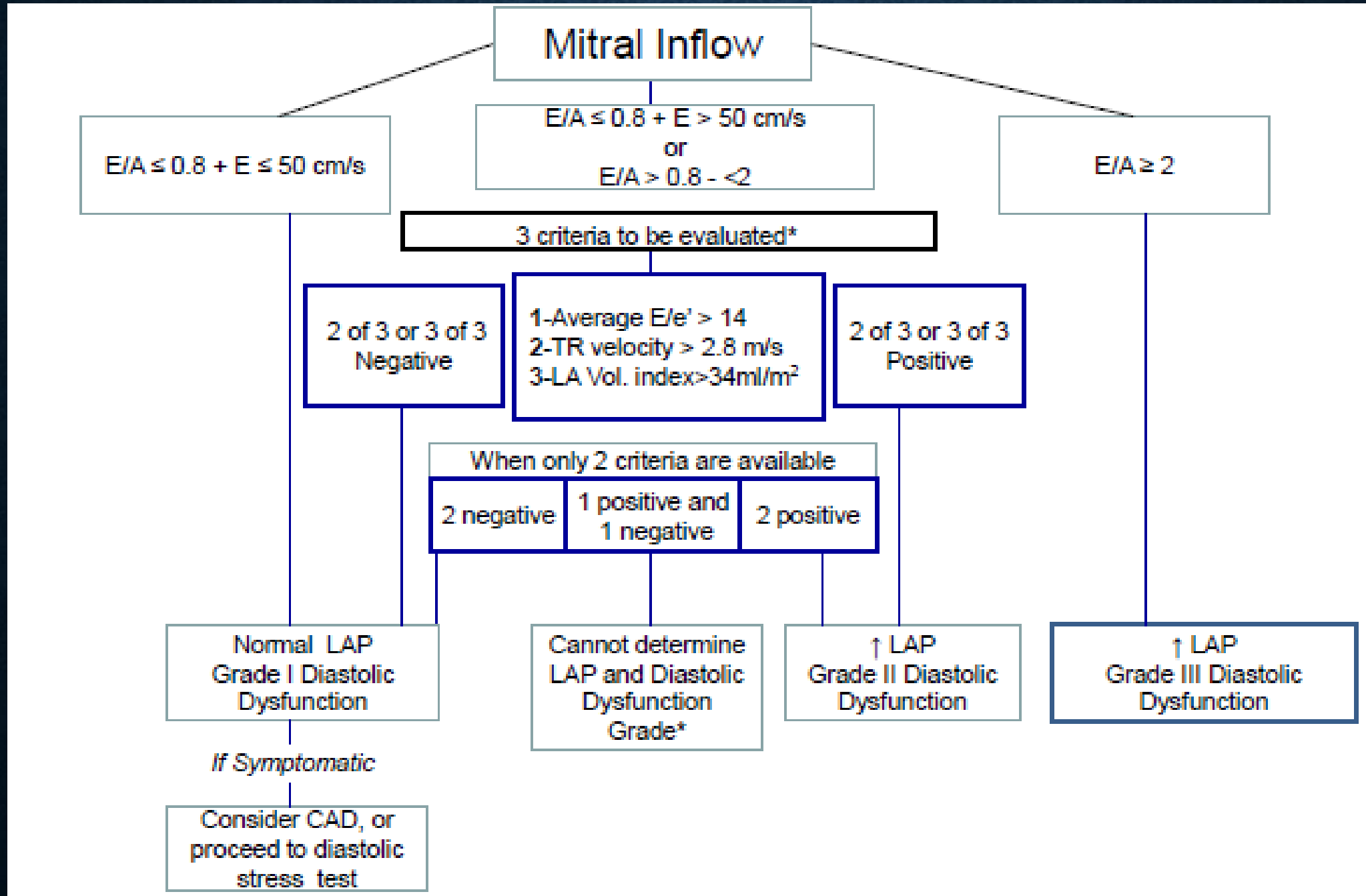
IMPORTANT SUBSET

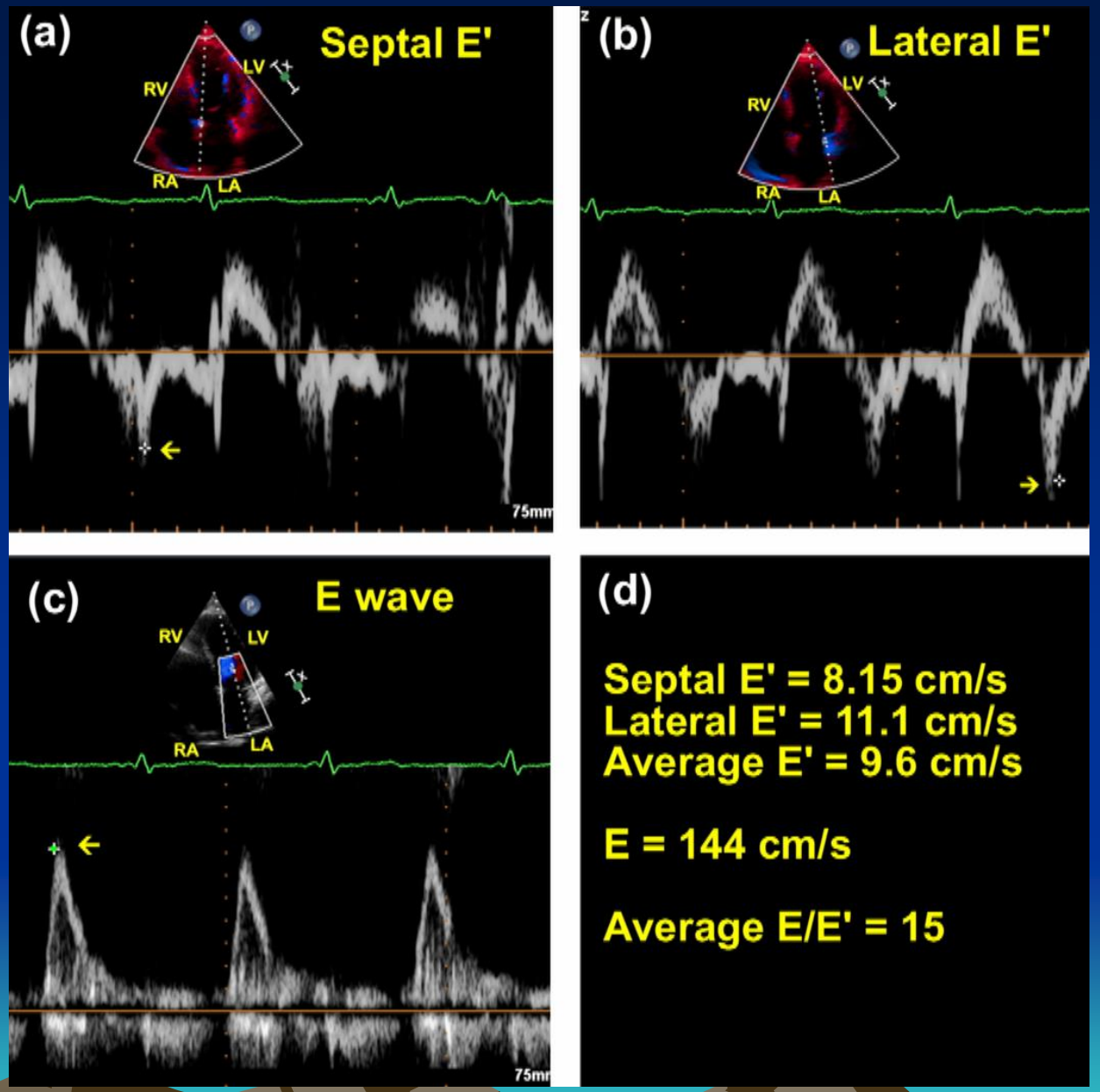
- Most patients with mitral E to A ratio of ≤ 0.8 (grade I diastolic dysfn) have delayed relaxation but normal LA filling pressure and normal LVEDP. A subset may have high LVEDP (> 16 mmHg) and hence left sided HF without elevated LA filling pressure (≤ 12 mmHg). These have PV reversal velocity duration (Ar) > mitral A wave duration (high sensitivity and specificity) or increased mitral M-mode A-C duration with inflection on A-C slope, B point/ bump (high specificity,low sens)

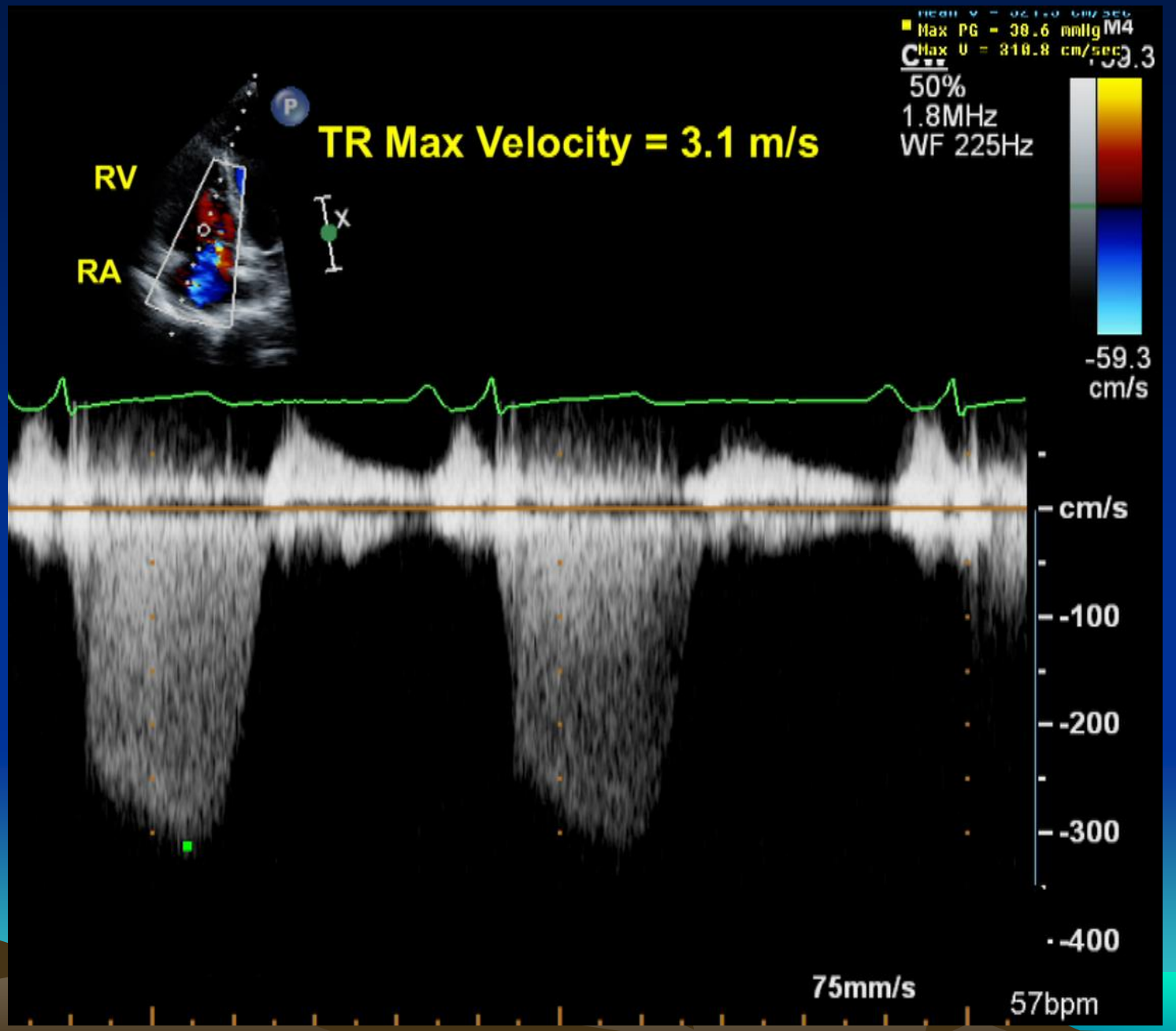


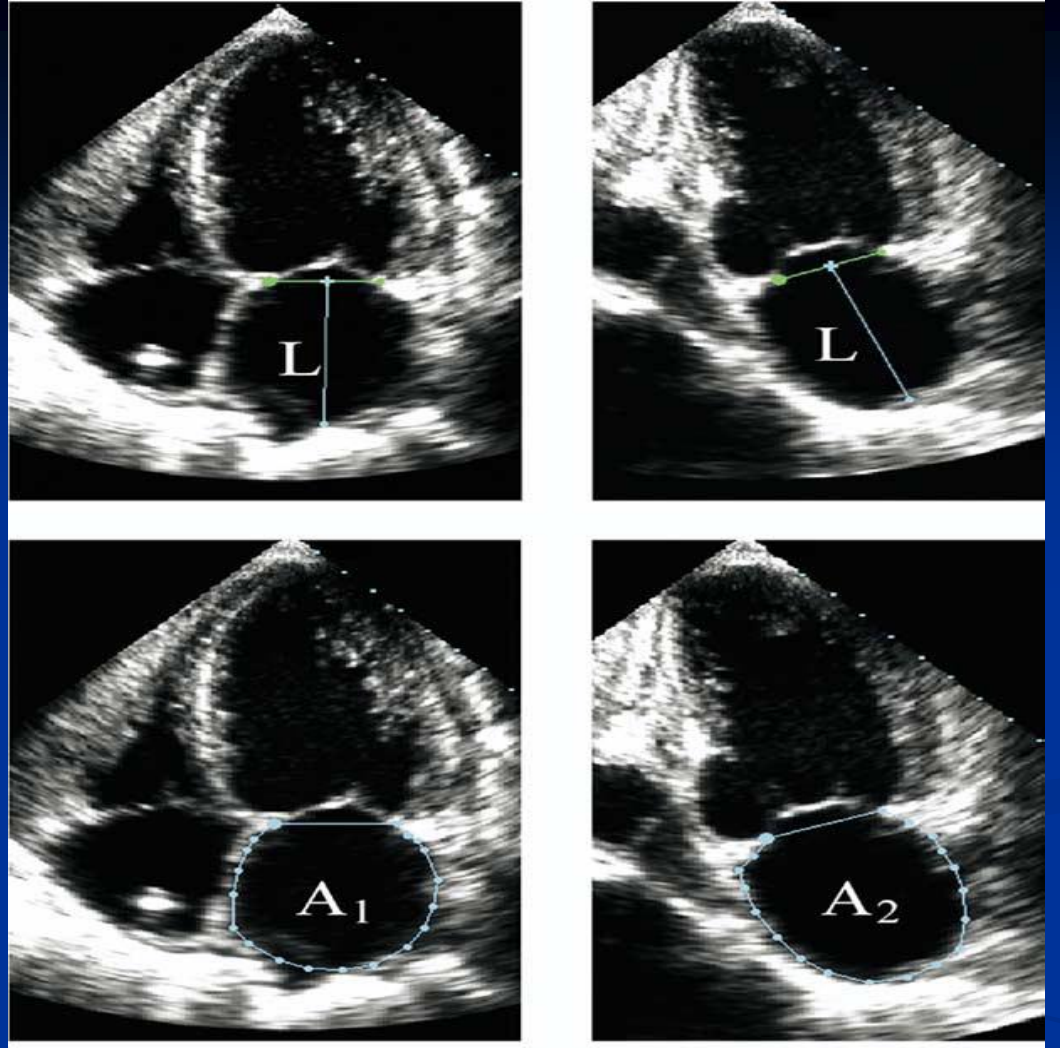
Nanda NC Gramiak R: Clinical Echocardiography 1978 Page 149 The C.V. Mosby Company St Louis


In patients with normal LV EF
1-Average E/e' > 14
2-Septal e' velocity < 7 cm/s or
Lateral e' velocity <10 cm/s
3-TR velocity > 2.8 m/s
4-LA volume index >34ml/m²
<50% positive
50% positive
>50% positive
Normal Diastolic function
Indeterminate
Diastolic Dysfunction


Mitral Inflow
E/A ≤ 0.8 + E ≤ 50 cm/s
E/A ≤ 0.8 + E > 50 cm/s
or
E/A > 0.8 - <2
E/A ≥ 2
3 criteria to be evaluated*
2 of 3 or 3 of 3
Negative
1-Average E/e' > 14
2-TR velocity > 2.8 m/s
3-LA Vol. index>34ml/m2
2 of 3 or 3 of 3
Positive
When only 2 criteria are available
2 negative
1 positive and
1 negative
2 positive
Normal LAP
Grade I Diastolic
Dysfunction
Cannot determine
LAP and Diastolic
Dysfunction
Grade*
↑ LAP
Grade II Diastolic
Dysfunction
↑ LAP
Grade III Diastolic
Dysfunction
If Symptomatic
Consider CAD, or
proceed to diastolic
stress test


(a)
Septal E'
RV
LV
RA
LA
75mm
(b)
Lateral E'
RV
LV
RA
LA
(c)
E wave
RV
LV
RA
LA
75mm
(d)
Septal E' = 8.15 cm/s
Lateral E' = 11.1 cm/s
Average E' = 9.6 cm/s
E = 144 cm/s
Average E/E' = 15

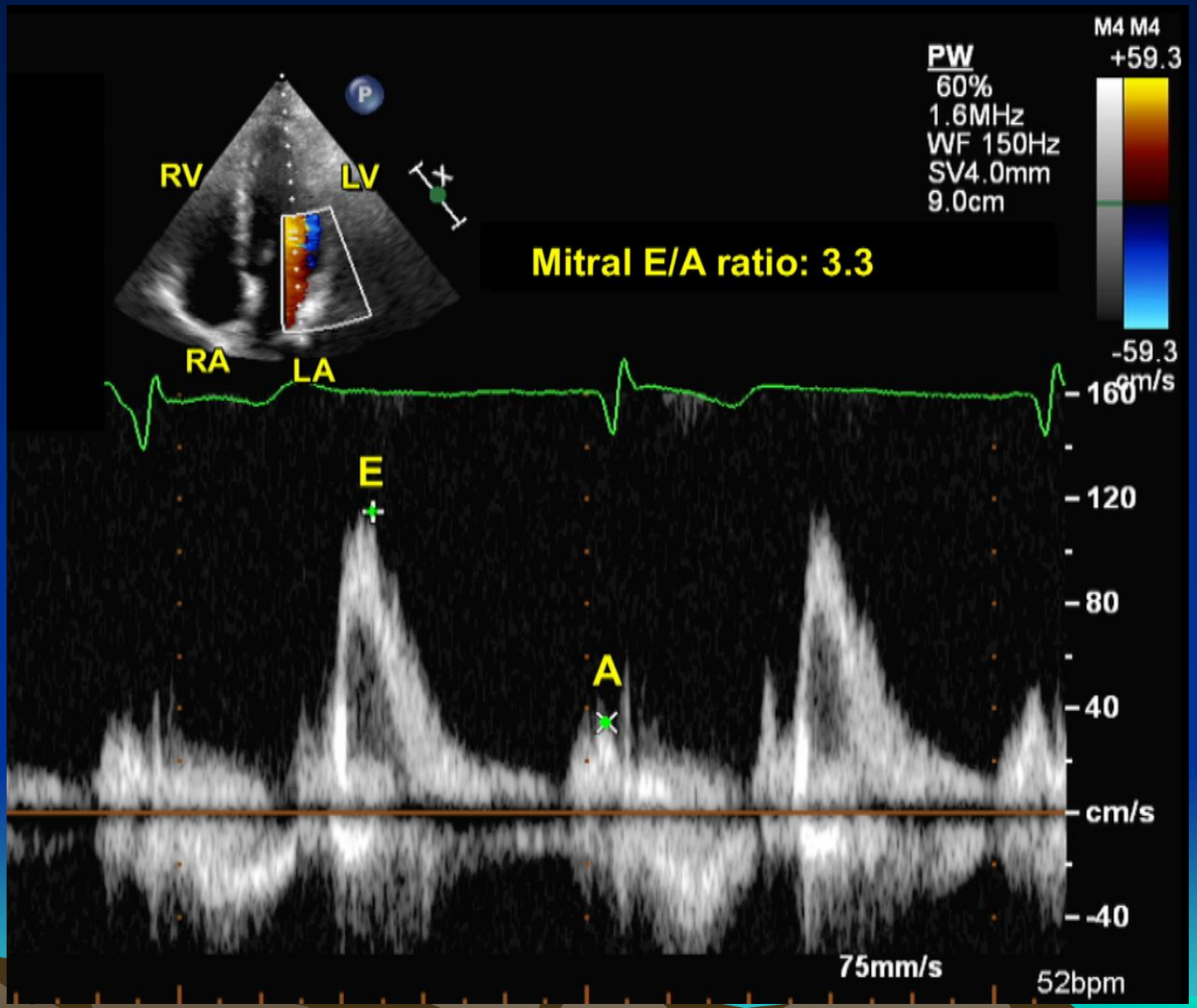

Max PG = 38.6 mmHg M4
Max V = 310.8 cm/sec
50%
1.8MHz
WF 225Hz
-59.3
cm/s
TR Max Velocity = 3.1 m/s
RV
RA
cm/s
-100
-200
-300
-400
75mm/s
57bpm



Left Atrial Volume =

$$8/3\pi[(A_1)(A_2)/(L)]\ *$$

* (L) is the shortest of either the A4C


RV
LV
RA
LA
PW
60%
1.6MHz
WF 150Hz
SV4.0mm
9.0cm
M4 M4
+59.3
-59.3
cm/s
Mitral E/A ratio: 3.3
E
A
160
120
80
40
cm/s
-40
75mm/s
52bpm

RELIABILITY

- These are reported to be more reliable in patients with cardiac disease and hence should be applicable in those with diabetes mellitus which is a known important risk factor for atherosclerotic heart disease

Drawbacks

Table 3
Operating characteristics of echocardiographic parameters for the diagnosis of heart failure with preserved ejection fraction

	AUC	P	Sensitivity (%)	Specificity (%)
Ejection Fraction <55%	0.52	.09	8	96
LV Hypertrophy	0.57	.0006	26	88
LA Volume Index >34 mL/m^2	0.66	<.0001	49	83
E/e' Ratio (septal) >9	0.69	<.0001	78	59
E/e' Ratio (septal) >13	0.66	<.0001	46	86
Septal e' Velocity <7 cm/s	0.62	<.0001	48	76
Right atrial pressure >10 mm Hg	0.56	<.0001	16	97
RV Systolic Pressure >35mm Hg	0.66	<.0001	46	86
RV Fractional Area Change <48%	0.64	<.0001	39	88
Tricuspid Annular Plane Systolic Excursion <16 mm	0.54	.0008	9	99
Visual RV Dysfunction	0.58	<.0001	22	94
Visual RV Dilatation	0.60	<.0001	32	88

Abbreviation: AUC, area under the curve.

Data from Reddy YNV, Carter RE, Obokata M, et al. A simple, evidence-based approach to help guide diagnosis of heart failure with preserved ejection fraction. Circulation 2018;138(9):861–70.

Obokata M, et al. The Role of Echocardiography in Heart Failure with Preserved Ejection Fraction: What Do We Want from Imaging?. Heart failure clinics. 2019 Apr 1;15(2):241-56

Limitations

- **LA size can be normal in Diast Fn with or without ↑ in LVFP**

- **LA size ↑ with normal LVFP in AF, MVD, High flow rates and TXP**

Nagueh, Sherif F., et al. "Recommendations for the evaluation of left ventricular diastolic function by echocardiography: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging." *European Journal of Echocardiography* 17.12 (2016): 1321-1360.

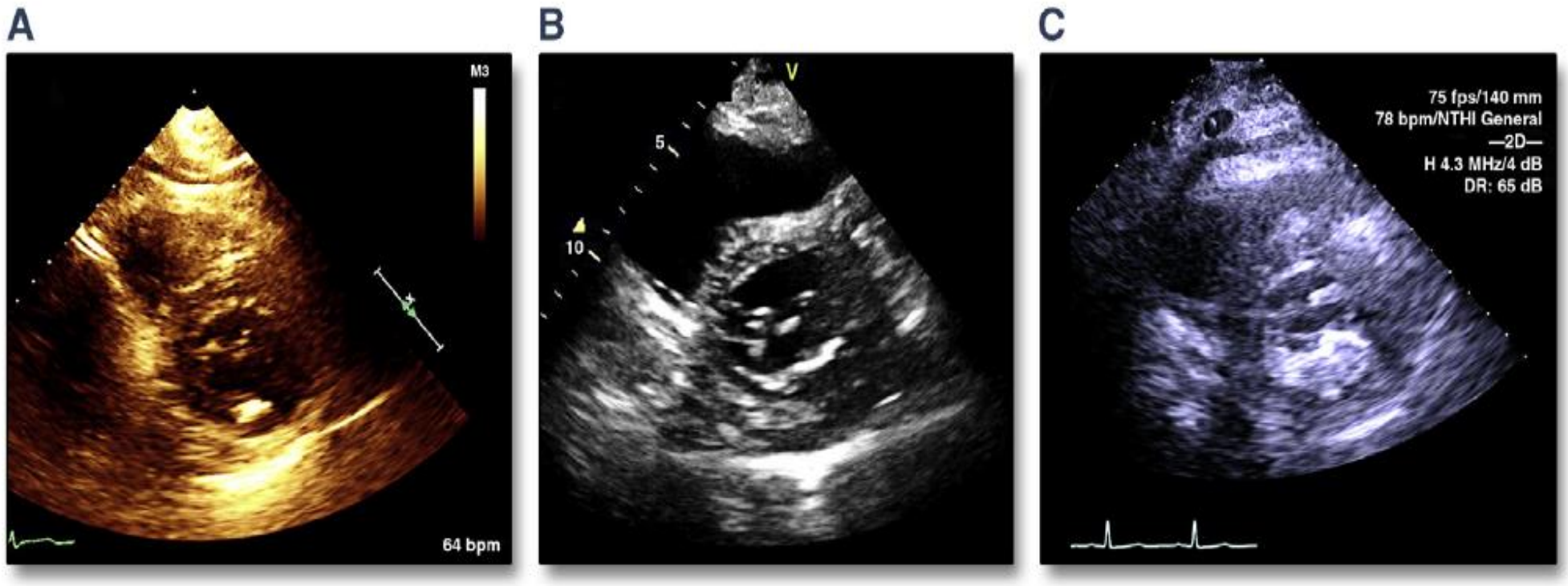
Limitations(cont.)

- Echo algorithms not applicable in:

1. Hypertrophic cardiomyopathy
2. Restrictive cardiomyopathy
3. Valvular heart disease
4. Cardiac transplantation
5. AF
6. AV block and pacing

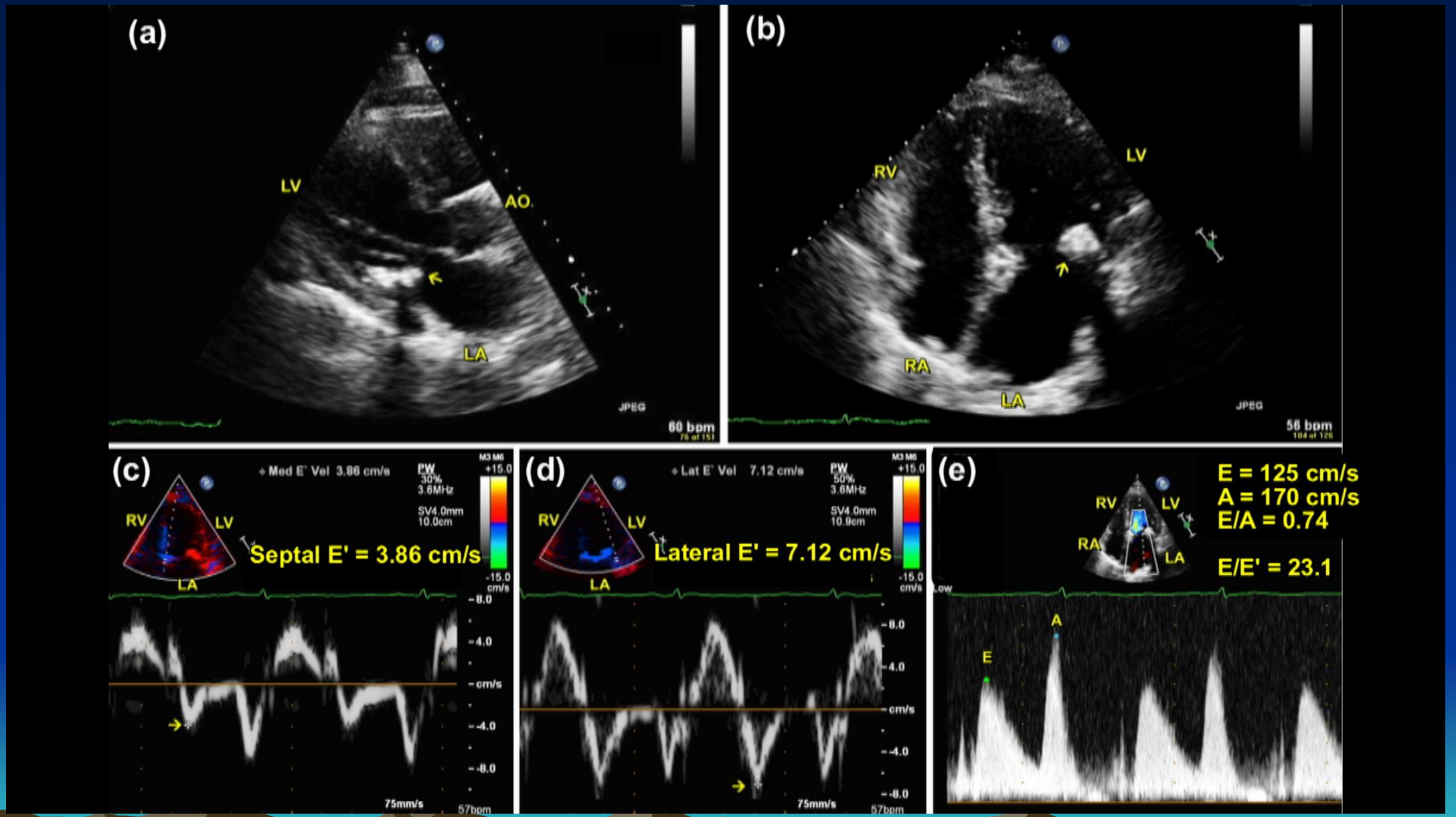
Nagueh, Sherif F., et al. "Recommendations for the evaluation of left ventricular diastolic function by echocardiography: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging." *European Journal of Echocardiography* 17.12 (2016): 1321-1360.

FIGURE 1 Representative Images of Patients With Mitral Annular Calcification



Parasternal short-axis echocardiographic views of the base of the left ventricle demonstrate **(A)** mild, **(B)** moderate, and **(C)** severe mitral annular calcification.

Abudiab, Muaz M., et al. "Doppler echocardiography for the estimation of LV filling pressure in patients with mitral annular calcification." JACC: Cardiovascular Imaging 10.12 (2017): 1411-1420.

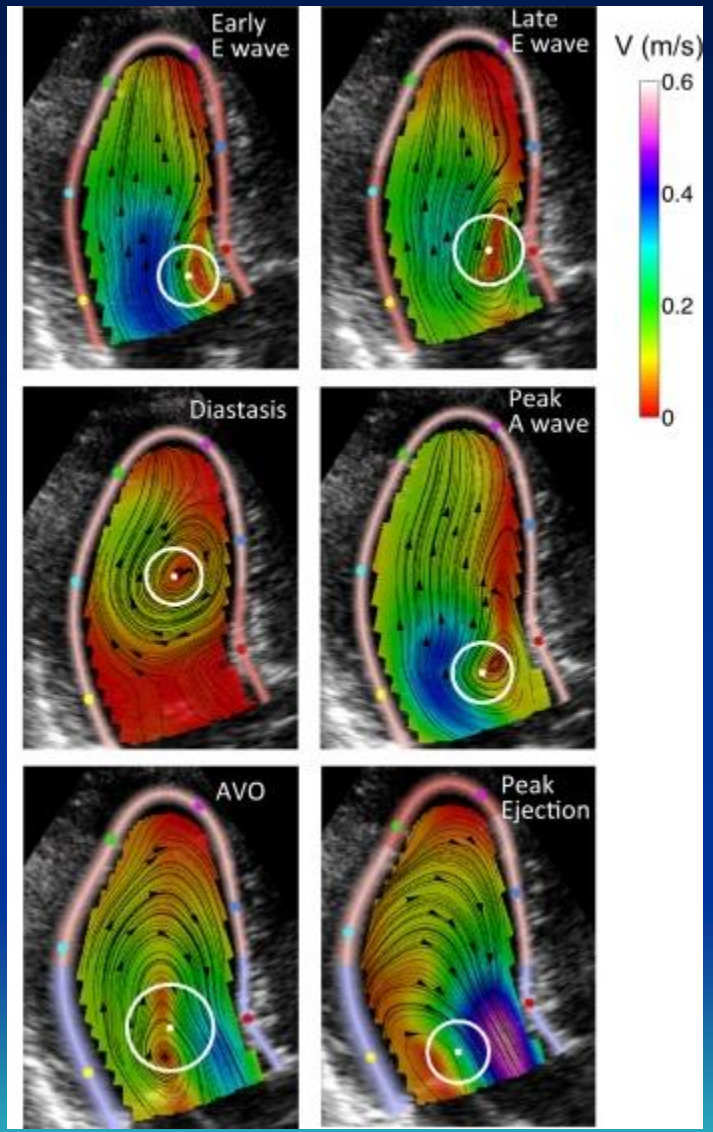

(a)
LV
AO
LA
JPEG
60 bpm
(b)
RV
LV
RA
LA
JPEG
56 bpm
(c)
Med E' Vel 3.86 cm/s
PW
30%
3.6MHz
SV4.0mm
10.0cm
M3 M6
+15.0
-15.0
cm/s
RV
LV
LA
Septal E' = 3.86 cm/s
-8.0
-4.0
cm/s
-4.0
-8.0
75mm/s
57bpm
(d)
Lat E' Vel 7.12 cm/s
PW
50%
3.6MHz
SV4.0mm
10.9cm
M3 M6
+15.0
-15.0
cm/s
RV
LV
LA
Lateral E' = 7.12 cm/s
-8.0
-4.0
cm/s
-4.0
-8.0
75mm/s
57bpm
(e)
RV
LV
RA
LA
E = 125 cm/s
A = 170 cm/s
E/A = 0.74
E/E' = 23.1
A
E

- # Significance of the LV Vortex formation:

Compared with an equivalent straight jet of fluid, a vortex can transport more mass and momentum Thus, the formation of vortex can improve LV filling efficiency and play an important role in cardiac diastolic function.

Studies have demonstrated that the occurrence of normal intraventricular vortex might minimize the intraventricular flow energy dissipation and optimize the cardiac efficiency.

Studies have demonstrated that the anterior vortex that continues into and persists throughout the isovolumic contraction (IVC) period, may redirect the transmitral flow toward the LV outflow tract (LVOT), prevent collision of flow, preserve kinetic energy, and thus facilitate the ejection of blood during LV early systole.

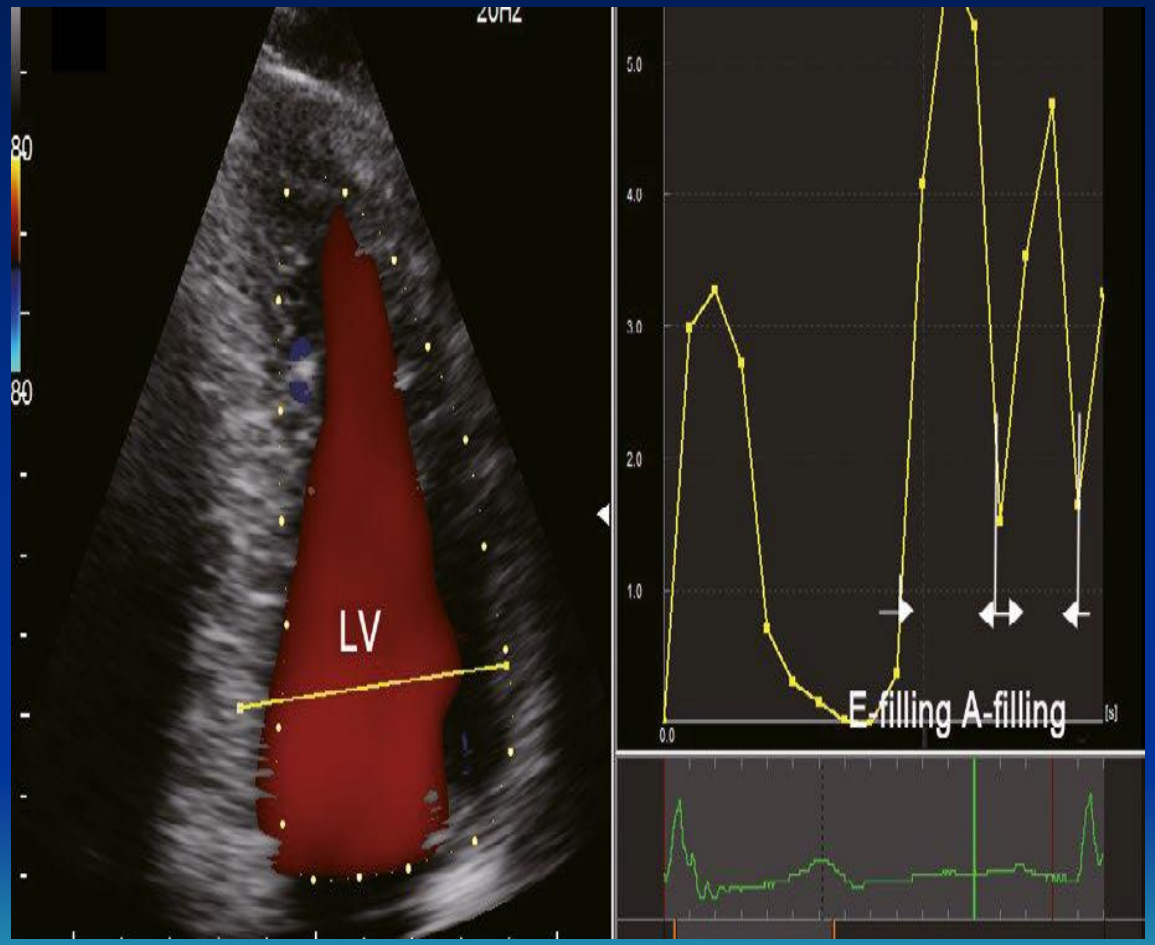


Reference:

1. Zhang H, Liu L, Chen L, et al. The evolution of intraventricular vortex during ejection studied by using vector flow.
2. Qiaozhen Li, Liang Huang, Na Ma, et al: Relationship between left ventricular vortex and preejectional flow velocity during isovolumic contraction studied by using vector flow mapping.

VFM in Diagnosis of Diastolic Dysfunction

- Introduction:
- The optimized blood flow dynamics can reflect the general function of left ventricle and the ability of cardiovascular system in maintaining the relative stabilization of blood circulation.
- VFM can diagnose diastolic dysfunction by calculating the left ventricle energy loss and the average vortex circulation during the different phases of diastole (early filling phase and atrial filling phase)



Reference: Wang W, et al. Evaluation of left ventricular diastolic function based on flow energetic parameters in chronic kidney disease with diastolic dysfunction. Echocardiography. 2019

H_2FPEF

	Clinical Variable	Values	Points
H_2	**H**eavy	Body mass index >30 kg/m^2	2
	Hypertensive	2 or more antihypertensive medicines	1
F	Atrial **F**ibrillation	Paroxysmal or persistent	3
P	**P**ulmonary Hypertension	Doppler echocardiographic estimated right ventricular systolic pressure >35 mm Hg	1
E	**E**lder	Age >60 y	1
F	**F**illing Pressure	Doppler echocardiographic E/e' >9	1
H_2FPEF score			Sum (0–9)

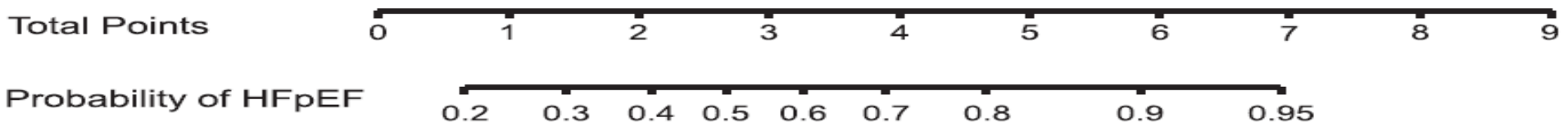
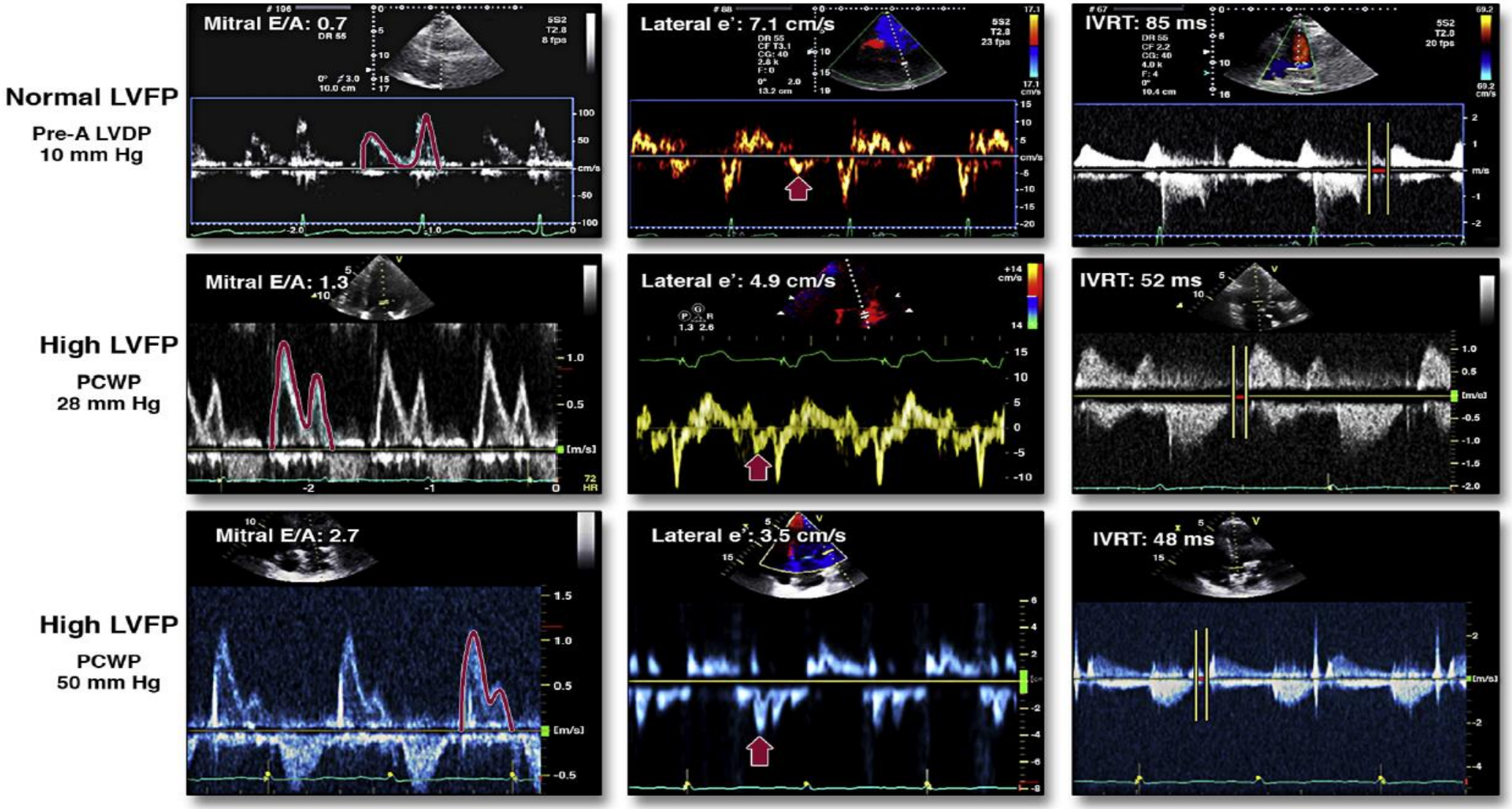


Fig. 1. The H_2FPEF score to aid in diagnosis HFpEF. In this score, the echocardiographic parameters that were independently predictive for HFpEF (E/e' >9 and RVSP >35 mm Hg) are incorporated in tandem with clinical characteristics to determine the probability that HFpEF is present in patients presenting with unexplained dyspnea. (*Adapted from* Reddy YNV, Carter RE, Obokata M, et al. A simple, evidence-based approach to help guide diagnosis of heart failure with preserved ejection fraction. Circulation. 2018;138(9):861–70; with permission.)

Obokata M, et al. The Role of Echocardiography in Heart Failure with Preserved Ejection Fraction: What Do We Want from Imaging?. Heart failure clinics. 2019 Apr 1;15(2):241-56

FIGURE 4 Doppler Assessment of Patients With Normal and High Left Ventricular Filling Pressure



Abudiab, et al. "Doppler echocardiography for the estimation of LV filling pressure in patients with mitral annular calcification." JACC: Cardiovascular Imaging 10.12 (2017): 1411-1420

Diastolic stress test

- Diagnosis is made by:

1. Average E/e’ > 14 or septal E/e’ ratio > 15
2. Peak TR velocity > 2.8 m/sec
3. Septal e’ velocity < 7 cm/sec

Nagueh, Sherif F., et al. "Recommendations for the evaluation of left ventricular diastolic function by echocardiography: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging." *European Journal of Echocardiography* 17.12 (2016): 1321-1360.