Diastolic function

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- The historical “gold standard” for assessment of diastolic function has been the invasively obtained pressure-volume loop

LV function

- 1.systolic ejection
- 2.diastolic filling

2a:IVR

2b:Rapid filling

2c:Diastasis

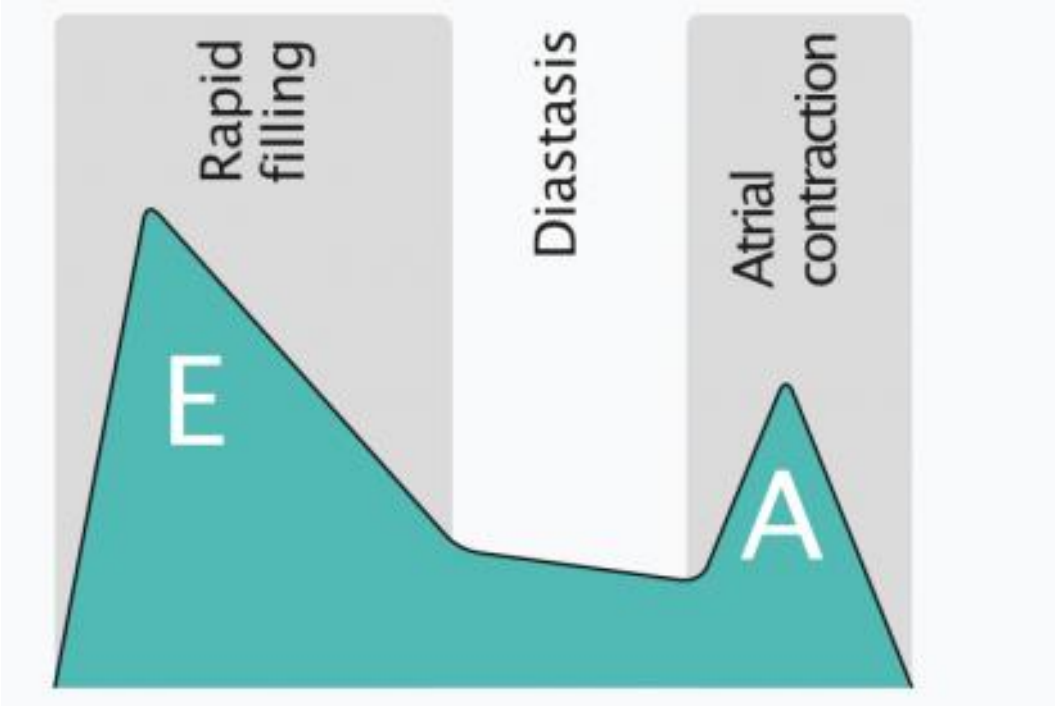
2d:late diastolic filling

LA function

- Reservoir in systole
- Diastolic

2a:conduit

2b:pump



- Stage
- Different parametrs
- Old criteria
- New guideline:2016
- HFPEF

grading

- Normal
- Mild DD =Garde I
- Moderate DD=Psudonormal =Garde II
- Severe DD=Restrictive DD=Garde III

- Analysis of diastolic dysfunction must be carried out with acknowledgment that
- (1) there are no absolute cutoffs for echo values that define the presence and degree of diastolic dysfunction at any LVEF
- (2) the age, hemodynamics, and presence of other cardiac disease (particularly mitral disease) may affect many values
- (3) no single index is accurate in isolation

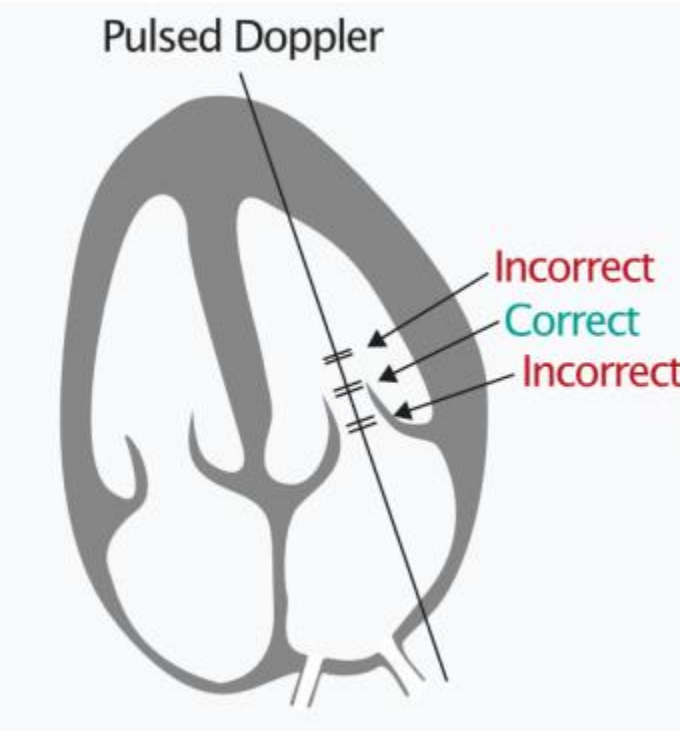
E&A

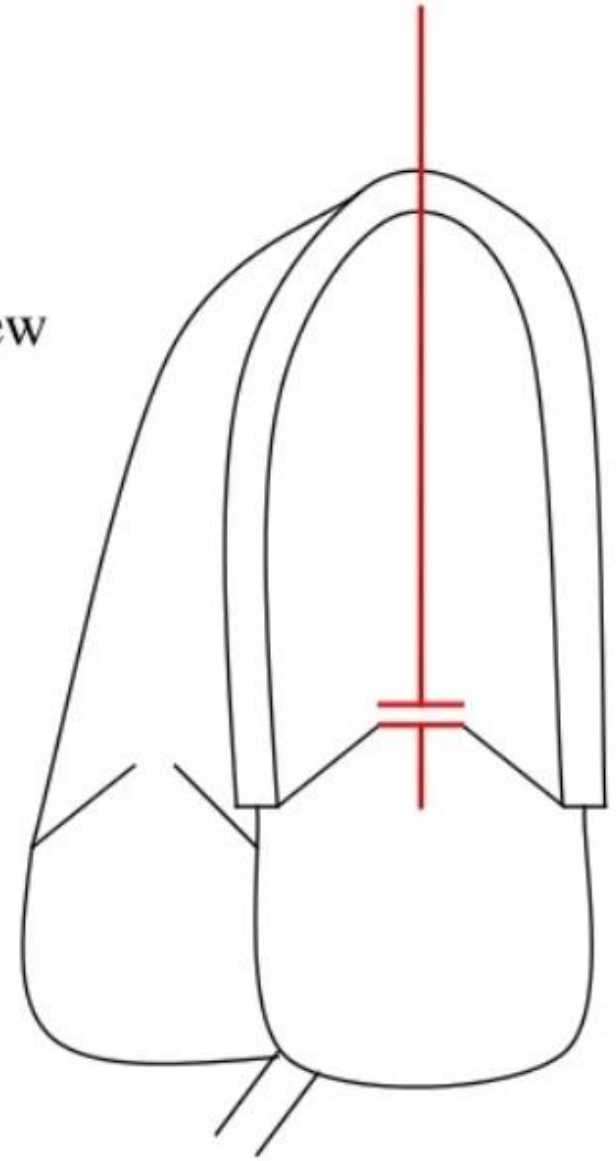
- TRANSMITRAL DOPPLER

EVALUATION OF LV DIASTOLIC FUNCTION

MITRAL VALVE INFLOW

apical 4-chamber view



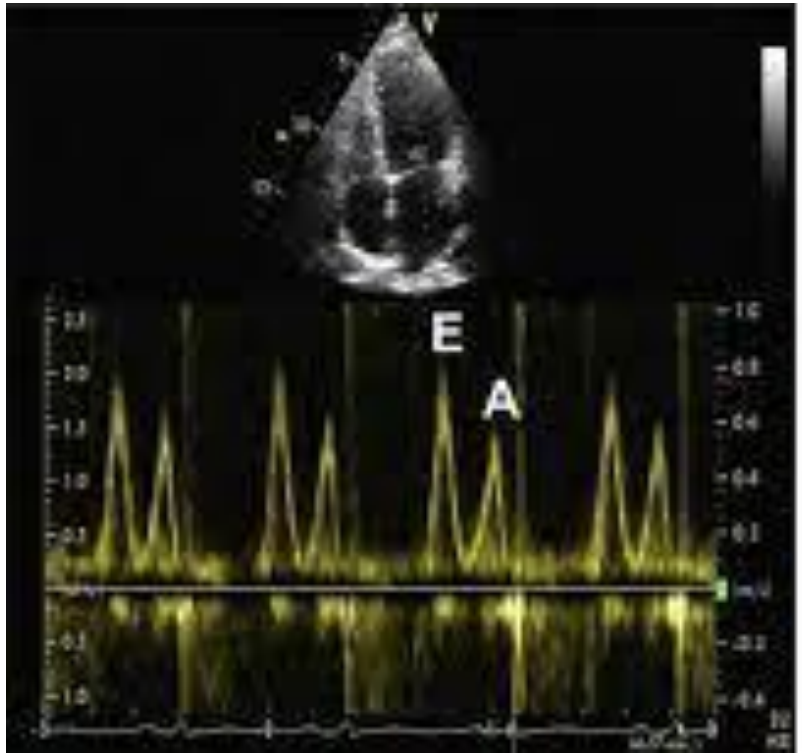


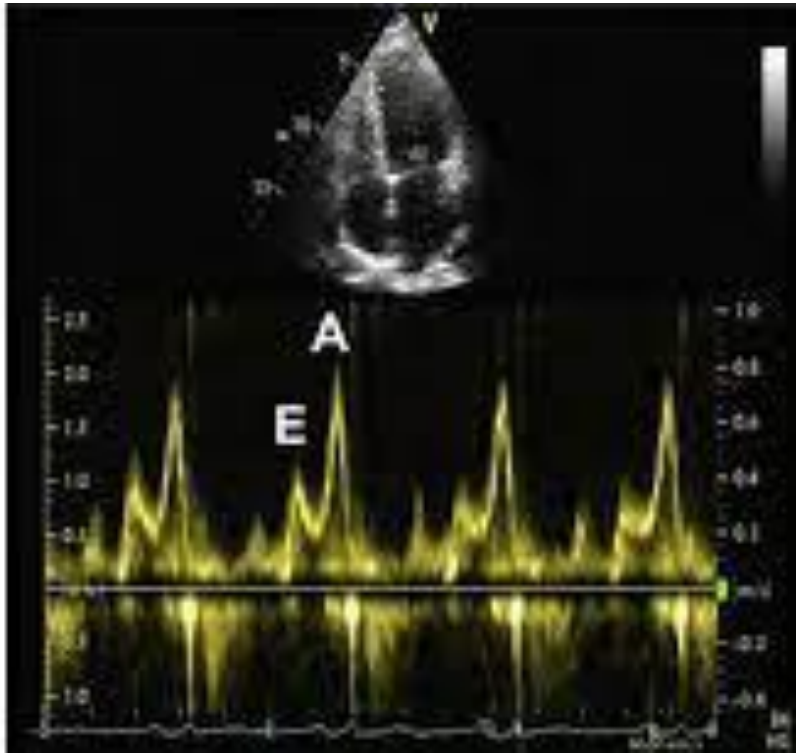
E wave

- E velocity is dependent on the transmitral pressure gradient and is thus directly related to LA pressure and inversely related to LV compliance.

A wave

- The height of the A wave is additionally dependent on the strength of atrial contraction.


E
A


A
E

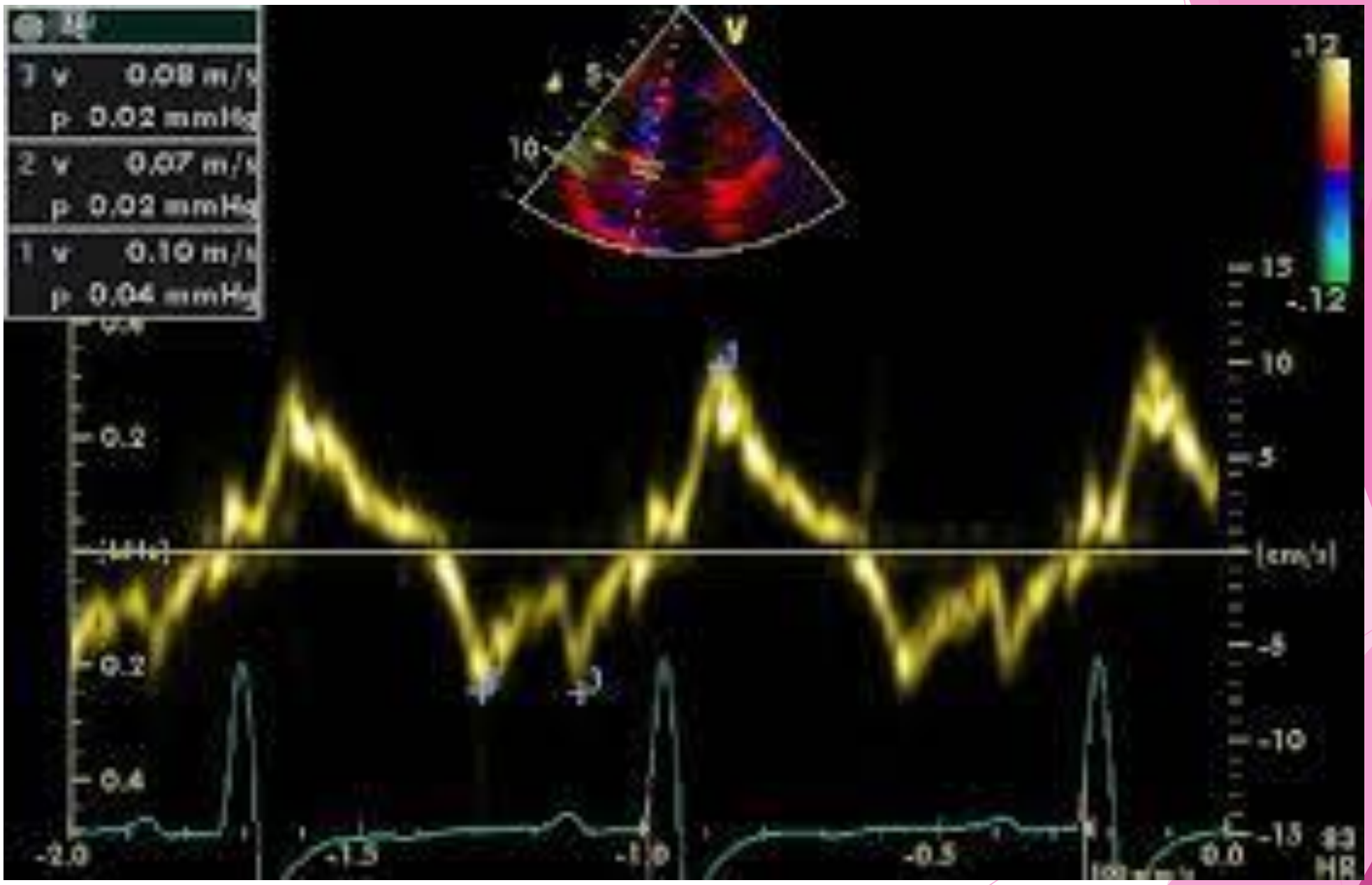
- Normally in individuals younger than 65, E wave height is greater than A wave height, with ratios of 1.0 or higher.

Tissue doppler

systolic contraction (the S′ wave) toward the relatively fixed apex, followed by early (e′) and late relaxation (a′) signals in diastole

The e′ velocity ranges up to greater than 20 cm/sec in children and young adults but declines rapidly in early adulthood and beyond.

Values less than 5 cm/sec are seen in patients with severe diastolic dysfunction (e.g., amyloidosis).


3 v 0.08 m/s
p 0.02 mmHg
2 v 0.07 m/s
p 0.02 mmHg
1 v 0.10 m/s
p 0.04 mmHg
V
5
10
.12
-.12
15
10
5
(cm/s)
-5
-10
-15
0.2
0.2
0.4
-2.0
-1.5
-1.0
-0.5
0.0
HR

- Because E velocity reflects the A-V pressure gradient, it is dependent on both LV compliance and LA pressure (i.e., preload dependent).

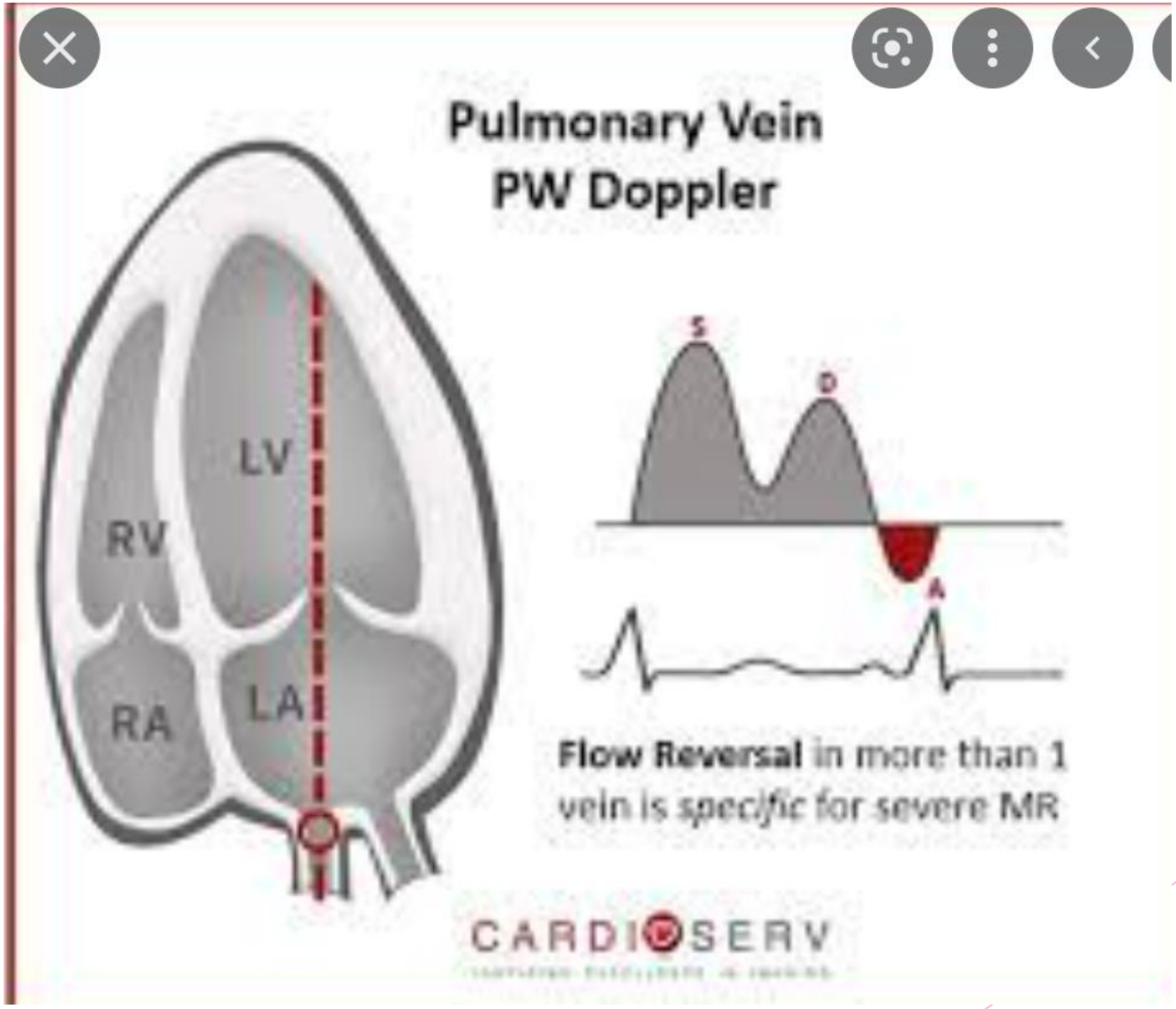
- In contrast, DTI e' :LV compliance alone.

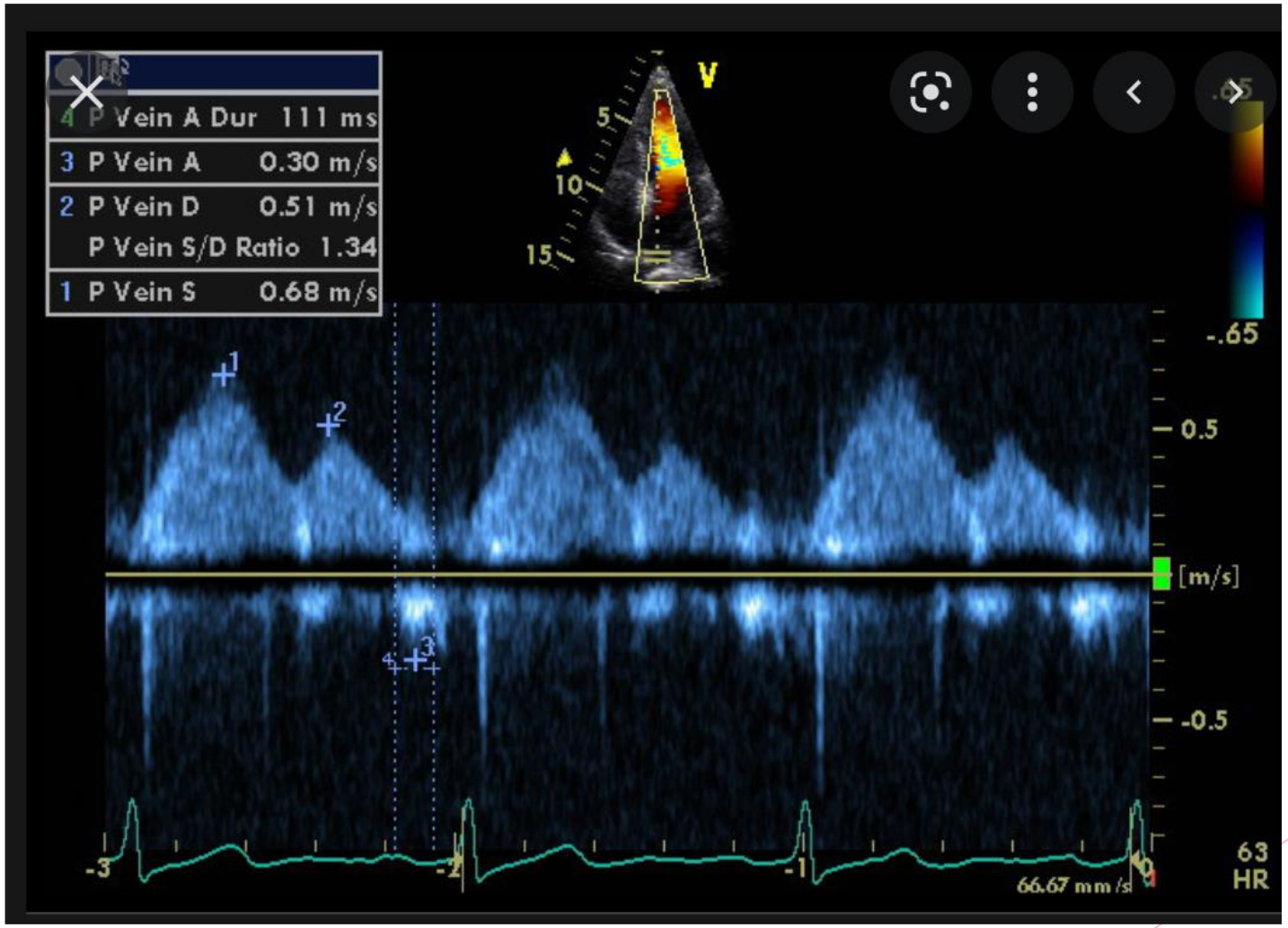
- E / e' :LA pressure, which usually approximates LVEDP.

An E/e’ ratio greater than 14 is considered abnormally high at any age and is usually indicative of elevated LVEDP

Pulmunary vein


B
RV
LV
RA
LA
RLPV


Pulmonary Vein
PW Doppler
LV
RV
RA
LA
S
D
A
Flow Reversal in more than 1 vein is specific for severe MR
CARDIOSERV

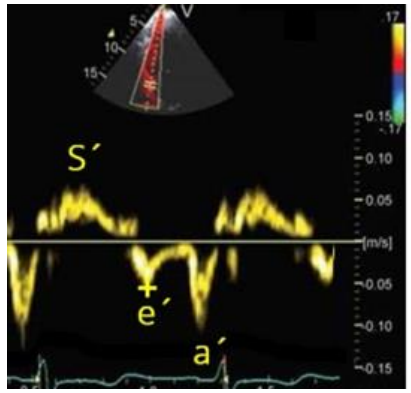

4 P Vein A Dur 111 ms
3 P Vein A 0.30 m/s
2 P Vein D 0.51 m/s
P Vein S/D Ratio 1.34
1 P Vein S 0.68 m/s
V
5
10
15
-.65
0.5
[m/s]
-0.5
-3
-2
-1
66.67 mm/s
63
HR

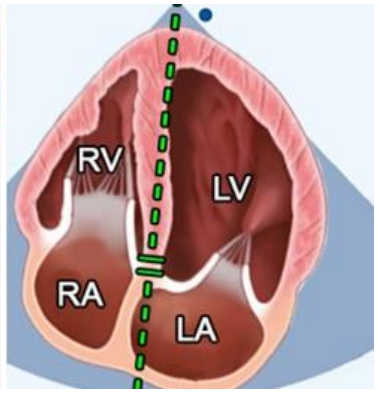
IVRT

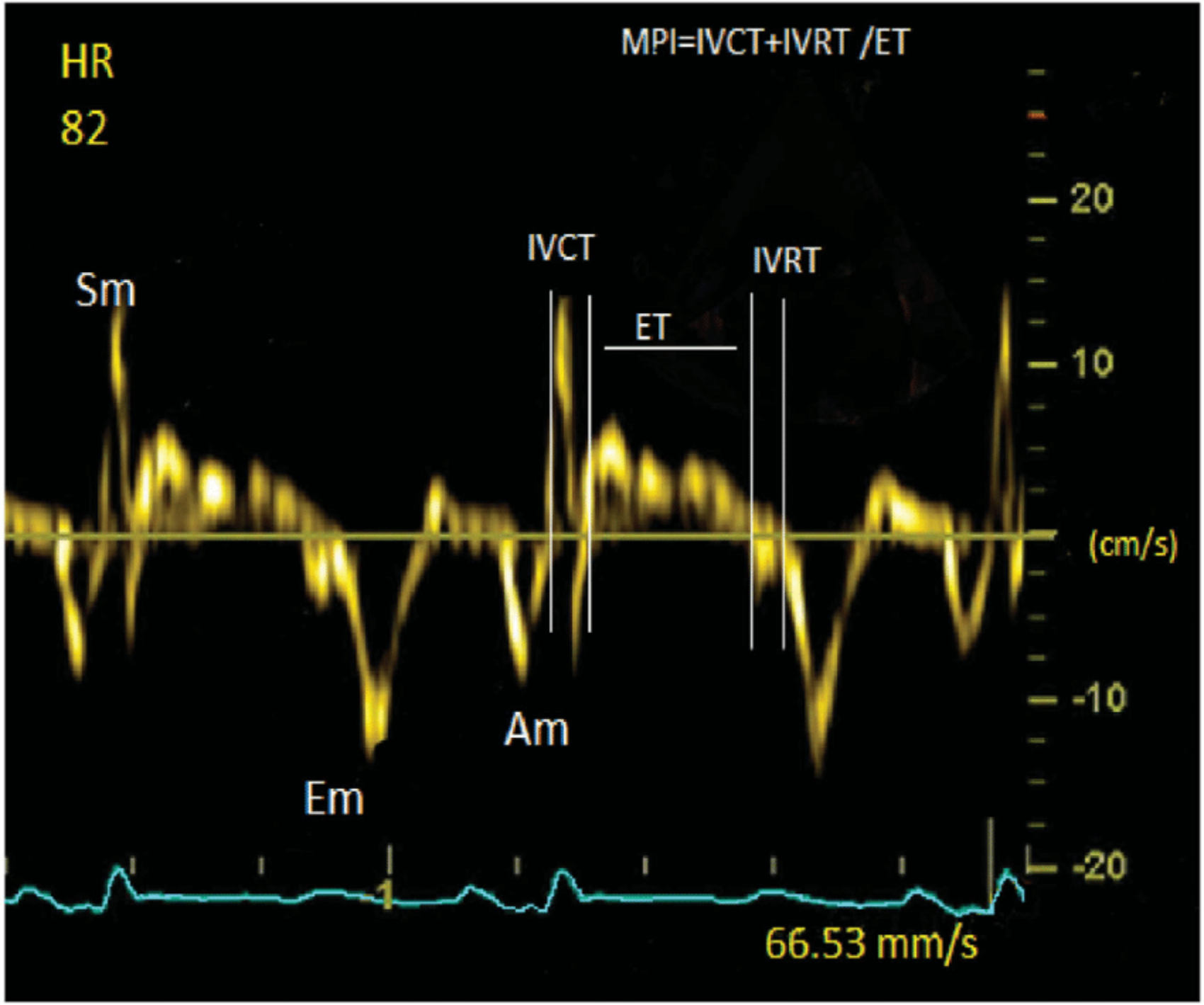
The isovolumic relaxation time

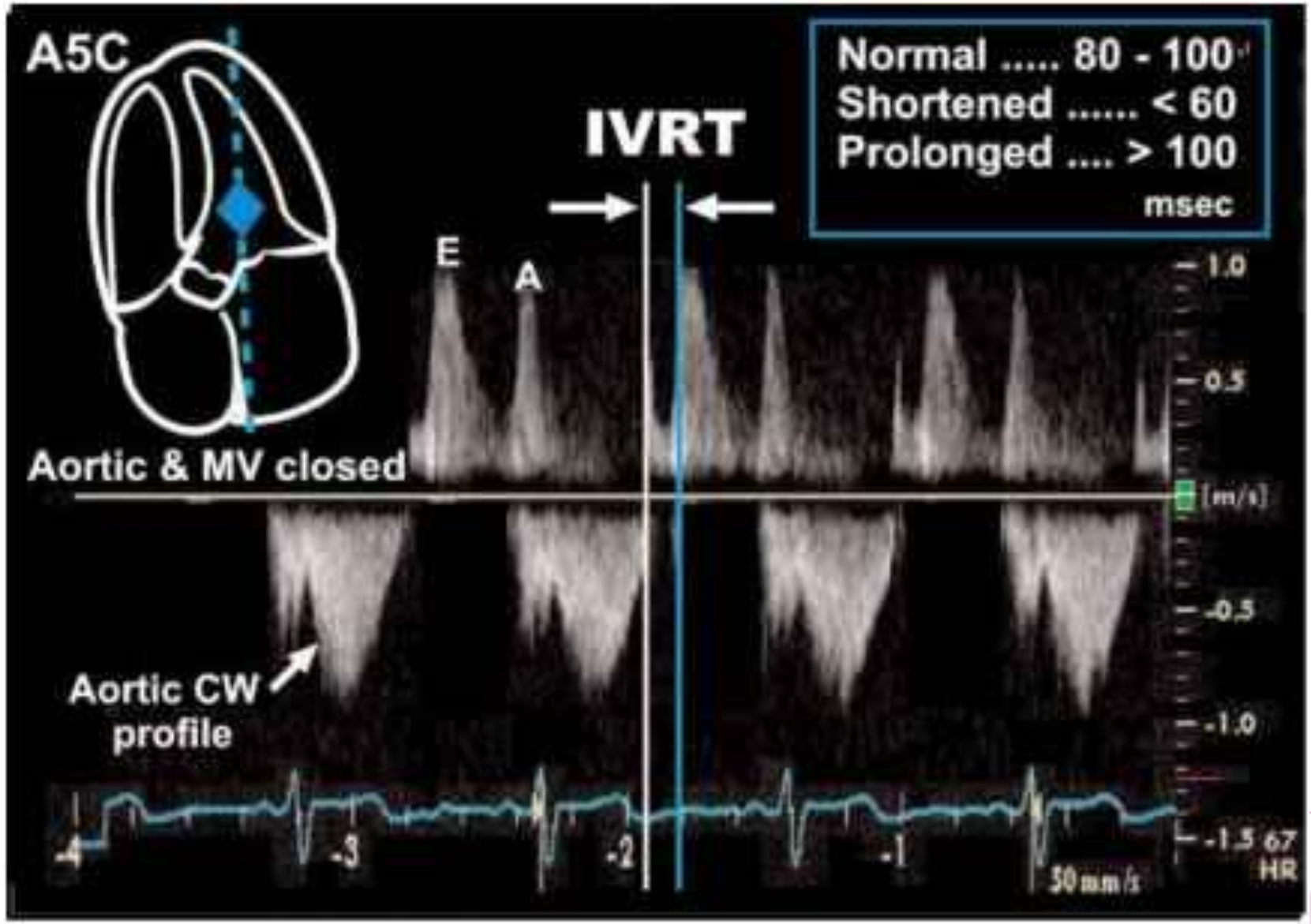
represents the period between closure of AV and the start of ventricular filling

Prolongation of the IVRT is associated with abnormal relaxation, and shortening of the IVRT can occur in patients with restrictive LV filling


S´
e´
a´


RV
LV
RA
LA

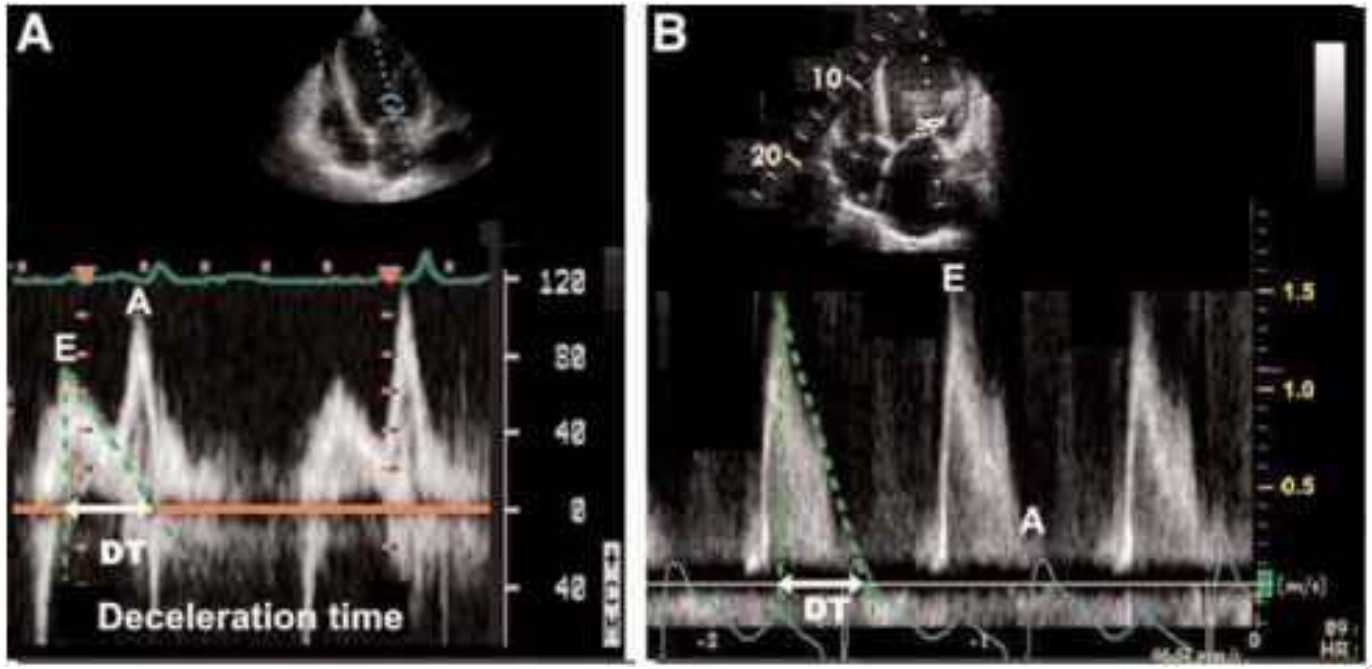

HR
82
MPI=IVCT+IVRT /ET
Sm
IVCT
IVRT
ET
Em
Am
20
10
(cm/s)
-10
-20
66.53 mm/s

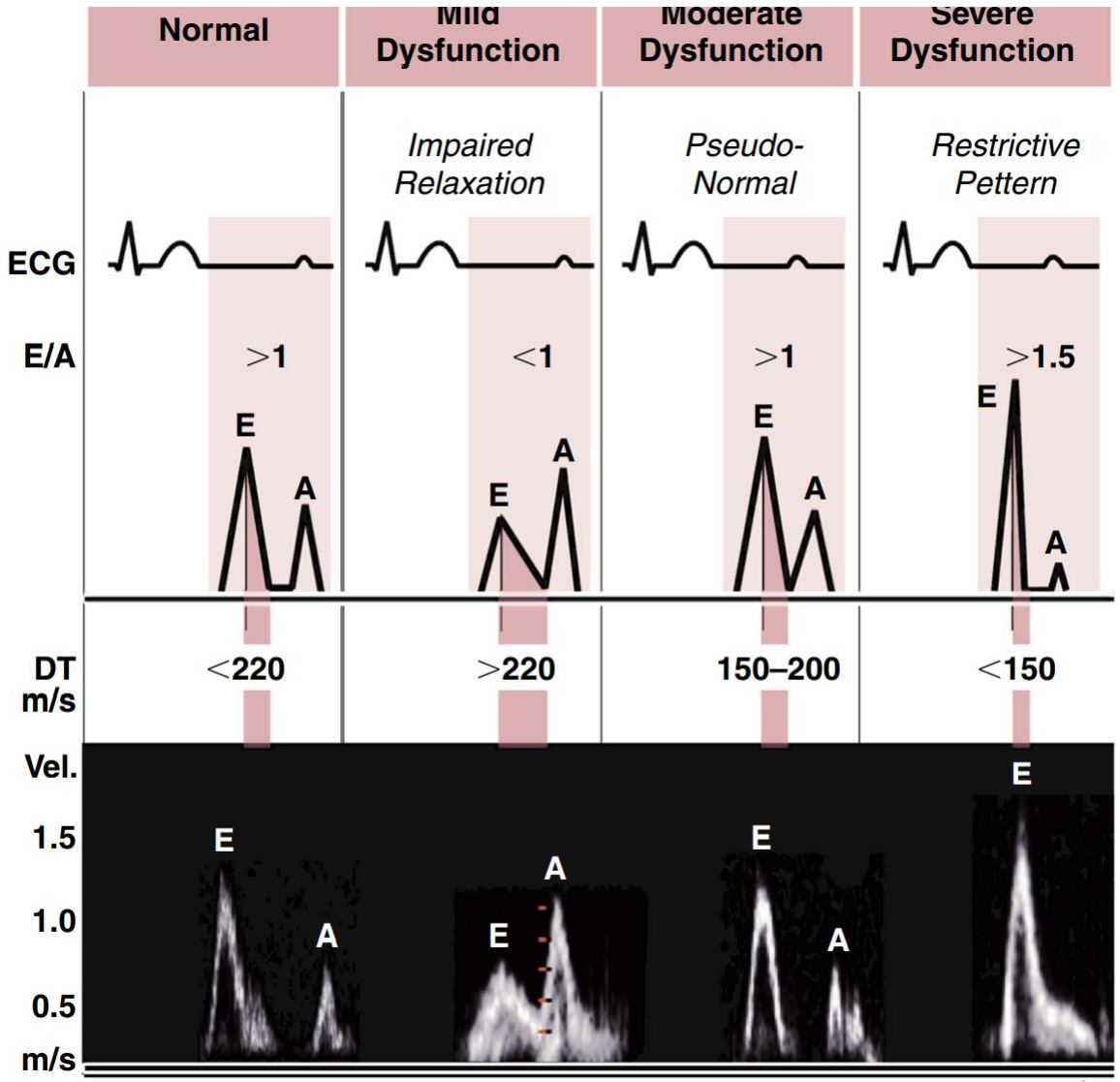

A5C
IVRT
Normal ..... 80 - 100
Shortened ..... < 60
Prolonged .... > 100
msec
E
A
Aortic & MV closed
Aortic CW profile
1.0
0.5
[m/s]
-0.5
-1.0
-1.5
67
HR
-4
-3
-2
-1
50 mm/s

DT

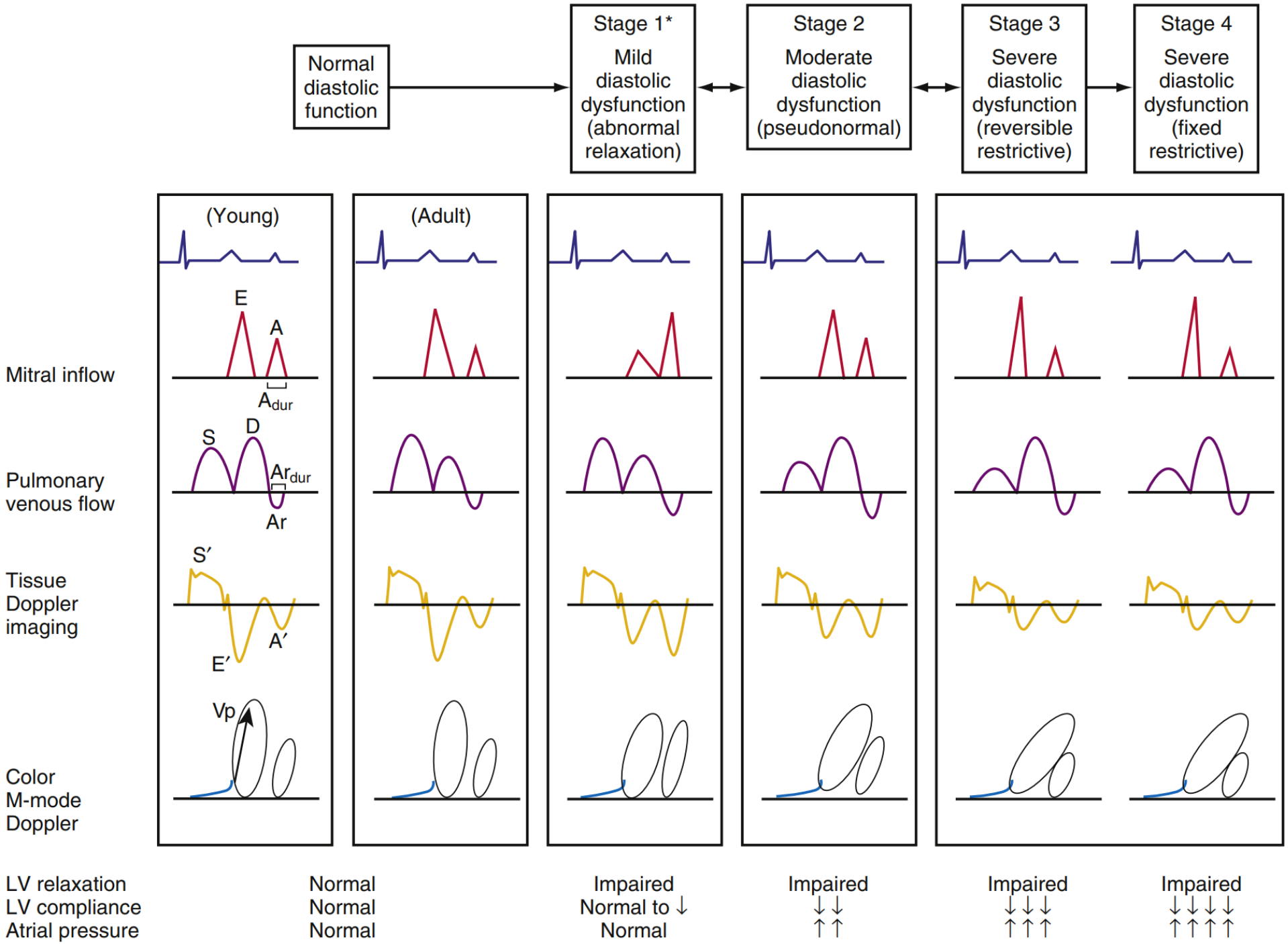
Mitral E wave DT is the interval from peak to no mitral inflow in early diastole. In early diastolic dysfunction, DT can actually increase.

However, in patients with severe restrictive physiology where the stiff ventricle reaches its volume limit suddenly, the DT will be very rapid<140ms




Normal
Mild Dysfunction
Moderate Dysfunction
Severe Dysfunction
Impaired Relaxation
Pseudo-Normal
Restrictive Pettern
ECG
E/A
>1
<1
>1
>1.5
E
A
DT m/s
<220
>220
150–200
<150
Vel.
1.5
1.0
0.5
m/s

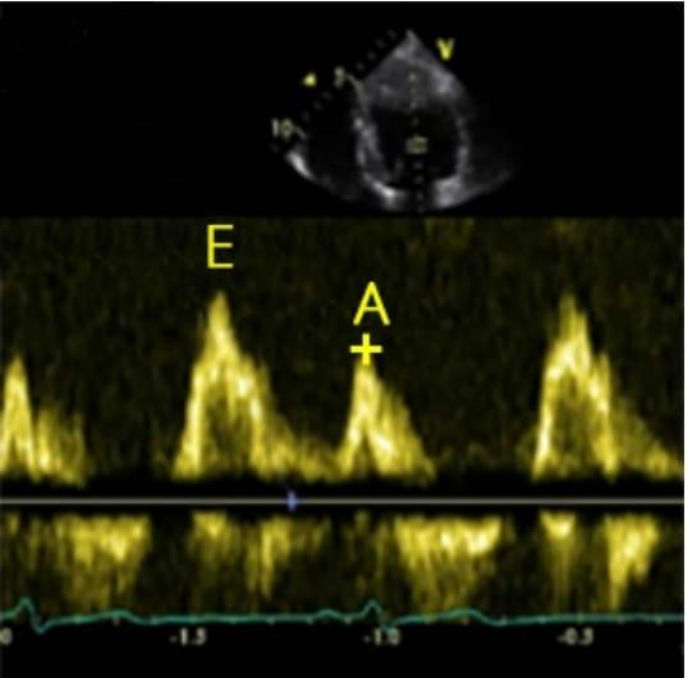
old

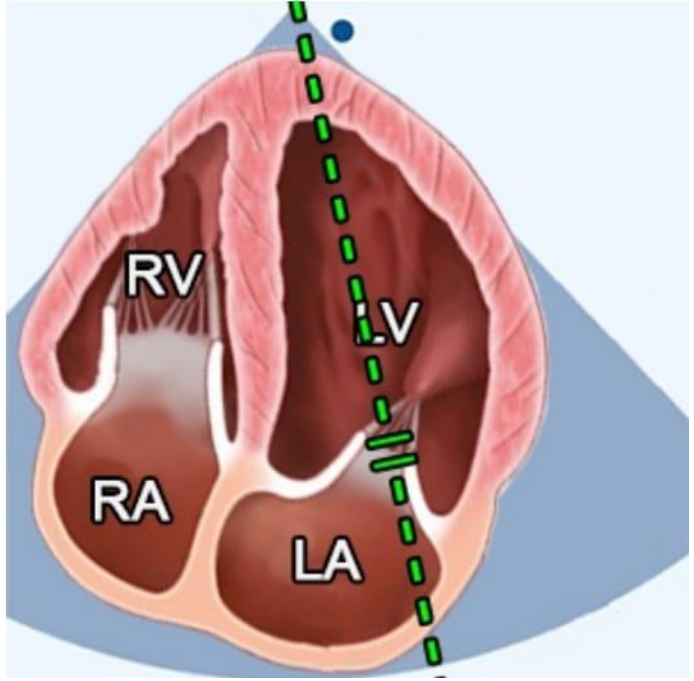

Normal diastolic function
Stage 1*
Mild diastolic dysfunction (abnormal relaxation)
Stage 2
Moderate diastolic dysfunction (pseudonormal)
Stage 3
Severe diastolic dysfunction (reversible restrictive)
Stage 4
Severe diastolic dysfunction (fixed restrictive)
(Young)
(Adult)
Mitral inflow
E
A
Adur
Pulmonary venous flow
S
D
Ardur
Ar
Tissue Doppler imaging
S′
A′
E′
Color M-mode Doppler
Vp
LV relaxation
LV compliance
Atrial pressure
Normal
Normal
Normal
Impaired
Normal to ↓
Normal
Impaired
↓↓
↑↑
Impaired
↓↓↓
↑↑↑
Impaired
↓↓↓↓
↑↑↑↑

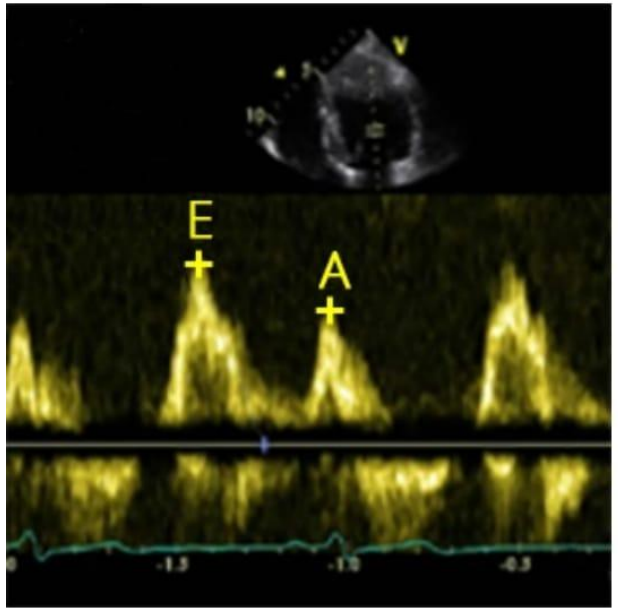
	AGE GROUPS (yr)					
	45–49	50–54	55–59	60–64	65–69	≥70
Mitral Inflow Parameters						
E (m/sec)	0.7 (0.5–0.9)	0.6 (0.5–0.9)	0.7 (0.5–0.9)	0.7 (0.5–0.9)	0.6 (0.4–0.8)	0.6 (0.4–1.0)
A (m/sec)	0.5 (0.3–0.7)	0.5 (0.4–0.8)	0.6 (0.4–0.9)	0.6 (0.4–0.9)	0.7 (0.4–1.0)	0.8 (0.5–1.1)
E/A	1.3 (1.0–2.0)	1.2 (0.8–2.0)	1.2 (0.7–1.8)	1.0 (0.7–1.6)	1.0 (0.6–1.5)	0.8 (0.6–1.3)
DT (msec)	208 (180–258)	217 (178–266)	210 (183–287)	222 (180–282)	227 (188–298)	242 (188–320)
TDI—Mitral Annulus						
Septal						
e'_S (m/sec)	0.10 (0.07–0.14)	0.09 (0.06–0.14)	0.09 (0.05–0.12)	0.09 (0.06–0.13)	0.08 (0.05–0.11)	0.07 (0.05–0.11)
E/e'_S	6.67 (4.62–11.25)	7.00 (4.55–11.67)	7.78 (4.62–13.33)	7.64 (5.00–12.00)	8.57 (5.45–13.33)	8.57 (4.55–16.67)
Lateral						
e'_L (m/sec)	0.13 (0.09–0.17)	0.12 (0.08–0.16)	0.11 (0.07–0.15)	0.10 (0.07–0.15)	0.09 (0.07–0.12)	0.08 (0.05–0.11)
E/e'_L	5.38 (3.75–7.78)	5.45 (3.75–8.89)	6.00 (3.85–10.00)	6.67 (4.62–8.89)	7.00 (4.17–11.25)	7.78 (5.00–14.00)
Pulmonary Vein Flow Parameters						
P_S/P_D	1.25 (0.86–2.00)	1.40 (1.00–2.00)	1.40 (1.00–2.00)	1.50 (1.00–2.25)	1.60 (1.00–2.50)	1.67 (1.00–2.50)
$PVAR_{dur}$ (msec)	118 (100–140)	122 (103–142)	123 (105–157)	123 (103–160)	127 (110–152)	130 (112–170)

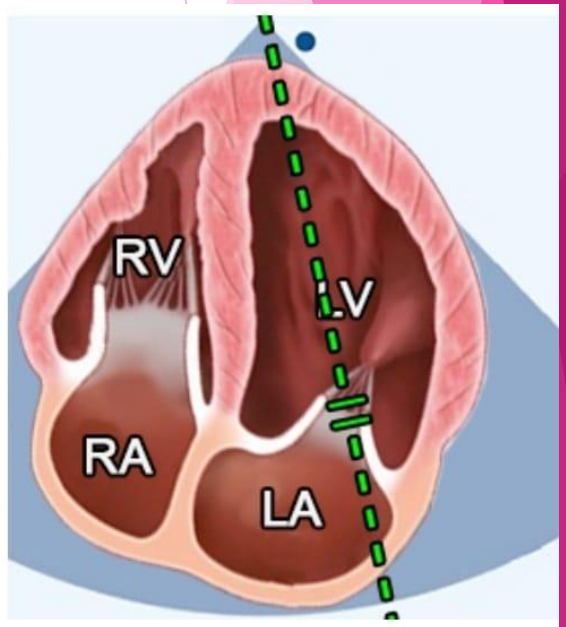
	IVRT abnormal	DT abnormal	E'se abnormal	E'lat abnormal	E/A abnormal
16-20 y	30-70	100-180	10	13	1-2.8
20-40 y	50-80	140-200	10	14	0.7-2.4
40-60 y	60-90	140-220	7.5	11.5	0.8-1.8
60-80 y	70-100	140-260	6	6	0.6-1.3

New

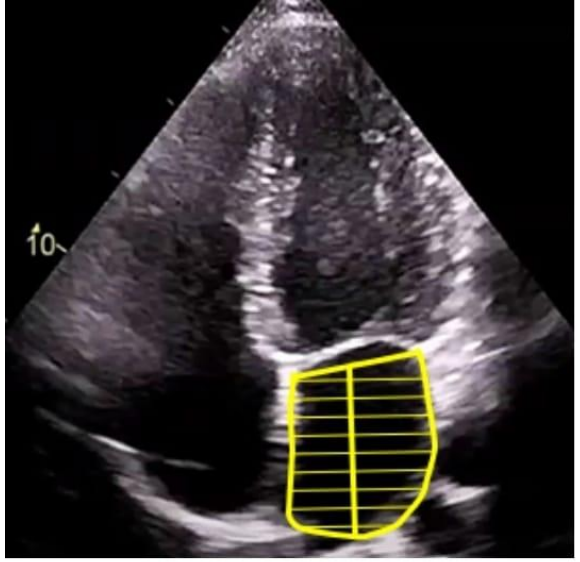


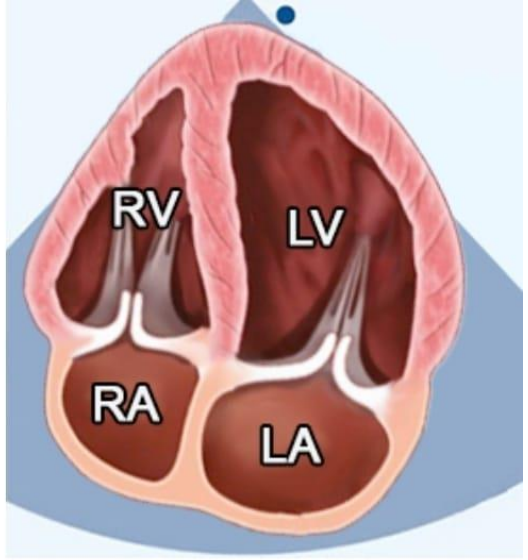




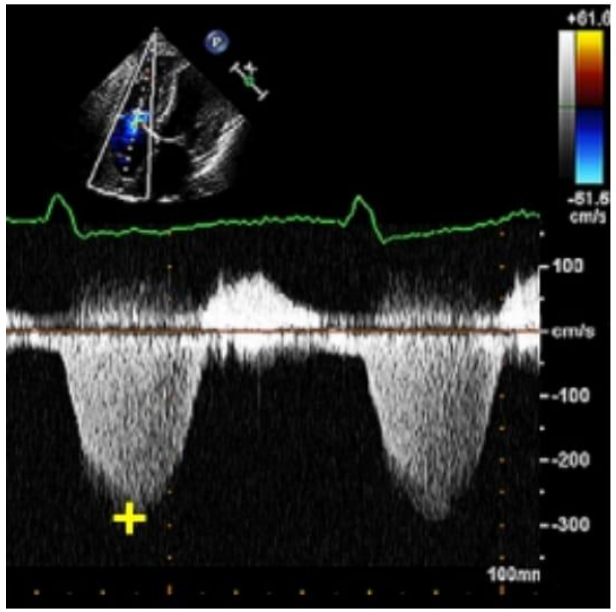


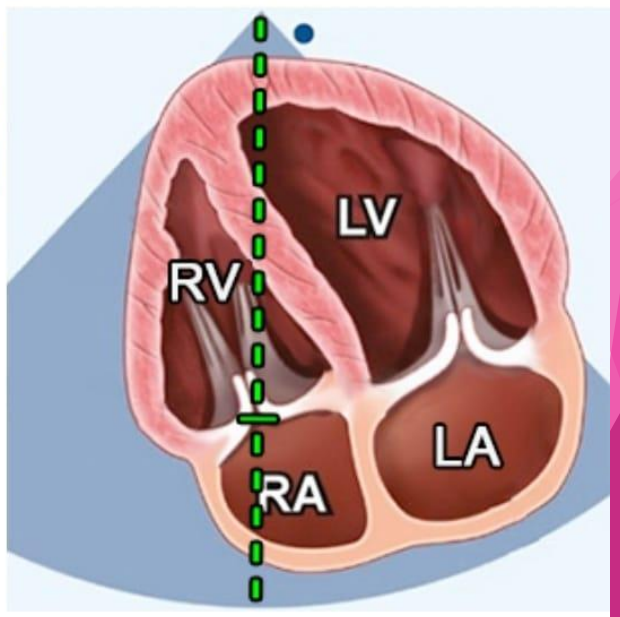
MV E/A



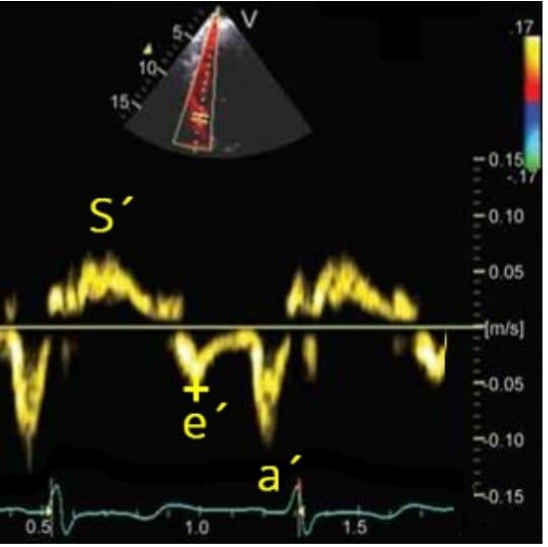


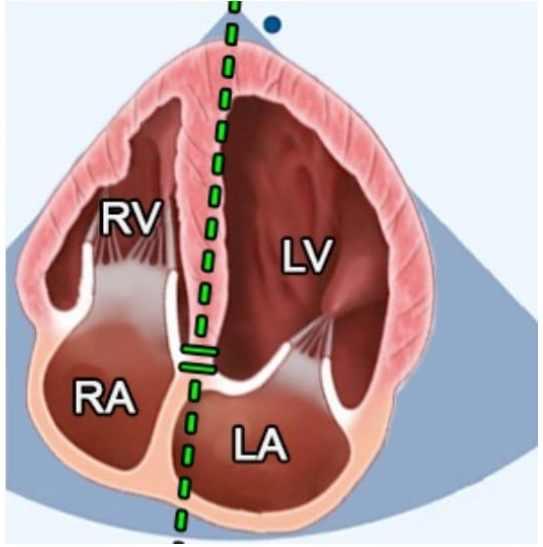
LA volume



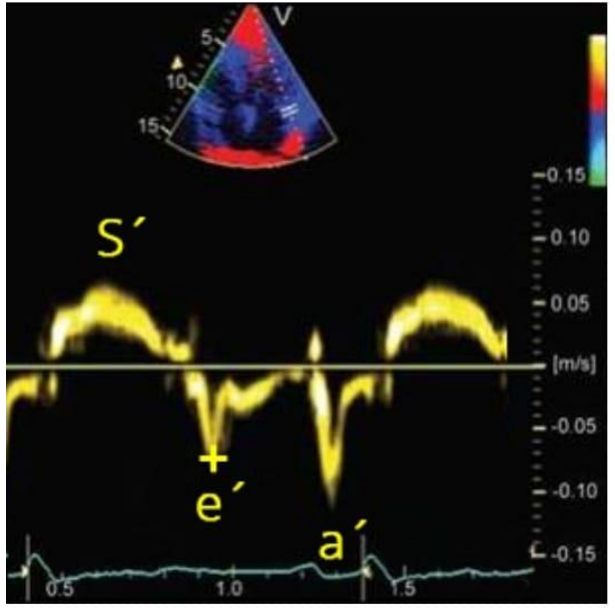


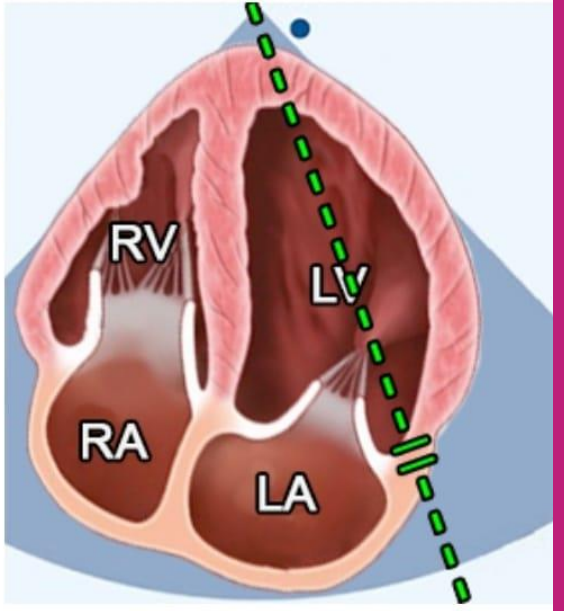
Vmax TR



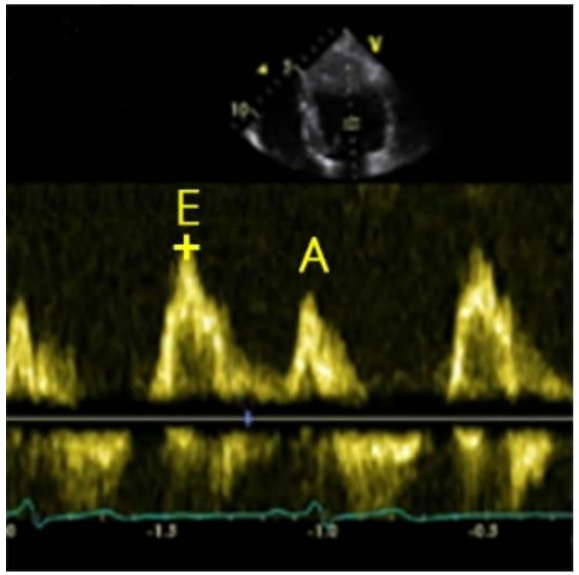


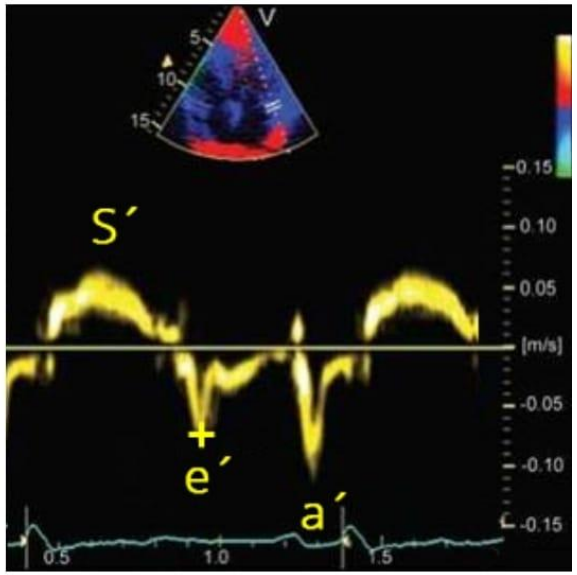
Septal e´



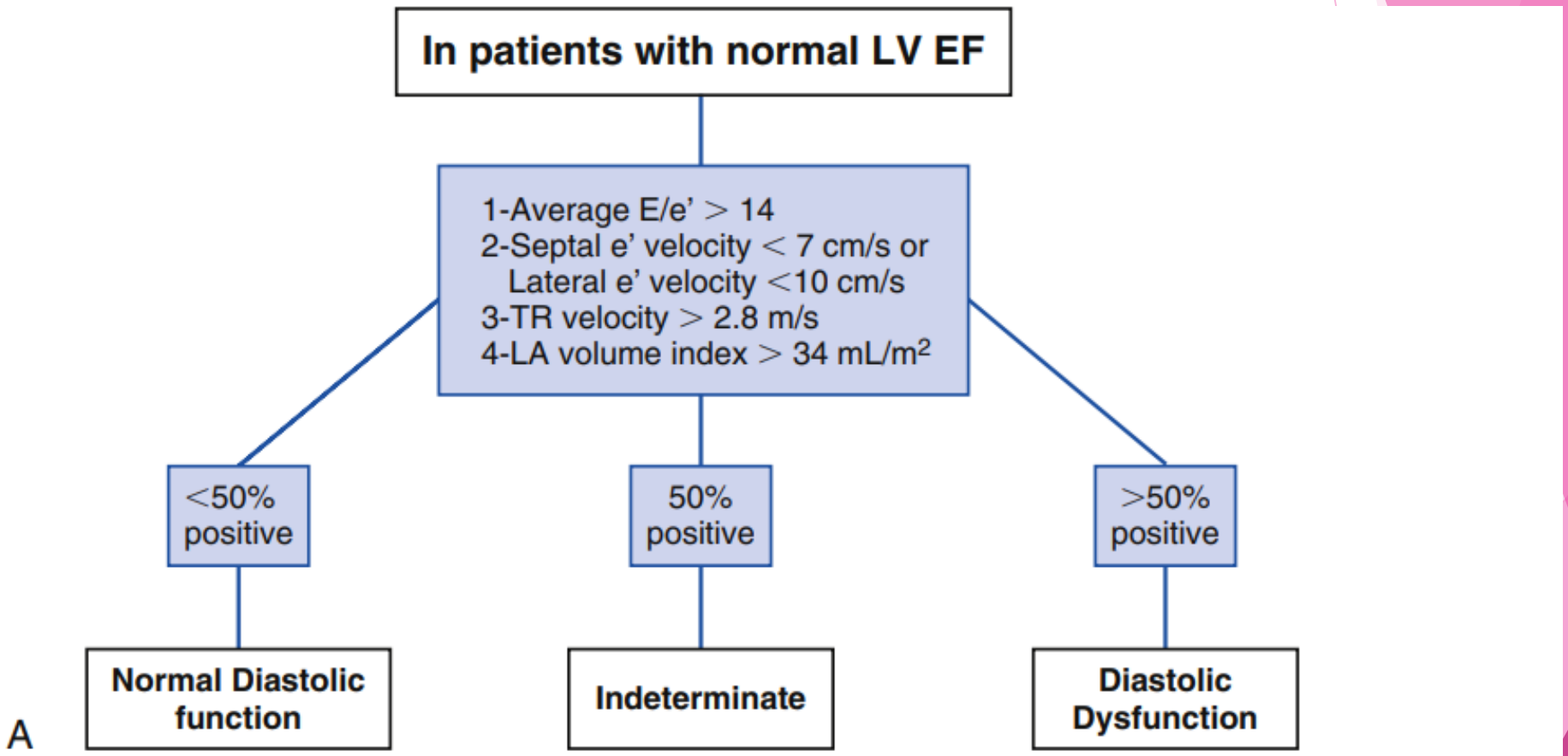


Lateral e´

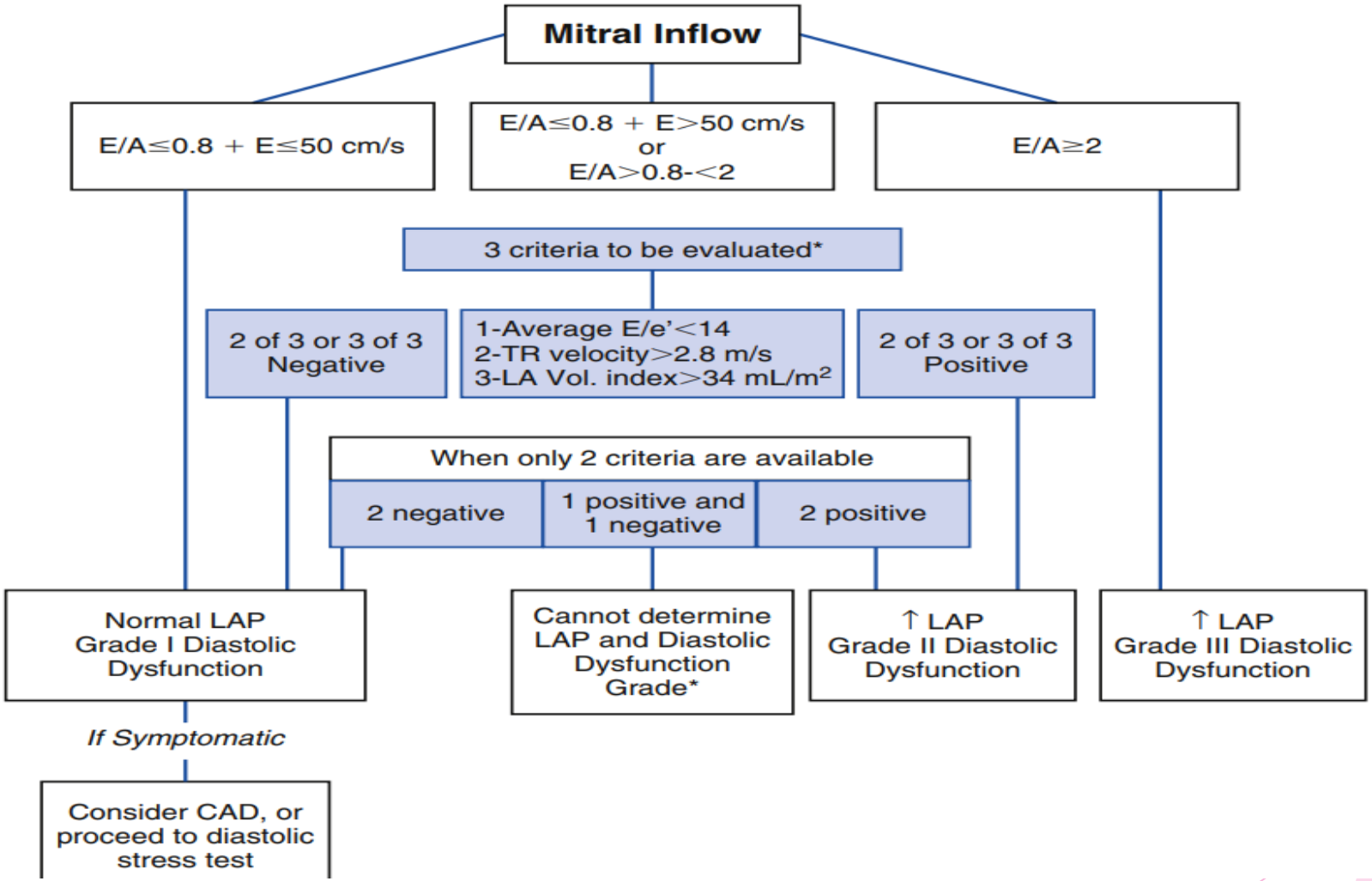




MV E/e´


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 > 34 mL/m²
<50% positive
50% positive
>50% positive
Normal Diastolic function
Indeterminate
Diastolic Dysfunction

A


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>34 mL/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

E/A>2 ????

- DT should be used for assessment of LV diastolic function in patients with recent cardioversion to sinus rhythm who can have a markedly reduced mitral A velocity because of LA stunning at the time of the echocardiographic examination thus leading to an E/A ratio >= 2 despite the absence of elevated LV filling pressures

In young individuals(<40 years of age), E/A ratios > 2 may be a normal finding, and therefore in this age group other signs of diastolic dysfunction should be sought.

Importantly, normal subjects have normal annular e’ velocity which can be used to verify the presence of normal diastolic function.

The approach starts with mitral inflow velocities and is applied in the absence of

- atrial fibrillation (AF)
- at least moderate mitral annular calcification [MAC]
- any mitral stenosis
- mitral regurgitation [MR] of more than moderate severity
- mitral valve repair or prosthetic mitral valve
- LV assist devices,
- left bundle branch block
- ventricular paced rhythm.

IV. CONCLUSIONS ON DIASTOLIC FUNCTION IN THE CLINICAL REPORT

The conclusion could be one of three options:

- elevated
- normal
- cannot be determined

In addition, the grade of LV diastolic dysfunction should be included in the reports along with the estimated LV filling pressures.

comparison with previous studies is encouraged to detect and comment on changes in diastolic function grade over time.

HFPEF

- ESC guideline has kept the nomenclature of HFpEF using an EF cut-off of 50%

- it is important to exclude other conditions that might mimic the HFpEF syndrome (e.g. lung disease, anaemia, obesity, and deconditioning)

- This simplified diagnostic approach starts with assessment of pre-test probability
- The diagnosis should include the following:

1. Symptoms and signs of HF.
2. An LVEF ≥50%.*
3. Objective evidence of cardiac structural and/or functional abnormalities

1. Diastolic stress testing is indicated in patients with dyspnea and grade 1 diastolic dysfunction at rest.

2. It is performed using supine bike or treadmill stress testing.

At rest, mitral E and annular e’ velocities should be recorded,
along with the peak velocity of TR jet from multiple windows. The same parameters are recorded during exercise or 1 to 2 min after termination of exercise when E and A velocities are not merged, because increased filling pressures usually persist for few minutes.

The test is considered positive when all ofthe following three conditions are met during exercise: average E/e, > 14 or septal E/e, ratio > 15, peak TR velocity > 2.8 m/sec and septal e’ velocity < 7 cm/sec.

Thank you for your attention