# What is new in the echocardiographic assessment of diastolic function
# Focused on the new ASE/EACI guidelines for the evaluation of LV diastolic function by echocardiography
# (Nagueh et al., JASE 2016,29:277-314)

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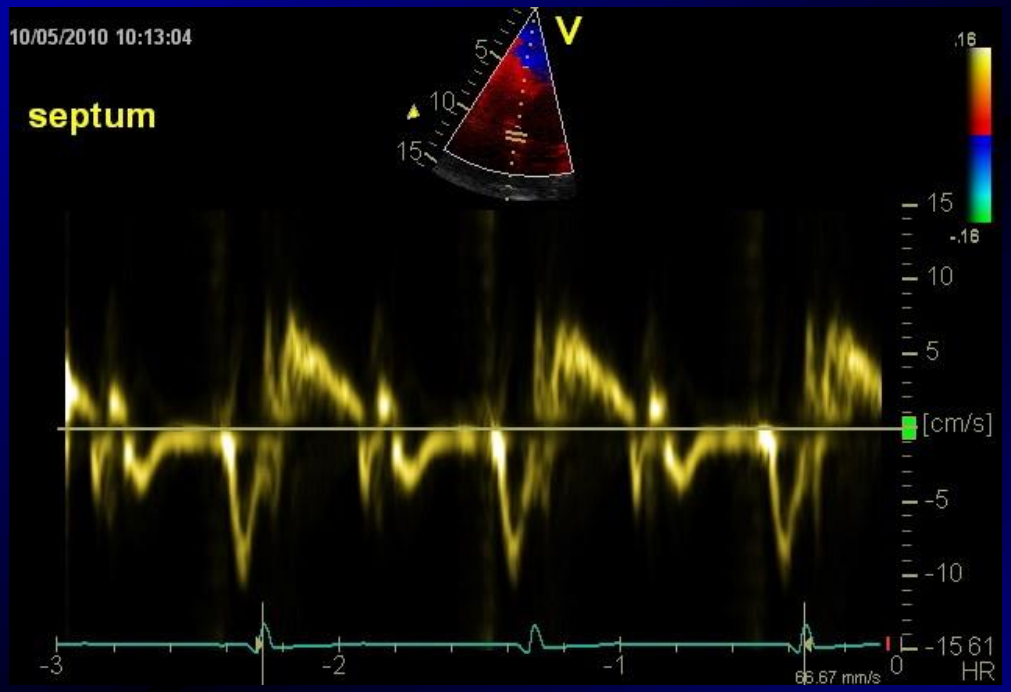
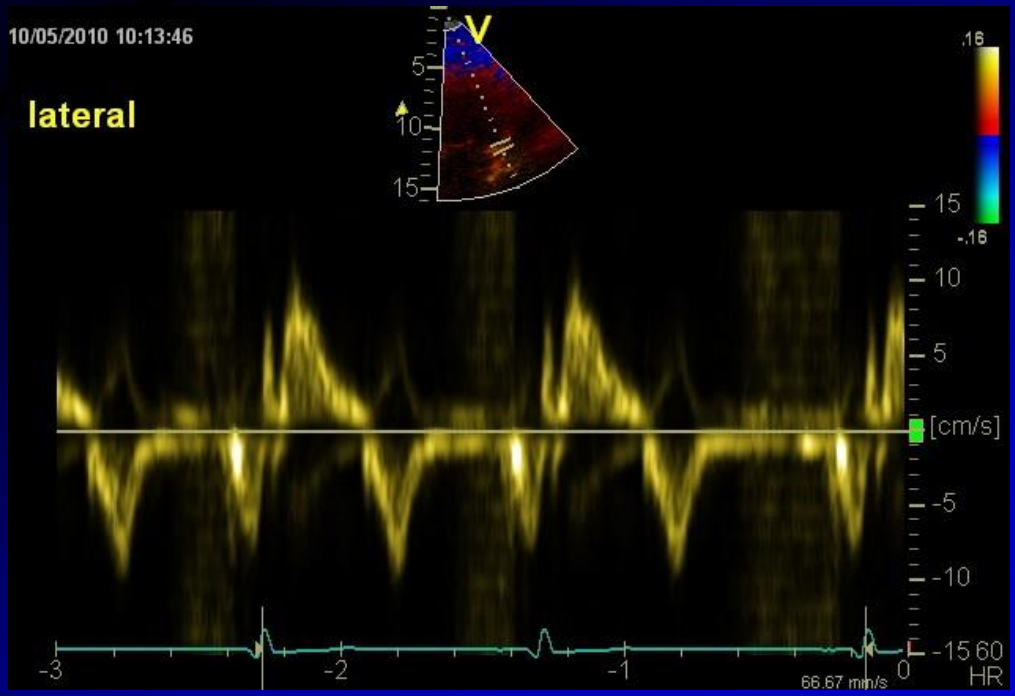
# General principles for echocardiographic assessment of LV diastolic function

- The guidelines are not necessarily applicable to children or in the perioperative setting
- If a Doppler signal is suboptimal, that signal should not be used in formulating conclusions about LV diastolic function
- The presence of a single measurement that falls within the normal range for a given age does not necessarily indicate normal diastolic function – none of the indices should be used in isolation
- Echo indices of diastolic function should be interpreted in a wider context that included clinical status and the other 2D and other Doppler parameters

# e´ measurements in the septal and lateral mitral annulus

| | | |
|---|---|---|
| Pulsed-wave TDI e′ velocity (cm/sec) | 1. Apical four-chamber view: PW Doppler sample volume (usually 5–10 mm axial size) at lateral and septal basal regions so average e′ velocity can be computed.<br>2. Use ultrasound system presets for wall filter and lowest signal gain.<br>3. Optimal spectral waveforms should be sharp and not display signal spikes, feathering or ghosting. | Peak modal velocity in early diastole at the leading edge of spectral waveform |

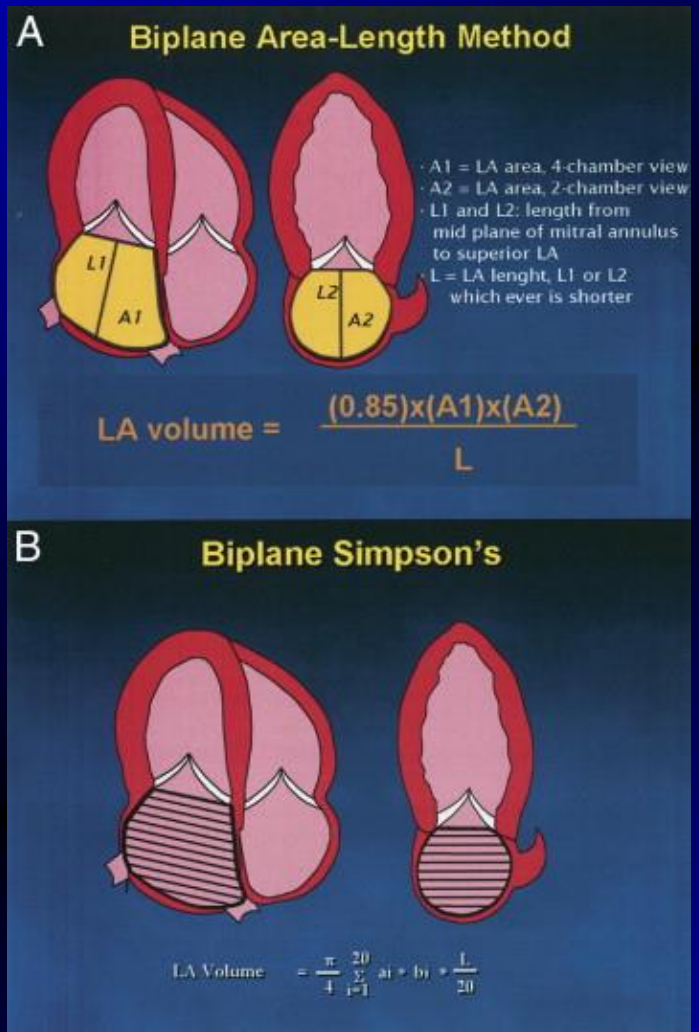


# Echocardiographic evaluation of left atrial volume

display signal spikes, feathering or ghosting.

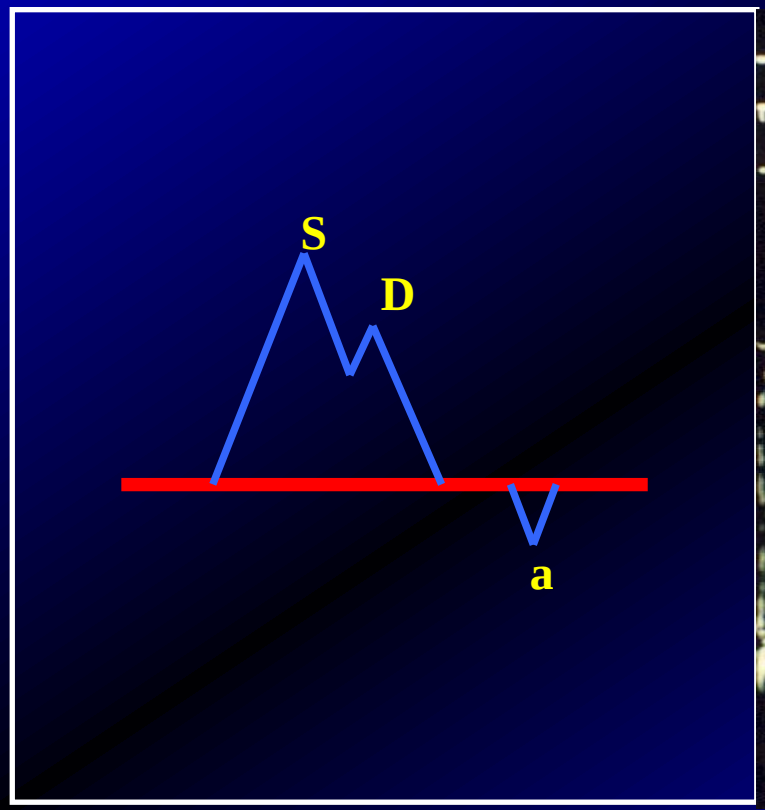
| | | |
|---|---|---|
| Mitral E/e′ | See above for acquisition of E and e′ velocities | MV E velocity divided by mitral annular e′ velocity |
| LA maximum volume index (mL/BSA) | 1. Apical four- and two-chamber: acquire freeze frames 1–2 frames before MV opening.<br>2. LA volume should be measured in dedicated views in which LA length and transverse diameters are maximized. | Method of disks or area-length method and correct for BSA. Do not include LA appendage or pulmonary veins in LA tracings from apical four- and apical two-chamber views. |

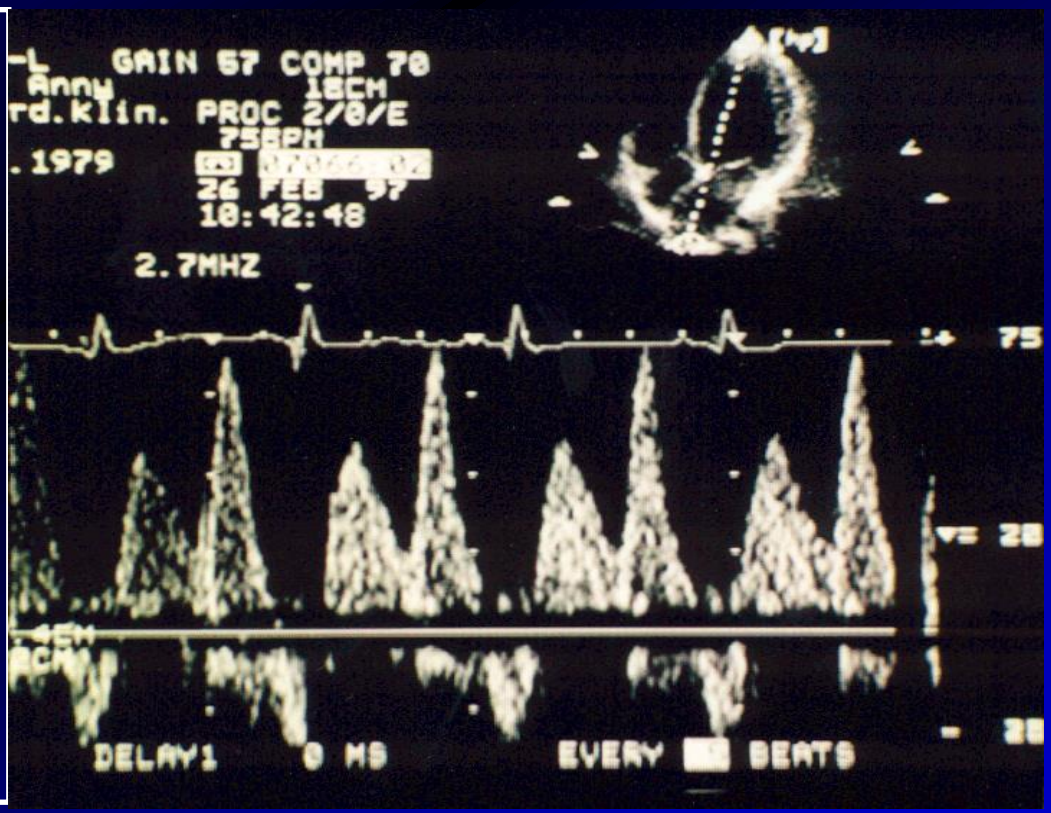



According to Lester et al. JACC 51,2008:679-89

# Doppler evaluation of pulmonary vein flow

| | | |
|---|---|---|
| PV S wave (cm/sec) | 1. Apical four-chamber with color flow imaging to help position pulsed Doppler sample volume (1–3 mm axial size).<br>2. Sample volume placed at 1–2 cm depth into right (or left) upper PV.<br>3. Use low wall filter setting (100–200 MHz) and low signal gain.<br>4. Optimized spectral waveforms should not display signal spikes or feathering. | Peak modal velocity in early systole at the leading edge of spectral waveform |

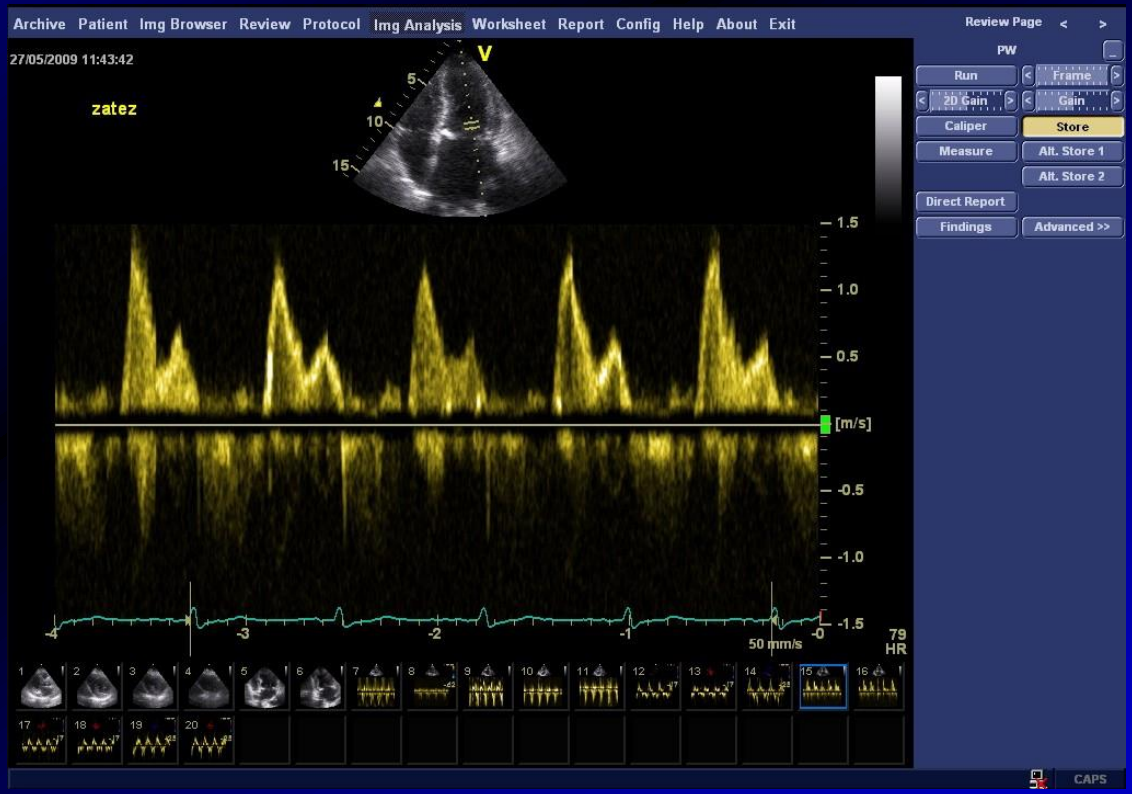


# Measurement of E and A velocity

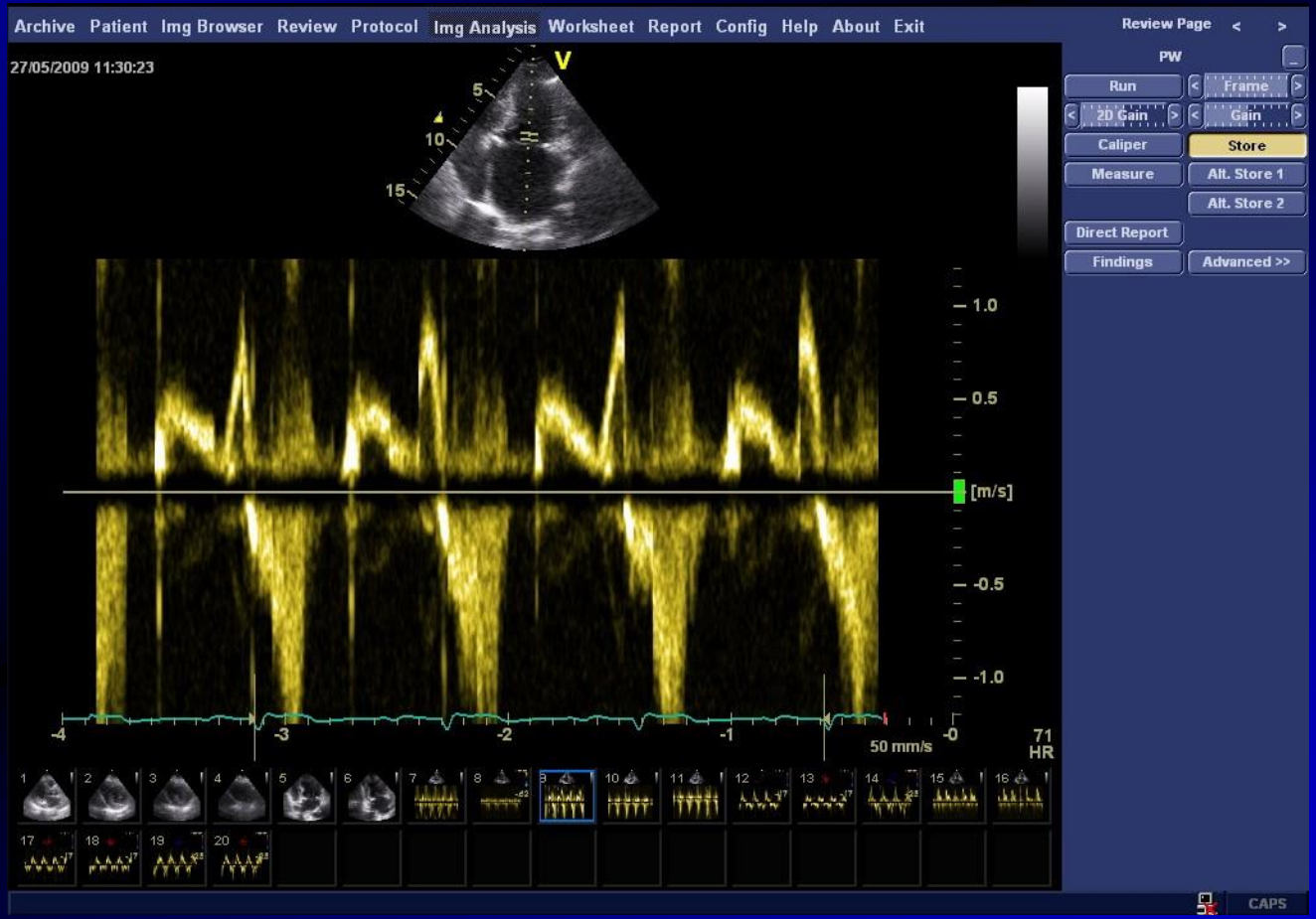
Table 1 Two-dimensional and Doppler methods for assessment of LV diastolic function

| Variable | Acquisition | Analysis |
|---|---|---|
| Peak E-wave velocity (cm/sec) | 1. Apical four-chamber with color flow imaging for optimal alignment of PW Doppler with blood flow.<br>2. PW Doppler sample volume (1–3 mm axial size) between mitral leaflet tips.<br>3. Use low wall filter setting (100–200 MHz) and low signal gain.<br>4. Optimal spectral waveforms should not display spikes or feathering. | Peak modal velocity in early diastole (after ECG T wave) at the leading edge of spectral waveform |

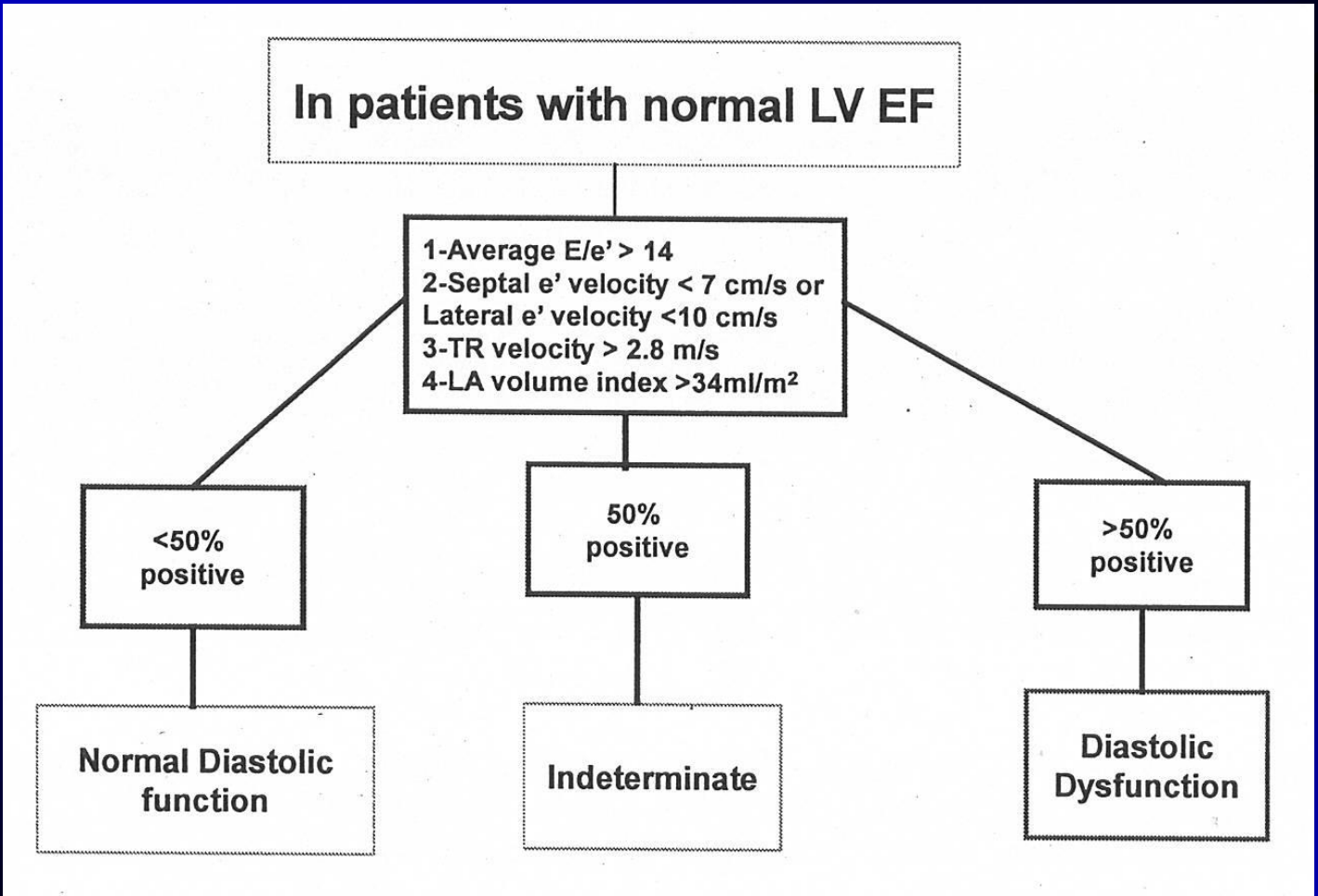


# Measurement of A duration

| | | |
|---|---|---|
| MV A duration (msec) | 1. Apical four-chamber with color flow imaging for optimal alignment of PW Doppler with blood flow.<br>2. PW Doppler sample volume (1–3 mm axial size) at level of mitral annulus (limited data on how duration compares between annulus and leaflet tips)<br>3. Use low wall filter setting (100–200 MHz) and low signal gain.<br>4. Optimal spectral waveforms should not display spikes or feathering. | Time interval from A-wave onset to end of A wave at zero baseline. If E and A are fused (E velocity > 20 cm/sec when A velocity starts), A-wave duration will often be longer because of increased atrial filling stroke volume. |



# Algorithm for diagnosis of LV diastolic dysfunction in subjects with normal LVEF




**LV diastolic function is normal if more than half of the available variables do not meet the cutoff values for identifying abnormal function. Diastolic dysfunction is present if more than half of the available parameters meet these cutoff values. The study is inconclusive if half of the parameters do not meet the cutoff values.**

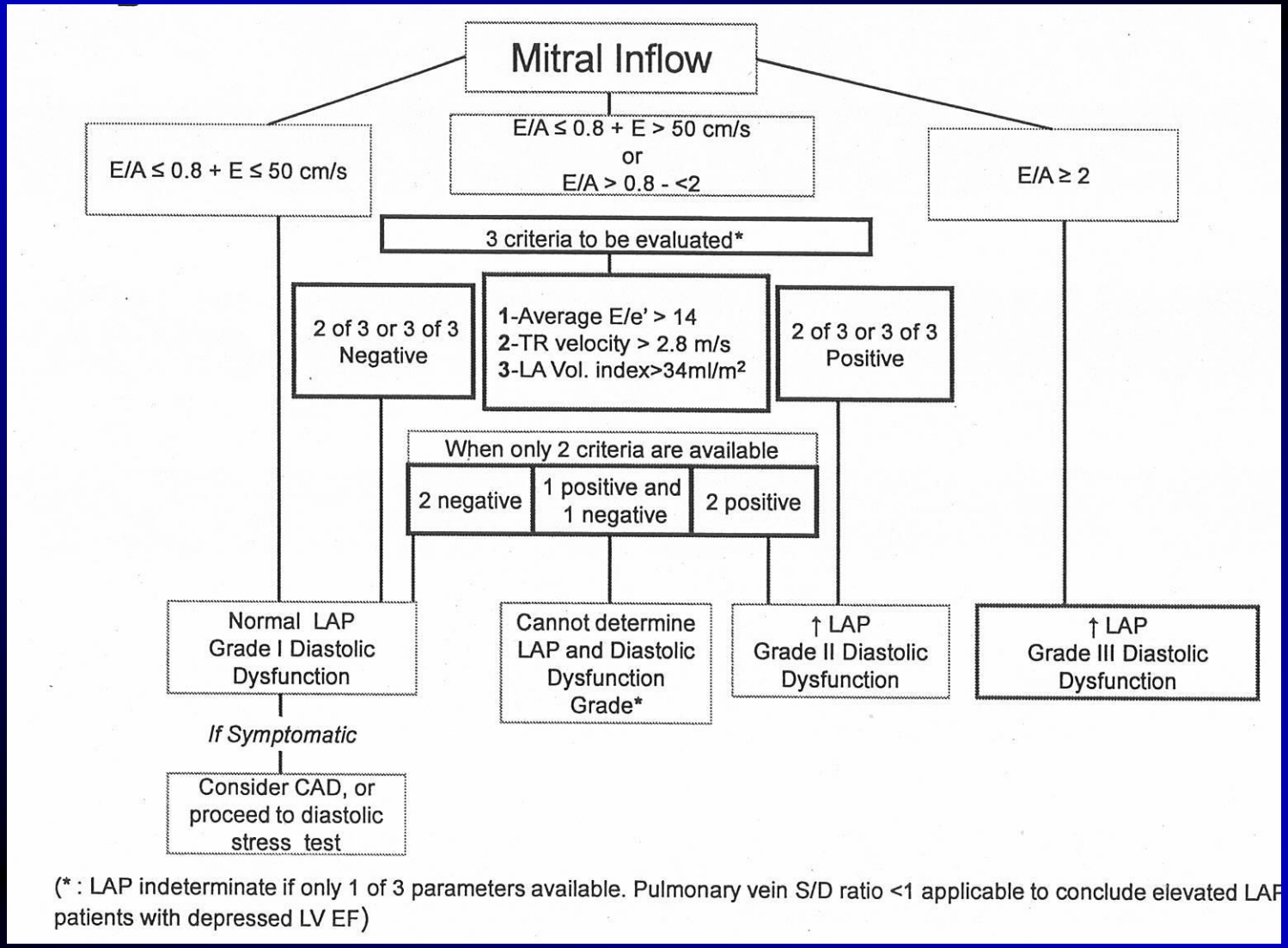
**According to Nagueh et al., JASE. 2016**

# Comments to parameters and algorithm presented

- Age should be taken into account when evaluating diastolic function variables. Parameters less influenced by age: E/e´, Ar-A (Ard – Ad), changes of transmitral flow velocities during Valsalva maneuver (decrease in E/A ratio of 50% or more is highly specific for increased LV filling pressures) (pseudonormal LV filling)

- It is also important to take into account other parameters reflecting LV diastolic function not included in the algorithm presented: Ar – A (reflect LVEDP elevation), LV hypertrophy, global longitudinal function LK (s´, GLS…), E/A, DT-E, lateral E/e´greater than 13, septal E/e´greater than 15 and other.

# Algorithm for estimation of LV filling pressures and grading LV diastolic function in patients with depressed LVEF and patients with myocardial disease and normal LVEF after consideration of clinical and other 2D data.




According to Nagueh et al., JASE, 2016

# Grading diastolic dysfunction

Table 4 LV relaxation, filling pressures and 2D and Doppler findings according to LV diastolic function

| | Normal | Grade I | Grade II | Grade III |
|---|---|---|---|---|
| LV relaxation | Normal | Impaired | Impaired | Impaired |
| LAP | Normal | Low or normal | Elevated | Elevated |
| Mitral E/A ratio | ≥0.8 | ≤0.8 | >0.8 to <2 | >2 |
| Average E/e′ ratio | <10 | <10 | 10–14 | >14 |
| Peak TR velocity (m/sec) | <2.8 | <2.8 | >2.8 | >2.8 |
| LA volume index | Normal | Normal or increased | Increased | Increased |

According to Nagueh et al, JASE 2016,29:277-314

# Conclusion on diastolic function in the clinical report

- Comments on the status of LV filling pressure - normal
  - elevated
  - cannot be determined
- Assessment of the diastolic dysfunction grade – grade I, II, III

## Estimation of LV filling pressures in specific cardiovascular diseases
## Hypertrophic cardiomyophy

- E/e´ > 14
- LAVindex > 34 ml/m2
- Ar – A duration 30 msec and more
- Peak velocity of TR jet by CW Doppler > 2.8 m/sec

- If more than half of the variables meet the cutoff values, then LAP is elevated and grade II diastolic dysfunction is present
- Grade III diastolic dysfunction is present in the presence of restrictive filling pattern and reduced e´ velocity (septal e´ < 7 cm/s, lateral e´ < 10 cm/s)

## Estimation of LV filling pressures in specific cardiovascular diseases
## Restrictive cardiomyopathy

- Patients with early disease usually have grade I diastolic dysfunction (DD) that progresses to grade II as the severity of the disease advances.

- In patients with advanced disease, grade III DD is present and is characterized by:

  E/A > 2,5

  DT-E < 150 ms

  IVRT < 50 msec

  decreased septal and lateral e´ velocities (3-4 cm/s)

# Estimation of LV filling pressures in specific cardiovascular diseases
## Heart transplantation

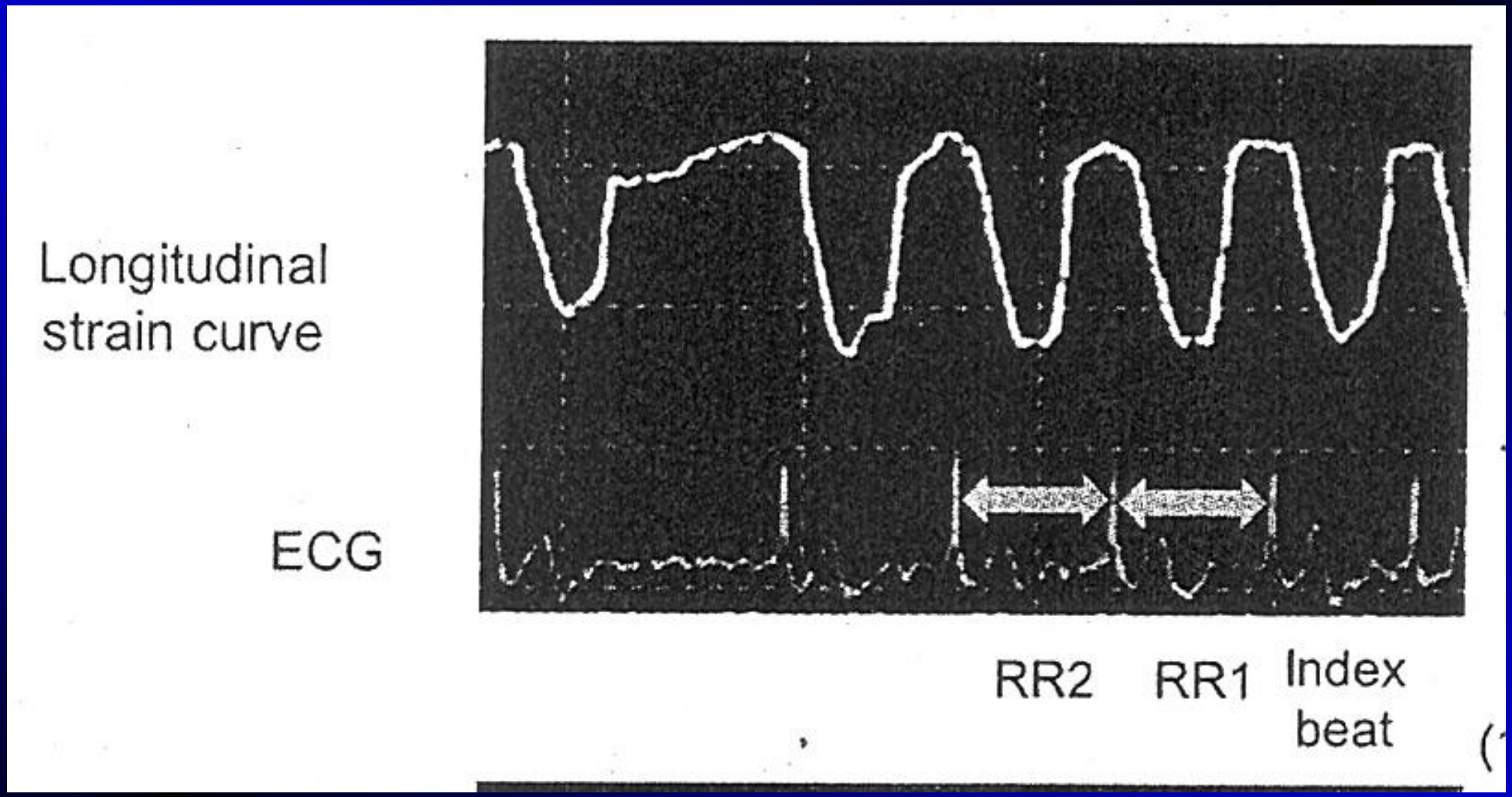
- There is difficult interpretation of findings due to the effect of heart denervation, tachycardia, disturbances in left atrial function, influence of the age of transplanted heart, translational heart motion influences e´velocity, etc.

- A restrictive filling pattern is a common finding after heart transplantation and is frequently observed in patients with normal LV diastolic function as donor hearts are usually obtained from healthy young individuals.

## Estimation of LV filling pressures in specific cardiovascular diseases
## Atrial fibrillation

- Peak TR velocity > 2.8 m/sec is suggestive of elevated LAP
- In patients with impossibility to measure peak TR velocity the following parameters can be applied: Peak acceleration rate of mitral E velocity 1,900 cm/s2 or more, IVRT 65 msec or less, DT of pulmonary venous diastolic velocity 220 msec or less E/Vp 1.4 or more, E/e´ 11 or more
- Similar RR intervals should be used for measurement of E and e´
- Individual parameters should be determined as a mean from 10 consecutive heart cycles, or using „index beat“ method or using 3 similar RR intervals (maximal RR differences 10-20%)

# Evaluation of myocardial function in atrial fibrillation (AF) using index beat approach




Kusunose et al, JASE 2012,25:953-9.

# Diastolic stress test

- Indication: when resting echo does not explain the symptoms of heart failure or dyspnea, especially with exertion
- Stress testing is performed with exercise – most frequently using supine bicycle test with recording of transmitral flows, mitral annulus tissue Doppler velocities, 2D images, and CW Doppler tricuspid regurgitation velocity – all at rest, during each stage including peak exercise and in recovery
- It is also possible to acquire recordings immediately after the finishing of exercise
- The test is considered abnormal when all of the following three conditions are met:

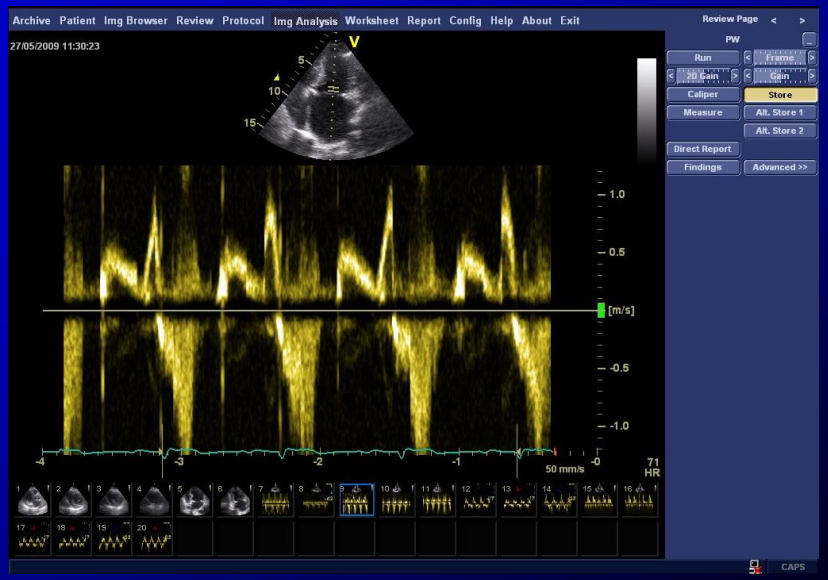
  Average E/e´ > 14 (or septal E/e´ > 15) with exercise

  peak TR velocity > 2.8 m/sec with exercise

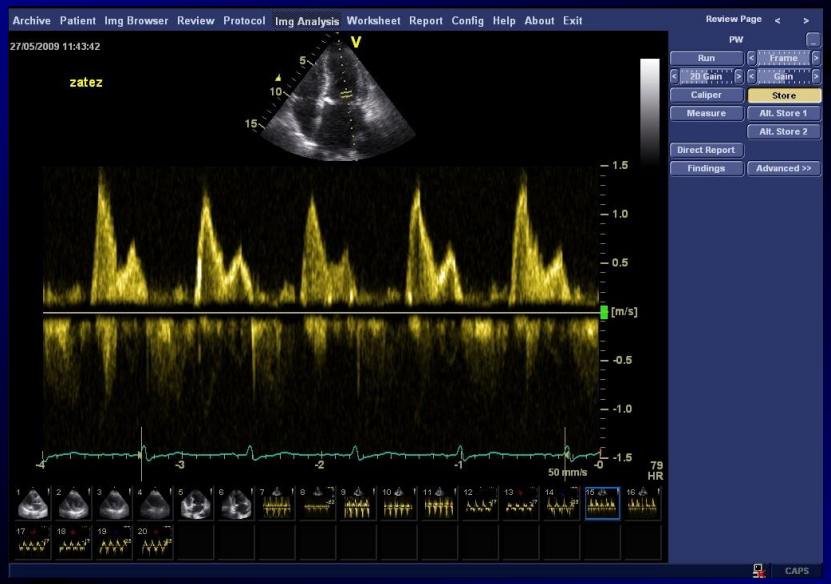
  septal e´ < 7 cm/sec or lateral e´ < 10 cm/s at baseline

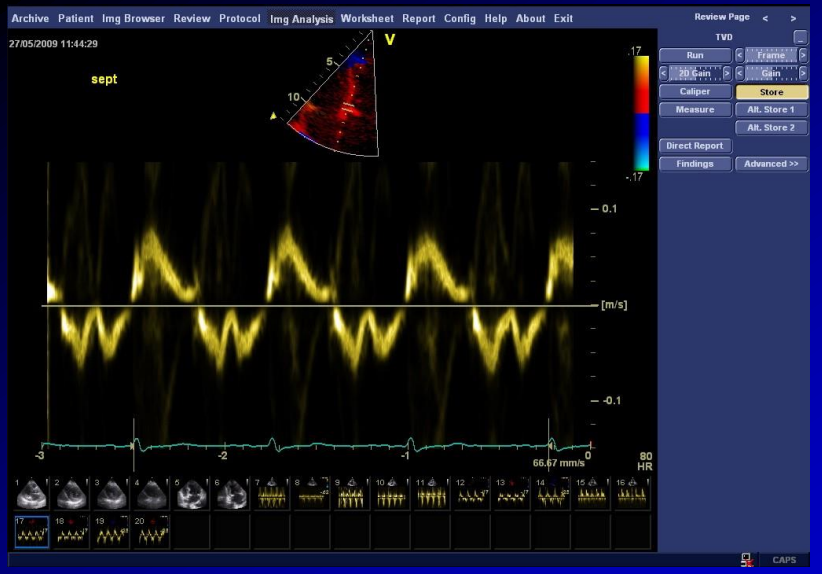
  The results are normal when average (or septal) E/e´ is < 10 with exercise and peak TR velocity is < 2.8 m/sec with exercise

# Exercise-induced elevation in LV filling pressure estimated by the E/e´ ratio (septal mitral annulus)








**DDNORMAR**

**Rest**

**E=60 cm/s**

**e´ = 5.1 cm/s**

**E/e´ = 11.8**

**Exercise**

**E= 127 cm/s**

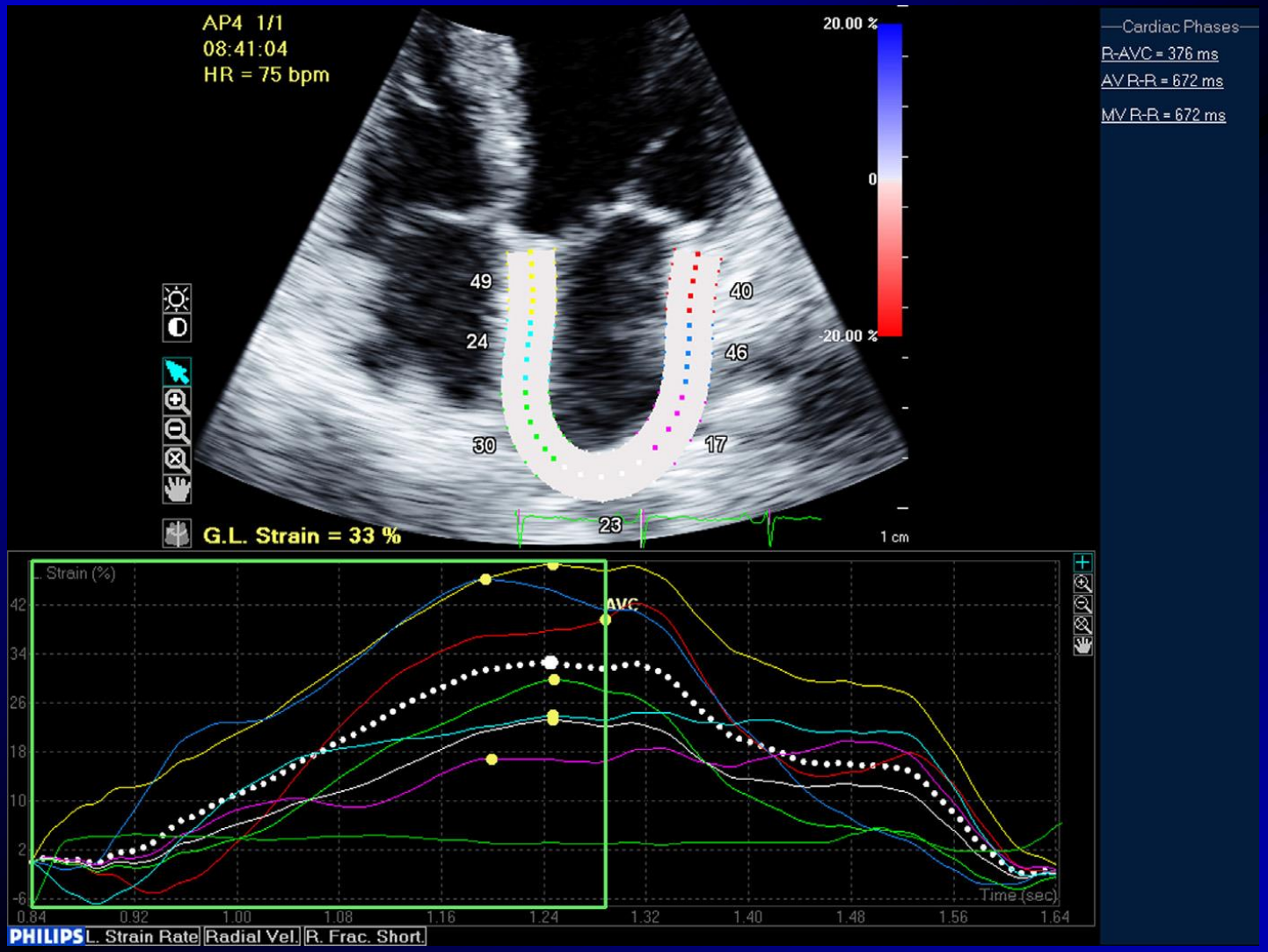
**e´ = 6.9 cm/s**

**E/e´ = 18.4**

# Novel indices of LV diastolic function

- Global longitudinal strain
- LV global longitudinal strain rate during isovolumic relaxation period
- LV global longitudinal strain rate during early diastole
- LV untwisting rate
- Left atrial systolic strain
- Assessment of  left atrial conduit function

# STE-derived left atrial strain




**Regional strains are denoted by the colored lines and global longitudinal strain by white dotted line (from Hoit, JACC 63, 2014, No. 6, 493-505.**

# Clinical importance of the assessment of LV diastolic function

- Establishing a diagnosis (mainly in patients with dyspnoe)
- Optimalization of management of heart failure (mainly in finding of elevated LV filling pressure)
- Prognostic evaluation of patients with heart failure (DT-E, restrictive and pseudonormal LV filling, E/e´, s´, e´ , PASP, LAVI, longitudinal strain, diastolic strain rate, LA strain ….)