The importance of left atrium in LV diastolic function

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"The very essence of cardiovascular medicine is recognition of early heart failure."
Sir Thomas Lewis 1933

Physiology

- **Diastole** is the period in which the myocardium loses its ability to generate force and returns to resting force and length.
- Normal **diastolic function** allows the ventricle to **fill** adequately during rest and exercise, without an abnormal increase in diastolic pressures.
- **Diastolic Dysfunction (DD)** refers to a condition in which abnormalities in mechanical function are present during diastole.

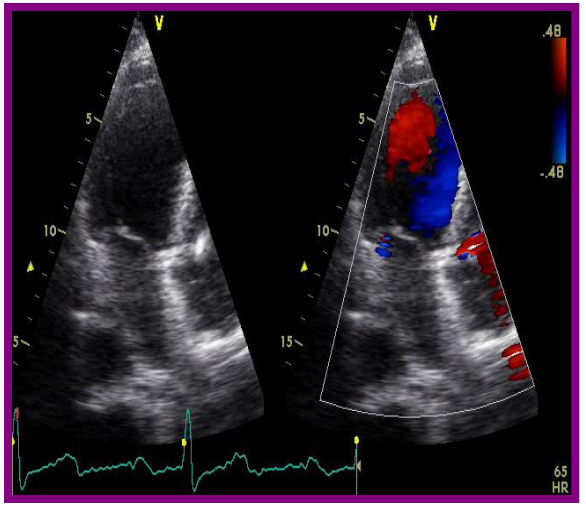
Left Atrium (LA)

Mechanical function:

is an important determinant of the left **ventricular filling** process

The LA **modulates** ventricular filling through its

- reservoir
- conduit
- pump functions



LA structural characteristics

M

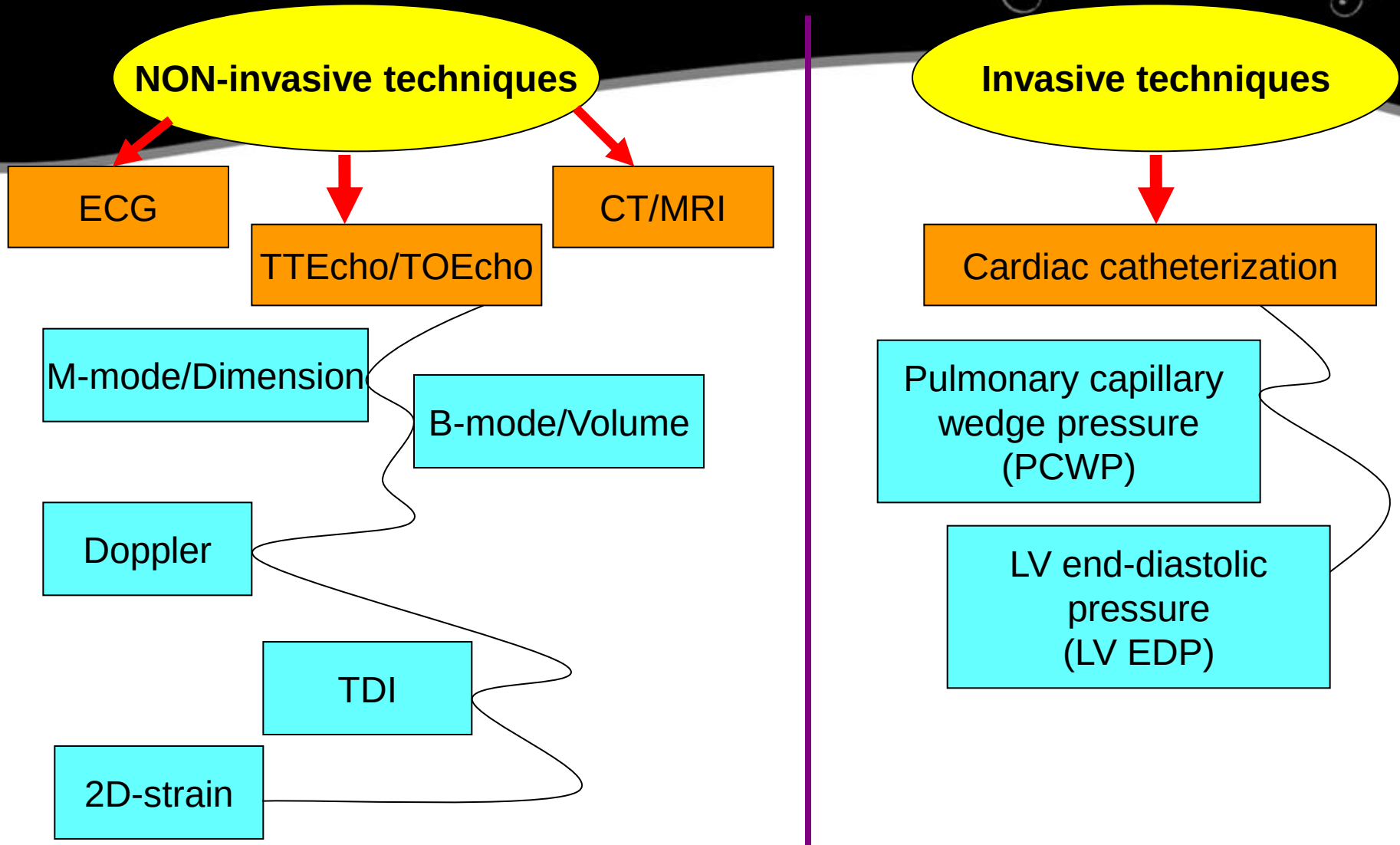
- the LA wall consist of intermingling circumferential and longitudinal muscular bundles;
- abrupt changes in orientation, and mixed arrangements are common between bundles;

H

- the **LA chamber** show myocytes of smaller dimensions and are characterized by the presence of chains of myosine with fetal type expressions (shorter duration of the action potential);
- the LA chamber do not need to exert a particularly strong contractile activity.

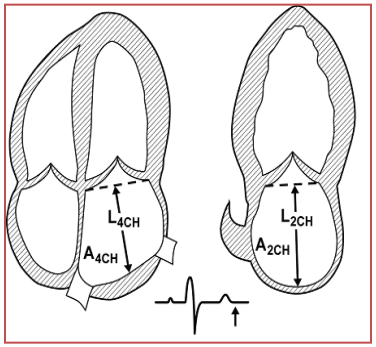
H: Reiser PJ et al. Am J Physiol Heart Circ Physiol 2001;280: H1814-H1820;
M: Siew Yen Hoa et al. Cardiovascular Research 54 (2002) 325 –336

Evalution methods of LA function

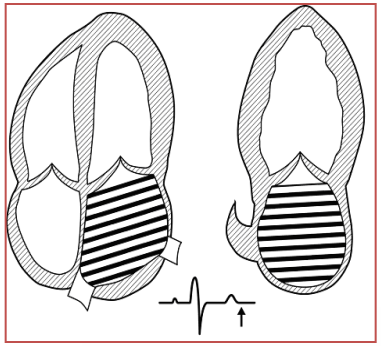


Left Atrium

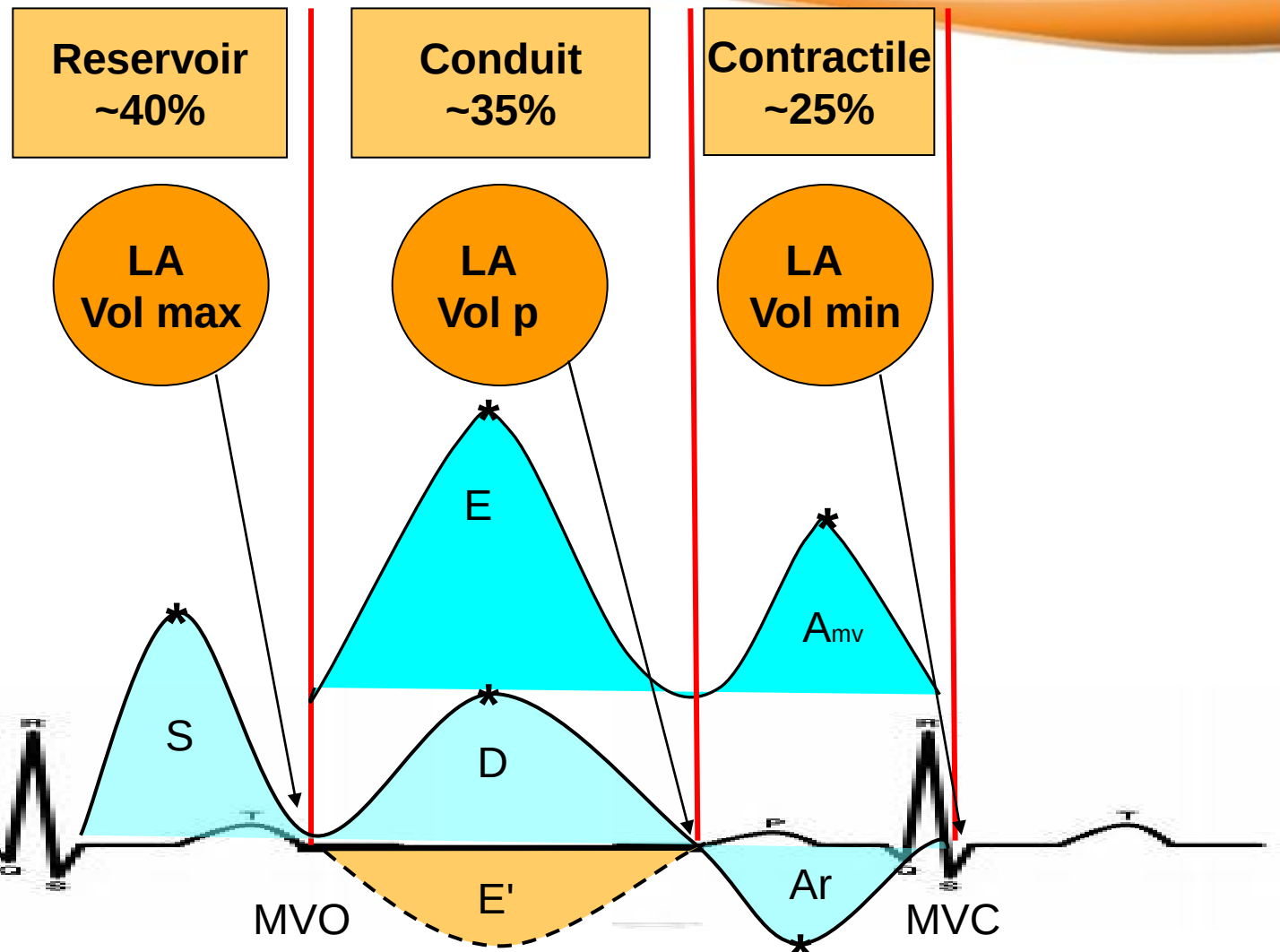
Mechanical function



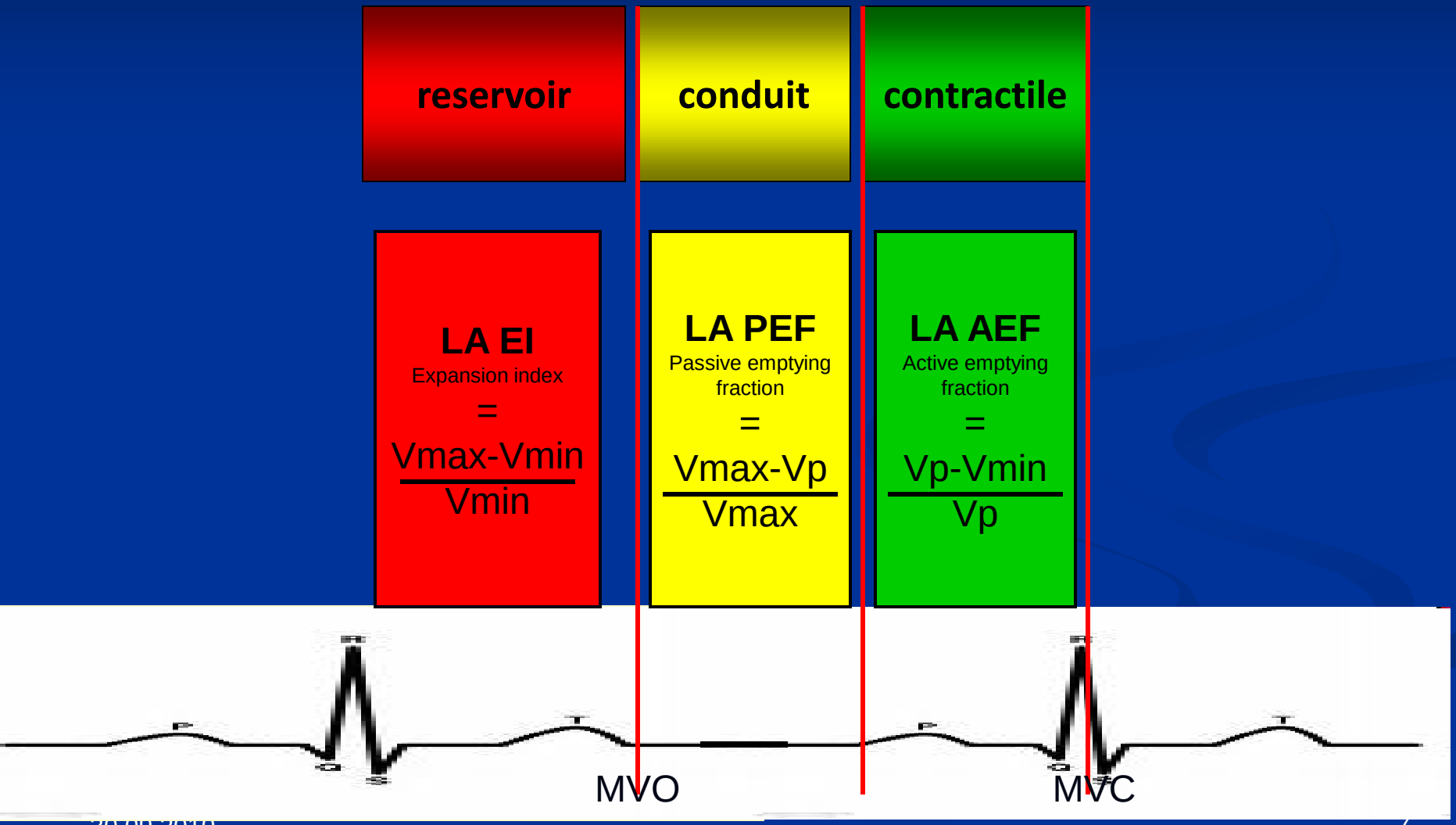
A-L



SIMPSON

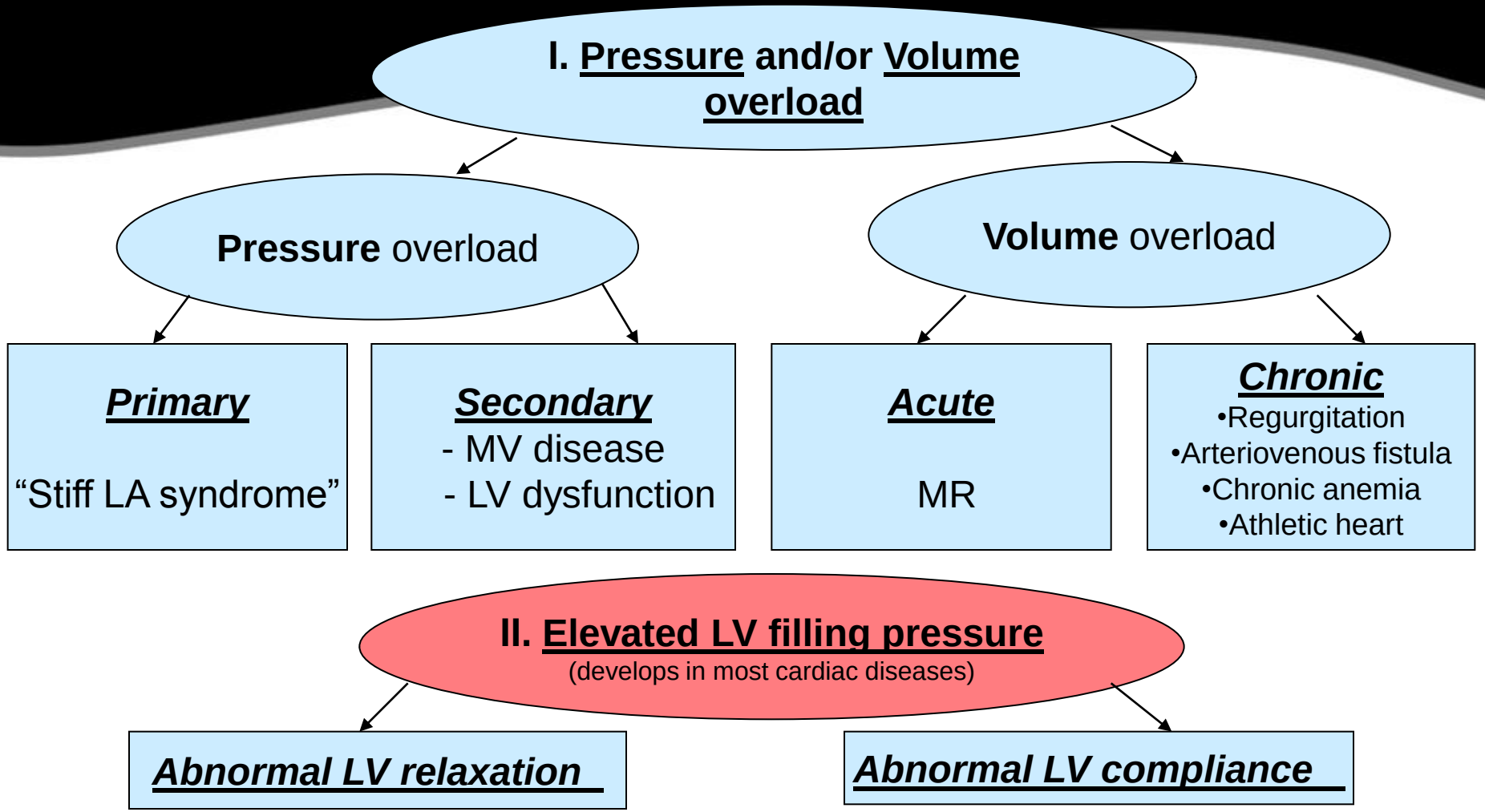


LA phasic function



N. P. Nikitin et al. Effect of Age and Sex on Left Atrial Morphology and Function. Eur J Echocardiography (2003) 4, 36–42

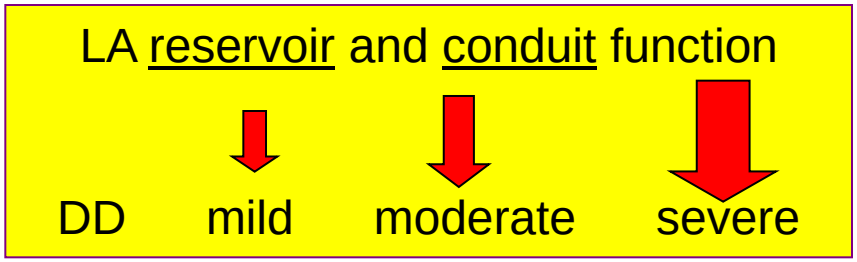
LA remodeling and dilatation

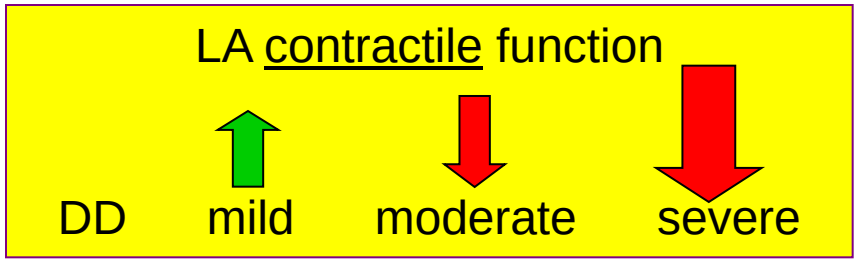


* Walter P. Abhayaratna et al. Left atrial size. JACC Vol. 47, 12;2357-63, 2006

Effect of diastolic dysfunction grade on LA volume

- LA volumes and LA function indices vary according to the severity of diastolic dysfunction (DD);
- LA volumes increase;
- LA **reservoir** and **conduit** function decrease as the severity of LV DD progresses;
- LA **contractile** function shows a compensatory augmentation in patients with mild DD;
- As LV diastolic dysfunction worsens, LA **contractile** function is depressed, resulting in the reduction of LA total emptying volume.





Kyoko Otani et al., Impact of Diastolic Dysfunction Grade on Left Atrial Mechanics Assessed by Two-Dimensional Speckle Tracking Echocardiography. JASE 2010 Vol.23;(9), pp. 961-967.

LA : dimension and volume (+)

- LA volume is a **barometer of LV filling** pressure and reflects the burden of DD;
- LA max volume index ≥34 mL/m² is an **independent predictor** of death, heart failure, atrial fibrillation, and ischemic stroke* (6657 patients);
- **Left atrial size** is certainly easy to assess and **LA volume** is superior to LA diameter as a measure of LA size*.

* Walter P. Abhayaratna et al. Left atrial size. JACC Vol. 47, 12;2357-63, 2006

LA : dimension and volume (-)
limitations

- LA size represents the integration of LV diastolic performance **over time (!)**;
- **ageing** is associated with **LA dilatation**[1];
- **LA max volume** index provided excellent sensitivity and specificity for the detection of severe (grade III or IV) DD, **BUT** sensitivity and specificity for detection of mild or moderate (grade I or II) DD **were less robust**[2].

Table 3. LAVi According to Diastolic Function Grade

Diastolic Grade	n	% of Cohort	LAVi, ml/m² (Mean ± SD)	% Meeting Criteria for LAE
Normal	1,212	73	→ 23 ± 6	9
Grade I	315	19	→ 25 ± 8	17
Grade II	118	7	→ 31 ± 8	48
Grade III to IV	12	1	48 ± 12	100

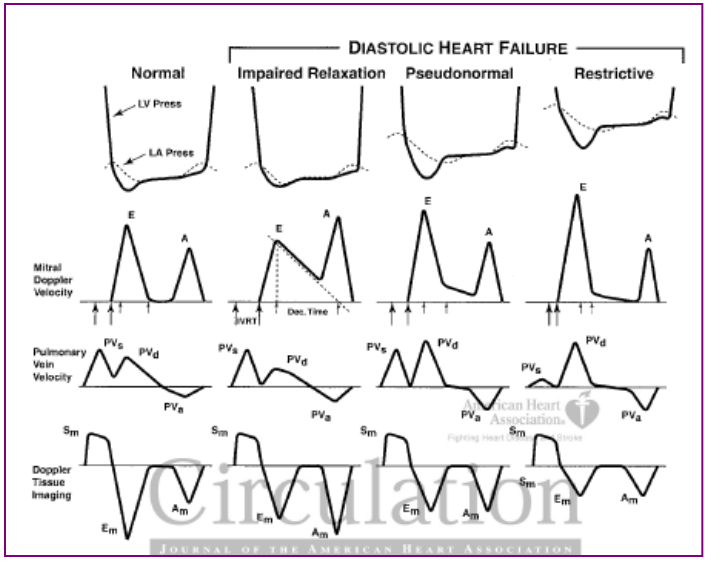
[1] Nikitin NP et al. Left Atrial Morphology and Function. Eur J Echocardiography, Vol. 4, 1, March 2003.

[2] Pritchett et al. Left Atrial Volume and Diastolic Dysfunction. JACC Vol. 45, No. 1, 2005.

LA : Doppler-derived measurements (+)

- **Doppler echocardiography** is widely used for the ***noninvasive*** assessment of diastolic filling of the left ventricle;
- **analysis** of the mitral inflow, pulmonary vein flow velocity curves has provided useful information **for determination of filling pressures;**

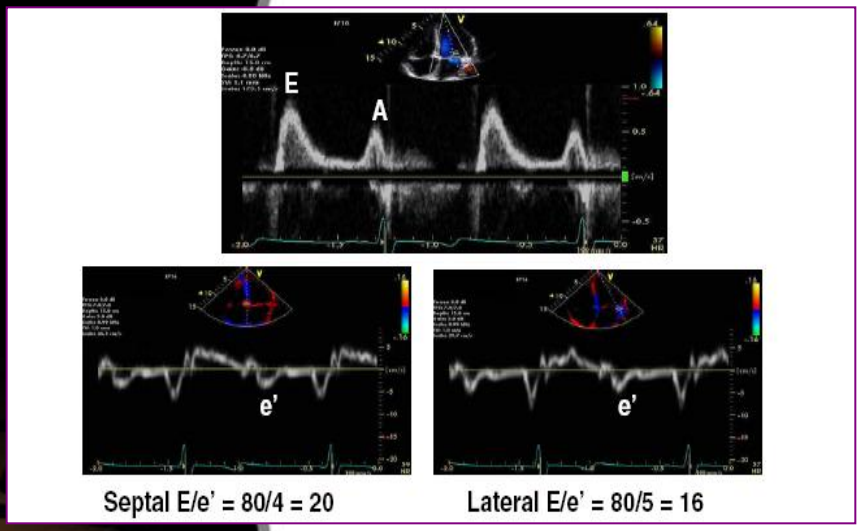
- **In 1982, Kitabatake** first described **the transmitral flow** velocity curves obtained with Doppler echocardiography **in different disease states**.



LA : Doppler-derived measurements (-)

- these techniques present **only a snapshot (at that moment)** view of diastolic function—the pattern would be altered if loading conditions changed;
- **mitral flow is dependent** on multiple interrelated factors, including the rate, age, loading conditions of the left ventricle. Different flow patterns may be seen only hours to days apart in the same person, depending on the left ventricular preload;
- **pseudonormal LV filling** (+ one major limitation of the Valsalva maneuver is that not everyone is able to perform this maneuver adequately, and it is not standardized);
- **pulmonary venous flow** may not be obtained on every patient;
- **too many** parameters.

TISSUE DOPPLER VELOCITY IMAGING (+)



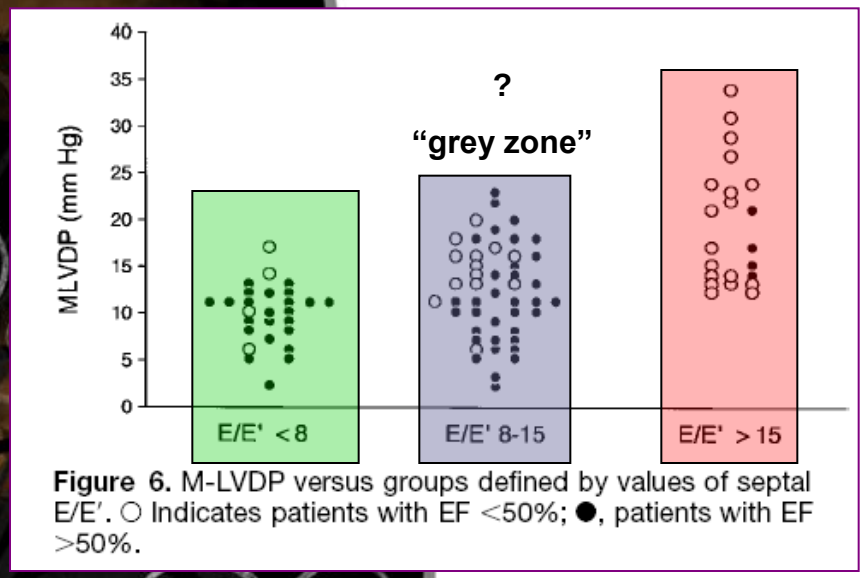


Figure 6. M-LVDP versus groups defined by values of septal E/E'. ○ Indicates patients with EF <50%; ●, patients with EF >50%.

E/E`

- **The ratio of mitral velocity to early diastolic velocity of the mitral annulus (E/E`) showed a better correlation with M-LVDP than did other Doppler variables for all levels of systolic function.**
- **E/E`< 8 accurately predicted normal M-LVDP**
- **E/E` >15 identified increased M-LVDP.**

S.R. Ommen et al. Non-invasive Prediction of LV Filling Pressure, *Circulation*. 2000;102:1788-1794.

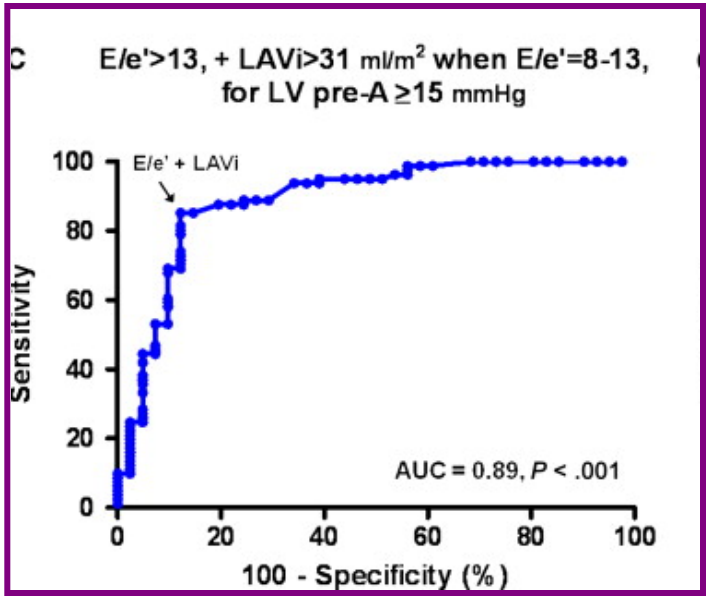
TISSUE DOPPLER VELOCITY IMAGING and LA VOLUME

- In patients with **preserved LVEFs**, adding **LAVi > 31 mL/m2 to E/e'** (when E/e' was in the gray zone, but not when E/e' was >13) significantly increased the accuracy of E/e' alone for the estimation of LV filling pressure.

(sensitivity 87%, specificity 88%)

E/E` 8-13 +
LA max vol ind >31 ml/m²

↑ **LV filling pressure**



Hisham Dokainish et al. Do Additional Echocardiographic Variables Increase the Accuracy of E/e′ for Predicting Left Ventricular Filling Pressure in Normal Ejection Fraction? An Echocardiographic and Invasive Hemodynamic Study JASE, 2010;23;156-61

TISSUE DOPPLER VELOCITY IMAGING (-)

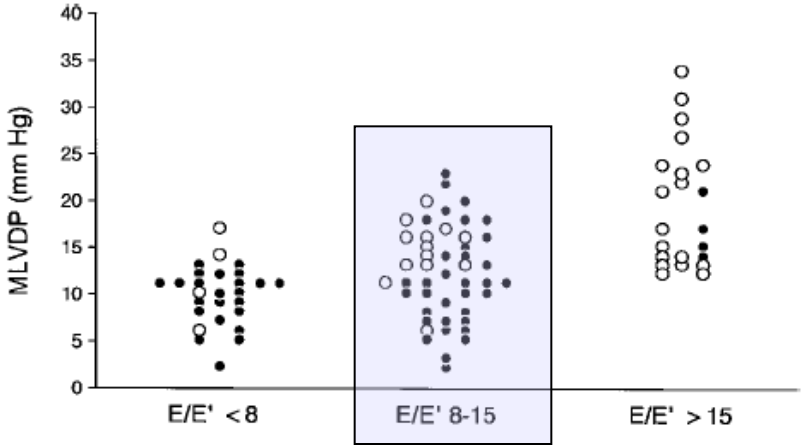


Figure 6. M-LVDP versus groups defined by values of septal E/E′. ○ Indicates patients with EF <50%; ●, patients with EF >50%.

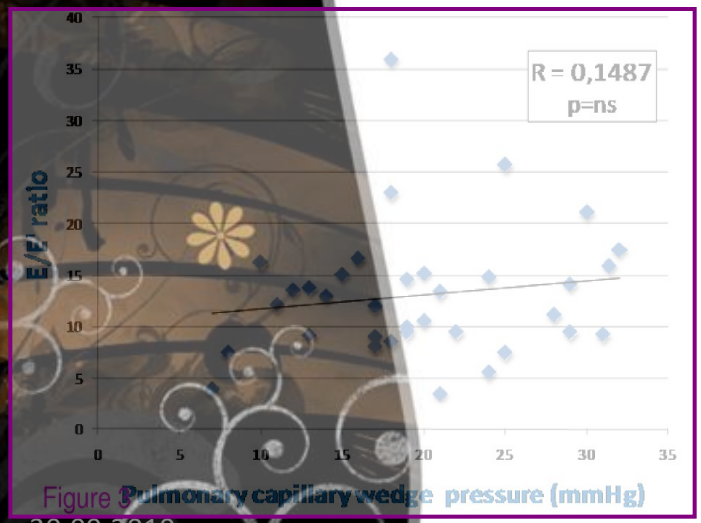


Figure 3

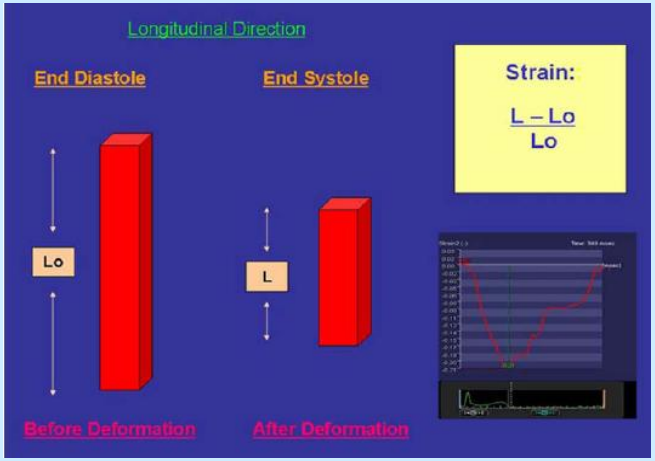
- **Wide variability with**

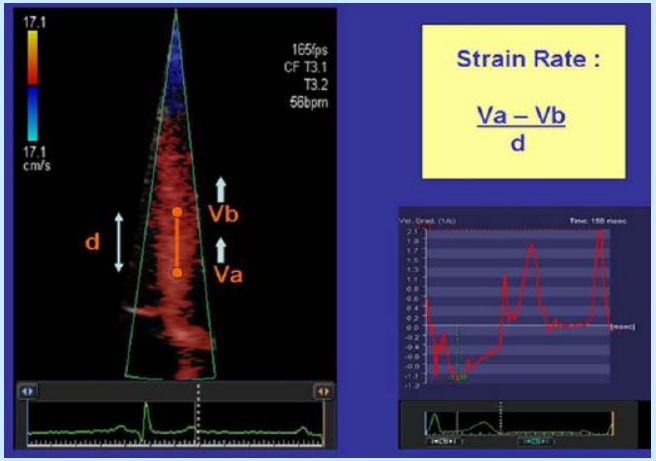
  E/E` of 8 to 15 (grey zone).
- **E` velocity** is usually **reduced** in patients with significant annular calcification, surgical rings, mitral stenosis, and prosthetic mitral valves.
- **In patients** with advanced systolic heart failure **(EF<35%)** mean E/E` ratio may not be a useful index to estimate filling pressures;

Matteo Cameli et al. Left atrial longitudinal strain by speckle tracking echocardiography correlates well with left ventricular filling pressures in patients with heart failure. Cardiovascular Ultrasound 2010, **8**:14.

LA Myocardial deformation

- An **alternative method** of exploring LA function;



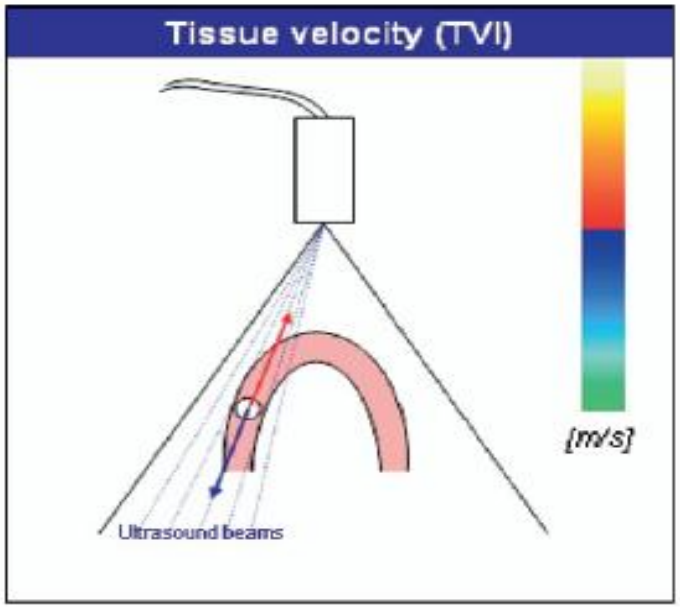
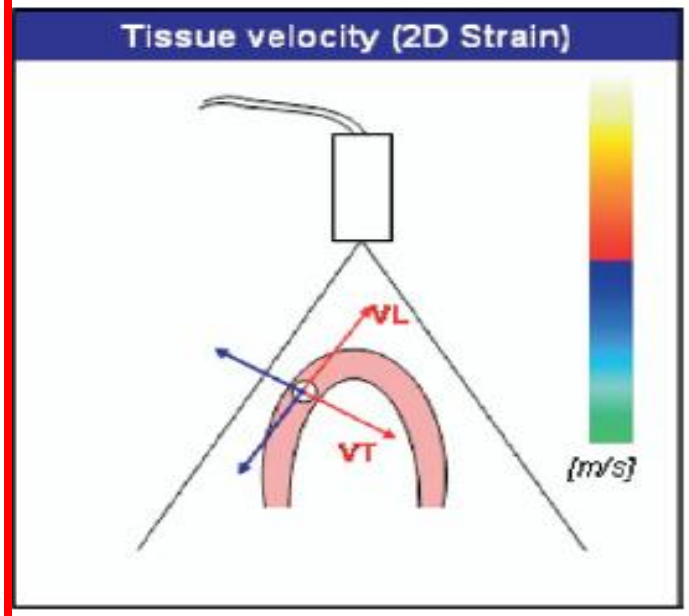


- **Strain and strain rate (SR)** imaging have emerged as a quantitative technique to accurately estimate myocardial function and contractility*.

*D'hooje J et al. Regional strain and strain rate measurements by cardiac ultrasounds: principles, implementation and limitations. Eur J Echocardiogr 2000;1:154-70.

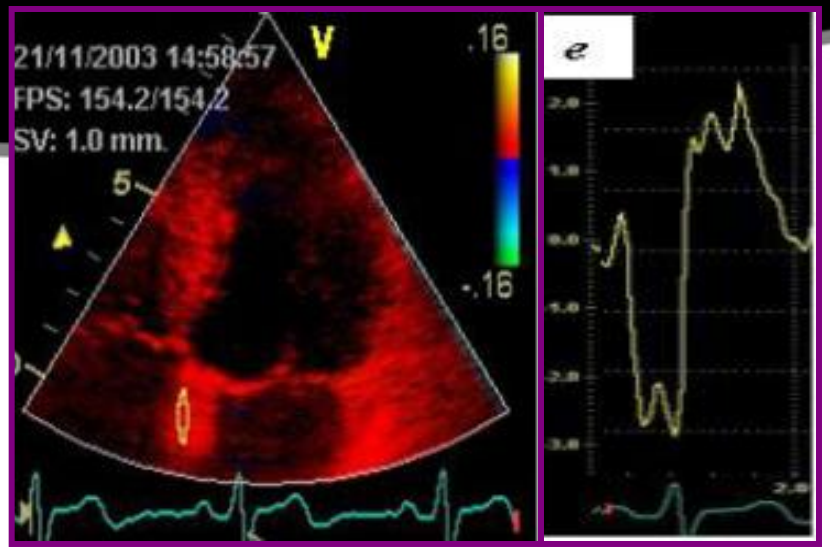
Harry Pavlopoulos. Strain and strain rate deformation parameters: from tissue Doppler to 2D speckle tracking. Int J Cardiovasc Imaging DOI 10.1007/s10554-007-9286-9

LA myocardial deformation assessment

	Doppler	Non-Doppler
		
Angle independency	+	-
Frame rate	115-300 fps	35-90 fps
«tethering»	+	-

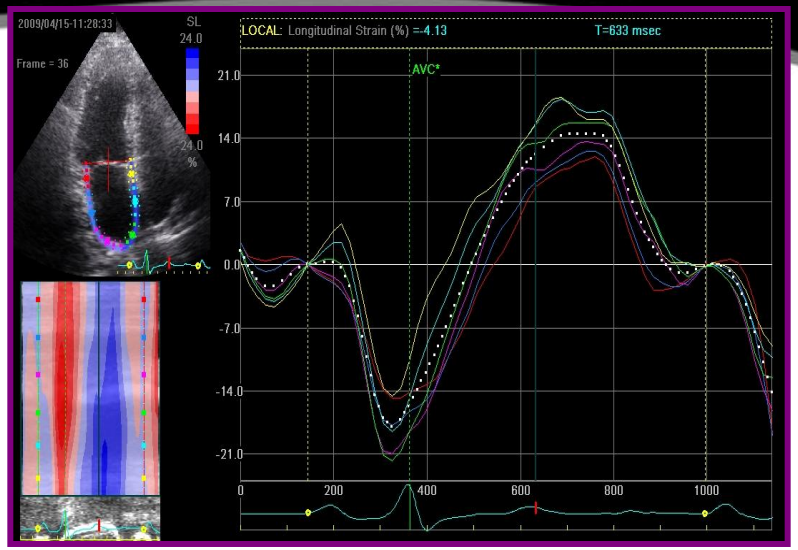
 Gila Perk et al. Non-Doppler Two-dimensional Strain Imaging by Echocardiography–From Technical Considerations to Clinical Applications. JASE Volume 20 Number 3, 2007

TDI



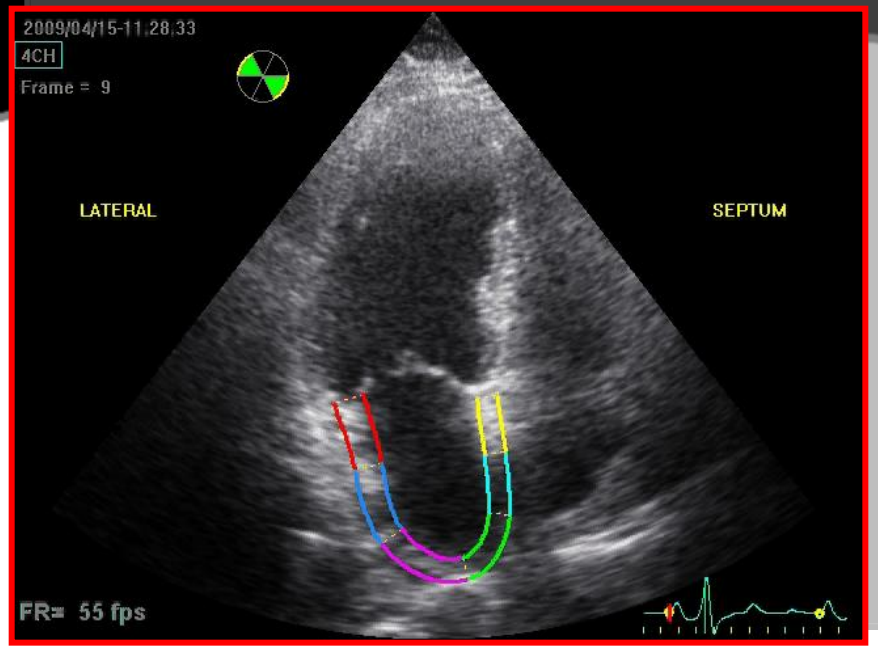
- regional LA deformation (+)
- only longitudinal function (-)
- suboptimal reproducibility (-)
- time-consuming: ~ 10 min./1 pat. (-)

2D-strain

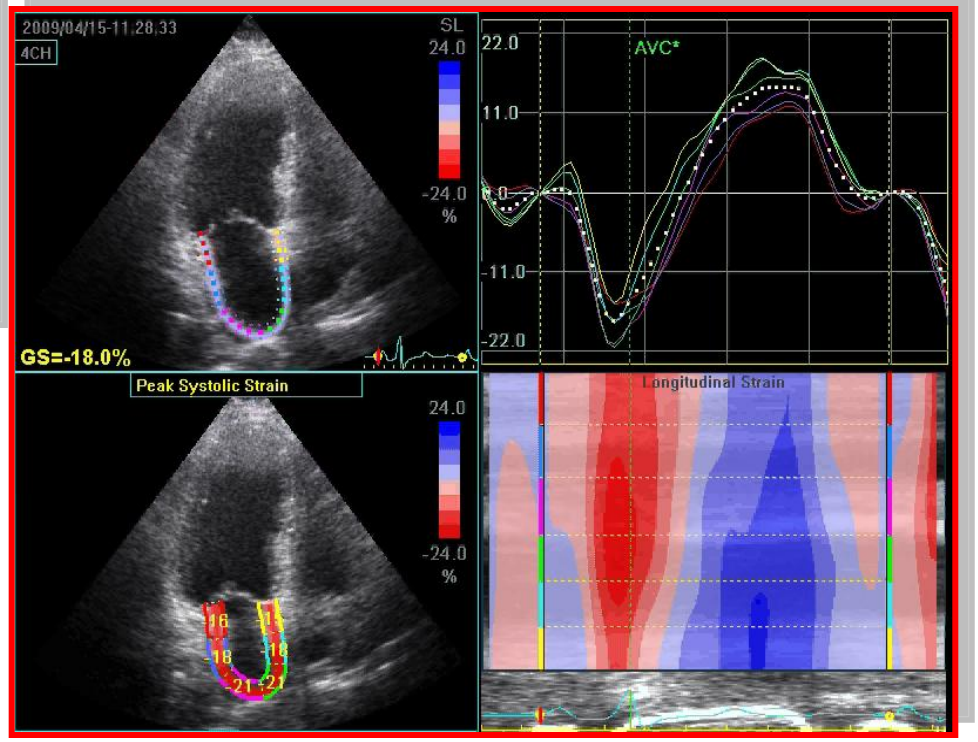


- regional and global LA deformation (+)
- longitudinal and radial function (+)
- good reproducibility (+)
- time: ~ 1-3 min./1 pat. (+)
- no special software for LA analysis (-)

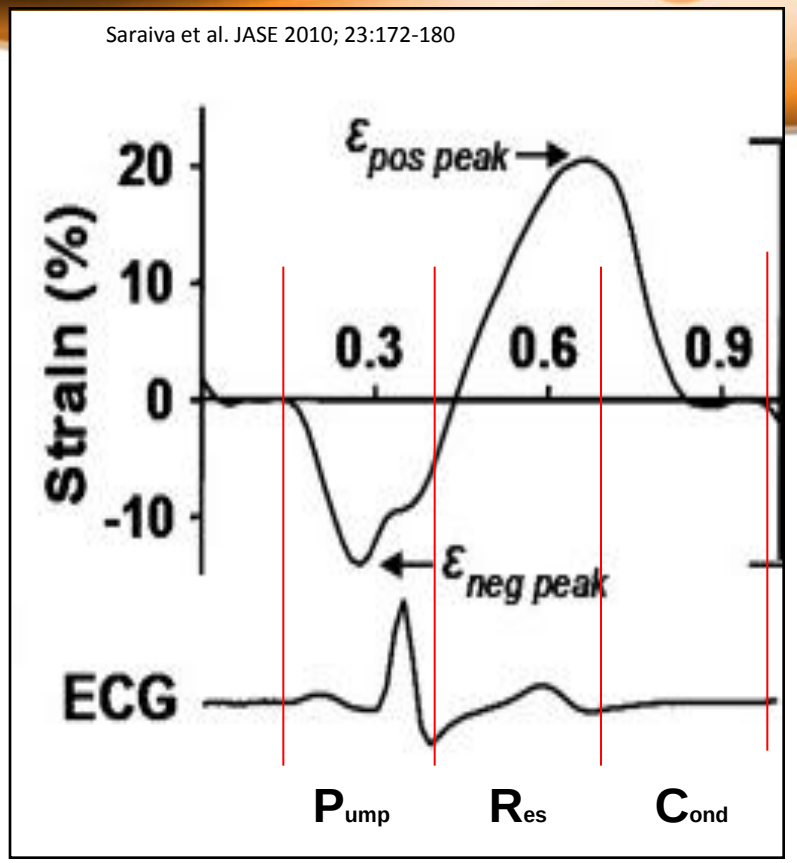
Two-dimensional Speckle Tracking (2D-strain): LA longitudinal function



6 LA segments



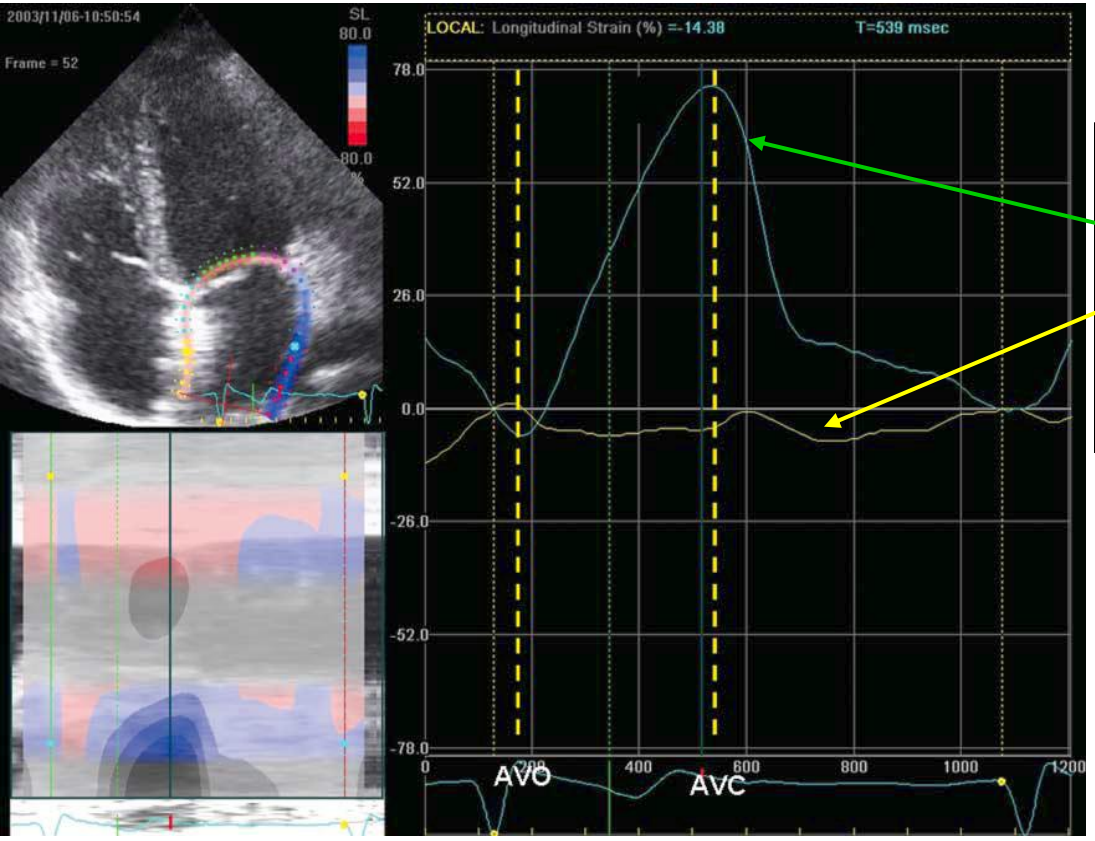
Left atrial longitudinal strain curves (%)



- strain (ε) : - **p**eak **a**trial **l**ongitudinal **s**train (regional - **PALS**)
  - peak averages strain (for 6 LA segments - **averages PALS**) · · · · · ·
  - global strain (4CH and 2CH averages ε – **global PALS**)

Correctness of 2D-strain

- This study demonstrates that 2D-strain is not influenced by global heart motion and tethering from adjacent segments.



LA strain curves:

green – lateral atrial wall

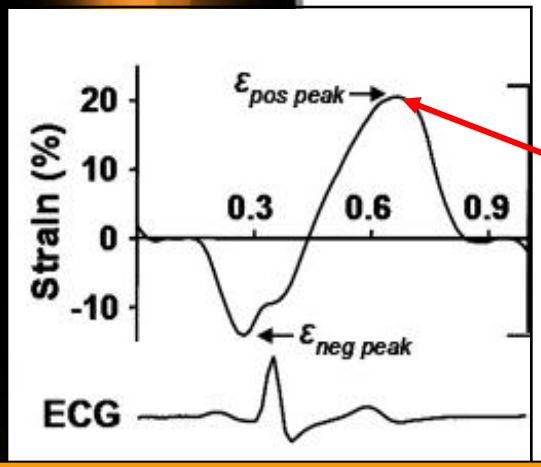
yellow – interatrial device

(AMPLATZER-occluder)

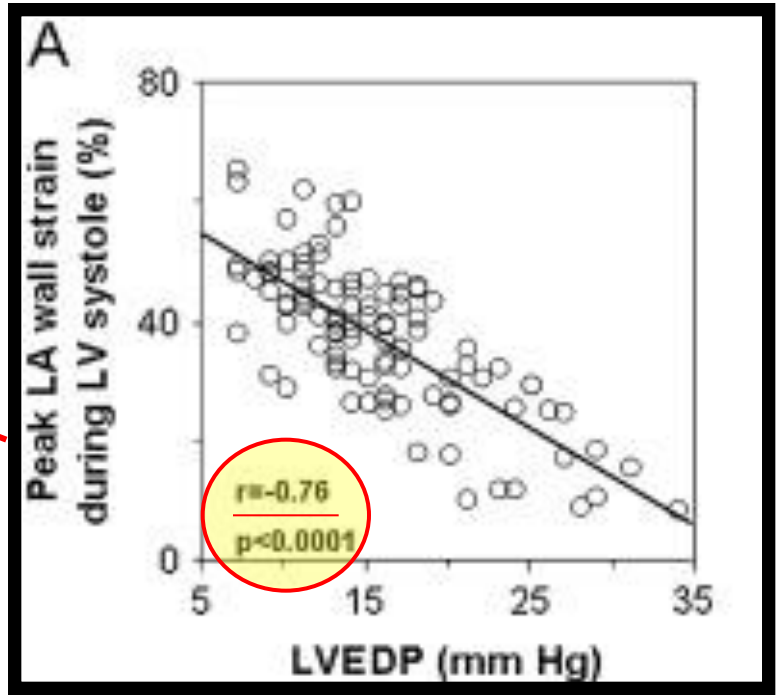
Giovanni Di Salvo et al. Two-dimensional strain and atrial function: a study on patients after percutaneous closure of atrial septal defect. European Journal of Echocardiography doi:10.1093/ejechocard/jen218, 2008.

Correlation between LV end-diastolic pressure (LVEDP) and Peak LA strain during reservoir phase

> 45 % PALS (cut-off value) : normal LVEDP



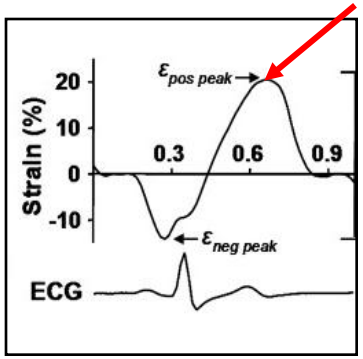
<30 % PALS (cut-off value) : ↑ LVEDP



- 101 patients (Age (y) 66±9 (31-84))
- EF 58 ± 16 % (19-84)

Wakami et al. Correlation between Left Ventricular End-diastolic Pressure and Peak Left Atrial Wall Strain during Left Ventricular Systole. JASE 2009;22:7

LA longitudinal strain by 2D-strain correlates well with LV filling pressures in patients with heart failure



Strain cut-off value 15.1%.

!

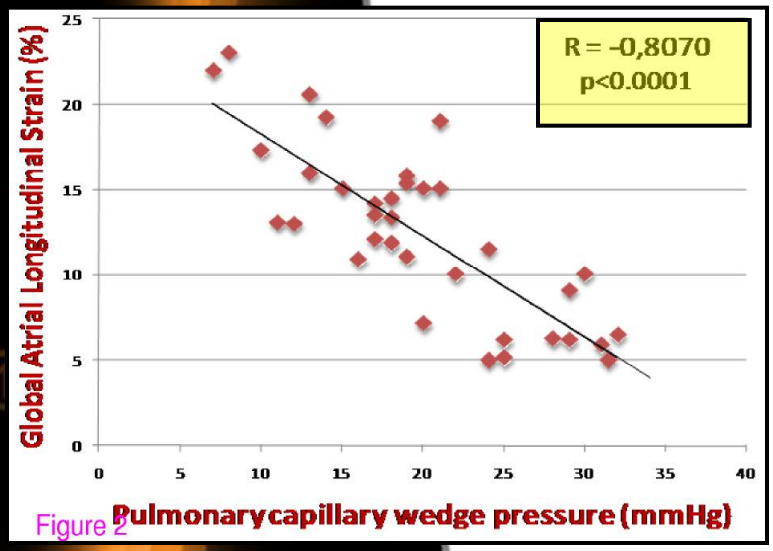


Figure 2

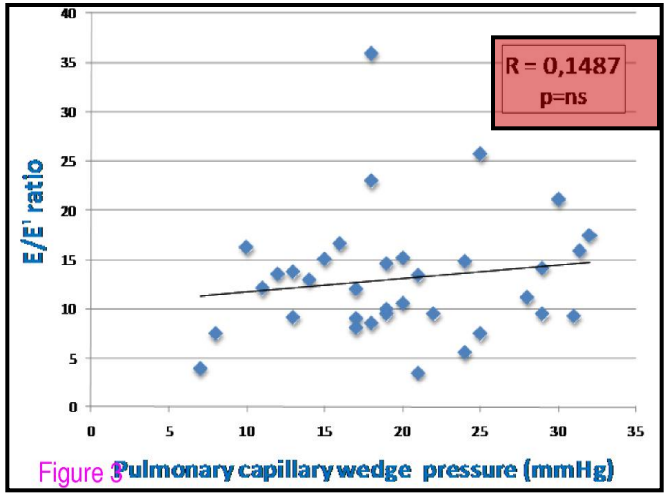


Figure 3

sensitivity 100%

specificity 93%

- 36 patients c EF ≤ 35 %

Matteo Cameli et al. Left atrial longitudinal strain by speckle tracking echocardiography correlates well with left ventricular filling pressures in patients with heart failure. *Cardiovascular Ultrasound* 2010, 8:14.

LA longitudinal strain (reservoir phase): physiological or pathological left ventricular hypertrophy

reservoir phase

Controls (25) | Athletes (45) | Hypertensive (40)

41- 46 y

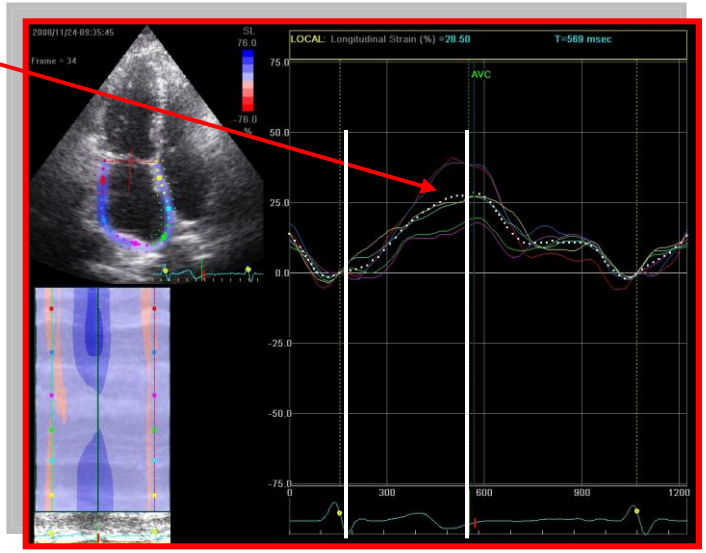
LA diameter 40-42 мм

Peak LA longitudinal strain (lateral wall LA)

47,3 % ±15,6

51,3 % ±17,9

37,2 %* ±15,6



*p<0.0001: Patients with hypertension vs controls and athletes.

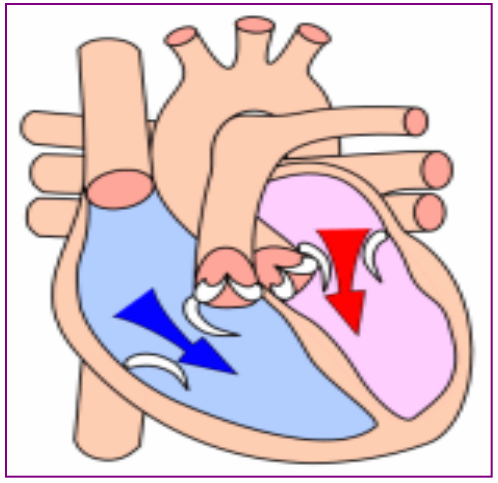
Left atrial myocardial function in either physiological or pathological left ventricular hypertrophy: a two-dimensional speckle strain study.

D'Andrea A et al. : Br J Sports Med. 2008 Aug;42(8):696-702

Conclusions

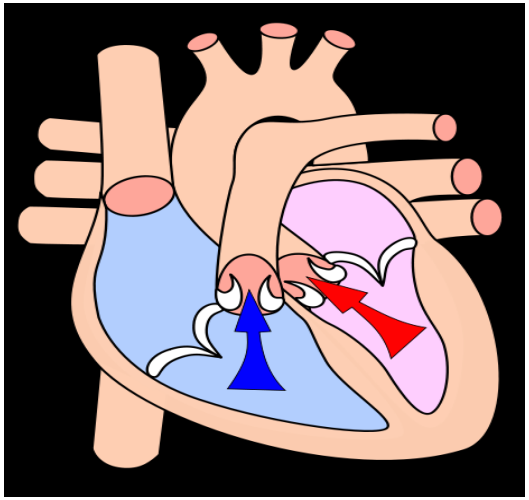
- **LA function** is an important determinant of the **LV filling process**.
- **The E/E` ratio** was the single best predictor of LV filling pressure but **did not** have adequate discriminatory power **to be used in isolation.**
- **The LA volume** is a biomarker of chronic diastolic dysfunction and cardiovascular disease risk.
- **Strain** measurements **by speckle tracking** appear to have good reproducibility and can be applied to study segmental and global deformation and to address mechanistic issues.

- **The report should include a conclusion on LV filling pressures and the presence and grade of diastolic dysfunction.**



No Diastole, No Sistole

dr. Kalinin :-)



Thanks for Your Attention