The Egyptian Journal of Hospital Medicine (April 2023) Vol. 91, Page 4427-4433

# An Overview about Left atrial Strain and its Imaging: Review Article

**Marwa Abdullah Abdulkarim, Mahmoud Hasan Abdalqader Shah,**
**Hala Gouda Abomandour, Moataz Hassan Ali**
Department of Cardiology, Faculty of Medicine, Zagazig University, Zagazig, Egypt
***Corresponding author:** Marwa Abdullah Abdulkarim, **Mobile:** (+20) 0 102 420 0845, **E-Mail:** adel1.3.1978@gmail.com

## ABSTRACT

**Background:** Strain is a metric that analyses the extent to which the segment under study has been deformed in comparison with its original dimensions. A percentage represents this value here. Strain and strain-rate imaging is better to conventional echocardiography for evaluating Left atrial (LA) function because it can distinguish between active and passive cardiac tissue movement.
**Objective:** Review of literature and assessment of left atrial strain as well as its imaging.
**Methods:** Left atrial strain and imaging were searched for on Science Direct, Google Scholar, and PubMed. The authors also reviewed the relevant literature, nonetheless, only the most recent or exhaustive analysis was included, covering the time span from May 2002 to January 2023. There are no translation resources available, thus non-English documents are out. Unpublished articles, oral presentations, conference abstracts, and dissertations were not included because they were not considered to be part of major scientific projects.
**Conclusion:** When compared to more conventional parameters of LA function, the strain parameter is less load dependent and more resistant to tethering effects. It is also possible to assess phasic atrial function throughout the cardiac cycle by measuring strain and strain rate.
**Keywords:** Left atrial strain, Imaging.

## INTRODUCTION

In the middle of the chest, behind the right atrium, is where the left atrium (LA) resides (RA). Located posteriorly and superiorly, the pulmonary venous component is immediately confluent with the body and features venous orifices at each corner [1]. The five layers of the left atrial wall are the roof, the infero-posterior, the left lateral, the septum, and the anterior (Figure 1).

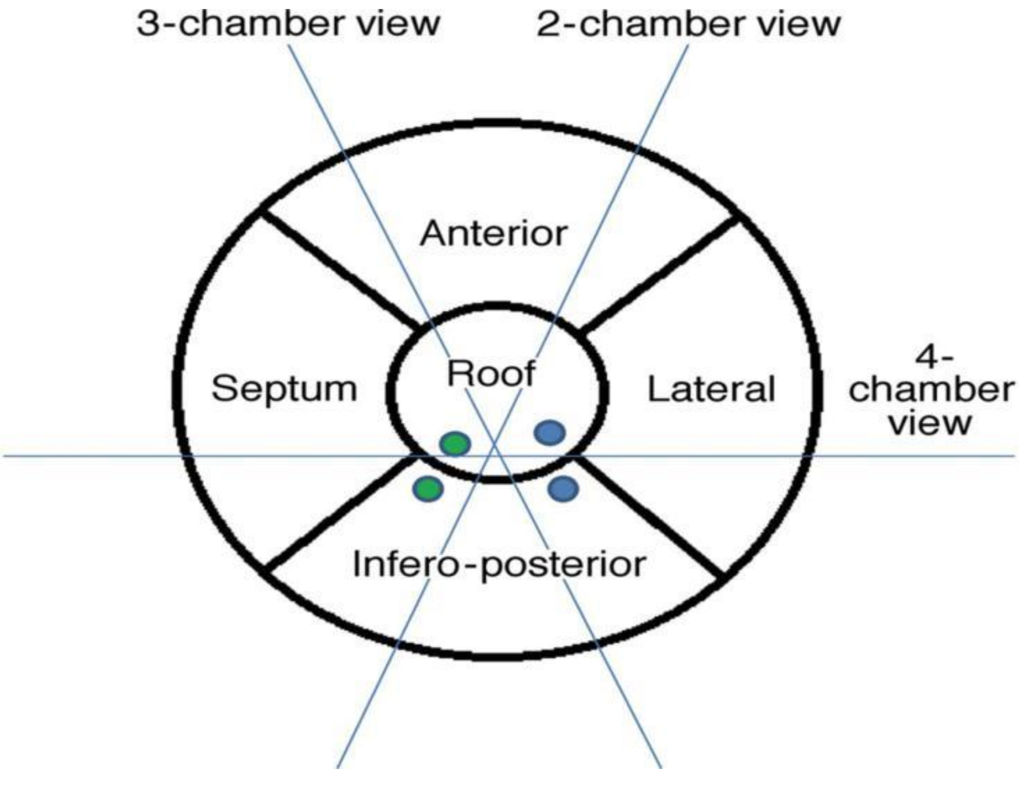


**Figure (1):** Segmentation of the left atrium using a five-segment model in transthoracic 2D echocardiography [2].



Received: 15/10/2022
Accepted: 17/12/2022

**Left atrial function:**

Left atria act as reservoir, a conduit, as well as booster pump, all of which influence how well the heart fills the left ventricle. Angiography, micromanometry, and pulmonary pressure measures were previously used to evaluate LA function. Doppler methods and strain technology offer novel, noninvasive ways to assess atria [3]. Recent years showed an increase in the recognition that defining left atrial (LA) function is a potent metric, especially in assessment of heart failure. Cases who had heart failure (HF) frequently exhibit left atrial (LA) dysfunction and remodeling, and there is mounting proof that LA dysfunction has a part in the onset and progressing of HF [4].

**The LA: Its physiology and phasic role:**

To put it simply, LA is a live, breathing creature. The left atrium (LA) is responsible for storing blood that has returned from the pulmonary veins until early ventricular diastole, when it pumps to increase ventricular filling. Every stage of left atrial (LA) activity is intertwined with LV function. The relaxation and compliance of the LA are reflected in its reservoir function, which is influenced by the LV systolic function as the LV base descends. LA conduit operation requires the suction force associated with LV relaxation and the stiffness of the LV chamber, whereas LV end-diastolic compliance and pressure are essential for LA booster functioning. The LV stroke volume in healthy persons decreases by 20% to 30% without LA contraction. Symptomatic decompensation in HF patients is an excellent example of how reduced LV function makes this phenomena considerably more clinically significant [5].

The phasic function of LA may be evaluated in terms of volume by comparing the largest and smallest quantities. Strain analysis has been used for the assessment of phasic functions in LA in recent years. Although the LA pressure relationship provides the most accurate evaluation of LA phasic function, it is too invasive to be routinely implemented in clinical settings [6].

**LA size:**

Different factors, such as the appendage and pulmonary veins' contributions to LA size and the shape and orientation of the fibers themselves, might cause diagnostic confusion. It is common practice to measure the size of the LA using M-mode or 2-dimensional echocardiography (2DE) (Figure 2) [7].

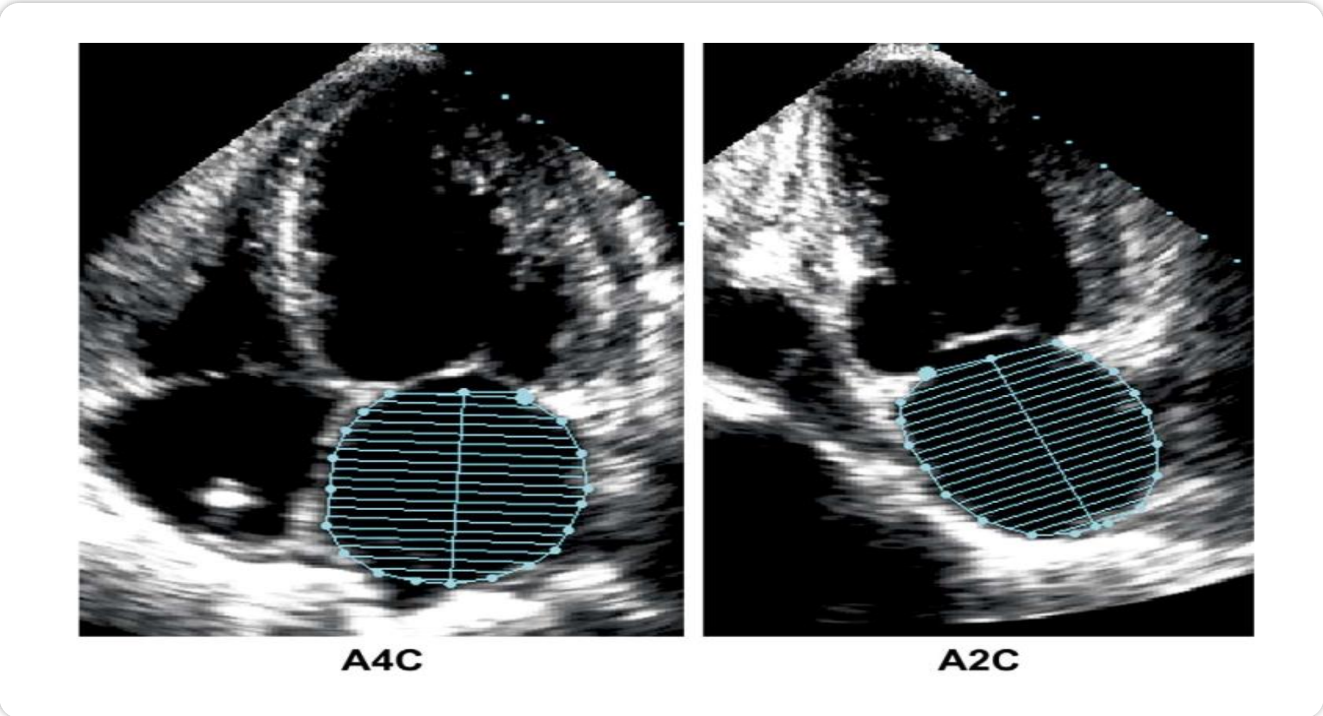


**Figure (2):** Measuring left atrial volume by apical 4-champer view (left) and apical 2-champer view (right) [7].

A biplane (LAV) of [>34 ml/m2 for both sexes] is the most reliable predictor of cardiovascular events and a measure of LA size (LA diameter and area). Utilising either the area-length or disc-sum techniques [8].

**LA phasic function:**

Echocardiography provides the most accurate assessment of LA phasic function. If all volumes can be obtained from a single volume trace, then 3D volumetric analysis may be used to assess the LA's phasic function [9, 10].

Other means of proving LA phasic function include tissue Doppler imaging (TDI) and 2-dimensional speckle-tracking, which measure volumetric and strain-derived LA phasic function (Figure 3) [11].

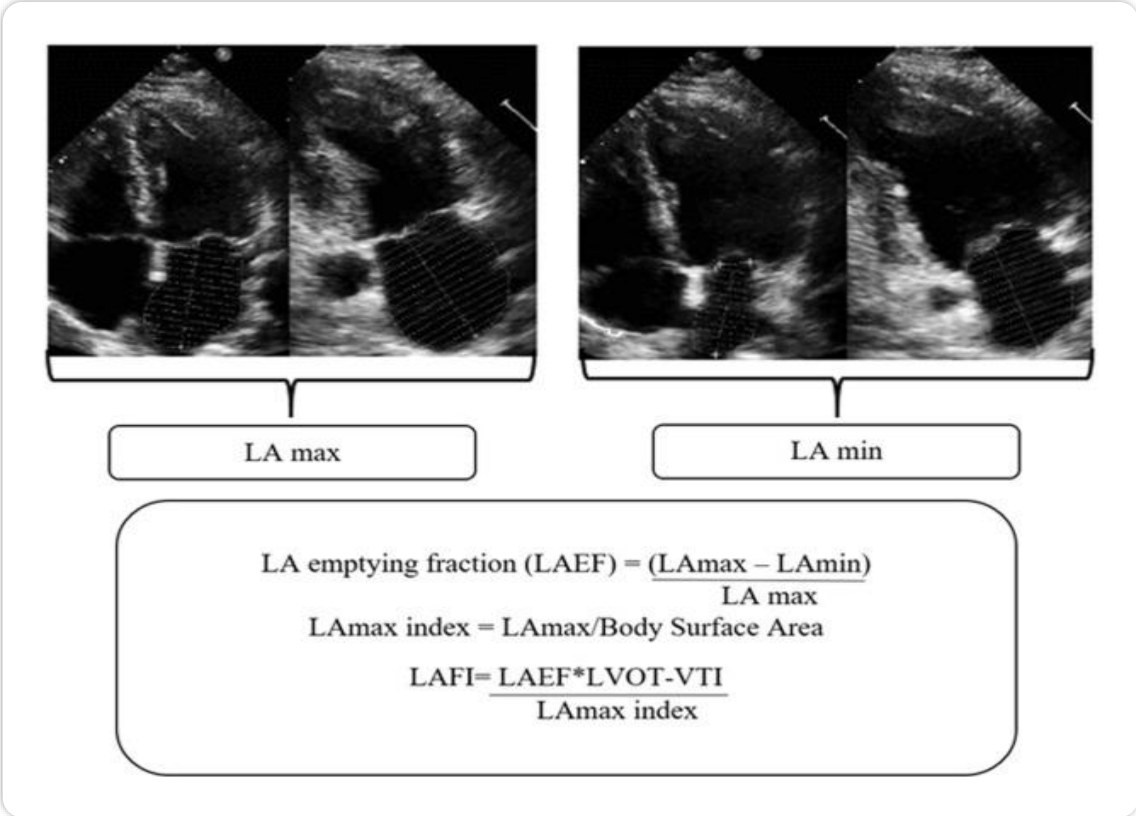


**Figure (3):** Estimation of LAEF, LAFI by measuring LAV (max) and LAV (min) [12].

---

**Speckle tracking echocardiography:**

Speckle-tracking echocardiography offers an objective and quantitative evaluation of global and localised cardiac activity independent of insonation angle or translational motions of the heart [13, 14]. Speckle-tracking: Speckles (described as spots formed by the interaction of the ultrasonic beam with cardiac fibers) are analyzed for their spatial displacement (called tracking) on conventional 2-dimensional sonograms in echocardiography [13].

During the cardiac cycle, speckles may be tracked by echocardiography, allowing for semi-automated derivation of longitudinal, radial, and circumferential myocardial deformation. Due to its semi-automation, speckle-tracking echocardiography exhibits high levels of both intra- and inter-observer reproducibility [15].

The left atrial (LA) isn't the only cardiac chamber that can benefit from this approach, despite its origins in assessing LV function [16].

**Main Technical Considerations:**

Speckle tracking means that this method relies heavily on the analysis of speckles captured at various points in the cardiac cycle. The unusual arrangement of the speckles leads to their merging into functional units (kernels) that can be identified unambiguously. Consequently, the programme can track each kernel over the whole cardiac cycle, much like an acoustic fingerprint. By analysing the motion of each kernel making up a conventional 2-dimensional grey scale picture, the system can determine the displacement, velocity, strain, and strain rate of the selected myocardial segments without the Doppler signal [13].

Samples for speckle-tracking echocardiographic investigations should be created by averaging at least 3 consecutive cardiac cycles, and the research recommends a frame rate of 60 to 110 frames per second for regular 2-dimensional picture collecting [17, 18]. It is challenging to study people with non-sinus rhythms using speckle-tracking echocardiography because of its inextricable relationship to single-cardiac-cycle strain analysis.

Recent validation against sono-micrometry and tagged MRI of measures produced from speckle-tracking echocardiography demonstrates its great feasibility and reproducibility. The novel method relies on high-frame-rate, high-quality 2-D pictures to accurately describe the endocardial border [19].

**Strain**

Strain is a metric that analyses the extent to which the segment under study has been deformed in comparison with its original dimensions. The value is a percentage [13-19].

**Strain and strain rate imaging of the LA:**

Compared to the standard echocardiography, strain and strain rate imaging provides various advantages when evaluating LA function. First, strain imaging can tell the difference between active and passive movement of heart tissue since it is not analysed in relation to the transducer position. When compared to the parameters of a standard LA function, the strain parameter is less sensitive to load and more immune to tethering effects [19, 20].

By monitoring strain and strain rate, cardiac phasic atrial function may be assessed at various points in the cardiac cycle. As of right now, there are no strain algorithms developed with the express purpose of assessing LA function. Despite this, some research has evaluated LA strain using left ventricular strain software, with certain modifications applied to the 'region of interest' (ROI) (Figure 4) [21, 22].

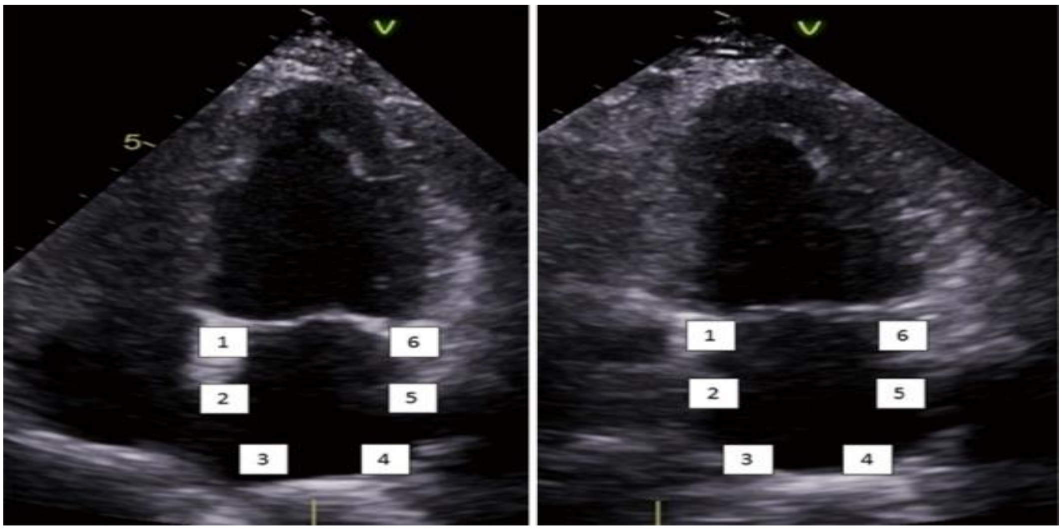


**Figure (4):** Apical four and two chambers [22].

In systole, immediately before the mitral valve opens, there is the greatest positive atrial strain, which occurs during the reservoir phase when the LA is full and straining. Atrial strain diminishes and the strain curve is deflected negatively up to a plateau time akin to diastasis because the LA passively empties as the mitral valve opens. Atrial systole is accompanied by a second change in the strain curve. Left atrial (LA) systolic strain or peak atrial longitudinal strain (PALS) marks the end of the reservoir phase (Figure 5) [23].

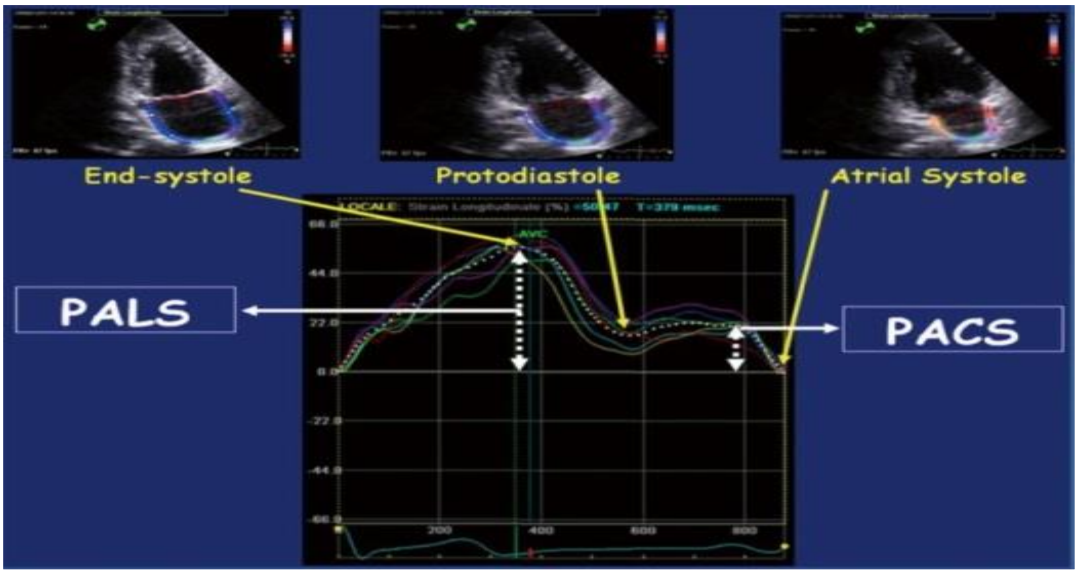


**Figure (5):** Peak atrial contraction strain (PACS) as well as peak atrial longitudinal strain (PALS) [23].

When processing starts at the start of the P wave (diastolic gating), the resulting LA strain curve is different from when processing starts at the start of the QRS complex [24-25]. If strain processing occurs at the beginning of the QRS, strain during early diastole displays atrial conduit function, while strain during late diastole correlates to atrial contractile activity. Atrial reservoir function and peak positive longitudinal strain [25].

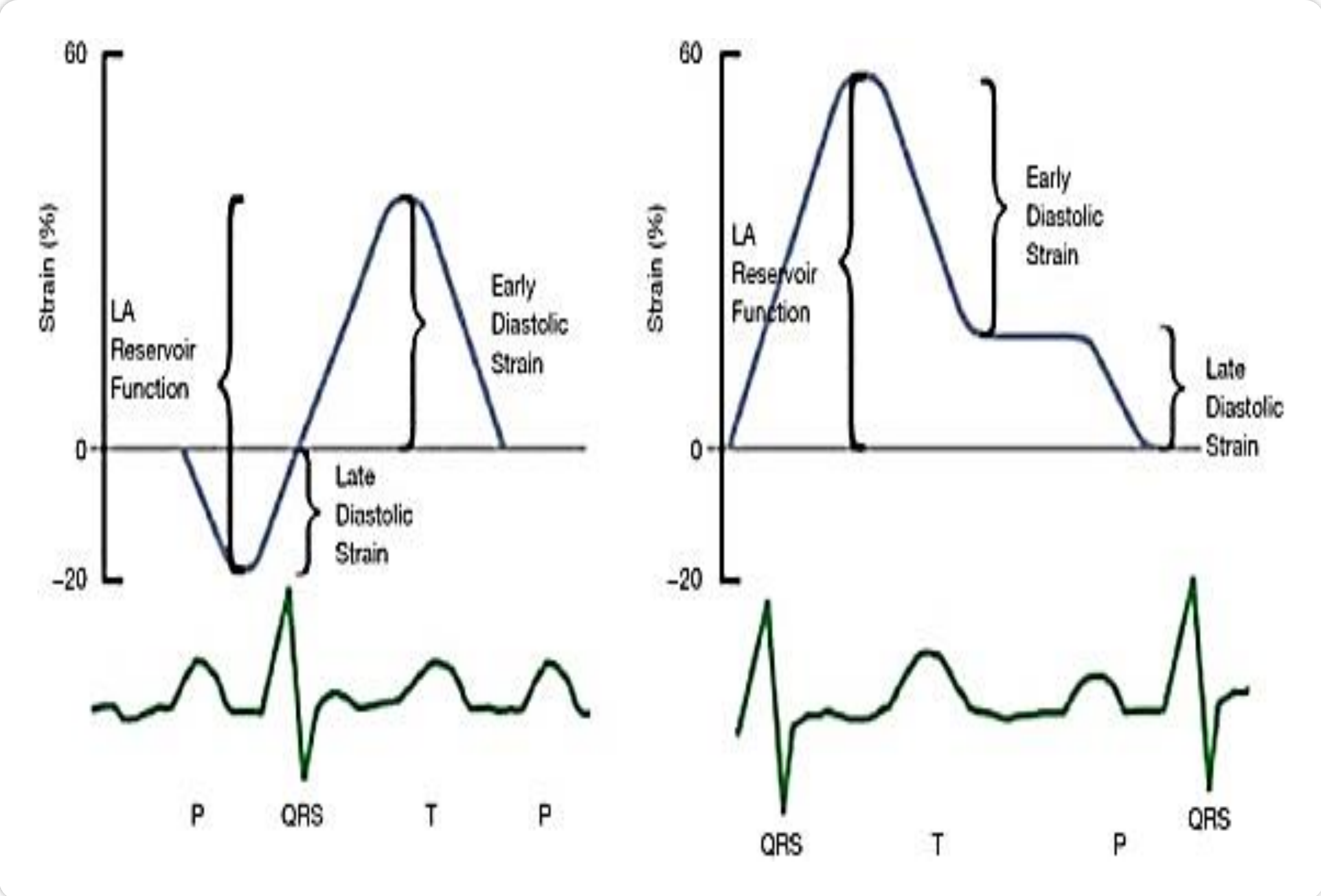


**Figure (6):** Choice of electrocardiographic gating affects the strain trace [26].

---

The onset of the P-wave, rather than the beginning of the QRS complex, has been shown in many recent studies to increase the connection between LA strain and indices of LA function as determined by 3D echocardiography [26]. However, no unified approach to LA strain analysis has been offered as of yet because of the varied timing of reference point selection across investigations. The LA reference strain and strain rate data have been made public (Figure 6) [25].

**LA strain by 2D STE:**

By following "speckles" or natural auditory indicators in a 2D ultrasound picture, STE is a relatively recent approach of echocardiography that detects strain and strain rate. Throughout the cardiac cycle, we track each speckle as it undergoes a unique geometric transformation. The use of STE strain to the study of LA mechanics is growing.

Traditional 2D echocardiography is employed to get apical 4- and 2-chamber images of the LA, and the frame rate is kept reasonably high (60-80 fps). Two- and four-chamber views are used to trace the endocardium of the LA, with a corresponding shift in the region of interest (ROI) to account for the atrium's thinner wall.

The endocardial and epicardial surfaces of the LA are extrapolated at the confluence of the pulmonary veins and the LA appendage to get the ROI in these regions of the LA wall where continuity is interrupted. ROI consists of six tiers and a total of twelve factors (Figure 7) [27].

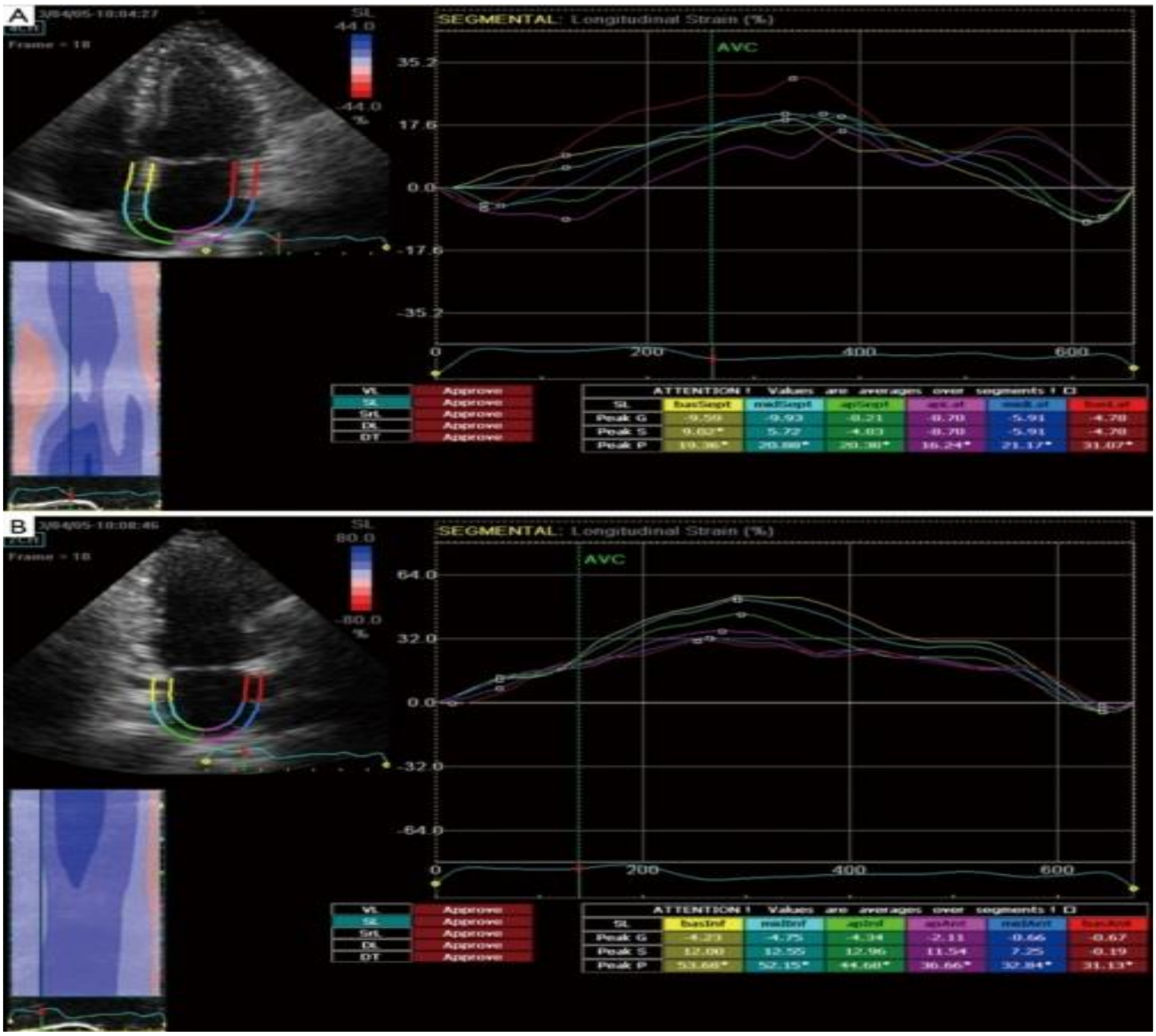


**Figure (7):** Segmental and global left atrial (LA) strain as measured by two-dimensional speckle-tracking echocardiography [27].

Multiple research have verified STE's practicability and reproducibility for investigating LA mechanics [29], and 90% of the time you'll be able to get it. The main restriction is the requirement for fast frame rate capture of high quality 2D images [25]**.**

**Heart Failure:**

The use of 2D STE LA strain in the care of HF patients has grown in recent years. Important in both the diagnosis of HF and the guidance of HF treatment. The strain in the LA is a reliable proxy for the pressure inside the LV. Thirty-six patients having right cardiac catheterization were diagnosed with severe systolic HF (ejection fraction [EF] 35%] [23]**.**

Left atrial (LA) systolic strain was shown to be the greatest predictor of pulmonary capillary wedge pressure and the strongest predictor of increased left ventricular (LV) filling pressure [24]. This was validated by a different study including 80 people who had left heart catheterization. In individuals with varied LV ejection percentages, the LA systolic strain was more strongly correlated with invasively collected LV filling pressures than were Doppler indices. In patients with an intact or minimally reduced LV ejection fraction, the mean E/E' ratio was substantially linked with LVEDP; in patients with a moderate or severe LV ejection fraction reduction, however, the correlation was not statistically significant [26]**.** Utilizing 2D STE LA strain, patients with heart failure with preserved ejection fraction (HFpEF) may be divided into two groups: those with diastolic dysfunction and those with clinical HFpEF. Using echocardiographic imaging and right cardiac catheterization, **Kurt *et al.*** [27] found that patients with HFpEF exhibited lower LA systolic strain compared to those with LV diastolic dysfunction but no HF. Most effectively predicting diastolic dysfunction and HFpEF was the LA stiffness index, calculated by dividing the LA systolic strain by the E/E' ratio**.**

## CONCLUSION

When compared to more conventional parameters of LA function, the strain parameter is less load dependent and more resistant to tethering effects. In addition, phasic atrial function during the cardiac cycle can be assessed using strain and strain rate measures.

**Supporting and sponsoring financially:** Nil.
**Competing interests:** Nil.

## REFERENCES

1. **Ho S, Anderson R, Sánchez-Quintana D (2002):** Atrial structure and fibres: morphologic bases of atrial conduction. Cardiovasc Res., 54: 325-36.
2. **Todaro M, Choudhuri I, Belohlavek M *et al.* (2012):** Khandheria, New echocardiographic techniques for evaluation of left atrial mechanics. European Heart Journal - Cardiovascular Imaging, 13: 973–984.
3. **Todaro M, Choudhuri I, Belohlavek M *et al.* (2012):** New echocardiographic techniques for evaluation of left atrial mechanics. European Heart Journal Cardiovascular Imaging, 13: 973–984.
4. **Gottdiener J, Kitzman D, Aurigemma G *et al.* (2006):** Left atrial volume, geometry, and function in systolic and diastolic heart failure of persons > or =65 years of age (the cardiovascular health study). Am J Cardiol., 97: 83–89.
5. **Kosaraju A, Goyal A, Grigorova Y *et al.* (2023):** Left Ventricular Ejection Fraction. Treasure Island (FL): StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK459131/
1. **Rosca M, Lancellotti P, Popescu B *et al.* (2011):** Left atrial function: pathophysiology, echocardiographic assessment, and clinical applications. Heart, 97: 1982-1989.
2. **Tsang T, Barnes M, Gersh B *et al.* (2002):** Left atrial volume as a morphophysiologic expression of left ventricular diastolic dysfunction and relation to cardiovascular risk burden. Am J Cardiol., 90: 1284-1289.
3. **Lang R, Badano L, Mor-Avi V *et al.* (2015):** Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. Eur Heart J Cardiovasc Imaging, 16: 233-270.
4. **Sugimoto T, Robinet S, Dulgheru R *et al.* (2018):** Echocardiographic reference ranges for normal left atrial function parameters: results from the EACVI NORRE study. Eur Heart J Cardiovasc Imaging, 19: 630-638.
5. **Thomas L, Levett K, Boyd A *et al.* (2002):** Ross Compensatory changes in atrial volumes with normal aging: is atrial enlargement inevitable?. J Am Coll Cardiol., 40: 1630-1635.
6. **Sardana M, Nah G, Tsao C *et al.* (2017):** Clinical and Echocardiographic Correlates of Left Atrial Function Index: The Framingham Offspring Study. J Am Soc Echocardiogr., 30 (9): 904-912.
7. **Rosca M, Lancellotti P, Popescu B *et al.* (2011):** Left atrial function: pathophysiology, echocardiographic assessment, and clinical applications. Heart, 97: 1982-1989.
8. **Perk G, Tunick P, Kronzon I (2007):** Non-Doppler two-dimensional strain imaging by echocardiography: from technical considerations to clinical applications. J Am Soc Echocardiogr., 20: 234–243.
9. **Geyer H, Caracciolo G, Abe H *et al.* (2010):** Assessment of myocardial mechanics using speckle tracking echocardiography: fundamentals and clinical applications. J Am Soc Echocardiogr., 23: 351–369.
10. **van Dalen B, Soliman O, Vletter W *et al.* (2009):** Feasibility and reproducibility of left ventricular rotation parameters measured by speckle tracking echocardiography. Eur J Echocardiogr., 10: 669–676.
11. **Vianna-Pinton R, Moreno C, Baxter C *et al.* (2009):** Two-dimensional speckle-tracking echocardiography of the left atrium: feasibility and regional contraction and relaxation differences in normal subjects. J Am Soc Echocardiogr., 22: 299–305.
12. **Teske A, De Boeck B, Melman P *et al.* (2007):** Echocardiographic quantification of myocardial function using tissue deformation imaging, a guide to image acquisition and analysis using tissue Doppler and speckle tracking. Cardiovasc Ultrasound, 5: 27. doi: 10.1186/1476-7120-5-27
13. **Serri K, Reant P, Lafitte M *et al.* (2006):** Global and regional myocardial function quantification by two-dimensional strain: application in hypertrophic cardiomyopathy. J Am Coll Cardiol., 47: 1175–1181.
14. **Amundsen B, Helle-Valle T, Edvardsen T *et al.* (2006):** Noninvasive myocardial strain measurement by speckle tracking echocardiography: validation against sonomicrometry and tagged magnetic resonance imaging. J Am Coll Cardiol., 47: 789–793.
15. **Marwick T (2006):** Measurement of strain and strain rate by echocardiography: Ready for prime time? J Am Coll Cardiol., 47: 1313-27.
16. **Yoon Y, Oh I, Kim S *et al.* (2015):** Echocardiographic Predictors of Progression to Persistent or Permanent Atrial Fibrillation in Patients with Paroxysmal Atrial Fibrillation (E6P Study). J Am Soc Echocardiogr., 28: 709-17.
17. **Hoit B (2014):** Left atrial size and function: role in prognosis. J Am Coll Cardiol., 63: 493-505.
18. **Cameli M, Lisi M, Righini F *et al.* (2012):** Novel echocardiographic techniques to assess left atrial size, anatomy and function. Cardiovasc Ultrasound, 10: 4. doi: 10.1186/1476-7120-10-4
19. **Marciniak A, Eroglu E, Marciniak M *et al.* (2007):** The potential clinical role of strain and strain rate imaging in diagnosing acute rejection after heart transplantation. Eur J Echocardiogr., 8 (3): 213–21.
20. **Vieira M, Teixeira R, Goncalves L *et al.* (2014):** Left atrial mechanics: echocardiographic assessment and clinical implications. J Am Soc Echocardiogr., 27: 463-78.
21. **Hayashi S, Yamada H, Bando M *et al.* (2015):** Optimal analysis of left atrial strain by speckle tracking echocardiography: P-wave versus R-wave trigger. Echocardiography, 32: 1241-9.
22. **Perk G, Tunick P, Kronzon I *et al.* (2007):** Non-Doppler two-dimensional strain imaging by echocardiography--from technical considerations to clinical applications. J Am Soc Echocardiogr., 20: 234-43.
23. **Yuda S, Muranaka A, Miura T (2016):** Clinical implications of left atrial function assessed by speckle tracking echocardiography. J Echocardiogr., 14: 104-12.
24. **Kadappu K, Abhayaratna K, Boyd A *et al.* (2016):** Independent Echocardiographic Markers of Cardiovascular Involvement in Chronic Kidney Disease: The Value of Left Atrial Function and Volume. J Am Soc Echocardiogr., 29: 359-67.
25. **Cameli M, Lisi M, Mondillo S *et al.* (2010):** Left atrial longitudinal strain by speckle tracking echocardiography correlates well with left ventricular filling pressures in patients with heart failure. Cardiovasc Ultrasound, 8: 14. doi: 10.1186/1476-7120-8-14.
26. **Cameli M, Sparla S, Losito M *et al.* (2016):** Correlation of Left Atrial Strain and Doppler Measurements with Invasive Measurement of Left Ventricular End-Diastolic Pressure in Patients Stratified for Different Values of Ejection Fraction. Echocardiography, 33: 398-405.
27. **Kurt M, Wang J, Torre-Amione G *et al.* (2009):** Left atrial function in diastolic heart failure. Circ Cardiovasc Imaging, 2: 10-15.