

Value of left atrial strain: a highly promising field of investigation

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The principal role of the left atrium (LA) is to modulate left ventricular filling and cardiovascular performance by functioning as (i) a reservoir for pulmonary venous return during ventricular systole, (ii) a conduit for pulmonary venous return during early ventricular diastole, and (iii) a booster pump that augments ventricular filling during late ventricular diastole. The interplay between these atrial functions and ventricular performance throughout the cardiac cycle is crucial in many pathophysiological conditions.^{1,2} However, in clinical practice, we do not really assess all of the components of LA function. In fact, quantification of LA function remains challenging. Calculating ejection fraction or atrial ejection force has occasionally been proposed as methods for quantifying LA function, but they are neither routinely used nor recommended in the literature.³

Standard recommendations in the literature propose using LA volume calculated from trans-thoracic 2D echocardiography orthogonal views.^{3,4} LA size correlates with both LA and left ventricular (LV) function and is a strong predictor of cardiovascular morbidity and death.⁵ The antero-posterior diameter, calculated with M-mode or 2D echocardiography, is no longer considered to adequately represent the true LA size. For these reasons, the ASE/EACVI joined paper³ recommends the measurement of LA volumes with either the area-length method or, ultimately, the Simpson's method in four- and two-chamber apical views.⁶ Nevertheless, it is clearly evident that a great deal of work has focused on the LA antero-posterior diameter. Consequently, the most recent ESC guidelines for evaluating hypertrophic cardiomyopathy recommend its measurement. Current ESC guidelines for predicting the risk of rhythmic events still recommend including the LA diameter in scores.⁷

From another perspective, the paper by Morris *et al.*⁸ is important because it provides normal values and presents evidence supporting the future value of LA strain as the best way to characterize our patients' atrial function. This especially applies to individuals with depressed left ventricular diastolic function, though its usefulness is not limited to this group of patients. In collaboration with Dr Morris, a number of Japanese investigators are participating in a prospective study that includes 706 patients in order to further advance

this important effort.⁸ The methodology and the results are likely to influence the direction of research studies in the near future.

Until recently, it must be remembered that investigators relied on a single software provided by one company. To date, there has clearly been no consensus and no real interchangeability between companies on how to process data for the measurement of LA strain. This is why the effort, such as that put forth by Morris,⁸ to collect a large amount of data from many centres is important. This is also one of the goals of a large prospective study (NORRE) by the EACVI and Lancellotti *et al.* who have already provided some normal values.⁹ The report on strain data are up-coming using imaging acquired with two types of echo-machines, though a single software is being used for quantifying the data. Prior to routine clinical application, companies providing software for strain quantification will have to develop some degree of standardization in order to ensure that at least the global systolic LA strain measurement is 'identical' across software packages.^{3,10}

Evaluation of LA deformation parameters is a new promising approach for analysing LA mechanics and perhaps electromechanical coupling (Figure 1). Early detection of LA dysfunction can be anticipated with strain measurement; it can also provide new insights into pathophysiology and perhaps guide clinical management. Towards that aim, Morris *et al.* have reported⁸ an LA strain and a strain rate feasibility of 95.1%. They are also reporting important physiological information. For instance, there were no differences in the LA pump function (LA-SRa) among different age groups, while there were some differences in the LA reservoir function. LA-Strain and LA-SRa were significantly lower in patients with NYHA class \geq II than in those with NYHA class $<$ 2. Thus, it seems that if LA volume serves as the HbA1c of diastolic function, LA strain is most likely more related to LV diastolic function and filling pressures. In normal subjects, the reservoir, passive conduit, and pumping phases account for 40, 35, and 25%, of the atrial contribution to stroke volume, respectively. The LA reservoir (Figure 1a: first positive peak of strain) phase is essential for LV filling because the energy stored by the LA during ventricular systole is released after mitral valve opening, greatly contributing to LV stroke volume.¹¹ The LA conduit phase (Figure 1b: plateau) spans early LV

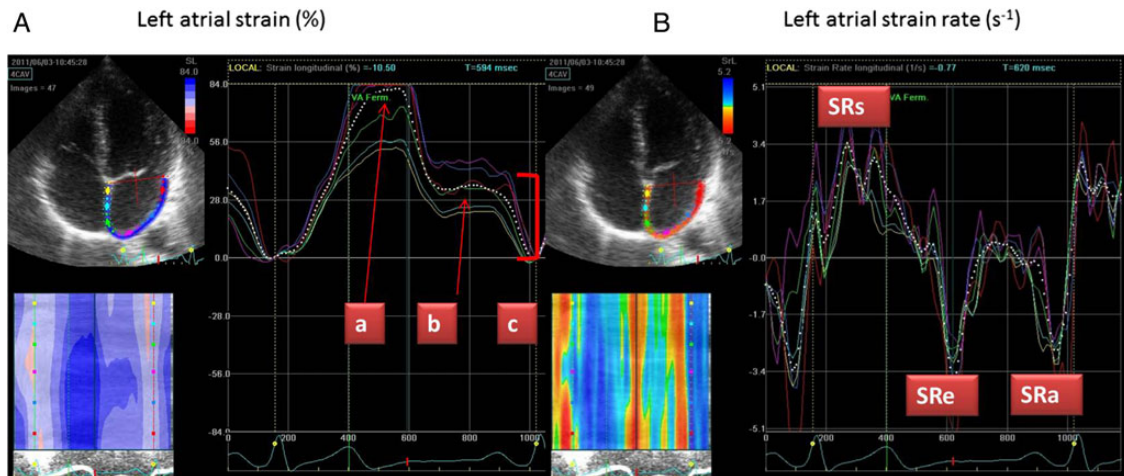


Figure 1 Example (A) of a typical left atrial (LA) strain recording with the phases: a, reservoir; b, conduit; c, booster pump function. (B) same patient, same recording but displaying the strain rate curves with s, e and a, the booster pump function.

filling and diastasis. LA contractile (Figure 1c: return to the zero line) phase performance depends on preload, afterload, intrinsic contractility, and electromechanical coupling. The early peak (a) largely reflects LA-compliance but also represents LA-reservoir function. A significant positive correlation has been found between peak LA strain (a) and LV systolic longitudinal strain.⁵ LA conduit function is dependent on LV relaxation and preload. The transfer of blood to the LV is accompanied by LA myocardial shortening, resulting in negative SR values (c).¹²

Based on this theoretical background and the findings of Morris *et al.*⁸ and those of other studies of pathological conditions,^{5,12} adding the LA strain measurement to the algorithm for the assessment of LV diastolic function is a realistic goal. Some have proposed a ratio similar to E/e' using LA strain data,¹³ while others have proposed using LA strain in addition to the CHADS score for predicting the embolic risk in atrial fibrillation.¹⁴ The work of Morris *et al.*⁸ as well as on-going investigations such as the NORRE study⁹ are needed to further validate the feasibility, reproducibility, and clinical value of LA strain and strain rate. We can expect from the Euro-Filling¹⁵ ongoing study that new data will encourage the addition of LA strain in the next recommendations and guidelines for evaluating diastole, filling pressures, and perhaps even heart failure with preserved ejection fraction. Nevertheless, the far-field location of the LA, the reduced signal-to-noise ratio, the thin atrial wall and the presence of the appendage and pulmonary veins all make strain imaging of the LA more difficult and more time consuming than for the LV, especially in light of the fact that the LV global longitudinal strain is becoming a standard in routine clinical care.⁵

References

1. Rosca M, Lancellotti P, Popescu BA, Pierard LA. Left atrial function: pathophysiology, echocardiographic assessment, and clinical applications. *Heart* 2011;**97**:1982–9.
2. Todaro MC, Choudhuri I, Belohlavek M, Jahangir A, Carerj S, Oretto L *et al.* New echocardiographic techniques for evaluation of left atrial mechanics. *Eur Heart J Cardiovasc Imaging* 2012;**13**:973–84.
3. Lang RM, Bierig M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA *et al.* American Society of Echocardiography's N, Standards C, Task Force on Chamber Q, American College of Cardiology Echocardiography C, American Heart A, European

- Association of Echocardiography ESoC. Recommendations for chamber quantification. *Eur J Echocardiogr* 2006;**7**:79–108.
4. Joint Task Force on the Management of Valvular Heart Disease of the European Society of C; European Association for Cardio-Thoracic Surgery; Vahanian A, Alfieri O, Andreotti F, Antunes MJ, Baron-Esquivias G, Baumgartner H *et al.* Guidelines on the management of valvular heart disease (version 2012). *Eur Heart J* 2012;**33**:2451–96.
5. Hoit BD. Left atrial size and function: role in prognosis. *J Am Coll Cardiol* 2014;**63**:493–505.
6. Messika-Zeitoun D, Bellamy M, Avierinos JF, Breen J, Eusemann C, Rossi A *et al.* Left atrial remodelling in mitral regurgitation—methodologic approach, physiological determinants, and outcome implications: a prospective quantitative Doppler-echocardiographic and electron beam-computed tomographic study. *Eur Heart J* 2007;**28**:1773–81.
7. Elliott PM, Anastasakis A, Borger MA, Borggreffe M, Cecchi F, Charron P *et al.* 2014 ESC guidelines on diagnosis and management of hypertrophic cardiomyopathy: The task force for the diagnosis and management of hypertrophic cardiomyopathy of the European Society of Cardiology (ESC). *Eur Heart J* 2014;**35**:2733–79.
8. Konomi S, Ohte N, Tanabe K, Osmanoglou E, Kühnle Y, Dungen H-D *et al.* Normal values and clinical relevance of left atrial myocardial function analyzed by speckle-tracking echocardiography—multicenter study. *Eur Heart J Cardiovasc Imaging* 2015;**16**:364–72.
9. Lancellotti P, Badano LP, Lang RM, Akhaladze N, Athanassopoulos GD, Barone D *et al.* Normal reference ranges for echocardiography: rationale, study design, and methodology (NORRE study). *Eur Heart J Cardiovasc Imaging* 2013;**14**:303–8.
10. Mor-Avi V, Lang RM, Badano LP, Belohlavek M, Cardim NM, Derumeaux G *et al.* Current and evolving echocardiographic techniques for the quantitative evaluation of cardiac mechanics: ASE/EAE consensus statement on methodology and indications endorsed by the Japanese Society of Echocardiography. *Eur J Echocardiogr* 2011;**12**:167–205.
11. Donal E, Ollivier R, Veillard D, Hamonic S, Pavin D, Daubert JC *et al.* Left atrial function assessed by trans-thoracic echocardiography in patients treated by ablation for a lone paroxysmal atrial fibrillation. *Eur J Echocardiogr* 2010;**11**:845–52.
12. Vieira MJ, Teixeira R, Goncalves L, Gersh BJ. Left atrial mechanics: echocardiographic assessment and clinical implications. *J Am Soc Echocardiogr* 2014;**27**:463–78.
13. Wang J, Khoury DS, Thohan V, Torre-Amione G, Nagueh SF. Global diastolic strain rate for the assessment of left ventricular relaxation and filling pressures. *Circulation*. 2007;**115**:1376–83.
14. Obokata M, Negishi K, Kurosawa K, Tateno R, Tange S, Arai M *et al.* Left atrial strain provides incremental value for embolism risk stratification over cha(2)ds(2)-vasc score and indicates prognostic impact in patients with atrial fibrillation. *J Am Soc Echocardiogr* 2014;**27**:709–16 e704.
15. Galderisi M, Lancellotti P, Donal E, Cardim N, Edvardsen T, Habib G *et al.* European multicentre validation study of the accuracy of e/e' ratio in estimating invasive left ventricular filling pressure: Euro-filling study. *Eur Heart J Cardiovasc Imaging* 2014;**15**:810–6.