

Evaluation of Left Atrial Function with Strain Imaging: Is it Ready for “Prime Time”?

MIGUEL A. QUIÑONES^{MACC}

Nearly one in three or four adults in the world (over 50 million people in the US alone) has systemic hypertension, many of whom are unaware and untreated. Hypertension is listed among the three leading risk factors for death from cardiovascular diseases by the World Health organization and thus, has been called “the silent killer”. It is also a leading cause of heart failure with preserved ejection fraction. Although the mechanisms by which hypertension leads to heart failure are not well elucidated, studies over the past three decades have identified changes in vascular stiffness, structural remodeling of the left ventricle and development of diastolic dysfunction (impaired relaxation and decreased compliance) as important components. (1) The term, “diastolic heart failure” has been used for years and preceded the more recently proposed term, “heart failure with preserved ejection fraction”. Regardless how these factors interact with each other, the fact is that by the time clinical manifestations of heart failure occur, patients show clear evidence of diastolic dysfunction and the majority have enlargement of the left atrium (LA). (2)

Subtle abnormalities of myocardial contraction and relaxation have been documented in asymptomatic hypertensive patients with normal left ventricular (LV) ejection fraction. In 1992, Habib et al reported abnormalities of diastolic filling consistent with impaired relaxation in both ventricles of asymptomatic hypertensive patients using pulsed-wave Doppler. (3) The magnitude of changes in the right ventricle paralleled those observed in the left. Since then a multiple of publications have described diastolic abnormalities in hypertensive patients, and although they tend to worsen with concentric hypertrophy, they can occur in the absence of hypertrophy and improve with sustained blood pressure reduction. (4) Likewise, there are several reports of reduced systolic mid-wall circumferential strain, longitudinal systolic strain and mitral annular descent in asymptomatic hypertensive patients with normal EF. (5-7) Furthermore, contraction abnormalities have been shown to relate closely with diastolic abnormalities, implying a functional and/or structural effect of the disease on the contractile apparatus of the myocardium. (6)

In this issue of *Revista Argentina de Cardiología*, Deschle et al report finding subtle contractile abnor-

malities in asymptomatic young (mean age, 44; range, 30-50 years) hypertensive patients compared to age-matched athletes and sedentary control subjects without hypertension. Similar to previous reports, LV longitudinal global systolic strain was reduced in the hypertensive group, and was seen in the absence of concentric LV hypertrophy or depressed EF. Furthermore, the authors observed a reduction in LA reservoir function (as depicted by the average peak longitudinal strain) and an increase in a noninvasive index of LA stiffness in these patients.

The left atrium acts as a reservoir for pulmonary venous return during ventricular systole, as a conduit for LV inflow during early and mid-diastole, and as a pump that boosts LV filling in late diastole. (8) LA enlargement occurs in response to elevated LV filling pressures and is, therefore, common in conditions leading to diastolic dysfunction including hypertension, particularly when concentric LV hypertrophy is present. Chronic LA enlargement has been found to be a marker for increased risk of heart failure in hypertensive patients, but also predicts higher incidence of cardiovascular events and mortality in patients with a variety of cardiovascular disorders. (9,10) LA enlargement has been also associated with higher incidence of atrial fibrillation in different populations including hypertensive patients, those with coronary artery disease, heart failure, chronic mitral regurgitation and / or obesity. (8) Recent studies have reported a strong association between LA enlargement and the occurrence of post-operative atrial fibrillation in patients undergoing coronary bypass or valve surgery. (11)

The function of the LA during each of its phases depends on several factors (Figure); some are inherent to the atrium while others are interlaced with the function of the left ventricle. (8) The reservoir function is influenced by atrial compliance during ventricular systole, by atrial contractility and relaxation, by the descent of the LV base during systole (a function of longitudinal systolic contraction) and LV end-systolic volume. Conduit function is influenced by atrial compliance, LA V-wave pressure and importantly by LV relaxation and compliance. Finally, the effectiveness of the atrial booster function depends on the timing of atrial contraction, atrial contractility, the degree of venous return (atrial preload) and left ventricular end

diastolic pressure (atrial afterload). It is, therefore, not surprising that parameters reflecting any of these functional phases have been found to be abnormal in hypertensive patients with subclinical systolic and diastolic dysfunction. What is interesting about the observations made by Deschle is that the patients were younger than those previously reported, did not have concentric LV hypertrophy or severe LV relaxation abnormalities nor did they have LA enlargement.

The findings by Deschle suggest that functional contraction and relaxation abnormalities in the left ventricle and atrium precede ventricular and atrial remodeling changes and occur early in the natural history of hypertension. Similar observations have been made previously in older patients and collectively they all provide strong support to Deschle's findings. (12) What the studies cannot answer is whether LA functional abnormalities occur in response to ventricular abnormalities or whether both chambers respond simultaneously to the load imposed by hypertension. An attractive hypothesis is that changes in ventricular function and compliance precede the atrial abnormalities. In Deschle's study, the mean E/e' for the hypertensive group was 10.48 (a value previously found to relate to a mean LA pressure between 12-15 mmHg [13]) with a standard deviation of 2.98, which implies that a subgroup of patients in the study had elevated filling pressures at rest. This ties well with the author's observation of increased LA stiffness in the hypertensive group given that the index of stiffness used by Deschle, and initially described by Kurt and associates (14), was found to relate well with pulmonary artery pressures by these authors. Thus, it is quite possible that subcritical diastolic dysfunction is the precursor

of the functional abnormalities observed in the LA and that these abnormalities precede enlargement of the atrium.

The application of strain imaging has allowed the early detection of functional abnormalities in hypertensive patients who otherwise show no signs of cardiac disease. Most of the newer ultrasound machines are equipped with strain imaging and software that facilitate measurements of regional and global strain. So, why not incorporate these measurements as part of a routine clinical examination? There are a few reasons to limit the use of these measurements, for now, to clinical research applications. First, acquisition of reliable strain curves requires echocardiographic images of good quality, training and attention to meticulous technique, without which the data loses accuracy and reproducibility. Second, measurements derived from these curves vary between different ultrasound vendors, which limit the establishment of normal ranges. Third, multiple parameters have been described by different investigators and we currently lack consensus as to which ones should be adopted for clinical use. Finally, at this time we do not know how to apply results into the management of a hypertensive patient. Would we do anything different than to treat the hypertension with an effective medication? Perhaps, a specific group of agents would be better for a patient who has subclinical functional abnormalities but this is a hypothesis that needs to be tested; until such data are available the routine use of strain to detect early LV and /or LA abnormalities in a patient with hypertension is of limited clinical value and has the danger of over diagnosing and creating unnecessary patient anxiety.

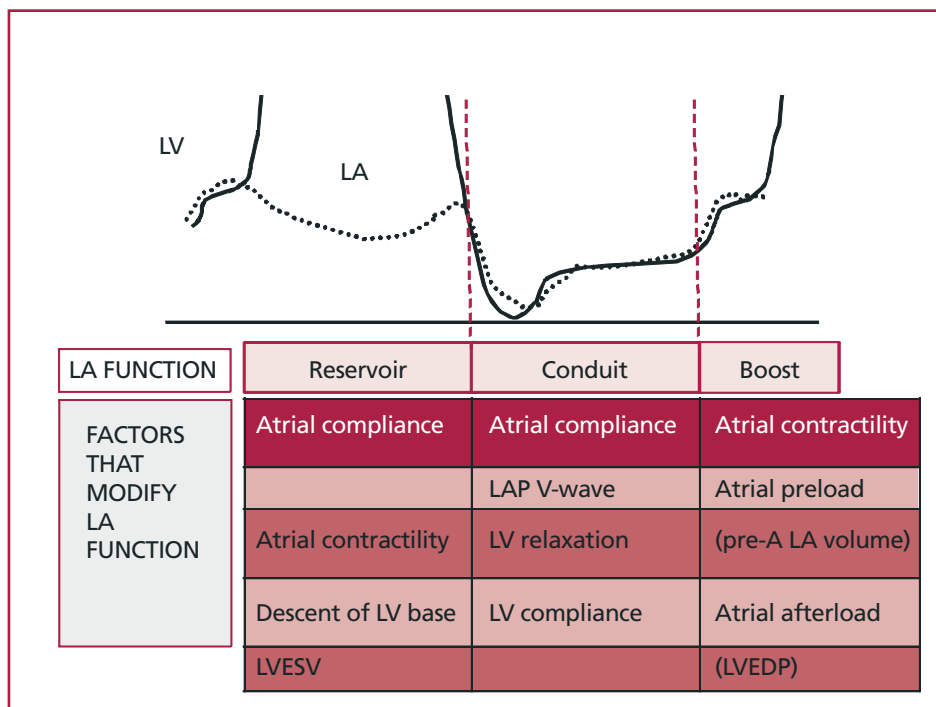


Fig. 1. Plots of LV and LA pressure curves indicating the 3 phases of LA function. The table below lists the factors that modify these phases. Abbreviations: LVESV= LV end-systolic volume; LVEDP = LV end-diastolic pressure.

Conflicts of interest

None declared

REFERENCES

1. Quiñones MA, Zile MR, Massie BM, Kass DA; Writing Committee of the Dartmouth Diastolic Discourses: Chronic heart failure: a report from the Dartmouth Diastole Discourses. *Congest Heart Fail* 2006;12:162-5. <http://doi.org/d3gvpz>
2. Zile MR, Baicu CF, Gaasch WH. Diastolic heart failure abnormalities in active relaxation and passive stiffness of the left ventricle. *N Engl J Med* 2004;350:1953-9. <http://doi.org/bg7pww>
3. Habib GB, Zoghbi WA. Doppler assessment of right ventricular filling dynamics in systemic hypertension: comparison with left ventricular filling. *Am Heart J* 1992;124:1313-20. <http://doi.org/d6jc9f>
4. Mottram PM, Haluska B, Yuda S, Leano R, Marwick TH. Patients with a hypertensive response to exercise have impaired systolic function without diastolic dysfunction or left ventricular hypertrophy. *J Am Coll Cardiol* 2004;43:848-53. <http://doi.org/cxv434>
5. Hare JL, Brown JK, Marwick TH. Association of myocardial strain with left ventricular geometry and progression of hypertensive heart disease. *Am J Cardiol* 2008;102:87-91.
6. Pavlopoulos H, Grapsa J, Stefanadi E, Philippou E, Dawson D, Nihoyannopoulos P. Is it only diastolic dysfunction? Segmental relaxation patterns and longitudinal systolic deformation in systemic hypertension. *Eur J Echocardiogr* 2008;9:741-7. <http://doi.org/cwhpbs>
7. Ballo P, Nistri S, Cameli M, Papesso B, Dini FL, Galderisi M, et al; Working Group Nucleus on Echocardiography, of the Italian Society of Cardiology. Association of left ventricular longitudinal and circumferential systolic dysfunction with diastolic function in hypertension: a nonlinear analysis focused on the interplay with left ventricular geometry. *J Card Fail* 2013;S1071-9164:01281-5.
8. Deschle HA, Gantesti J, Culaciatu G, Casso N, Alfie L, Gingins M et al. Left Atrial Longitudinal Strain: Early Alterations in Young Patients with Mild Hypertension. *Rev Argent Cardiol* 2014;82:117-23.
9. Hoit BD. Left atrial size and function: role in prognosis. *J Am Coll Cardiol* 2013;S0735-1097(13):06081-6.
10. Takemoto Y, Barnes ME, Seward JB, Lester SJ, Appleton CA, Gersh BJ, et al. Usefulness of left atrial volume in predicting first congestive heart failure in patients or ≥ 65 years of age with well-preserved left ventricular systolic function. *Am J Cardiol* 2005;96:832-6. <http://doi.org/dv25cr>
11. Pritchett AM, Mahoney DW, Jacobsen SJ, Rodeheffer RJ, Karon BL, Redfield MM. Diastolic dysfunction and left atrial volume: a population-based study. *J Am Coll Cardiol* 2005;45:87-92. <http://doi.org/c45bnm>
12. Pritchett AM, Mahoney DW, Jacobsen SJ, Rodeheffer RJ, Karon BL, Redfield MM. Left atrial volume predicts the risk of atrial fibrillation after cardiac surgery: a prospective study. *J Am Coll Cardiol* 2006;48:779-86. <http://doi.org/fwnj7k>
13. Mondillo S, Cameli M, Caputo ML, Lisi M, Palmerini E, Padeletti M, et al. Early detection of left atrial strain abnormalities by speckle-tracking in hypertensive and diabetic patients with normal left atrial size. *J Am Soc Echocardiogr* 2011;24:898-908. <http://doi.org/czr2w2>
14. Nagueh SF, Appleton CP, Gillebert TC, Marino PN, Oh JK, Smiseth OA, et al. Recommendations for the evaluation of left ventricular diastolic function by echocardiography. *J Am Soc Echocardiogr* 2009;22:107-33. <http://doi.org/fw9g99>
15. Kurt M, Wang J, Torre-Amione G, Nagueh SF. Left atrial function in diastolic heart failure. *Circ Cardiovasc Imaging* 2009;2:10-5. <http://doi.org/dd5q4m>