Estimating Left Ventricular Relaxation and Filling Pressure Using Speckle Tracking Strain

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Determination of increased left ventricular (LV) filling pressure is an important factor in the diagnosis of primary systolic and diastolic heart failure, and an important marker of poor prognosis. An established non-invasive parameter for estimating LV filling pressure is the ratio of peak early diastolic transmitral flow velocity (E) to peak early diastolic mitral annular velocity (e') derived from conventional pulsed-wave and tissue Doppler echocardiography. However, mitral flow parameters have several limitations, and one of the most critical problems is pseudonormalization of mitral flow parameters. e' , which is derived from tissue Doppler imaging (TDI), has been found to be less preload-dependent without pseudonormalization at high LV filling pressure.^{1,2} A previous investigation reported that the E/ e' ratio correlated strongly with LV filling pressure and was a better predictor of elevated mean pulmonary capillary wedge pressure (PCWP) compared with the conventional Doppler parameters or individual TDI measures.^{3,4} In some studies, however, using the E/ e' ratio to predict LV filling pressure was found to be suboptimal.^{5,6} Moreover, Mullens et al did not find any correlation between the E/ e' ratio and PCWP for patients with advanced decompensated heart failure and LV ejection fraction (LVEF) <30%.⁷ It therefore remains unclear whether the E/ e' ratio can be used to predict the LV filling pressure in patients with reduced LVEF. The guidelines of the American Society of Echocardiography recommend using the E/ e' ratio to evaluate LV filling pressure, especially for patients with preserved LVEF ($\geq 50\%$).⁸ On the other hand, 2D speckle tracking echocardiography is angle-independent and not affected by tethering or translation, and the 2D speckle tracking-derived parameters have been shown to be better associated with LV relaxation and filling pressure than conventional and TDI-derived parameters. In particular, the ratio of E to peak early diastolic 2D longitudinal or circumferential strain rate correlates well with LV filling pressure and can therefore predict elevation of mean PCWP.^{9,10} However, it has not been elucidated which speckle tracking-derived parameter (strain or strain rate, and systolic or diastolic), and which direction of LV myocardial deformation (longitudinal or circumferential) is the most useful marker of estimating LV relaxation and filling pressure.

In this issue of the Journal, Hayashi et al¹¹ report on their prospective multicenter study conducted in 5 institutions in Japan to compare the correlation of TDI- and 2D speckle tracking-derived parameters with the time constant of LV pressure decay (τ) and LV mean diastolic pressure (LVMDP) in 77 patients with various cardiac diseases. The main findings of this study were that the correlation of e' with τ was weak, and that of peak global longitudinal strain (LS) was the strongest among the 2D speckle tracking-derived parameters. In addition, the ratio of E to peak global LS (E/LS) correlated well with invasively measured LVMDP, which is significantly better than E/A or E/ e' . The receiver-operating characteristic analysis showed that E/LS had the largest area under the curve for distinguishing elevated LVMDP compared with E/ e' and E/A.

Global LS assessed by means of 2D speckle tracking strain is now widely used as a powerful prognostic marker, and in patients with various cardiac diseases^{12–14} it enables the detection of subtle LV systolic myocardial dysfunction beyond conventional echocardiographic assessment. Moreover, global LS is associated with LV relaxation, and reduced global LS can coexist with LV diastolic dysfunction in heart failure patients with normal LVEF.¹⁵ Because this study showed that global LS may be an important marker of early-stage LV diastolic dysfunction, E/LS should be evaluated in routine examinations as a parameter of LV filling pressure. As the next step, we need to investigate the utility of E/LS as a prognostic marker in a larger number of patients with various cardiac diseases.

References

1. Nagueh SF, Middleton KJ, Kopelen HA, Zoghbi WA, Quinones MA. Doppler tissue imaging: A noninvasive technique for evaluation of left ventricular relaxation and estimation of filling pressures. *J Am Coll Cardiol* 1997; **30**: 1527–1533.
2. Nagueh SF, Sun H, Kopelen HA, Middleton KJ, Khoury DS. Hemodynamic determinants of the mitral annulus diastolic velocities by tissue doppler. *J Am Coll Cardiol* 2001; **37**: 278–285.
3. Sundereswaran L, Nagueh SF, Vardan S, Middleton KJ, Zoghbi WA, Quinones MA, et al. Estimation of left and right ventricular filling pressures after heart transplantation by tissue doppler imaging. *Am J Cardiol* 1998; **82**: 352–357.
4. Nagueh SF, Mikati I, Kopelen HA, Middleton KJ, Quinones MA, Zoghbi WA. Doppler estimation of left ventricular filling pressure in sinus tachycardia: A new application of tissue doppler imaging. *Circulation* 1998; **98**: 1644–1650.

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5. Geske JB, Sorajja P, Nishimura RA, Ommen SR. Evaluation of left ventricular filling pressures by doppler echocardiography in patients with hypertrophic cardiomyopathy: Correlation with direct left atrial pressure measurement at cardiac catheterization. *Circulation* 2007; **116**: 2702–2708.
6. Olson JJ, Costa SP, Young CE, Palac RT. Early mitral filling/diastolic mitral annular velocity ratio is not a reliable predictor of left ventricular filling pressure in the setting of severe mitral regurgitation. *J Am Soc Echocardiogr* 2006; **19**: 83–87.
7. Mullens W, Borowski AG, Curtin RJ, Thomas JD, Tang WH. Tissue doppler imaging in the estimation of intracardiac filling pressure in decompensated patients with advanced systolic heart failure. *Circulation* 2009; **119**: 62–70.
8. 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**: 107–133.
9. Meluzin J, Spinarova L, Hude P, Krejci J, Podrouzkova H, Pesl M, et al. Estimation of left ventricular filling pressures by speckle tracking echocardiography in patients with idiopathic dilated cardiomyopathy. *Eur J Echocardiogr* 2011; **12**: 11–18.
10. Dokainish H, Sengupta R, Pillai M, Bobek J, Lakkis N. Usefulness of new diastolic strain and strain rate indexes for the estimation of left ventricular filling pressure. *Am J Cardiol* 2008; **101**: 1504–1509.
11. Hayashi T, Yamada S, Iwano H, Nakabachi M, Sakakibara M, Okada K, et al. Left ventricular global strain for estimating relaxation and filling pressure: A multicenter study. *Circ J* 2016; **80**: 1163–1170.
12. Okada K, Yamada S, Iwano H, Nishino H, Nakabachi M, Yokoyama S, et al. Myocardial shortening in 3 orthogonal directions and its transmural variation in patients with nonobstructive hypertrophic cardiomyopathy. *Circ J* 2015; **79**: 2471–2479.
13. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: An update from the american society of echocardiography and the european association of cardiovascular imaging. *J Am Soc Echocardiogr* 2015; **28**: 1–39.e14, doi:10.1016/j.echo.2014.10.003.
14. Enomoto M, Ishizu T, Seo Y, Yamamoto M, Suzuki H, Shimano H, et al. Subendocardial systolic dysfunction in asymptomatic normotensive diabetic patients. *Circ J* 2015; **79**: 1749–1755.
15. Yip GW, Zhang Q, Xie JM, Liang YJ, Liu YM, Yan B, et al. Resting global and regional left ventricular contractility in patients with heart failure and normal ejection fraction: Insights from speckle-tracking echocardiography. *Heart* 2011; **97**: 287–294.