EDITORIAL

Left Atrium a Microscope for Left Ventricle: Left Atrial Expansion Index (LAEI) One of the Lens: What can We See with this?

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Overt clinical disease is easy to diagnose clinically. However, a patient's cardiopulmonary reserve may be limited by the subclinical disease. The perioperative physician will need to assess and prepare for it, especially when the patient is subjected to surgical stress. Effort tolerance is an important parameter used by the clinician to quantify the cardiopulmonary reserve. It may also identify underlying cardiopulmonary disorders. However, this evaluation is subjective.

Echocardiography (echo) is helpful for hemodynamic optimization in perioperative, emergency, and ICU settings. It can detect structural cardiac abnormalities and functional disturbances in cardiac physiology. It also helps the medical team determine the cause of cardiopulmonary compromise and monitor the effects of therapy and prognosis. In addition, screening patients with echo preoperatively can detect subclinical disease. If detected, it may direct perioperative management through increased monitoring, fluid and drug therapy, and predict perioperative complications.

Identifying ventricular systolic and valvular dysfunction on echocardiography is often simple. However, diastolic dysfunction may not be evident from routinely measured indices of ventricular function like ejection fraction or visual ventricular function assessment. Similarly, left atrial (LA) function assessment is overlooked during routine echocardiography. Adequate assessment of LA is essential because LA dilation is predictive of cardiac complications. Moreover, LA dysfunction may manifest prior to changes in LA volume. LA dysfunction may be secondary to left ventricle (LV) systolic or diastolic dysfunction and can manifest even before the patient becomes symptomatic. Therefore, an impairment of LA function is a potential marker of disease pathogenesis and can help manage patients before the development of overt heart failure or atrial arrhythmias. Also, evaluation of LA function in overt cardiac disease may help assess treatment efficacy and predict short or long-term outcomes. In the perioperative period, LA function may act as a biomarker for diastolic dysfunction, necessitating more careful monitoring and appropriate fluid therapy.

The LA function is monitored by changes in volumes or volume-derived variables on echo. Both volumetric and strain analysis can be performed to evaluate LA phasic function. In two-dimensional (2D) echocardiography, LA volume is measured in the apical 4-chamber view using the Simpson technique.[1] Recent advances in three-dimensional (3D) imaging have significantly improved the accuracy of measurements of LA volume and mechanical functions.[2] The LA volume measurements of clinical significance are:

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Vmax (max LA volume), measured at the T wave end and one frame before mitral valve opening,

Vmin (minimum LA volume), measured in the first frame after mitral valve closure at QRS wave beginning, and

VpreA, measured at the P wave beginning and one frame before mitral valve reopening.

Using these measurements, LA function can be assessed using the following parameters:

- LA Total Emptying Volume (TEV) = Vmax - Vmin,
- LA Total Emptying Fraction (TEF) = TEV / Vmax × 100,
- LA Active Emptying Volume (AEV) = VpreA–Vmin,
- LA Active Emptying Fraction (AEF) = AEV / VpreA × 100
- LA Passive Emptying Fraction (PEF) = (Vmax – VpreA) / Vmax × 100,
- LA Expansion Index (EI) = TEV/ Vmin × 100,
- LA maximum volume index (LAVI) = Vmax / Body Surface Area.

Among the many parameters described, a single best parameter for LA function is yet to be identified. A few important patterns have been described. For example, in patients with worsening diastolic dysfunction, the increase in Vmin is more pronounced than the increase in Vmax.[3] Vmin has also been suggested to be an independent predictor of major adverse cardiac events in patients attending a general outpatient clinic.[4] Similarly, the left atrial expansion index (LAEI) is another potential parameter of interest.

LAEI represents the LA reservoir function determined primarily by LA active relaxation and LA compliance. LA compliance may be affected by increased atrial fibrosis due to hypertension, diabetes and aging. As LAEI represents the combination of active atrial relaxation and compliance, it may be an early indicator of atrial remodelling. While LA volume measurements represent a snapshot of LA function at a specific point of the cardiac cycle, LAEI may identify diastolic dysfunction in patients with preserved systolic function as it is an independent predictor of increased LVEDP.[5] Therefore, LAEI is an important parameter relevant to LA volumetric study.[6]

The concept of LAEI in cardiac surgery was initiated three decades ago. Chandran CB et al. reported that LAEI and the maximum volume increase during the initial third of systole, measured as early systolic expansion index differentiated well between moderate and severe mitral regurgitation.[7] Subsequently, multiple studies have evaluated the utility of LAEI in various settings.

Park et al. evaluated the LA function in a group of never treated hypertensive patients for a night dip of blood pressure. They noted that the LAEI and LA active emptying volume and LA active emptying fraction were all increased in non-dippers (nighttime blood pressure decrease by less than 10%) compared to the dippers.[8] On the other hand, in another study, higher LAEI with a reduction in passive systolic function was observed more in prehypertensive individuals than in controls.[9]

The LAEI can be helpful in the prognostication of heart failure patients and titration of heart failure medications.[10] In one study, low LAEI predicted heart failure, atrial fibrillation and all-cause mortality in patients with severe ventricular dysfunction. The adverse events were proportional to the LAEI, and LAEI was a better predictor of adverse events than indexed LA volume and tissue Doppler parameters.[11]

Pulmonary capillary wedge pressure (PCWP) estimation is pivotal in cardiac disease diagnosis and management. Right heart catheterization provides accurate PCWP measurement but is invasive. In a recent study, log-transformed LAEI (lnLAEI) correlated with PCWP ($r = -0.73$, $p < 0.001$).[12] lnLAEI had an independent and additive predictive role for PCWP estimation over clinical and diastolic dysfunction parameters like E/e′. The diagnostic accuracy of lnLAEI for elevated PCWP identification was higher than either the single diastolic dysfunction parameters or their combination. Therefore, lnLAEI might be a valid echocardiographic parameter for noninvasive PCWP estimation.

Suzan Hatipoglu et al. investigated the relationship between invasively measured LV end-diastolic pressure (LVEDP) and real-time full-volume 3D echocardiography LA volumes and phasic atrial functions in a patient population with preserved LV systolic function.[5] Minimum LA volume index, active LA ejection fraction and LAEI were significant predictors of LVEDP ≥ 16 mm Hg, and LAEI was an independent predictor of elevated LVEDP.

Govindan M et al. demonstrated the prognostic value of LAEI along with N terminal-pro atrial natriuretic peptide to predict recurrent AF after cardioversion.[13] LAEI may help identify patients at an early stage in their disease with intact neurohumoral feedback systems and less advanced atrial remodeling. The association of LA function and cardioembolic events is intuitive since LA enlargement promotes stasis and thrombus formation. LA fibrosis after LA dysfunction may also play a significant role in thrombogenesis. LAEI has been described to be a predictor of thromboembolic events.[14] A LAEI of less than 62.5% is superior to LA volume and mitral E/e′ as an independent predictor of recurrent stroke of both embolic and non-embolic origin (76% sensitivity and 68% specificity).

In a study on 342 patients undergoing coronary revascularization with a stent, LAEI measured before and one month after stent placement showed an association of LAEI with exercise capacity, the pretest probability of restenosis and positive predictive value of exercise test.[15] Moreover, revascularization improved both exercise capacity and LAEI.

The utility of LAEI extends to patients undergoing univentricular repair as well. Patients undergoing univentricular repair need to be followed up for deterioration in ventricular function and ensuing atrial dysfunction, as atrial dysfunction may precede the onset of arrhythmias. In a long-term follow-up of patients undergoing Fontan surgery, the LAEI was lower in failing Fontan than in functional Fontan (23.5 ± 13.5 vs 59.5 ± 8.7, $p < 0.01$).[16]

Beyond cardiac function, LAEI may also be an early indicator of renal function decline.[17] This can enable the institution of early intervention to prevent worsening renal function.

In the background of this evidence, LAEI may be a good tool for early diagnosis and prognostication of cardiovascular compromise. With the widespread availability of 3D echocardiography and automated imaging, LAEI may assume a broader role. However, LAEI may be combined with the conventional assessment to avoid suboptimal management. The utility of LAEI during the perioperative period is another potential area of research for predicting postoperative complications after cardiac and non-cardiac surgeries.

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