Simultaneous 4-Chamber Strain: More and Faster Analysis, But Is It Good Enough?

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Analysis of myocardial deformation, or strain imaging, is becoming part of routine echocardiography.¹ The most widely accepted parameter to date has been global longitudinal strain as a measure of global left ventricular (LV) function. Global longitudinal strain (LS) of the LV, in (negative) percent, is the average of the maximal shortening (in percent) in the apico-basal direction of each of 18 LV segments visualized in the 3 standard apical views. The strain curves are computed using speckle tracking to determine myocardial velocity in a region of interest from which local strain is derived. LS is defined as deformation (shortening or lengthening) along the midline of LV walls, that is, in an apico-basal direction, but following the curvature of the LV walls.² Similarly, global left or right atrial or right ventricular LS can be obtained as average of segmental peak LS. Strain data are highly dependent on image quality and frame rate, as well as physiological parameters as blood pressure.

See Article by Addetia et al

The article of Addetia et al³ in this issue of Circulation: Cardiovascular Imaging explores LS values from all 4 chambers obtained simultaneously from the 4-chamber view of the same cardiac cycle using a software (Epsilon Imaging, Ann Arbor MI) that can accommodate data acquired with echo machines from different echo manufacturers, although for this article, only echoes acquired with one brand of echo machines were used. LS analysis was based on speckle tracking in 21 segments per patient (6 for the LV, 3 for the right ventricle, and 6 each for left and right atrium, using the same 3 septal segments for both); for each chamber, a global strain curve was calculated by averaging the segmental LS of the pertinent segments. Less than 1% of segments were excluded because of bad quality, which is a remarkably high success rate. For unclear reasons, the size of individual segments presented in Figure 1 of Addetia et al is somewhat variable, most conspicuously for the small basal right ventricular free wall segment. Global peak LS and heart rate–corrected time-to-peak LS were measured for each chamber, and data from 259 healthy individuals, stratified by sex and age, are presented.

Peak LV LS values, calculated from the 6 segments of the 4-chamber view, were −18±2%. This is lower than a recent meta-regression from the published literature reported for classic global LS (calculated from the 18 segments of the 3 apical views), namely −19.7%; 95% confidence interval, −20.4% to −18.9%.⁴ Although the reduction compared with published values may seem low, 1.7% absolute percent difference corresponds to 9% relative change. Because strain measurements are typically used to detect small, subtle, subclinical changes, this is not a negligible difference.

Peak left atrial strain values reported in the study of Addetia (+38±13%) are close to the published values.⁵,⁶ For the right ventricular free wall, a normal range of −23±6% was found, again lower than currently recommended normal values from (−29±4.5%).³ Given the smooth appearance of the strain curves, postprocessing may have contributed to underestimation, which re-emphasizes that strain values are dependent on underlying software and hardware.

A puzzling detail of the left ventricular and atrial strain curves is their timing. From Figure 1 of Addetia et al (the only one with an electrocardiographic tracing), it seems that LV and left atrial strain curves both start at zero at the end of the electrocardiographic QRS complex. However, physiologically, left atrial (LA) expansion in sinus rhythm starts at the onset or even before the QRS complex⁷ (see Figure), and LV longitudinal shortening also starts during QRS.

The authors found higher strain values in women than in men and a decrease of peak left and right atrial strain with age, findings generally in line with the literature,⁸,⁹ and new for the right atrium. Time-to-peak strain measurements from all chambers are also reported. However, their clinical relevance is unclear at this point because this parameter to date has been used mainly to assess regional differences in contraction timing in the LV, and applications for global values are unclear.

The main attraction of the presented technique is that from one view and within one heart beat, function (more properly, LS) of all 4 chambers is evaluated quantitatively in a semiautomatic way. Is this the future for time-pressed echocardiographers? Several caveats apply. Echocardiographic acquisition of an apical 4-chamber view is usually optimized for showing LV structures as well as possible, mostly the LV endocardium and the mitral valve. Recognizing this, current guidelines for right ventricular (RV) assessment explicitly call for an extra, optimized, RV-focussed view to best evaluate right ventricular morphology and function.¹ Similarly, renewed interest in LA volume as a marker of diastolic function and general prognosis has reminded us that in many 4-chamber views, the LA is foreshortened, and often LA-optimized views are necessary to better delineate this structure, sometimes at the expense of detail in other chambers. Thus, it is likely that...
using one single 4-chamber view heart cycle will not produce optimal evaluation of each chamber, even if technically adequate tracking is reported in over 99% of patients by Addetia et al. Additionally, if RV free wall function is to be evaluated by speckle tracking, much higher frame rates and thus better data can be achieved by sector narrowing if acquisition is focussed on this structure. Thus, and because of its monoplane representation of the LV, this approach is unlikely to replace dedicated analysis of single chambers. The example offered by Addetia et al of a patient with severe pulmonary hypertension (Figure 7 of Addetia et al) underlines this. The authors state that, “compared with the normal values...the peak LS RA/LA (right atrial / left atrial) and RV/LV ratios were elevated, suggesting that right heart function is hypercontractile when compared with left heart function.” However, RV/LV peak strain ratio is given as 1.2 for the pulmonary hypertension patient, not much different from 1.1, the ratio reported for normals.

Importantly, the independence of (left or right) atrial and ventricular LS is questionable. Because atrium and ventricle are tethered to each other in mechanical continuity, longitudinal shortening of 1 of the 2 must be associated with lengthening of the other, and vice versa, because the total volume and the apico-basal dimension of the heart are constant throughout the cardiac cycle.\(^\text{8,11}\) Although strain measures local deformation, this deformation itself physiologically depends on preload and afterload, which are affected by the adjacent myocardium. Because the myocardial mass of the left atrium (15–45 g at autopsy)\(^\text{12}\) is much smaller than the LV mass, it is likely that peak left atrial strain, which occurs at LV end-systole, heavily depends on LV mechanics.

In conclusion, Addetia et al present a first experience with a formidable feat of image postprocessing, allowing a quick glimpse of deformation in all 4 chambers from one echo view and one heartbeat. The place of this approach in the clinical arena remains to be determined.

**Disclosures**

None.

**References**


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