Atrial strain in cardiovascular magnetic resonance imaging, a sensitive companion of ventricular strain

The function of human heart is that of maintaining blood in motion by accommodating the incoming low-pressure venous blood into the atrium, transferring it from atrium to ventricle, and propelling into the circulation with high pressure. This process, where blood transits and acquires potential energy, is allowed by the generation of differences of pressure between atrium and ventricle and between ventricle and downstream artery, which, in turn, are achieved through a sequence of expansions and contractions in a harmonious synchrony between atria and ventricles [1].

Last two decades have witnessed the application of advanced techniques of image analysis to follow the motion of the myocardium and allow measuring its deformation; such techniques took the name of feature tracking (FT) in cardiac magnetic resonance (CMR) or speckle tracking in echocardiography, where many features are speckles. They were predominantly applied to the left ventricle (LV) where the global longitudinal strain (GLS), the shortening of the myocardium along the long-axis direction, was eventually the featuring parameter that may help, under some pathological circumstances, to identify the presence of a subclinical LV systolic dysfunction [2].

More recently, the same techniques were applied to the atria and gained increasing interest both in echocardiography [3] and in CMR [4]. Indeed, the structure of the left atrium (LA) is weaker than that of the LV; as such, alteration of strain measured on the LA may appear at the early stage of a disease before the dysfunction has progressed enough to be noticeable in terms of LV strain [5,6]. This hypothesis raised the interest in studying atrial function as an early marker of subclinical diseases and on its incremental prognostic value.

Technically, the accuracy of strain evaluated by feature (or speckle) tracking depends on image quality that affects the confidence during the process of recognizing the same tissue element along subsequent images. Accuracy also depends on spatial resolution, because displacements smaller than the size of a pixel are not detectable; it also depends on time resolution that must not be either too low, to avoid large tissue displacements between images that are distant in time, or excessively high to ensure noticeable displacement from one frame to the next. However, despite the potential clinical relevance of atrial deformation parameters, firm references regarding appropriate figures to be used in terms of spatial and time resolution in CMR were lacking.

In this issue of the IJC, Schmidt-Rimpler et al. [7] report a systematic analysis of CMR-derived atrial deformation with varying spatial and temporal resolution. The analysis is executed in both the LA and the right atrium (RA) and performed in terms of atrial strain and strain-rate. This is a technical study that is carefully executed and which presents an immediate impact on clinical activity. Results may be considered as non-definitive because the number of subjects is limited (12 volunteers and 9 patients); however, each subject was scanned 12 times, using 3 different spatial resolutions and 4 temporal frequencies making this study a reliable first reference of the type.

Results reported in [7] indicate that spatial resolution has a limited influence on strain and strain-rate assessment until images are clinically acceptable. Differently, time resolution impacts the results more quantitatively; a minimum of 30 images per heart cycle is required for a reliable assessment of GLS, while 50 images are a very minimum for strain-rate. The reported data is in line with existing knowledge built in the LV. Possibly, a slightly higher spatial resolution is required for the LA to identify the thinner atrial structures, but that is not necessarily true as tracking rely more on small features like the endocardium more that on the entire myocardium. It is also consistent that strain-rate requires about twice the resolution than strain, given that the former is related to strain by time-differentiation that requires two values for its evaluation. The availability of firm references of image acquisition parameters, of which [7] is a prime example, is a requisite for reliable evaluation of atrial strain and improve comparability between different studies.

The importance of atrial strain, however, should not divert attention from the analysis of the corresponding ventricle which is a more important functional chamber. The LA is weaker than the LV and LA strain is largely driven by LV's [8]; on the other hand, the weaker atrium may be a more sensitive indicator of dysfunction affecting either LA or LV [9]. In general, LA and LV work in synergy during the different phases of the heart cycle, as shown in Fig. 1, and the evaluation of ventricular-atrial coupling is valuable for a comprehensive understanding of pathophysiological mechanisms [10]. In particular during diastole, when the atrio-ventricular valve is open, the two chambers are directly connected as a single cavity and the unitary assessment of both becomes important to identify when their synergistic functional rhythm gets altered.

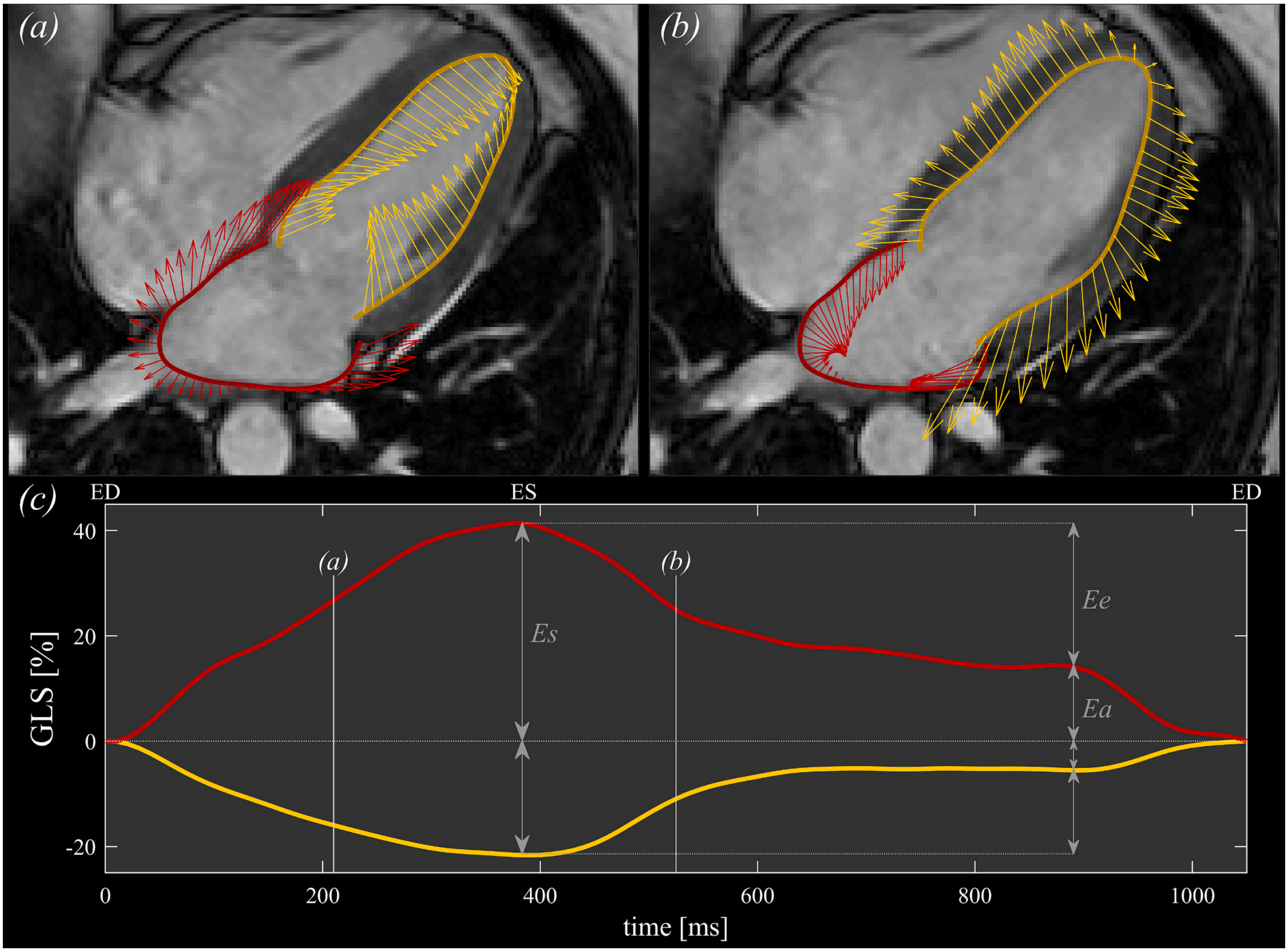

Fig. 1. Long-axis 4-chamber images of a normal heart during systolic contraction *(a)* and early diastolic expansion *(b)*, the instantaneous endocardial border and velocity vectors are indicated for for left atrium (LA, red) and left ventricle (LV, yellow). Time profile *(c)* of the global longitudinal strain (GLS) for both chambers during the heart cycle.
LA and LV work in reciprocal synergy during the different phases of the cardiac cycle when the contraction of the former is accompanied by expansion of the latter and vice versa. The values of LA-GLS during reservoir (*Es*), conduit (*Ee*) and booster (*Ea*) phases are evidenced, the values for LV-GLS at the corresponding phases are also indicated. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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