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How To Do LA Strain

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Introduction

With the development of speckle tracking techniques, atrial global longitudinal strain emerged as a new parameter with the potential of improving the diagnostic accuracy and prognostic value of echocardiography [1] in different clinical scenarios, such as heart failure (HF) [myocardial infarction, diastolic function, atrial fibrillation, valvular heart disease or as a measure of LV filling pressure.

Although at first glance easy to perform, deformation analysis of the LA bears certain challenges compared to LV speckle tracking as the LA wall is very thin, the LA interatrial septum is frequently extremely mobile and therefore difficult to track, and the orifices of the LA appendage and pulmonary veins require an arbitrary extrapolation of the LA contour [2]. In addition, atria are positioned in the far field of the image with respectively suboptimal signal quality and lateral resolution.

The following article is intended to provide guidance on how to deal with these obstacles in order to reliably achieve accurate and reproducible measurements of LA strain. All recommendations are in-line with the recently published joint European Association of Cardiovascular Imaging /American Society of Echocardiography consensus document on the same topic [2].

Imaging

LA strain assessment requires dedicated image acquisitions. As image depth is high, narrowing the image sector to just wrap the LA can be used to increase frame rate, but also line density and with this lateral resolution [Figure 1A]. Furthermore, it is necessary to obtain non-foreshortened images of the LA, as its long axis deviates from the long axis of the LV [Figures 1B].

A good quality ECG trace with well visible P wave is mandatory. The additional acquisition of mitral valve and aortic valve Doppler spectra supports a better retrospective definition of time intervals.

Determining the Region of Interest

Whenever possible, dedicated software should be used. This allows to take advantage of the automatic LA wall detection algorithm which reduces the need for interventions by the reader and contributes so to a better reproducibility of the results.

The region of interest (ROI) definition usually starts with delineating the endocardial contour which should be drawn from the mitral annulus on one side, extrapolates across pulmonary vein and/or LA appendage orifices and ends at the mitral annulus on the opposite side [Figure 1C]. For a full-wall-ROI, care should be taken that the ROI wraps the LA myocardium, but avoids as much as possible the strong signals of the stationary pericardial tissue. A region of interest of 3mm has been recommended, but might require individual adaptation [Figure 1D].

After tracking, the motion of the ROI should reflect the motion of the underlying tissue. Common tracking problems include that both ends of the ROI do not follow the mitral annulus or that the ROI is too much attracted by stationary artefacts or pericardial structures. If tracking quality cannot be improved by adjusting the ROI, the image should not be used for strain analysis.

Data Analysis

LA strain is measured as global longitudinal strain (GLS) of the entire wall. Segmental strain is not considered. Given the limited thickness of the LA wall and the minimum thickness of any ROI, a distinction of endocardial strain and full wall strain is not needed.

Zero reference is end-diastole, defined by mitral valve closure. In the clinical routine, the ECG R-trigger is a good surrogate for that, but may not reflect end-diastole in certain circumstances, e.g. when the QRS is wide due to conduction delays. A feasible approach is to simply refer to the nadir of the atrial strain curve. Some studies have used a zero reference at the beginning of atrial contraction which, however, results in different strain values, has otherwise no advantages, and is not feasible in atrial fibrillation [Figure 1E].

The morphology of the strain curve is characterized by a monophasic systolic part and a diastolic part with an early shortening, a variable stationary phase (diastasis) and a late diastolic shortening during the active atrial contraction. The definition of the latter is most challenging, as there is no other clearly defined reference than the strain curve itself. The top of the ECG P wave or the second opening motion of the leaflets in an M-mode across the mitral valve may serve as guidance when there is no clear shoulder in the strain curve visible.

Phasic Strain Calculation

End-diastole (zero by definition), the systolic peak strain and the strain value at the beginning of atrial contraction allow to calculate the deformation of the atrial wall during three phases [Figure 6]:

- **Reservoir Strain (LASr):** It encompasses the time of left ventricular isovolumic contraction, ejection, and isovolumic relaxation and is calculated as the difference of the strain value at the strain curve peak minus end-diastole. This value is always positive.

- **Conduit Strain (LAScd):** Occurs from the time of mitral valve opening through diastasis until the onset of LA contraction in patients in sinus rhythm. In patients with atrial fibrillation it continues until the end of ventricular diastole (mitral valve closure). Consequently, it is calculated in sinus rhythm as difference of the strain value at the onset of atrial contraction minus the peak value of the curve and is always negative. In patients with atrial fibrillation, LAScd has the same value as LASr, but with a negative sign.

- **Contraction Strain (LASc):** Occurs from the onset of LA contraction until end diastole in patients with sinus rhythm and is therefore calculated as difference of the strain value at enddiastole (by definition zero) minus the value at onset of atrial contraction. LASc occurs only in sinus rhythm and has always a negative value.

Clinical Interpretation

LA and LV share the mitral annulus which moves like a piston between the two chambers. Atrial and ventricular global strain curves therefore mirror each other while the ratio of the amplitude values reflects the inverse of the ratio of the respective chamber volumes. This interdependence of atrial and ventricular strain leaves little room for added information beyond what could be obtained from other, classical echocardiographic measurements. The added value of LA strain measurements lies in the fact that they combine information on LV function, LV and LA chamber size as well as other factors in one single parameter. It is therefore not surprising that several studies have shown an added diagnostic or prognostic value of LA strain measurements. Finally, normal values of LA strain have been obtained using software packages developed for the left ventricle and adapted to LA, and mostly using non-dedicated LA views. Whether this reference values are valid for LA strain measurements obtained using dedicated software packages, and what the feasibility and reproducibility of such strain measurements is, remains to be clarified.

Figure Legends

Figure 1A: Left atrial focused 4-chamber view, obtained with narrow image sector (left panel) and a normal image sector (right panel). Note the marked difference in resolution of the grey scale images (upper panels). Speckle tracking such data can lead to marked differences (lower panels).

Figure 1B: Left atrial (LA) focused acquisition (left panel) compared to a standard 4-chamber view (right panel). Note the marked difference in shape and length of the LA. Accordingly, speckle-tracking based strain values obtained from foreshortened are higher than those obtained from the LA focused image.

Figure 1C: Anatomical features that cause uncertainty during the delineation of the left atrium (LA). Left panel, 4-chamber view. Right panel, 2-chamber view. Red arrow – thin, sometimes invisible interatrial septum. Orange arrows – entries of the pulmonary veins. Yellow arrow – atrial appendage.

Figure 1D: The width of the region of interest (ROI) influences tracking results. A ROI which is too wide (right panel) may include strong signals from the surrounding pericardium and result in lower strain values. Correct measurements are achieved if the region is around 3 mm thin and covers only the left atrial myocardium (right panel).

Figure 1E: Atrial strain is measured with an end-diastolic reference (left panel). Some studies use the beginning of atrial contraction as reference (right panel). This, however, leads to lower strain values due to the longer baseline length of the LA myocardial contour, has otherwise no advantages, and is not feasible in patients with atrial fibrillation. Three measurements are done at end-diastole (yellow arrow), peak systole (red arrows) and onset of atrial contraction (orange arrow) in order to calculate reservoir, conduit and atrial contraction strain (see text).

NB: Figures show a pre-release version of a tracking software

Table Legend

Table 1: Step-by-step approach to atrial strain assessment.

References

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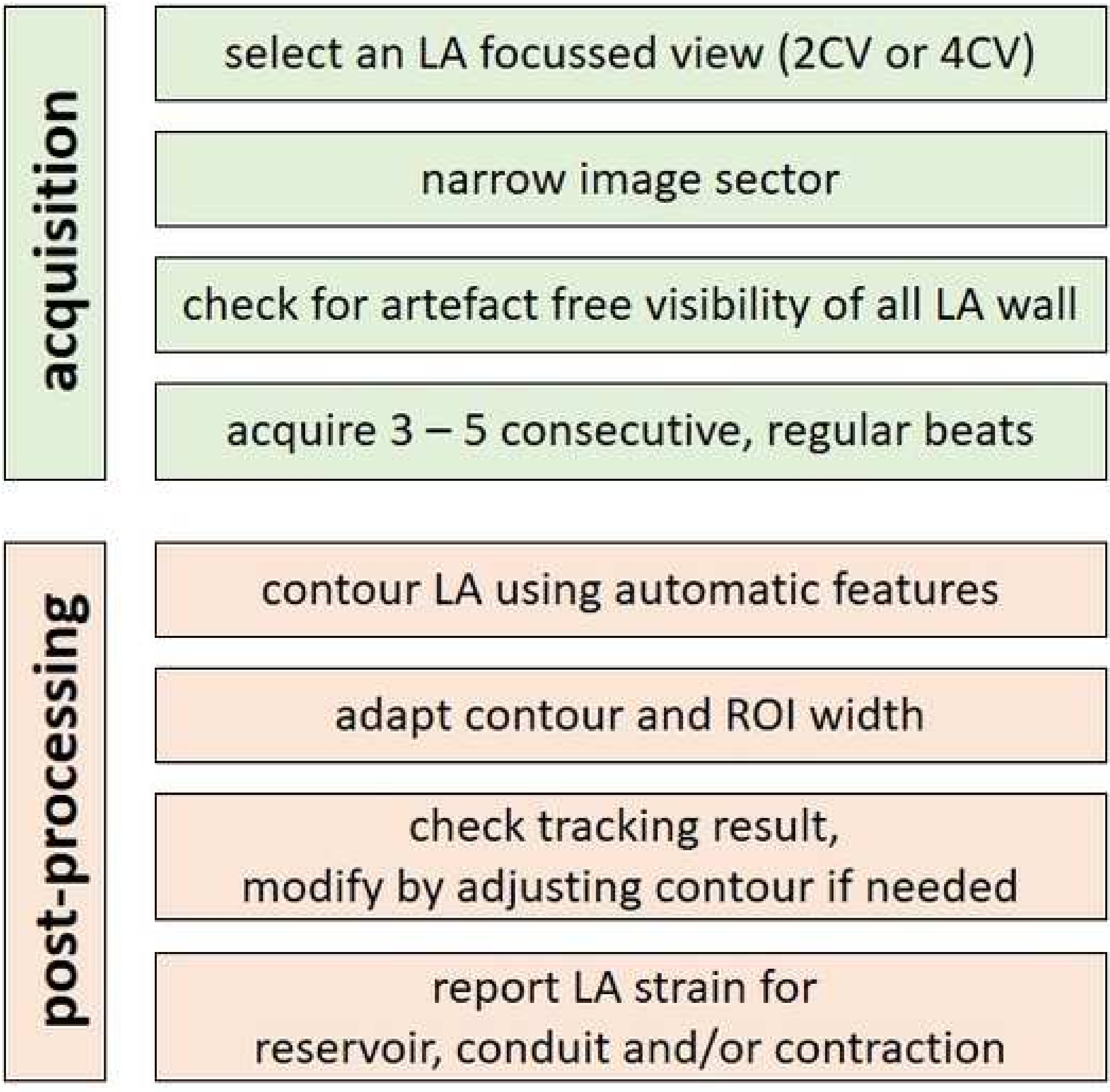
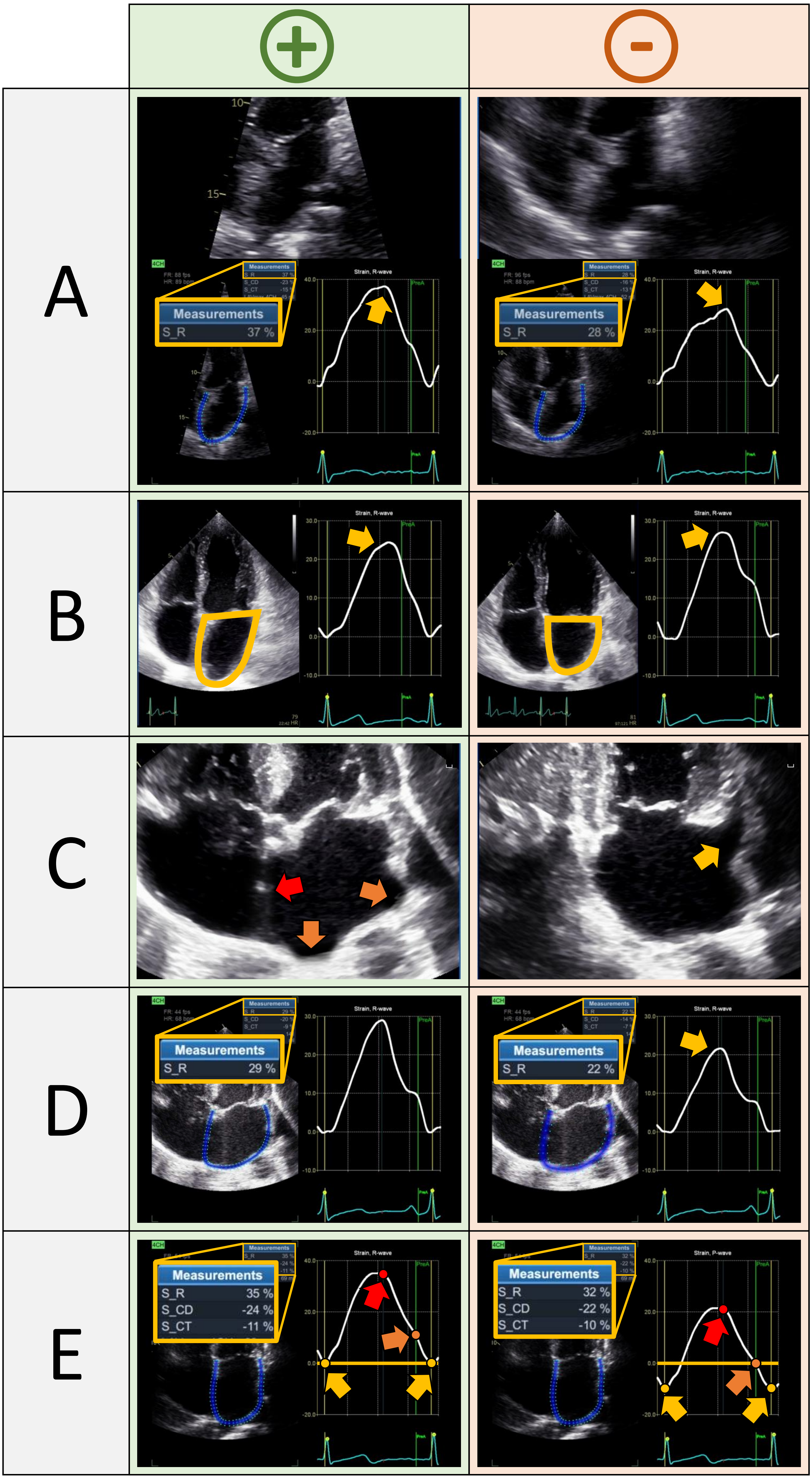
2. Badano LP, Kolias TJ, Muraru D, Abraham TP, Aurigemma G, Edvardsen T, et al. Standardization of left atrial, right ventricular, and right atrial deformation imaging using two-dimensional speckle tracking echocardiography: A consensus document of the EACVI/ASE/Industry Task Force to standardize deformation imaging. Eur Heart J Cardiovasc Imaging. 2018;

Word Count: 1099

Table


acquisition
select an LA focussed view (2CV or 4CV)
narrow image sector
check for artefact free visibility of all LA wall
acquire 3 – 5 consecutive, regular beats
post-processing
contour LA using automatic features
adapt contour and ROI width
check tracking result,
modify by adjusting contour if needed
report LA strain for
reservoir, conduit and/or contraction

Figure



A
B
C
D
E
Measurements
S_R 37 %
Measurements
S_R 28 %
Strain, R-wave
Measurements
S_R 29 %
Measurements
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Measurements
S_R 35 %
S_CD -24 %
S_CT -11 %
Measurements
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Strain, P-wave