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Review

Left atrial strain: A useful index in atrial fibrillation

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ABSTRACT

Left atrial (LA) strain is a speckle tracking echocardiography (STE)-derived parameter applied to the analysis of chamber function that provides highly reproducible measures of LA deformation by a non-Doppler, angle-independent quantification. In recent years, data regarding accuracy and clinical application of LA strain are rapidly increasing.

This review describes the main features of LA strain and examines the role of STE in the evaluation of various aspects of AF, as the risk of developing the arrhythmia in general population, the evaluation of LA fibrosis and LA impairment, the quantification of cardioembolic risk and of recurrence after cardioversion or ablation therapies.

1. Background

Atrial fibrillation (AF) represents the most common cardiac arrhythmia, affecting up to the 2% of the population [1]. It has an enormous clinical impact: studies show how these patients are characterized by elevated rates of strokes [2], other thromboembolic events [3], left ventricular dysfunction and heart failure (HF) [4,5], a low quality of life and death [6,7].

Every patient with a new diagnosis of AF, and periodically during followup, should undergo a transthoracic echocardiography (TTE) [8,9] in which particular attention must be paid to the assessment of left atrial (LA) structure and sizes, valvular anatomy and function, left ventricular systolic and diastolic condition. Speckle tracking echocardiography (STE) could currently represent an important surplus value in addition to the evaluation of LA volume.

2. Speckle tracking echocardiography: left atrial strain

Speckle tracking echocardiography (STE) represents a non-Doppler-based method for an objective quantification of myocardial deformation, derived from standard bi-dimensional (2D) data acquisitions. During years, it has demonstrated significant feasibility and reproducibility [10–13]. STE shows several advantages in contrast to classic Doppler-derived indexes, thanks to its angle-independence and lower reverberation effects, side lobes and drop-out artifacts. Originally, STE was developed to study ventricular function but it has been extensively used also to evaluate atrial chambers function in recent years: [14] atrial longitudinal strain in particular, is an excellent parameter for analysis of LA function in several conditions between which atrial fibrillation (AF) indeed. Also the new EACVI/EHRA Expert Consensus Document for the evaluation of patients with AF, indicates STE and LA strain as very promising tools in this setting [15].

2.1. Strain measurement

Two-dimensional STE is a technique that uses standard B-mode images for speckle tracking analysis. The speckle pattern (acoustic backscatter generated by the reflected ultrasound beam) is followed frame-by-frame, identifying the best matching area by statistical approach. The displacement of the analyzed pattern is considered to follow myocardial movement and every change between speckles is evaluated as a myocardial deformation [16].

LA apical 4- and 2-chamber views images are got using conventional 2D gray scale echocardiography, during a brief breath hold and with a stable ECG recording. Typically, three consecutive heart cycles are recorded and averaged but in patients with AF is required an averaged measurement of almost five consecutive beats. The recommended frame rate is set between 60 and 80 frames per second [10]. Recordings are then processed using a specific acoustic-tracking software, allowing off-line semi-automated analysis of speckle-based strain.

During the processing, LA endocardium surface is manually traced in both 2- and 4-chamber views by a point-and-click approach. The epicardial surface tracing is automatically generated by the system in order to obtain a region of interest (ROI). The ROI can be manually adjusted in width and shape then the software divides it into 6 segments and the resulting tracking quality for each segment is automatically

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scored as either acceptable or non-acceptable, with the possibility of further additional corrections. Segments in which no adequate image quality can be obtained, are rejected by the software and automatically excluded from the analysis. If the patient has adequate image quality, a total of 12 segments are then analyzed [10], and for each of these segments, the software gives the longitudinal strain curves as well as a mean curve of all segments that reflects the pathophysiology of LA function.

2.2. Left atrial strain curves

During atrial reservoir phase, LA fills and stretches so its strain curve increases, reaching a positive peak at the end of atrial filling, before the opening of the mitral valve. After mitral opening, LA empties quickly, its volume reduces so the strain initially decreases, up to a plateau corresponding to the phase of diastasis. In patients that are in sinus rhythm, normally the plateau is followed by a second positive peak, smaller than the first, which corresponds to the period preceding atrial contraction and finally by a negative peak after the atrial contraction [10].

In AF, peak atrial longitudinal strain (PALS), measured at the end of reservoir phase, is the most important strain parameter since this phase depends essentially on atrial compliance; PALS values, obtained for each segment in four- and two-chamber views, are averaged (four- and two-chamber average PALS, Fig. 1). Peak atrial contraction strain (PACS) is measured, only in sinus rhythm, just before the start of active atrial contractile phase (Fig. 2).

3. Atrial strain in atrial fibrillation patients

3.1. Assessment of atrial remodeling

Given the great epidemiological, clinical and economic role covered by AF, it is important to identify echocardiographic parameters that, detecting prematurely an alteration in atrial structure and function, could predict AF onset.

LA enlargement was originally studied for this purpose: a bigger atrial volume is associated with a higher risk of AF in older patients [18]. In particular, between minimum (at mitral valve closure) and maximum LA volume (just before mitral valve opening), the first was an independent predictor of AF; [19] these studies, however, showed high variability between operators and a predictive capacity no more than moderate. In adults without a history of atrial arrhythmia, it seems that PACS could represent the best parameter, with great sensibility and specificity: a reduction LA booster function is due to structural remodeling and therefore it can prove the initial adverse process towards AF development [20].

Typical of AF is an important LA remodeling. Reactive deposition of collagen fibers in the interstitium causes massive fibrosis [21], with consequent alterations in normal conduction [22,23]. Moreover, fibrosis tents to increase progressively, favoring conversion to a permanent form. Prevention of atrial fibroblastic remodeling is fundamental; identification of an advanced stage of fibrosis can guide a specific and focused therapeutic strategy [24]. Cardiac magnetic resonance (CMR) with Gadolinium represents an important tool in atrial fibrosis

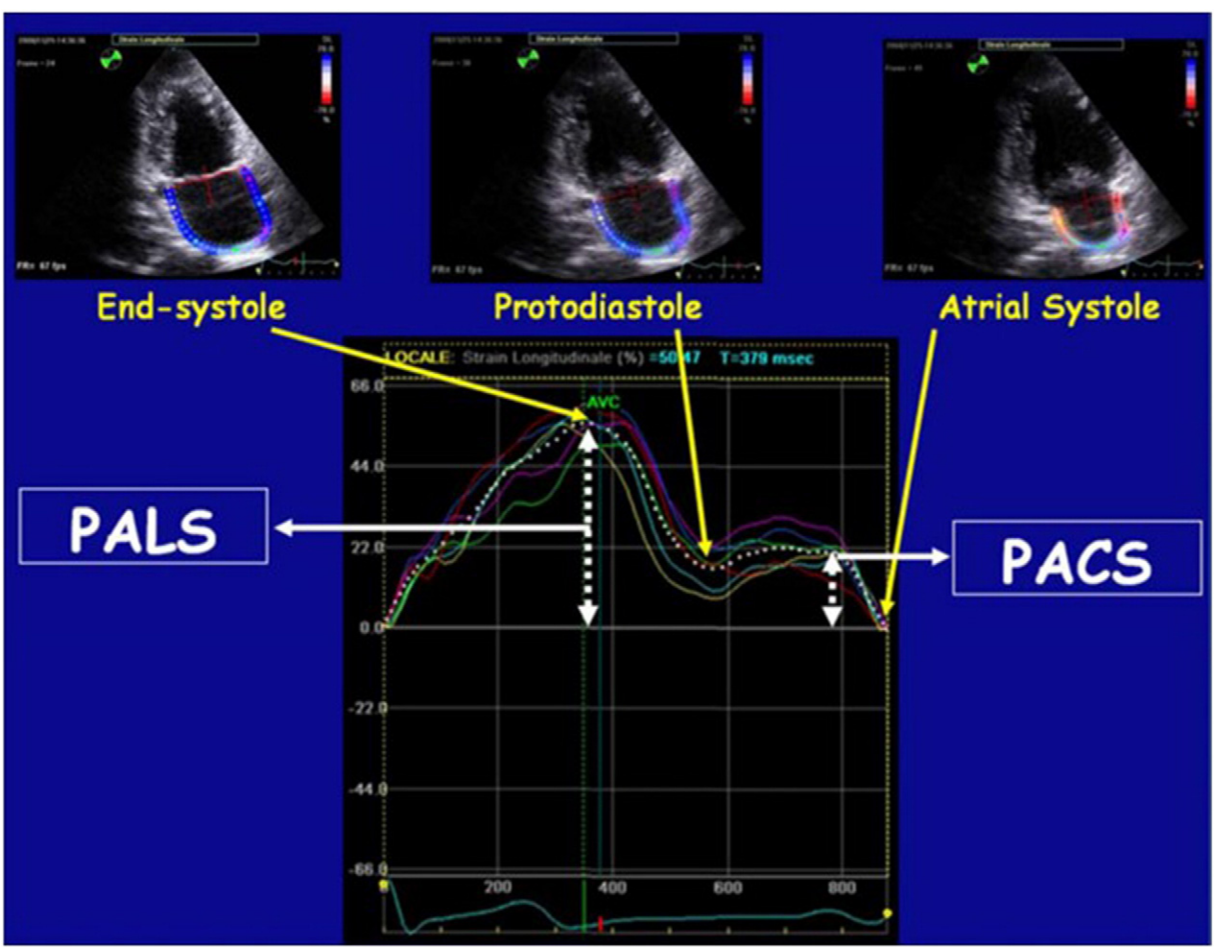

Fig. 1. Left atrial strain. Measurement of peak atrial longitudinal strain (PALS) at the end of reservoir phase and peak atrial contraction strain (PACS) before the start of atrial systole. The dashed curve represents the average atrial longitudinal strain during the cardiac cycle [14].