My Approach to Assessing Right Ventricular Strain

Como Fazer a Avaliação do Strain do Ventrículo Direito

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Right ventricular (RV) systolic dysfunction is an independent predictor of morbidity and mortality in patients with pulmonary hypertension,[1] heart failure,[2] and coronary artery disease.[3] For this reason, RV function analyses are extremely important in clinical practice.

Echocardiography is an accessible, noninvasive, and fast method that enables accurate analyses of RV function. Despite the limitations related to the complex geometry of this cavity, new parameters have emerged in this context to improve the diagnostic accuracy.

Tricuspid annular plane systolic excursion and tricuspid lateral annular systolic excursion velocity are routinely used to evaluate RV systolic function due to their simplicity, reproducibility, and prognostic value in populations with heart failure and other cardiovascular diseases. However, these methods have limitations as they vary with pressure and volumetric load, can evaluate only a single RV segment (not consider regional function differences), and are angle-dependent.[4] Other analysis techniques, including fraction area shortening (FAS) and the Tei index, have prognostic value established in the literature. However, the FAS has low interobserver reproducibility, while the Tei index cannot be used in cases of increased right atrial pressure.[4]

RV strain overcomes some of these limitations. Two-dimensional systolic longitudinal deformation, calculated using speckle tracking echocardiography, has emerged as a viable and reproducible measure of RV systolic function. RV strain can be used to evaluate contractile function that corrects translation errors, being less dependent on the angle of the image plane.[5] Several studies in the literature have used it for determining both diagnosis and prognosis, especially in patients with heart failure,[6-8] pulmonary hypertension,[9-12] ischemic heart disease,[13] infiltrative heart diseases,[14,15] and heart valve diseases.[16,17]

Two-dimensional RV strain analysis requires an apical four-chamber window toward the RV that optimizes gain and depth with high frame rates (40–80 frames/s) and at least three heart beats. Patients should preferably be in apnea and have good electrocardiogram tracing.[18]

Keywords

Echocardiography; Strain; Ventricular Dysfunction, Right.

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The apical window toward the RV is obtained by lateral displacement of the transducer from the conventional apical position via transducer rotation (Figure 1A) to position the apex of the left ventricle (LV) in the center of the sector (avoiding its shortening) and simultaneously display the largest basal diameter, long axis, and entire RV free wall (Figure 1B).

Genovese et al. demonstrated that RV strain parameters determined in a directed apical four-chamber window were more reproducible than those identified in the conventional apical four-chamber window, reinforcing its use in clinical practice.[19]

The software used to measure the RV strain was originally created to evaluate the LV systolic function, being later adapted for the RV. Some companies are currently developing specific software for offline analysis on a workstation.

Similarly, to the LV, the RV region of interest (ROI) is defined by the endocardial borders (internal myocardial contour) and the epicardial borders (external myocardial contour) or, in the case of interventricular septum involvement, the left endocardial contour of the septum. The tracing must be started by marking the lateral tricuspid ring, medial ring, and apex. The ROI is generated automatically after these markings are made and can be adjusted by the examiner. The user must observe whether the ROI movement follows the wall movement. Inclusion of the pericardium and reference points below the tricuspid ring or inside the right atrium should be avoided because it will result in underestimation of the strain values.[5,20] Due to the thin wall of the RV, it is recommended that the ROI have a standard width of 5 mm.[20] In addition to observing the tracking of the points to verify their quality, the derived curves must be analyzed (Figure 2).

Most studies evaluating RV strain used longitudinal strain defined as strain in the direction tangential to the RV endocardial border in the apical window. The RV radial strain is inaccurate due to its thin wall, so its use is not recommended in the literature.[20]

RV strain calculation can analyze the six segments, including the interventricular septum, obtain the global longitudinal strain (GLS-RV) or an arithmetic mean of the strain values of the three segments of the free wall (basal, medium, and apical segments), and obtain the RV free wall longitudinal strain (FWLS-RV). The absolute GLS-RV values are lower than the FWS-RV values.[21,22] The interventricular septum is mainly composed of LV fibers, although it also improves RV systolic performance to a lesser extent.[21] In this sense, most studies showed a more robust FWS-RV prognostic value.[23,24] The literature recommends the use of this method to improve standardization, although the GLS may also be an option.[20] Because the two methods

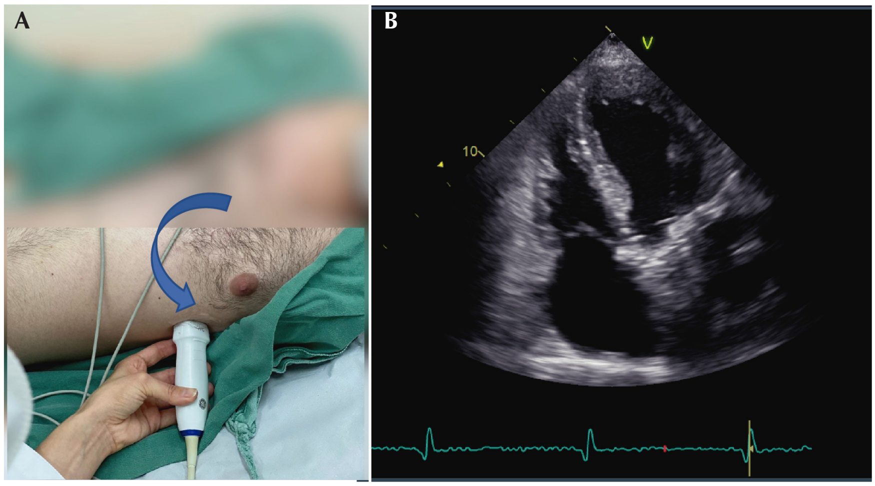

Figure 1 – *(A) Lateral displacement of the transducer from the conventional apical position. (B) Sample apical window image taken toward the right ventricle (including the largest basal diameter, long axis, and entire right ventricle free wall).*

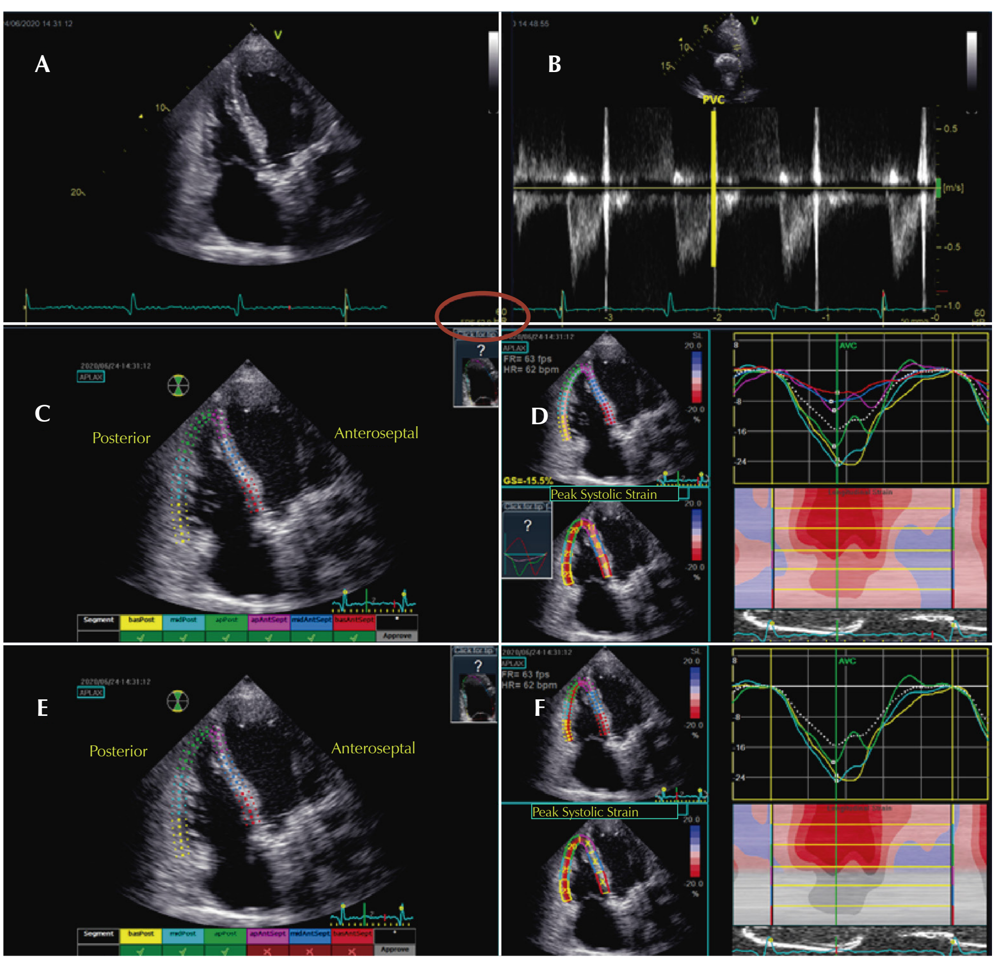

Figure 2 – *The first step in obtaining the right ventricular strain is acquiring a directed apical image (A) with an adequate frame rate (red ovoid) and marking the pulmonary valve closure time (B). Subsequently, points are marked on the septal and lateral tricuspid ring as well as on the right ventricle apex to observe the appropriate size of the region of interest and if the ventricular movement is being monitored, indicating adequate tracking (C, D). Finally, the septal curves are excluded to analyze only the global longitudinal strain of the free wall (E, F).*

achieve different results, it is necessary to specify the parameter used in the report. Even when the objective is to obtain only the FWS-RV, it is recommended that all six segments be initially tracked (free wall and interventricular septum) because the algorithms recognize the true RV apical segment better with this procedure.[5]

As with the calculation of LV strain, RV strain curves can generate four values, although only the peak systolic strain (that is, the highest deformation value during systole) has been studied and recommended. To adjust the cardiac cycle, it is assumed that the final diastole must be defined by tricuspid valve closure and the final systole by pulmonary valve closure, and both are obtained by Doppler tracing of these valves.[20]

Reference values vary among devices and software packages.[4] A systematic review published by Fine et al.[25] of healthy patients without cardiopulmonary disease reported normal FWS-RV values estimated at -27% ± 2% (95% confidence interval , 24–29%).[25] Muraru et al.[21] reported values of -29.3 ± 3.4% (lower limit of normal, -22.5%) for men and -31.6 ± 4.0% (lower limit of normal, -23.3%) for women. The same study reported GLS-RV values within the normal range as -24.7 ± 2.6% (lower limit of normal, -20.0%) for men and -26.7 ± 3.1% (lower limit of normal, -20.3%) for women.[21] The studies used devices created by the same manufacturer (General Electric). A recent study of 1,457 healthy volunteers analyzed 1,143 patients using EchoPAC software (GE) and reported FWS-RV values of -28.5 ± 4.8% (lower limit of normal, -20.2%) and GLS-RV values of -22.3 ± 2.4% (lower limit of normal, -17.4%). In contrast, 186 patients were evaluated using Syngo VVI software (Siemens), with FWS-RV values of -21.7 ± 4.2% (lower limit of normal, -13.4%) and GLS-RV values of -20.4 ± 3.2% (lower limit of normal, -14.1%).[26] The American Society of Echocardiography guideline for cardiac chamber quantification published in 2015 suggests that absolute FWS-RV values below 20% are probably abnormal. However, it also states that further large studies using equipment from various manufacturers are needed to obtain definitive reference values.[4]

Few studies in the literature have compared RV longitudinal strain values between manufactures, which could be a limitation. However, some studies[2,27] reported low inter- and intraobserver variation using equipment from the same manufacturer, which indicates good reliability.[28]

Park et al.[29] compared RV longitudinal strain analyzed by GE and Siemens software and reported lower intraobserver variability with the former and similar interobserver variation with both.[29]

Finally, it is worth mentioning that RV strain plays an important role in clinical practice. However, the method has some limitations requiring consideration because the software used was originally created to evaluate the LV and was later adapted for the RV. However, the RV has a more complex anatomy than the LV. RV-specific software has been developed and recently used to overcome this limitation.[28] Good image quality is essential to improving point tracking. Small random errors in point detection, as in limited acoustic windows, can lead to inaccurate results and greater inter- and intraobserver variability. Thus, this method may not be applicable in patients who are obese or have pulmonary disease.[30] An RV evaluation is performed in only one window (apical four-chamber), whereas an LV evaluation is performed through three windows (apical four-, two-, and three-chamber), a fact that limits the analysis of part of the RV walls and, therefore, of their systolic function. Unlike the LV, for which comparative studies have been performed of equipment created by different manufacturers,[31] RV strain requires additional studies on this subject to enable comparisons among brands. Due to technical difficulties correctly evaluating RV strain, its use should be restricted to trained and experienced echocardiographers unlike LV strain, which can be performed by less experienced professionals due to less interference in the result. Learning curve studies have reported that at least 100 FWS-RV analysis studies must be performed for a beginner to reach the skill level of a specialist.[26,32]

Perspectives include RV strain performed by the three-dimensional method, which can be an interesting tool that provides data on the longitudinal, circumferential, and radial functions of this cavity.[33] However, it also has its limitations. The strain technique is based on the point tracking analysis. Therefore, high temporal resolution, good image quality, and a regular heart rate are essential to its feasibility. However, one of the main limitations of the three-dimensional method is its relatively low temporal resolution. In addition, additional studies on protocols and reference values are needed to standardize this method.[28] Thus, such facts reduce its use in clinical practice today.

Authors' contributions

Manuscript writing: PMM and TCG; critical review of the manuscript for important intellectual content: BRBM and BD.

Conflict of interest

The authors have declared that they have no conflict of interest.

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