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2D-speckle tracking right ventricular strain to assess right ventricular systolic function in systolic heart failure. Analysis of the right ventricular free and posterolateral walls

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ABSTRACT

Background: Right ventricular (RV) systolic function is a powerful prognostic factor in patients with systolic heart failure. The accurate estimation of RV function remains difficult. The aim of the study was to determine the diagnostic accuracy of 2D-speckle tracking RV strain in patients with systolic heart failure, analyzing both free and posterolateral walls.
Methods: Seventy-six patients with dilated cardiopathy (left ventricular end-diastolic volume ≥ 75 ml/m^2) and left ventricular ejection fraction ≤ 45% had an analysis of the RV strain. Feasibility, reproducibility and diagnostic accuracy of RV strain were analyzed and compared to other echocardiographic parameters of RV function. RV dysfunction was defined as a RV ejection fraction ≤ 40% measured by radionuclide angiography.
Results: RV strain feasibility was 93.9% for the free-wall and 79.8% for the posterolateral wall. RV strain reproducibility was good (intra-observer and inter-observer bias and limits of agreement of 0.16 ± 1.2% [−2.2–2.5] and 0.84 ± 2.4 [−5.5–3.8], respectively). Patients with left heart failure have a RV systolic dysfunction that can be unmasked by advanced echocardiographic imaging: mean RV strain was −21 ± 5.7% in patients without RV dysfunction and −15.8 ± 5.1% in patients with RV dysfunction (p = 0.0001). Mean RV strain showed the highest diagnostic accuracy to predict depressed RVEF (area under the curve (AUC) 0.75) with moderate sensitivity (60.5%) but high specificity (87.5%) using a cutoff value of −16%.
Conclusions: RV strain seems to be a promising and more efficient measure than previous RV echocardiographic parameters for the diagnosis of RV systolic dysfunction.

1. Introduction

In patients with left ventricular systolic dysfunction (LVSD), risk stratification is mandatory in order to select patients for whom heart transplantation or left ventricular assist device implantation is required. Right ventricular ejection fraction (RVEF) is a powerful independent prognostic factor in patients with moderate to severe heart failure [1,2]. Hence, evaluation of right ventricular (RV) structure and function is an essential component of clinical management. Although there have been significant improvements in cardiac imaging, the assessment of RV function is still a challenge. The complex geometry of the right ventricle, the limited definition of its endocardial surface caused by the trabeculated myocardium and its retrosternal position that limits echocardiographic windows lead to multiply parameters to assess RV function. Speckle tracking, a new angle-independent echocardiographic approach, has recently been extended for the analysis of RV function. This technique provides an objective quantification of global and segmental RV longitudinal strain [3,4]. We hypothesized that global functional indices are more effective to diagnose RV dysfunction than segmental parameters. We wondered if taking into account two right

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ventricular walls by averaging posterolateral wall strain in addition to the usual free wall strain could be of interest. The aim of the study was to evaluate the diagnostic accuracy of 2D-speckle tracking mean RV strain in patients with LVSD in comparison to RV assessment with radionuclide angiography. The secondary objective was to compare mean RV strain to classic RV echographic parameters assessing RV function.

2. Methods

2.1. Study population

From 2013 to 2014, we included 76 consecutive patients with stable dilated cardiopathy defined as a left ventricular end-diastolic volume (LVEDV) ≥ 75 ml/m^2 associated with a left ventricular ejection fraction (LVEF) ≤ 45%, receiving optimal medical therapy, hospitalized for prognostic assessment at the Cardiologic Hospital of Lille, France.

2.2. Echocardiography

Echocardiography was performed with a Vivid E9 (GE, Medical System) with the determination of standard and Doppler parameters according to recommendations of the American Society of Echocardiography [5]. TAPSE, tricuspid S wave, RV fractional area change (RVFAC), myocardial performance index (MPI) and isovolumic acceleration (IVA) were measured for RV function assessment. The pulsed tissue Doppler method was used for MPI measurement. For speckle tracking analysis of right chamber, images were obtained using conventional two-dimensional gray-scale echocardiography, storing the images for off-line semi-automated analysis of speckle-based strain (EchoPAC V12.0.0 GE Medical System). The frame rate ranged from 50 to 60 Hz. We analyzed the free wall RV strain using an apical four-chamber view centered on the right ventricle. The RV posterolateral wall imaging was obtained from an apical 2 chambers view after tilting the probe towards the RV inlet chamber. We obtained the apical coronary sinus view defined by the American Society of Echocardiography [6] that allowed us to study the RV posterolateral wall. Right ventricular strain was derived by a manually delineation of the endocardial border of the myocardial wall, obtaining a region of interest, divided into three segments (basal, mid and apical). The software generated strain curves for each segment and allowed to calculate mean RV strain (Fig. 1). We took into account the strain systolic peak for each RV segment. Mean RV strain was assessed by taking average of the three free-wall segments and the three posterolateral wall segments. In patients in whom some segments were excluded because it was not possible to achieve adequate tracking, RV strain was calculated by averaging values measured in the remaining segments.

2.3. Right ventricular function assessment

Equilibrium radionuclide angiography was performed in the supine position with a Symbia S camera (Siemens, 2012) after the injection of technetium-99 m. Radionuclide RVEF was considered as the gold standard for the assessment of RV dysfunction. Two subgroups of patients were defined according to radionuclide RVEF (≤ or >40%). Radionuclide angiography and echocardiography were performed during the same hospitalization so that time lag did not exceed two days.

2.4. Statistical analysis

Continuous variables are expressed as mean ± standard deviation. Categorical variables are presented as absolute numbers and percentages. Groups are compared using Student's *t*-test, and Chi-2 test or Fisher's exact tests were used as appropriate for categorical variables. Pearson correlation coefficients were calculated to assess the relations among continuous variables. To evaluate the diagnostic accuracy of the echocardiographic indexes, receiver operating characteristic curves were built. To assess the reproducibility of strain, 30 patients were randomly selected and Bland-Altman analysis was performed to evaluate the intra- and inter-observer agreements by repeating the analysis by the same observer and a second independent observer. A p value <0.05 was considered statistically significant. Analyses were performed using GraphPad Prism 6.0d software.

3. Results

3.1. Patients

Clinical characteristics of the 76 patients are summarized in Table 1. The mean age was 54 ± 10 years old. Seventy-two percent of the study population were carrying an implantable cardioverter defibrillator (ICD) (36% of single-chamber, 33% of dual-chamber and 31% of biventricular). Twenty-eight percent of ICD were implanted as a secondary prevention of sudden cardiac death. The mean LVEF was 30 ± 8%. Most of the patients were in functional class NYHA 2. Seventy-three patients (96%) had a β blocker treatment (bisoprolol (74%): mean dosage 8.8 ± 2.3 mg/day, nebivolol (11%): mean dosage 9.1 ± 2.0 mg/day, carvedilol (10%): mean dosage 61.6 ± 29.4 mg/day). Seventy-five patients (99%) received an angiotensin-converting enzyme inhibitor (ramipril (56%): mean dosage 9.2 ± 1.8 mg/day, perindopril (28%): mean dosage 8.9 ± 2.0 mg/day) or an angiotensin II-receptor blocker (candesartan (13%): mean dosage 20.4 ± 11.4 mg/day). Fifty-six patients (74%) received mineralo-corticoid receptor antagonists (spironolactone (59%): mean dosage 33.1 ± 14.9 mg/day, eplerenone (41%): mean dosage 35.9 ± 12.7 mg/day). The mean radionuclide RVEF was 38 ± 10%. We defined two subgroups of patients: 33 patients (43%) had a normal RV function defined by a RVEF > 40% and 43 patients (57%) had a RV dysfunction with a RVEF ≤ 40%. There were no significant

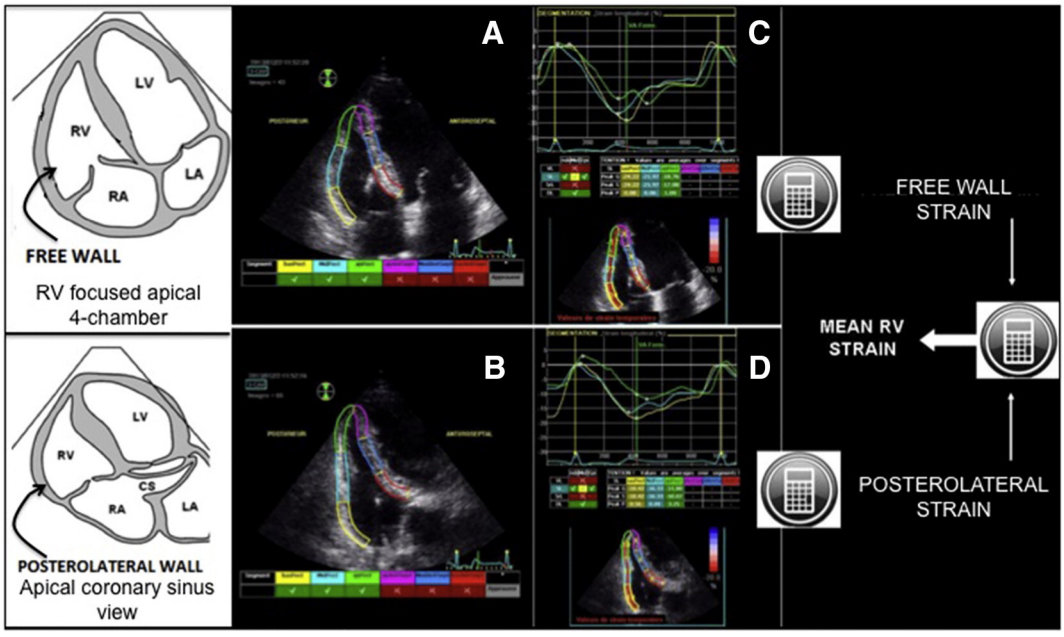

Fig. 1. Calculation of mean RV strain. Storage of a RV focused apical 4-chamber view and an apical coronary sinus view as defined by the ASE guidelines [6]. Off-line analysis by tracking of a 6-segment region of interest with manually exclusion of the septal segments for RV free wall (A) and RV posterolateral wall (B). The software generated strain curves for RV free wall (C) and RV posterolateral wall (D). Mean RV strain was calculated manually by averaging strains from free wall segments and posterolateral wall segments.

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