Folia Cardiologica 2023
vol. 18, no. 1, pages 10–15
DOI: 10.5603/FC.a2022.0065

ISSN 2353–7752
e-ISSN 2353–7760

The assessment of right atrial function with the use of speckle tracking echocardiography

Ocena funkcji prawego przedsionka za pomocą echokardiografii metodą śledzenia markerów akustycznych

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Abstract

Introduction. Speckle tracking echocardiography (STE) is a well-established tool to assess cardiac function parameters, however, the value of this tool in the assessment of right atrial (RA) function is still largely unknown. The aim of the study is to investigate the feasibility of RA function assessment by STE and the relationship between right ventricular (RV) deformation and the function of the RA.

Material and methods. 94 patients with various cardiovascular pathologies have been included in the study group. All patients underwent transthoracic echocardiography with subsequent off-line analysis using speckle tracking technique and measurement of numerous RA deformation parameters, including peak atrial longitudinal strain (PALS) and peak atrial contraction strain (PACS), as well as established indices of RV function, such as tricuspid annular peak systolic excursion (TAPSE) and global longitudinal strain (GLS).

Results. RA function assessment by STE was feasible in all patients. A statistically significant correlation was observed between RA strain (PACS and PALS) and RV parameters. RV-GLS showed weak correlation with PALS ($r = -0.38$; $p = 0.0015$) and PACS ($r = -0.30$; $p = 0.013$). Similarly, TAPSE correlated with PALS and PACS ($r = 0.34$; $p = 0.02$) and ($r = 0.23$; $p = 0.04$) respectively.

Conclusion. RA function assessment by STE is feasible. The RA deformation parameters weakly correlate with RV function indices, indicating that other factors significantly influence RA function. Therefore, the RA function cannot be regarded as a direct barometer of the RV function.

Key words: right atrium, right ventricle, speckle tracking echocardiography

Folia Cardiologica 2023; 18, 1: 10–15

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Introduction

Speckle tracking echocardiography (STE) has become a widely recognized tool to assess cardiac function and gather both prognostic and predictive information [1]. The software used to evaluate echocardiographic images was initially designed to evaluate left ventricular function, but its use in assessing the function of other cardiac chambers has become increasingly more common and well-established [2].

From a physiologic point of view, the right atrial (RA) has proven to have an impact on overall right ventricle (RV) performance and *vice versa* [3]. In a single-centre study, RA strain has proven to be significantly impaired in patients with pulmonary arterial hypertension (PAH) [4] being independently associated with systolic pulmonary arterial pressure (SPAP) and showing high sensitivity and specificity in predicting an increased SPAP [5]. Moreover, peak atrial contraction strain (PACS) and peak atrial longitudinal strain (PALS) showed significant association with RV global longitudinal strain (GLS) of the free wall (RV GLS FW) [6]. Right atrium strain is also prognostic for hospitalizations and mortality [7–10]. In this study population, it was aimed to investigate the feasibility of RA function assessment by STE and the relationship between RV function and its impact on the RA parameters.

Materials and methods

Study population

The present retrospective study included 94 patients (60 male, mean age 61.9 ± 14.4 years) with good echocardiographic image quality and various cardiac pathologies: hypertension (12), ischaemic heart disease (37), and valvular heart disease (50). Patients suffering from atrial fibrillation were excluded.

Echocardiography

The patients underwent transthoracic echocardiography and the echocardiographic images were analysed offline using EchoPac Software (GE Healthcare, Chicago, IL, USA). Apical 4-chamber view images were used to estimate the RV end-systolic area (RV ESA) and the RV end-diastolic area in order to calculate RV fractional area change (RV FAC). The RV inflow tract was measured just below the tricuspid valve between RV free wall and interventricular septum. Tricuspid annular plane systolic excursion (TAPSE) was assessed using M-mode, measuring the distance of tricuspid annular movement between end-diastole and end-systole. Peak systolic annular excursion (S') was assessed by tissue Doppler imaging.

Speckle tracking echocardiography

For STE assessment was used the QRS method and the apical 4-chamber view. The region of interest (ROI) was defined as the area between the inner endocardial border (inner contour of RA/RV) wall and the outer epicardial border (outer contour of RA/RV) and if needed manually adjusted. If more than 1/3 of the ROI was missing the image was rejected [11]. Once the ROI was fully adjusted, the software generated longitudinal strain curves for each segment. RA strain was assessed using peak atrial longitudinal strain (PALS) and peak atrial contraction strain (PACS). PALS was measured at the end of the RA reservoir phase. PACS was measured just before the start of the active contractile phase of the atrium [11]. Global PALS and PACS (Figure 1) are averages of all segments. In the RV was assessed global longitudinal strain (RV GLS) as the peak systolic strain of all tracked segments. Moreover, RV GLS FW was measured based on the 3 segments of the free wall. If image assessment was not possible due to image quality, affected images and measurements were excluded.

Statistical methods

Continuous variables were initially tested for normality of data distribution by the Kolmogorov-Smirnow test. Normally distributed variables are expressed as mean ± standard deviation. Categorical variables are presented as percentages (%). Regression and correlation analysis was used to assess the relationship between RA and RV parameters (MedCalc Software, Frank Schoonjans, Belgium).

Results

Table 1 summarises the mean values and standard deviations of echocardiographic parameters in the study group.

Tables 2 and 3 present the relationship between RA functional parameters (PALS and PACS) and right ventricular parameters, whereas Tables 4 and 5 presen t the relationship between PALS and RA size. PALS showed a negative correlation with RA size expressed as ESA ($r = -0.42$; 95% CI: –0.59/–0.22; $p = 0.0001$) and RA end-systolic volume ($r = -0.41$; 95% CI: –0.58/–0.22; $p = 0.0001$). Also, PACS correlated with RA size expressed as ESA ($r = -0.32$; 95% CI: –0.51/–0.11; $p = 0.004$) and RA end-systolic volume ($r = -0.35$; 95% CI: –0.53/–0.14; $p = 0.002$).

We also found significant, yet weak, correlations between RA functional parameters (PALS and PACS, respectively) and RV parameters. PALS correlated with RV GLS ($r = -0.38$; 95% CI: –0.57/–0.15; $p = 0.0015$), TAPSE ($r = 0.34$; 95% CI: 0.13/0.52; $p = 0.002$) and RV GLS FW ($r = -0.35$; 95% CI: –0.56/–0.09; $p = 0.0095$).

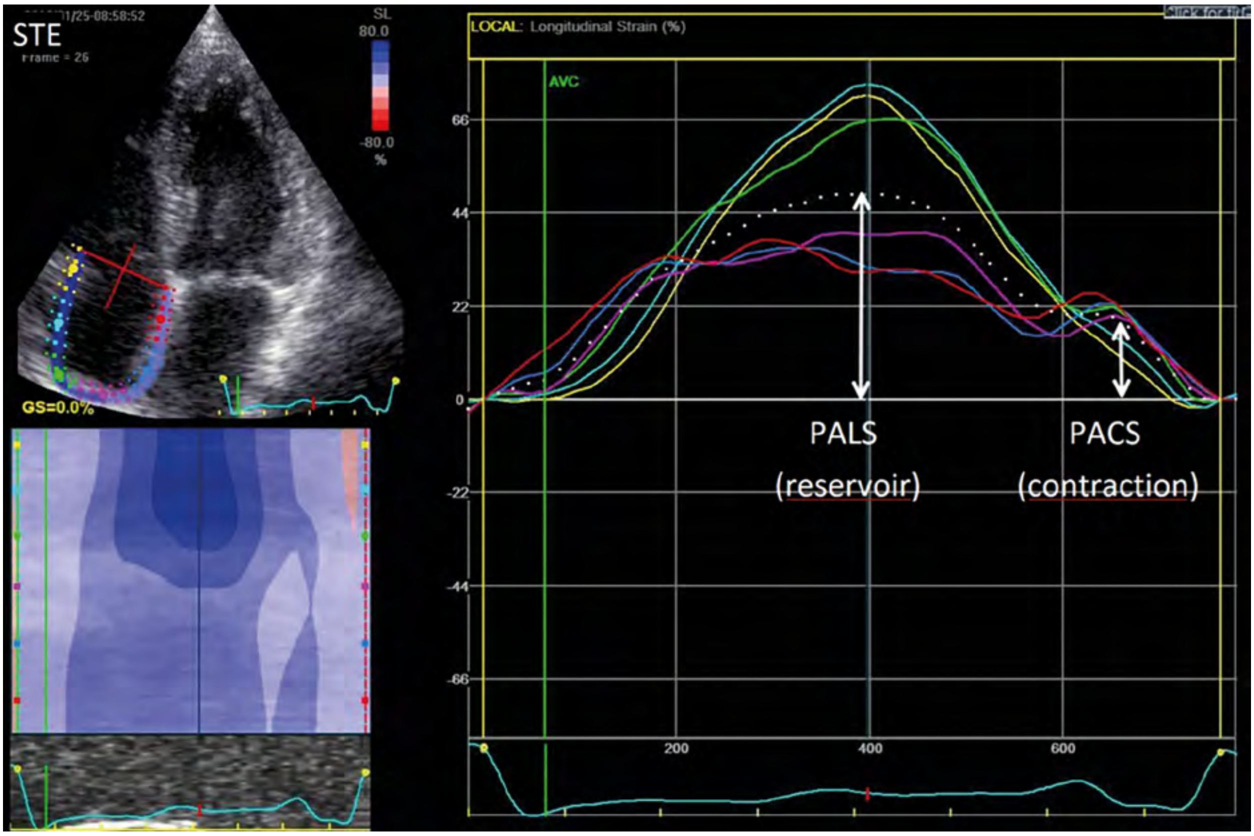

Figure 1. Speckle tracking assessment of the right atrium with measurement of PALS and PACS; PACS — peak atrial contraction strain; PALS — peak atrial longitudinal strain; STE — speckle tracking echocardiography

Table 1. The mean values and standard deviations of measured echocardiographic parameters

Parameter	Mean	SD
PALS (%)	30.8	12.7
PACS (%)	14.8	6.9
RA Ø (cm)	3.5	0.6
RA ESV (mL)	34.5	20.4
GLS (%)	–17.8	6
TAPSE (cm)	21.7	4.9
RVITD (cm)	3.5	0.6
S' (m/s)	11.4	2.7

ESV — right atrial end-systolic volume; GLS — global longitudinal strain; PACS — peak atrial contraction strain; PALS — peak atrial longitudinal strain; RA Ø — right atrial diameter; RVITD — right ventricular inflow tract diameter; S' — peak systolic annular velocity; SD — standard deviation; TAPSE — tricuspid annular plane systolic excursion

Table 2. Correlation coefficients between peak atrial longitudinal strain and RV parameters

Parameter	R	95% CI	p
RV GLS	–0.38	–0.57/–0.15	0.0015
RV FAC	0.21	–0.2/0.43	0.08
TAPSE	0.34	0.13/0.52	0.002
S'	0.08	–0.15/0.31	0.46
RV GLS FW	–0.35	–0,56/0.09	0,0095
RVITD	0.08	–0.15/0.31	0.48

CI — confidence interval; FAC — functional area change; FW — free wall; GLS — global longitudinal strain; RV — right ventricular; RVITD — right ventricular inflow tract diameter; S' — peak systolic annular velocity; TAPSE — tricuspid annular plane systolic excursion

PACS significantly correlated with RV GLS (r = –0.3; 95% CI: –0.51/–0.07; p = 0.013) and TAPSE (r = 0.34; 95% CI: –0.01/0.4; p = 0.04). Neither PALS nor PACS showed significant associations with RV size (r = –0.03; 95% CI: –0.21/0.27; p = 0.78) and (r = –0.005; 95% CI: –0.24/0.23; p = 0.96), respectively.

The analysis of subgroups disclosed a mean PALS of 37.25 ± 11.01% for healthy individuals and 29.92 ± ± 12.69% for patients suffering from cardiovascular pathologies. Stronger correlations between PALS and RV GLS were noted in the patients' group (r = –0,37; 95% CI: –0.57/–0.12); p = 0.005; n = 68) than in the healthy subjects group (r = –0.3; 95% CI: –0.78/0.4; p = 0.39; n = 10). However, this may be a result of a small subgroup of healthy subjects. Independent sample t-test yielded

Table 3. Correlation coefficients between peak atrial contraction strain and RV parameters

Parameter	r	95% CI	p
RV GLS	-0.3	-0.51/-0.07	0.013
RV GLS FW	-0.26	-0.5/0.01	0.059
RV FAC	0.21	-0.1/0.37	0.26
TAPSE	0.34	0.01/0.4	0.04
S'	0.08	-0.22/0.25	0.91

CI — confidence interval; FAC — functional area change; FW — free wall; GLS — global longitudinal strain; RV — right ventricular; S' — peak systolic annular velocity; TAPSE — tricuspid annular plane systolic excursion

Table 4. Correlation coefficients between peak atrial longitudinal strain with RA size

Parameter	r	95% CI	p
RA area	-0.42	-0.59/-0.22	0.0001
RA ESV	-0.41	-0.58/-0.22	0.0001
RA TD	-0.31	-0.50/-0.09	0.005

CI — confidence interval; ESV — end-systolic volume; RA — right atrial; TD — transverse diameter

Table 5. Correlation coefficients between peak atrial contraction strain with RA size

Parameter	R	95% CI	P
RA area	-0.32	-0.51/-0.11	0.004
RA ESV	-0.35	-0.53/-0.14	0.002
RA TD	-0.27	-0.46/-0.05	0.016

CI — confidence interval; ESV — end-systolic volume; RA — right atrial; TD — transverse diameter

a non-significant difference in PALS between healthy and diseased subjects (p = 0.08).

Discussion

The main finding of this study is that in patients with good image quality RA function analysis by STE is feasible and the RA deformation parameters correlate weakly with RV function indices, indicating that other factors significantly influence RA function. Therefore, the RA function cannot be regarded as a direct barometer of the RV function.

We used the QRS method (measuring the strain using two consecutive QRS complexes as intervals) [12] during the analysis of the strain of RA. This method was utilised by Padeletti et al. [13] to determine reference values of normal RA strain yielding feasible results. In the present study, the PALS of the study's healthy volunteers (PALS = 37.25%) yielded similar results to the reference values suggested by Padeletti et. al. (PALS = 49 ± 13%). In comparison, the strain measured in the study's patient population was uniformly lower (PALS = 29.92%). However, due to the small sample size, the difference was not statistically significant.

Numerous studies have demonstrated a profound impact of right ventricular stress, represented by increased right ventricular end-systolic pressure, on the haemodynamic properties of the right atrium [3, 14]. An adequate atrial response to an increased RV end-systolic pressure consists of an increase in reservoir function and a decrease in conduit-to-reservoir ratio, which in turn is inversely related to cardiac output [3]. It is being proposed that a "flexible atrium" stores elastic energy during systole and hence, atrial compliance plays a crucial role. The correlation between PALS and markers of RV function in this study population can be, at least partially, attributed to the underlying effects of this hypothesis.

No correlation was found between PALS and RA size in healthy volunteers, nevertheless, in patients suffering from cardiac pathology, there is a significant correlation between RA size and PALS, hinting at common underlying factors. Querejeta Roca et al. [16] pointed out that in patients suffering from PAH, RA reservoir and passive conduit function are impaired independently of RA size and greater dysfunction was associated with RV dysfunction and overload. PALS and PACS both showed significant correspondence to right ventricular parameters, namely: RV GLS (as a prognostic marker in right heart disease [2] and a correlate to RVEF [16, 17]) both with and without IV septum segment. Even though the cardiovascular pathologies of the patients in this study vary, patients with diminished atrial compliance (represented by decreased PALS), were also more likely to show diminished mechanical deformation of the RV (measured by RV GLS and RV FW GLS). Wright et al. [6] pointed out, the RA has a tethering effect on the free wall of the ventricle as other cohorts influence RV deformation as well, and therefore the association should not be overestimated.

Limitations

This was a single-centre study with a small group of subjects. It should also be kept in mind that the Echopac software was originally programmed for the left ventricle, warranting further adjustment of the ROI to measure the much thinner RA wall correctly.

Conclusion

RA function assessment by STE is feasible. The RA deformation parameters weakly correlate with RV function indices, indicating that other factors significantly influence RA function. Therefore, the RA function cannot be regarded as a direct barometer of the RV function.

Streszczenie

Wstęp. Echokardiografia metodą śledzenia markerów akustycznych (STE) jest uznanym narzędziem oceny parametrów czynności serca, jednak wartość tego narzędzia w ocenie czynności prawego przedsionka (RA) jest nadal w dużej mierze nieznana. Celem pracy jest zbadanie możliwości oceny funkcji RA za pomocą STE oraz związku między deformacją prawej komory (RV) a funkcją RA.

Materiał i metody. Do badanej grupy włączono 94 osoby z różnymi patologiami sercowo-naczyniowymi. U wszystkich pacjentów wykonano echokardiografię przezklatkową z późniejszą analizą off-line z wykorzystaniem techniki śledzenia markerów akustycznych i pomiarem licznych parametrów deformacji RA, w tym szczytowe odkształcenie podłużne przedsionków (PALS) i szczytowe napięcie skurczowe przedsionków (PACS), a także ustalonych wskaźników funkcji RV, takich jak: wychylenie skurczowe pierścienia trójdzielnego (TAPSE) i globalne odkształcenie podłużne (GLS).

Wyniki. Ocena funkcji RA za pomocą echokardiografii śladowej plamki była możliwa u wszystkich pacjentów. Zaobserwowano statystycznie istotną korelację między odkształceniem prawej komory (PACS i PALS) a parametrami RV. RV-GLS wykazało słabą korelację z PALS ($r = -0{,}38$; $p = 0{,}0015$) i PACS ($r = -0{,}30$; $p = 0{,}013$). Podobnie TAPSE korelowało z PALS i PACS ($r = 0{,}34$; $p = 0{,}02$) i ($r = 0{,}23$; $p = 0{,}04$).

Wnioski. Ocena funkcji RA za pomocą echokardiografii metodą śledzenia markerów akustycznych jest możliwa. Parametry deformacji RA słabo korelują ze wskaźnikami funkcji RV, co wskazuje, że inne czynniki mają istotny wpływ na funkcję RA. Dlatego funkcja RA nie może być traktowana jako bezpośredni barometr funkcji RV.

Słowa kluczowe: prawy przedsionek, prawa komora, echokardiografia metodą śledzenia markerów akustycznych

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