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The study of myocardial deformation assessed by 2D speckle tracking technique in hypertensive patients

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Abstract

Hypertension is one of the most common cardiovascular risk factors in general population, with a great impact on morbidity and mortality. It can determine structural and functional changes in the heart muscle through many mechanisms with consequences on diastolic function and contractility even in patients with normal systolic function. Our study aimed to highlight this early contractility changes by speckle tracking echocardiography in 64 hypertensive patients presented with acute chest pain in our hospital. We excluded a potential ischemic etiology by performing coronary angiography in all patients. We found that global (GLS) and basal longitudinal strain (BLS), as markers of myocardial deformation assessed by speckle tracking technique, were more altered in hypertensive patients compared with normotensive group. Also, GLS was more altered in patients with significant coronary stenosis compared with patients without coronary lesions. Hypertensive patients without coronary lesions had similar values of GLS evaluated on 18 segments like patients with significant coronary lesions and with normal blood pressure. In conclusion, hypertensive patients has altered myocardial deformation regardless of the presence of ischemic heart disease.

Keywords: hypertension, speckle tracking, myocardial deformation, longitudinal strain, left ventricular contractility

Introduction

Hypertension represent a major health issue with a great impact on morbidity and mortality. The SEPHAR II study, founded a hypertension prevalence in Romania of 40.4%. Only 59.1% of hypertensive subjects were treated and only 25% of them were therapeutically controlled [1]. New data from SEPHAR III study will be published soon.

It is well known that hypertension can lead to target organ damage [2]. The heart is structurally and functionally affected by increased afterload pressure and neurohormonal activation with cardiomyocytes hypertrophy and myocardial fibrosis through collagen deposits [3]. Microcirculation can be affected also by endothelial dysfunction, vascular wall remodeling and capillary density reduction [4].

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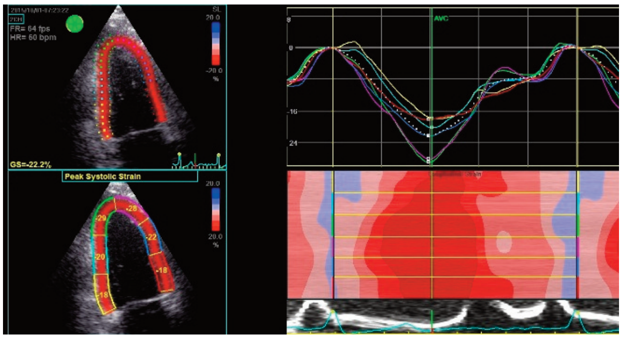

Figure 1. ROI, curves of left ventricle segments and longitudinal strain values on segments in 2 chamber view.

The cardiovascular investigations begins with electrocardiography and transthoracic echocardiography but a correct assessment of subclinical changes can require more sensitive investigations.

Speckle tracking is a new echocardiographic technique that can highlight the subtle left ventricle function changes expressed in a quantitative manner as longitudinal, radial or circumferential strain alteration. It is measured by semi-automated contouring (region of interest- ROI) and tracking of the left ventricle walls on segments. The software recognizes markers in gray scale in the images and measures their displacement frame by frame (Figure 1). This technique is sensitive and is more repro¬ducible compared to classic ejection fraction [5,6].

In our study we used this new technique to highlight early contractility changes that appears in hypertensive patients, changes that can modify the therapeutic approach.

Methods

We studied a cohort of 64 patients admitted in the Emergency Clinical Hospital, Bucharest, Cardiology Department, for acute chest pain. The cohort was chosen according to the inclusion and exclusion criteria. (Table 1).

A complete medical history and a complete clinical examination was performed for all patients including blood pressure measurement according to actual ESH/ESC indications (after 3-5 minutes of rest, two measurements spaced 1-2 minutes apart, in the sitting position). The blood tests included complete blood count, glucose, cholesterol, triglycerides, myocardial necrosis enzymes (troponin, CK, CK-MB) and creatinine. The cardiovascular investigations were completed with electrocardiogram, transthoracic echocardiography and coronary angiography.

The echocardiographic examinations were performed on the Vivid E9 machine with M5S probe. The following echocardiographic parameters were obtain: chamber and walls measurements in 2D echocardiography, examination of the valves with color and spectral Doppler, ejection fraction assessed by Simpson method and diastolic function by spectral and tissue Doppler measurements.

The myocardial deformation was assessed by speckle tracking techniques. There were used three beats acquisitions at 50-70 FPS in 2, 3 and 4 chambers view. The imagines was processed in an offline, (semi) automated function imaging (AFI) method on Echo PAC workstation software.

Global longitudinal strain was calculated as the average strain from the 18-segments model -GLS18 (6

Table 1. Inclusion and exclusion criteria

Inclusion criteria
Chest pain more than 5 minutes in the last 24 hours
Exclusion criteria
Suboptimal echo window
STEMI
NSTEMI /ACS
Myocarditis
Dilated cardiomyopathy
Systolic dysfunction
Pericardial effusion
Aortic dissection/aneurism
Severe/moderate valvulopathies
Arrhythmias
LBBB
Obvious non-cardiac cause

basal, 6 mid-ventricular and 6 apical) and 12-segments model- GLS12 (6 basal and 6 middle segments). BLS was calculated as the average strain from the 6 basal segments.

The quality of the acquisitions is mandatory and a poor acoustic window represented an exclusion criteria in our study.

All the patients enrolled in the study underwent coronary angiography to detect significant coronary stenosis (>70%).

In Figure 2 is presented the study protocol.

Statistical analysis was performed using SPSS software for Windows. Data was presented as percentages for qualitative variables and as mean ± standard deviation (SD) for quantitative variables. The differences between variables were assessed with the Student t test for quantitative variables and the Pearson's correlations for qualitative variables. Statistical significance was defined at the level of p<0.05.

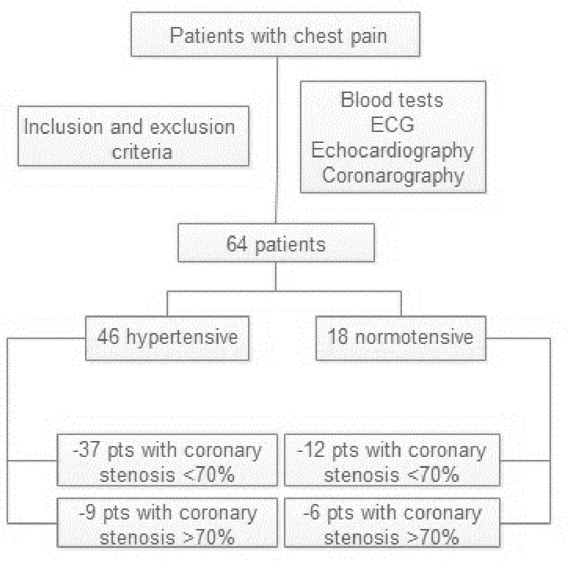

Figure 2. Study protocol.

Results

The cohort included 64 patients with a mean age of 56.4 ± 10 years. Patients characteristics are mentioned in table 2.

According to the actual ESH/ESC guideline [2], 71.9% of patients were hypertensive (BP>140/90 mmHg). When we analyzed data from echocardiography and coronary angiography we obtained the following results:

Table 2. Cohort characteristics.

Characteristics	Number	Percent
Age mean	56.44	
Min	33	
Max	82	
Male	32	50
Female	32	50
Smoking	17	26.6
Diabetes mellitus	18	28.1
Obesity (BMI>30)	19	29.7
Dyslipidemia	46	71.9
Hypertension	46	71.9

Overall, longitudinal strain was more altered in hypertensive group compared with normotensive ones. We found statistically significance (p<0.05) for GLS 12 (-16,6 ±3.1 vs -18.8 ± 2.6) and BLS (-15.6 ±3.1 vs -18 ±2.5) but not for GLS18 (-18.9 ±3.6 vs -20.5 ±2.6) (Table 3).

After performing coronary angiography, 41 patients (64%) had no significant coronary lesions and 23 patients (36%) had coronary stenosis > 70%. In hypertensive patients, longitudinal strain was more altered in patients with significant coronary lesions compared to those without stenosis for GLS18 (-17.3% ± 4,1, vs -19.3% ± 3,4) and GLS12 (-15.9% ± 2,8 vs -

Table 3. Longitudinal strain in hypertensive patients vs normotensive patients

	Hypertensive	Normotensive	
GLS 18	-18.96 ± 3.6	-20.55 ± 2.6	
GLS 12	-16.63 ± 3.1	-18.8 ± 2.6	p<0,05
BLS	-15.64 ± 3.1	-18.03 ± 2.5	p<0,05

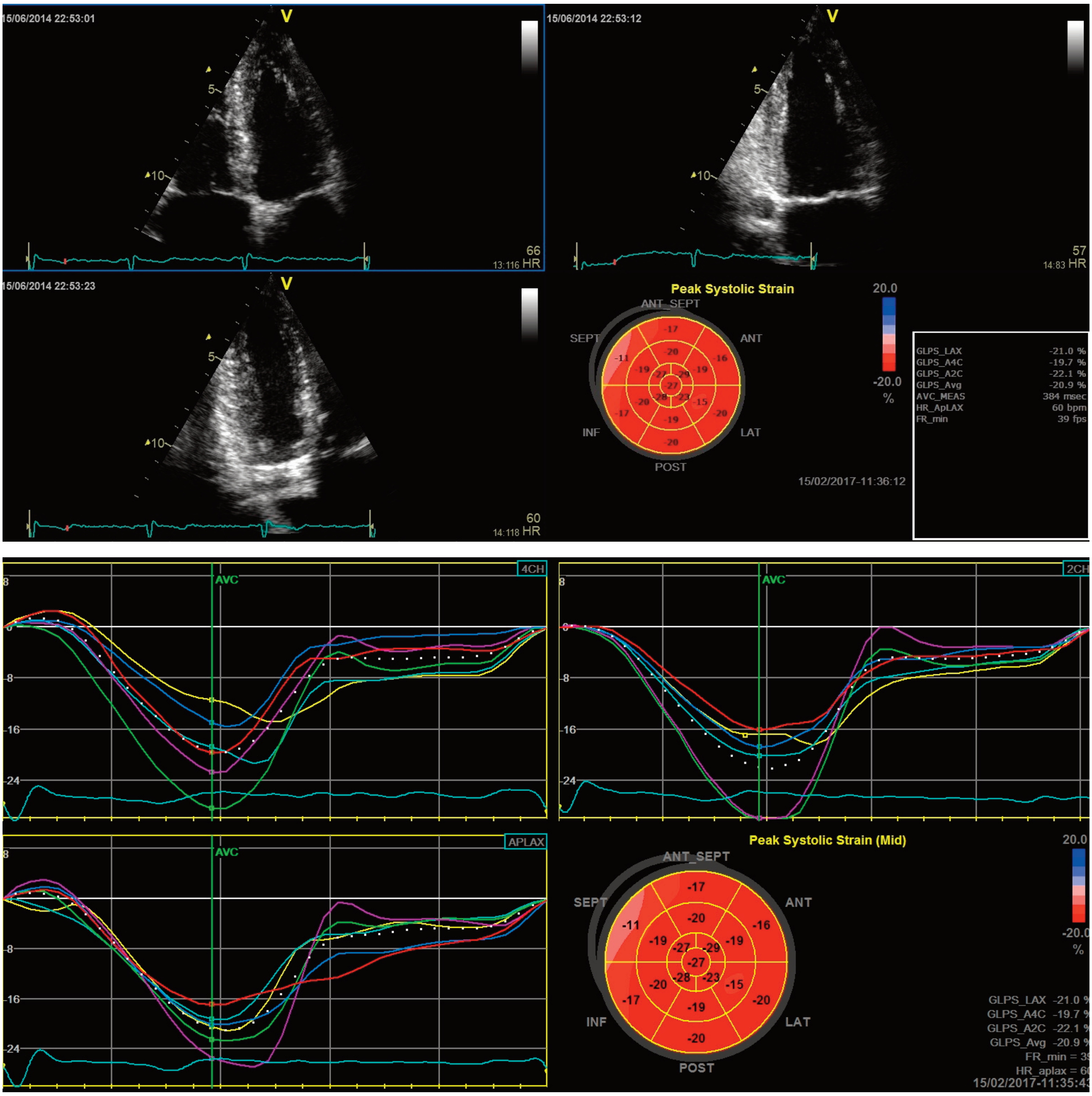

Fig.3 Normotensive patient (normal coronarography): normal LV walls, minimal/ insignificant longitudinal strain alteration in basal septal segment (bull's eye), average GLS -20.9%

16.7% ± 3,1), but without statistical significance. For BLS, the alteration was similar regardless of the presence of coronary lesions in hypertensive patients (-15.61% ± 2,5 vs. -15.65% ±3,2).

Also, in patients with normal coronary arteries, myocardial deformation was more altered in hypertensive patients (Figures 3, 4).

Another observation is that GLS18 was similar in hypertensive patients with normal coronary arteries and normotensive patients with significant coronary stenosis (-19,7% ±2,7 and -19,36% ±3,4 respectively) (Table 4).

Discussion

Speckle tracking technique proved to be a new useful tool in assessing the myocardial deformation in multi-

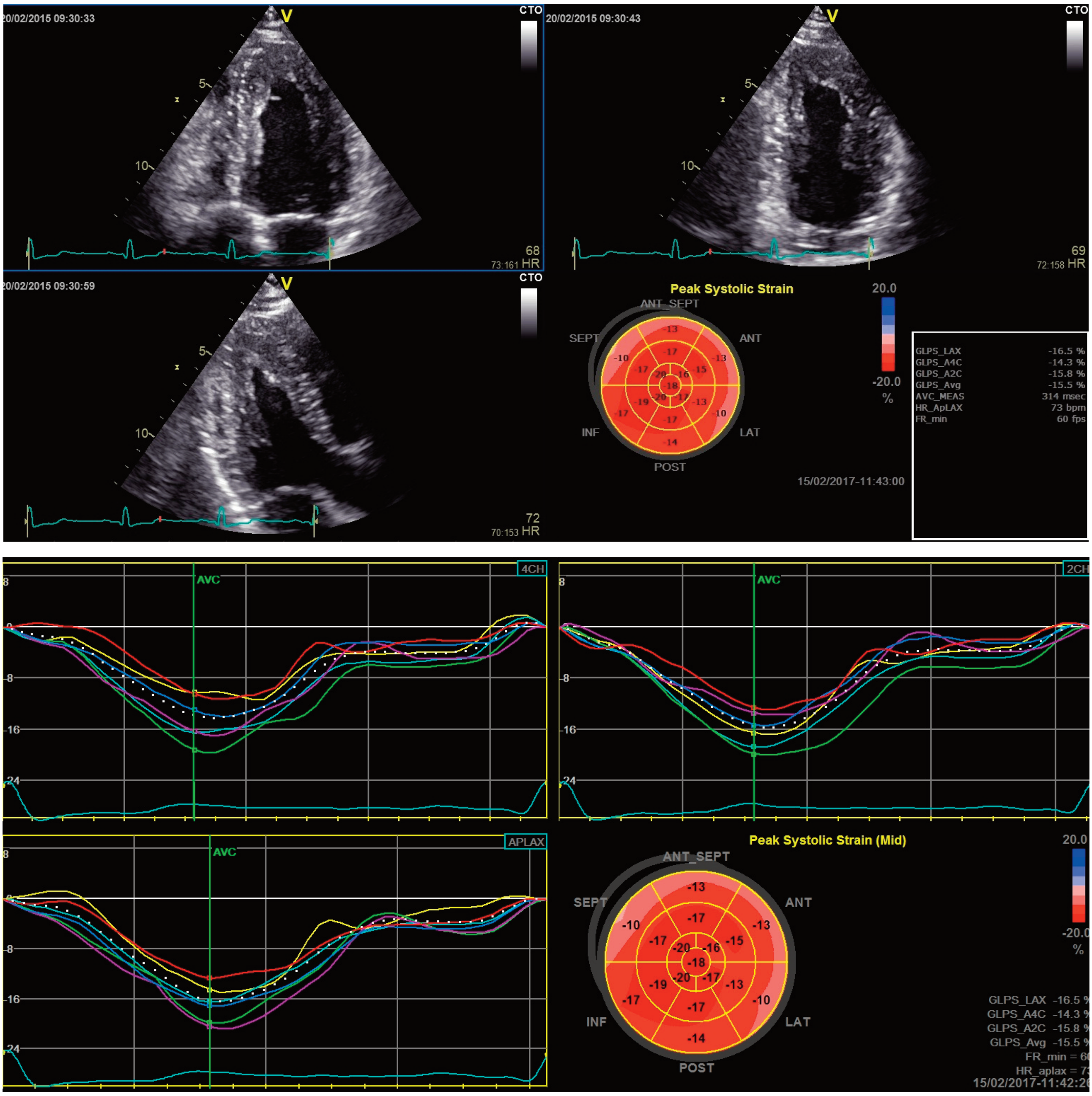

Fig 4. Hypertensive patient (normal coronarography): thicker walls, more extended longitudinal strain alteration in middle and basal segments (bull's eye), average GLS -15,5 %

ple pathologies from ischemic heart disease to cardiomyopathies and heart failure with preserved ejection fraction [7].

European association of echocardiography (EACVI) together with the American Society of Echocardiography (ASE), elaborated in 2015 a consensus paper for the standardization of the 2D speckle tracking echocardiography technique in deformation imagined evaluation [8]. A meta-analysis of 24 studies performed on 2957 subjects reported normal values for global longitudinal strain between -15.9% and -22.1% and the blood pressure was the only parameter that was associated with variation in normal values [9] but the normal limits are not very well established.

In hypertensive patients, longitudinal strain may be affected by multiple mechanisms. The increase in afterload, seems to be associated with alteration in myocardial deformation as it is shown in a clinical study

Table 4. GLS values in hypertensive and normotensive patients according to coronary stenosis presence

Group Statistics						
High BP		**CAD**	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
No	GLS18	<70%	12	-20.938333	2.6579002	.7672697
		>70%	6	-19.786667	2.7446724	1.1205078
	GLS12	<70%	12	-19.069167	2.9781094	.8597061
		>70%	6	-18.278333	1.8056513	.7371541
	BLS	<70%	12	-18.267500	2.9801072	.8602828
		>70%	6	-17.583333	1.7206937	.7024702
Yes	GLS18	<70%	37	-19.368919	3.4234792	.5628165
		>70%	9	-17.308889	4.1878856	1.3959619
	GLS12	<70%	37	-16.789189	3.1973847	.5256468
		>70%	9	-15.991111	2.8084980	.9361660
	BLS	<70%	37	-15.658919	3.2730862	.5380921
		>70%	9	-15.612222	2.5003339	.8334446

that measured strain parameters and invasive left ventricular pressure in different acute loading conditions using fluids and nitrates [10]. This hypothesis is sustained by the observation that the strain parameters partially normalize after aortic stenosis correction and decrease of afterload pressure [11]. Another mechanism of longitudinal strain alteration in hypertensive patients is the common association of microcirculation impairments due to endothelial dysfunction, vascular wall remodeling with increase wall to lumen ratio and reduction in arterioles and capillaries density [4] as shown in several studies [12].

The results of our study showed that myocardial deformation assessed by global longitudinal strain suffers changes even in the absence of ischemic lesions or other cardiac pathologies that we excluded, due to structural and functional alterations that occurs in this condition. Previous clinical studies have also documented the association between myocardial deformation and blood pressure [13].

One of the most important pathologies that can be assessed by speckle tracking echocardiography is the ischemic heart disease. In hypertensive patients, speckle tracking has a lower specificity in detection of myocardial ischemia because of the structural alterations induced by hypertension, and not by coronary lesions, as we showed in our study. For 6 segments evaluation, the difference was even less significant, with similar BLS values for patients with and without coronary lesions. Also, the hypertension on non-ischemic heart had the same impact on myocardial deformation as the significant coronary stenosis in normotensive patients. Speckle tracking echocardiography is sensitive but not specific. For this reason, the hypertensive etiology must be a diagnosis of exclusion, after a complete investigation protocol.

In the last years, the studies had demonstrated the association of myocardial deformation with other parameters in hypertensive patients in different stages. The clinical trials have showed that higher degree of left ventricular hypertrophy was associated with more pronounced lowering of longitudinal deformation [14] and the alterations in longitudinal strain can be detected even before left ventricular hypertrophy, in the concentric remodeling stage. When the structural changes become more pronounced, with concentric hypertrophy, the radial strain is also significantly lower [15].

Another important parameter that proved to correlate with longitudinal strain alteration is the diastolic dysfunction, common in hypertensive patients with or without concentric hypertrophy [16].

A study that included 185 patients showed that longitudinal strain gradually and significantly decreased from normotensive controls across masked hypertension to sustained hypertensive patients [17]. This fact denotes that the target organ damage can be present even in patients without office high blood pressure and the 24-hour ambulatory blood pressure monitoring can be very useful in detecting patients at risk. The same result was obtained for patients with white coat hypertension [18, 19]. A study that included 153 patients, proved that the myocardial deformation is altered even in the right ventricle in patients with white coat hypertension [19].

Myocardial deformation changes in hypertensive patients is not only a marker of early target organ damage but an outcome predictor too. Patients with alteration of the global longitudinal strain had a greater risk of major adverse cardiac events (MACE) compared with patients with normal myocardial geometry as it was shown in a 4 years follow-up trial [20]. Another trial that included 272 patients with a mean follow-up of 26± 16 months, showed that the longitudinal systolic strain of basal segments adjusted by the systolic and diastolic arterial pressure obtained at the time of echocardiography, were independent predictors of cardiac events and mortality [21].

By the ability to detect early myocardial deformation alterations and to predict outcomes, speckle tracking technique can be a useful tool in risk stratification in hypertensive patients and to determine the moment for treatment intensification in order to prevent the progression of target organ damage. Prevention in hypertension must be started in early stages.

Conclusions

The study demonstrated that hypertensive patients has a more altered myocardial deformation regardless of the presence of coronary stenosis especially in middle and basal segments (GLS12 and BLS). The presence of hypertension has the same impact on myocardial deformation as the presence of significant coronary lesions in normotensive patients (for GLS18). Speckle tracking technique can be used for risk stratification in hypertensive patients without other causes of myocardial deformation alteration.

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Conflict of interests:

There are no conflicts of interests.

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