Early detection of myocardial damage using 2D speckle tracking echocardiography through strain assessment in hypertensive patients

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Abstract

Background: The prevalence of hypertension in Vietnam is increasing consecutively. Hypertension is the cause of many complications in several vital systems such as the nervous system, kidney and, especially, the cardiovascular system. Recently, the 2D speckle tracking echocardiography (STE) technique helped to assess subclinical changes in cardiac function when there was an abnormal tissue function without any changes in morphology and cardiac function. The aim of the study was to evaluate the early change in left ventricular systolic function by STE technique in hypertensive patients with and without heart failure with preserved ejection fraction (HFpEF).
Material and methods: In a cross-sectional observational study, STE technique was used to analyze left ventricular systolic strain in 151 hypertensive patients and 43 participants without cardiovascular disease as a control group. Subclinical left ventricular dysfunction was detected by echocardiographic strain parameters, especially global longitudinal strain (GLS).
Results: GLS decreased in hypertensive patients without heart failure with preserved ejection fraction compared to the control group (–11.93 ± 2.21 *vs.* –16.52 ± 1.19). This reduction increased in hypertensive patients with heart failure with preserved ejection fraction (–11.04 ± 2.5 *vs.* –16.52 ± 1.19). The threshold of the global longitudinal strain was –14.364. The rate of reduction in GLS in hypertensive patients without HFpEF was relatively high (93.3%).
Conclusion: STE technique helps to detect subclinical changes in left ventricular systolic function with high sensitivity.

Key words: speckle tracking echocardiography; systolic function; strain parameters; hypertension; heart failure with preserved ejection fraction; Vietnam

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Introduction

Hypertension has become a major global health problem today. It is estimated that the current prevalence of hypertension is about 30–45% in the general population and this proportion increases with age [1]. In Vietnam, the incidence of hypertension has also increased from 18.69% in

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2002 to 25.1% in 2012 [2]. Hypertension is the main modifiable risk factor of many organs failure, especially the heart. Therefore, early detection of preclinical cardiac dysfunction may give way to better treatment strategy.

In general, ordinary methods such as M-mode and Simpson can only detect myocardial deformity when symptoms have occurred. Tissue Doppler echocardiography can early detect these changes but depending on the angle. MRI, which is the gold standard for evaluating myocardial deformity, is quite expensive and impracticable. Many studies have shown that the speckle tracking echocardiography (STE) technique can evaluate the discreet impairment of cardiac function in the presence of tissue dysfunction without changes in cardiac morphology [3, 4] with relatively high sensitivity. Therefore, we performed this study to investigate the possible utility of left ventricular dysfunction assessment with methods beyond standard ultrasound.

STE is a relatively new technique; most studies have been done on European populations, and a few studies have been done on Asian populations. In Vietnam, studies using STE technique to detect cardiac abnormalities in hypertensive patients are scarcely available, therefore no reference values of myocardial strain parameters in the Vietnamese population are available. Therefore, we aimed to detect myocardial entity damage in the preclinical stage in hypertensive patients with and without heart failure with preserved ejection fraction (HFpEF) and determine reference values for future studies.

Material and methods

Researching process is presented in Figure 1.

Research objects

Hypertensive group

The study group consisted of 151 patients with established hypertension.

Sampling criteria: according to the classification of hypertension of the European Society of Hypertension/European Society of Cardiology 2018 and according to the Association of Hypertension Vietnam 2014.

Exclusion criteria: (1) Ejection fraction ≤ 50%; (2) Acute or chronic coronary artery disease; (3) Valvular disease: mild to severe valve stenosis, moderate to severe regurgitation; (4) Pericardial disease;

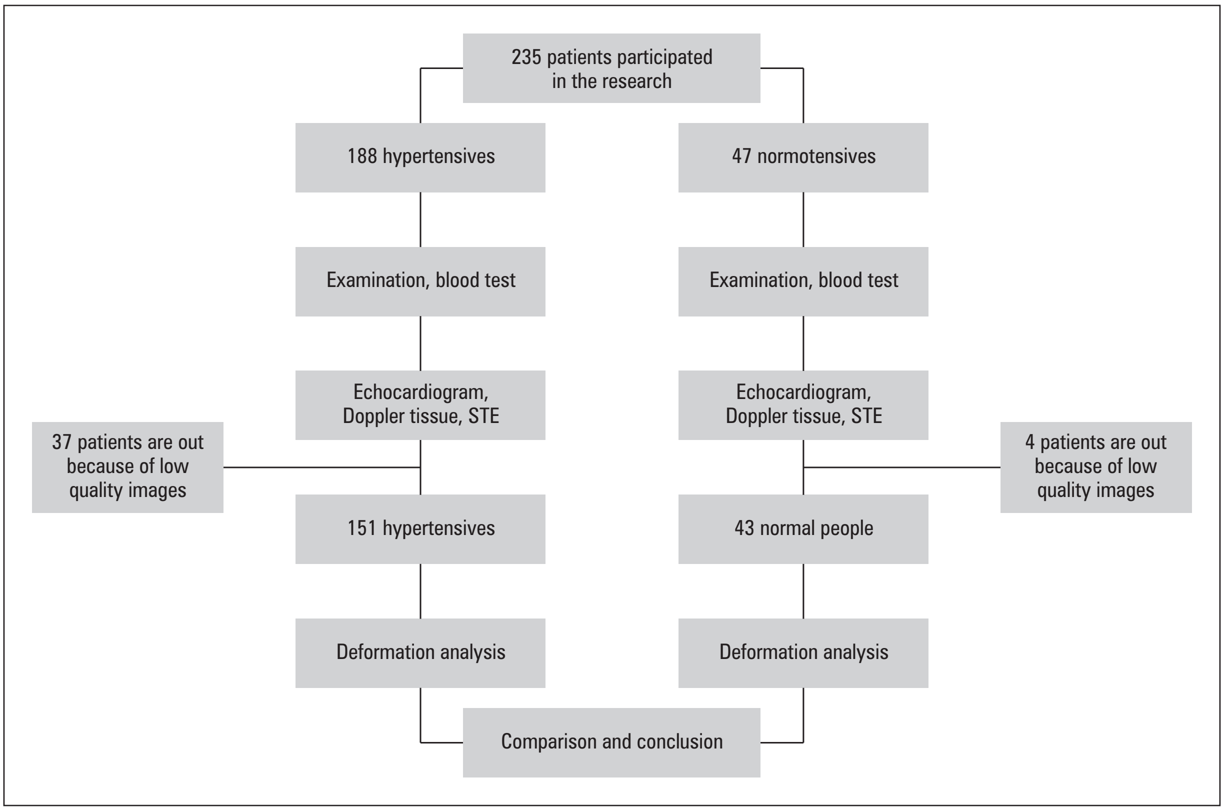

Figure 1. Study flow chart. STE — speckle tracking echocardiography

Table 1. General characteristics of the study sample

Variable	Normotensives (n = 43)	Hypertensives (n = 151)	p value
Age [years]	58.33 ± 821	60.91 ± 8.13	> 0.05
Male (%)	39.7	37.7	> 0.05
Female (%)	60.5	62.3	> 0.05
BMI	22.13 ± 2.27	22.83 ± 2.23	> 0.05
BSA [m^2]	1.58 ± 0.144	1.58 ± 0.141	> 0.05
Systolic blood pressure [mm Hg]	114.19 ± 10.63	137.62 ± 12.8	< 0.001
Diastolic blood pressure [mm Hg]	68.02 ± 9.01	81.52 ± 8.54	< 0.001
Frequence [l/ph]	68.63 ± 12.3	70.32 ± 11.47	> 0.05
LVMI [g/m^2]	72.44 ± 14.92	87.43 ± 23.68	< 0.001
PWT [cm]	0.8 ± 0.1	0.95 ± 0.49	< 0.05
RWT	0.35 ± 0.05	0.42 ± 0.21	< 0.05
EF-Mode (%)	69.53 ± 5.54	70.65 ± 6.18	> 0.05
EF-Simpson (%)	65.79 ± 5.71	65.28 ± 6.33	> 0.05
FS (%)	39.3 ± 4.55	40.12 ± 5.12	> 0.05

BMI — body mass index; BSA — body surface area; LVMI — left ventricular mass index; PWT — posterior wall thickness; RWT — relative wall thickness; EF — ejection fraction; FS — fractional shortening

(5) Congenital heart disease; (6) Cardiac arrhythmia, non-sinus rhythm; (7) Secondary hypertension; (8) Chronic lung disease; (9) Liver failure, kidney failure, organ transplantation; (10) Diabetes; (11) Poor picture quality (loss of > 3 cardiac segments/1 cross-section or failure to analyze one cross-section in 6 cross-sections), the endothelial margin is unknown or electrocardiogram is noisy.

Control group

The control group consisted of 43 healthy individuals who underwent regular health check-ups at the Vietnam National Heart Institute.

Sampling criteria: patients who at the enrollment were free of (1) cardiovascular disease; (2) diabetes; (3) pulmonary hypertension; (4) abnormal echocardiographic values according to the American Heart Association 2015 standards, which meant dilatation of the left ventricle, LVH, LVEF < 55%, abnormal LAVi, valvular defects incl. MS, MR and moderate or higher aortic valve, we used as a control group.

Exclusion criteria: cases with poor echocardiography image quality, or who did not agree to participate in the study.

General characteristics of the study sample

In all, 235 people were eligible for the study but 41 were excluded from the study due to poor image quality; another 43 were lost to follow up. Finally 151 hypertensive patients were studied at our site i.e., Bach Mai Hospital, Hanoi and 43 people without cardiovascular disease as a control group.

Clinical characteristic is tabulated in Table 1 and Table 2. No differences in age, sex, BMI, heart rate and left ventricular ejection fraction between the hypertensive group and the control group were evident; 40.4% of patients were classified as HFpEF. Abnormal serum lipids profile comprised most prevalend CV risk factor in our cohort. Grade and course of hypertension is characterized in Table 2.

Table 2. Clinical characteristics with selected risk factors of the study sample

Variable	Hypertensives (n = 151)	
Heart failure with preserved ejection fraction (HFpEF)	61	(40.4%)
Overweight — obesity	74	(49.1%)
Smoking	11	(7.3%)
Dyslipidaemia	122	(80.8%)
Hypertension		
Grade I	7	(4.6%)
Grade II	45	(29.8%)
Grade III	99	(65.6%)
Hypertension progression		
< 5 years	41	(27.2%)
5–10 years	75	(49.7%)
> 10 years	35	(23.2%)

Figure 2. Figure of longitudinal cross section. **A.** Four-chamber section at the apex. **B.** Two-chamber section at the apex. **C.** Cross section of 3 chambers at the apex

Location and time

The study was conducted at Bach Mai Hospital in Hanoi, Vietnam from October 2012 to July 2013.

Methods

Study design

The cross-sectional observational study compared patients with diagnosed hypertension and healthy people.

Sample size

The sample size we selected by applying the following formula:

$$n = \frac{Z^2_{1-\frac{\alpha}{2}} \cdot P(1-P)}{d^2}$$

With: Z0.975 = 1.96; α = 0.05; d = 0.07; p = 0.153 is the rate of subclinical left ventricular systolic dysfunction assessed by strain parameters in hypertensive patients [5]. Instead, the formula was n ≥ 102 patients. In fact, we performed a study on 151 patients as the hypertensive group and 43 healthy as the control group.

Data collection

There was 3-step data collection: (1) clinical examination; (2) glucose test along with ECG; (3) echocardiography.

The speckle tracking echocardiography (STE) technique was performed with the following protocol:

1. Images acquisition: patients were in supine position at on the left side, at 90 degrees and then take a cross-section of the thymus and 3 images in the cross-section of the radial axis (base, middle and apex). Then left side with 30–40 degrees for cross-section of 4 chambers, 2 chambers and 3 chambers at the tip. The right longitudinal section passes through the heart apex (the section with the longest left ventricle). Each image was taken at 3 consecutive heart cycles. Then copy the image to the CD (Fig. 2A–C).
2. Next, (measuring the interval) measure the time from the beginning of the QRS complex to the initiation of the aortic valve opening (R-AVO) and the closure of the aortic valve (R-AVC) in the 5-chamber section with a continuous Doppler. Next, measure the time from the beginning of the QRS complex to the initiation of the mitral valve opening (R-MVO) and the closure of the mitral valve (R-MVC) in the quadrupole section with pulse-Doppler (Fig. 3).
3. Strain analysis: Myocardial strain analysis using offline software QLAB version 9.0. Carry out the analysis according to these parameters: (1) Global longitudinal strain Choose 3 points (two points on either side of the valve ring, 1 point at the apex, Fig. 3A). Then the software automatically determines the endothelial margin (Fig. 3B and D1) and gives the myocardial strain parameters of each myocardial segment in each section. Strain parameters and strain velocity of each segment

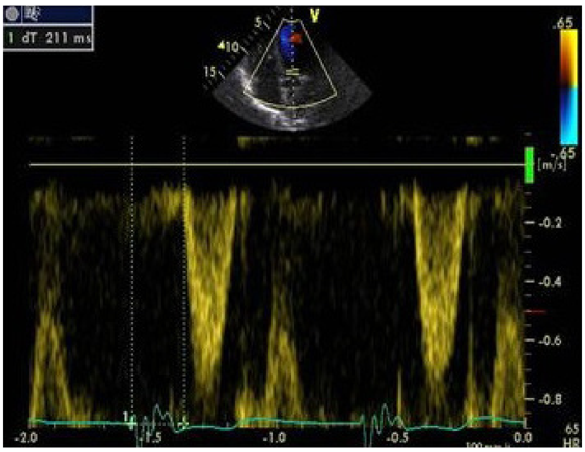

Figure 3. How to measure R-AVO (R-AVO is the time from the beginning of the QRS complex to the beginning of the aortic valve opening)

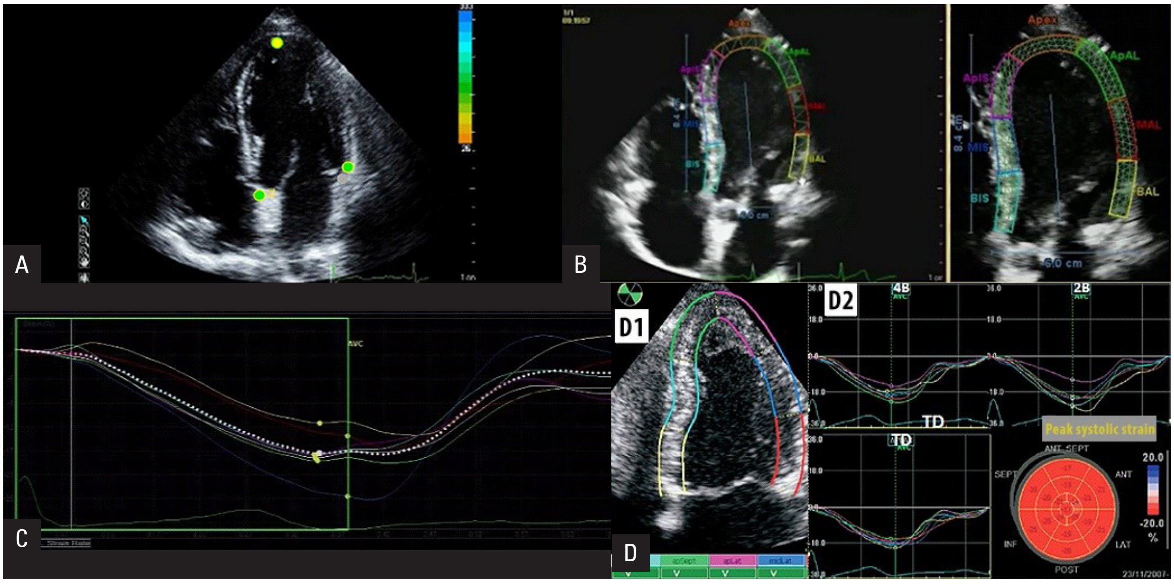

Figure 4AD. Myocardial deformation analysis

and the whole section are shown on the curve and target diagram (Fig. 3C and D) (2) Global circumferential strain, global radial strain and the torsion. Select the center point of the section, the software automatically identifies the endothelium, the radial axis and analyzes the myocardial strain parameters by itself. Strain parameters and strain velocity of each segment and the entire section are shown on the curve and target diagram [6] (Fig. 4A–D).

Assessment of the early left ventricle damage

The evaluation of patients with HFpEF: study the correlation of myocardial strain indexes between groups: control group, hypertensive patients without heart failure with preserved ejection fraction and hypertensive patients with HFpEF.

Cut-off threshold value and the sensitivity of the method

The sensitivity of the method was assessed by the rate of abnormality of myocardial strain parameters in the hypertensive group, in HFpEF group and according to the Tei index.

Correlation of systolic strain parameters with left ventricular ejection fraction (EF).

The strain parameters and strain velocity along the longitudinal axis and peak circumference are the peak negative values in the systolic period before the aortic valve closes. Strain parameters and velocity along the radial axis are the highest positive values in the systolic before the aortic valve closes (Fig. 5).

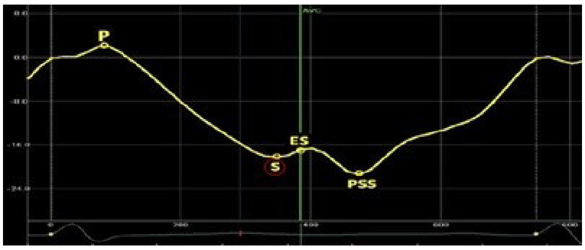

Figure 5. Measurement of peak systolic strain. Reading the peak systolic strain at point S. P — peak positive strain; S — peak systolic strain; ES — end-systolic strain; PSS — post-systolic strain; AVC — aortic valve closure; The dotted line — begins QRS, green line — closes the aortic valve [6]

For left ventricular torsional strain: the torsional strain is analyzed only on two sections (base transverse and apex). Normally in the systolic phase the base of the heart rotates clockwise, giving negative values. Therefore, the torsional peak angle, the systolic at the base of the heart is the most negative value in the systolic tense. Conversely, the crown of the heart rotates counterclockwise, giving a positive value, the torsional peak angle of the inner apex, the systolic is the highest positive value before the aortic valve closes. Torsional strain is calculated from the conical rotation angle minus the heart base rotation angle. Therefore, the torsional strain has a positive value (Fig. 6).

Calculation of strain parameters

Export parameters to excel 2007 to calculate the strain average: Global longitudinal strain (GLS) and global longitudinal strain rate (GLSR) are the strain mean and strain velocity of 3 sections (4 chambers,

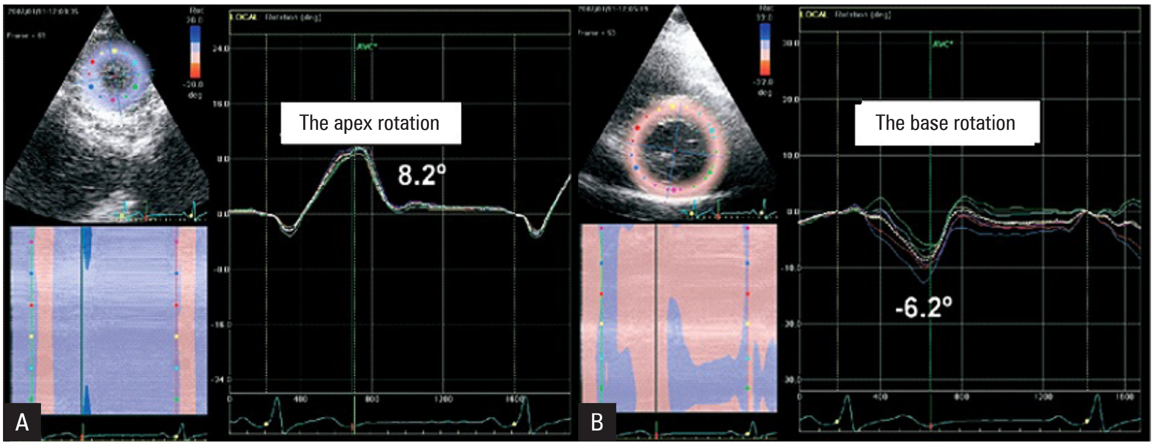

Figure 6. Torsional strain analysis [26]

2 chambers and 3 chambers at the apex) consisting of 17 heart muscle segments, with negative values. Two parameters represent the shortening of the left ventricle along the longitudinal axis. Global circumferential strain (GCS) and global circumferential strain rate (GCSR) are the strain mean and strain velocity of the three transverse thymus axial sections (base, middle and apex) consisting of 17 cardiac muscle segments, with negative values. The two parameters represent the shortening of the myocardial regions along the circumference of the heart. Global radial strain (GRS) and radial velocity (radial vel) are the strain mean and strain velocity of the three transverse thymus axial sections (base, middle and apex of the cardiac) consisting of 17 cardiac muscle segments, which are of positive value. These are two parameters that represent the thinner and thickening of the heart wall. Torsional strain is a parameter showing the difference between the rotation angle of the heart base and the rotation angle of the apex, calculated by the formula [7]:

$$Torsional\ peak\ angle\ (0) = crest\ angle - base\ of\ heart\ rotation$$

$$Torsional\ speed\ (0/s) = crown\ of\ the\ heart\ speed - base\ of\ the\ heart$$

Time reaching peak torsion is the time to reach the highest torsion value (measured from the beginning of the QRS). The longitudinal-perimeter index has a negative value is calculated by the formula:

$$Index\ of\ longitudinal - perimeter = \frac{GLS + GCS}{2}$$

The systolic index has a positive value, which is calculated using the formula [8, 9]:

$$The\ systolic\ index = \frac{GRS - (GLS + GCS)}{3}$$

Analysis and processing of data

Research results were analyzed using SPSS18.0 software. Descriptive statistics: quantitative variables described by mean ± standard deviation. Qualitative variables describe frequencies, and rate. (1) The Quantitative variables were determined by independent t-test for normal distribution or Mann- Whitney test for non-normal distribution. If comparing ≥ 3 groups, 1-way ANOVA was used for normal distribution, and Kruskal-Wallis test for non-normal distribution; (2) The qualitative variable was described by CHI squared if there were ≤ 20% of the cells with the expected value < 5. Correlations between intercontinental variables were assessed using univariate regression (Pearson correlation) (normal distribution) or Spearman correlation (non-normal distribution). P-value < 0.05 was considered statistically significant. Correlation coefficients: (1) 0.01–0.1: very low correlation; (2) 0.2–0.3: low correlation (3) 0.4–0.5: average correlation (3) 0.6- 0.7: high correlation (4) ≥ 0.8: very high correlation. Determined the reduction of myocardial strain was the value ≤ 2.5 percentile from the control group [9].

Research ethics

Our research strictly adheres to ethical criteria in medical research and was approved by the Hue University Council with decision No.717 on 10th April 2012.

Results

Early assessment of left ventricular damage in patients with and without HFpEF

Table 3 shows that strain and systolic strain velocity along the longitudinal axis, circumference and

Table 3. Comparison of systolic strain parameters in heart failure patients with and without heart failure with preserved ejection fraction (HfpEF) and control group

Parameters	Normotensives (n = 43)	Hypertensives	
		Without HfpEF (n = 90)	HfpEF (n = 61)
GLS (%)	–16.52 ± 1.19	–11.93 ± 2.21 **p < 0.001***	–11.04 ± 2.5 **p < 0.001***
GLSR [1/s]	–0.96 ± 0.13	–0.74 ± 0.15 p **< 0.001***	–0.71 ± 0.14 **p < 0.001***
GCS (%)	–17.92 ± 2.39	–14.0 ± 4.79 **p < 0.001***	–12.82 ± 5.17 **p < 0.001***
GCSR [1/s]	–1.11 ± 0.15	–0.92 ± 0.23 **p < 0.001***	–0.86 ± 0.24 **p < 0.001***
GRS (%)	12.33 ± 1.94	10.63 ± 3.19 **p < 0.05***	9.66 ± 3.65 **p < 0.001***
Radial vel [cm/s]	1.98 ± 0.35	1.71 ± 0.39 **p < 0.05***	1.56 ± 0.43 **p < 0.001***
Torsional peak angle [°]	11.33 ± 4.51	10.9 ± 5.06 p > 0.05	10.04 ± 5.83 p > 0.05
Torsional speed [°/s]	90.13 ± 34.19	76.39 ± 32.14 p > 0.05	82.7 ± 36.17 p > 0.05
Time reaching peak torsion [s]	1.19 ± 0.29	1.14 ± 0.27 p > 0.05 (k)	1.12 ± 0.25 p > 0.05 (k)
Longitudinal-perimeter index	–17.22 ± 1.44	–12.97 ± 2.49 **p < 0.001***	–11.93 ± 3.21 **p < 0.001***
Systolic index	15.59 ± 1.46	12.19 ± 2.61 **p < 0.001***	11.21 ± 3.21 **p < 0.001***

GLS — global longitudinal strain; GLSR —global longitudinal strain rate; GCS — global circumferential strain; GCSR — global circumferential strain rate; GRS — global radial strain

radial axis were much reduced in patients without heart failure and they most decrease in the presence of HFpEF. Evaluation of cardiac function in many directions showed that the longitudinal-perimeter index and the systolic index were decreased in both hypertensive patients, with and without HFpEF ($p < 0.01$).

Mean, cut-off value and the sensitivity of the method

Table 4 shows that the abnormal cutoff value of systolic strain along the longitudinal axis is 14.364; circumference is –14.703; the radial axis is 8.369; torsional peak angle 3.742.

Table 5 shows the systolic strain index along the longitudinal axis and the longitudinal-perimeter index capable of detecting the systolic dysfunction with the highest rate (> 80%).

Table 6 shows that in hypertensive patients without HFpEF, 93.3% had a decreased GLS; 62.2% a reduction in GCS; 27.8% a reduction in GRS and in the group with HFpEF these rates were 96.7%, 68.9% and 37.7%, respectively.

Table 7 shows that in the group with normal Tei index there are 88.5% GLS abnormalities; 57.7% abnormal GCS; 26.9% abnormal GRS; 71.3% abnormal longitudinal index; 50% systolic abnormality and the rate of these abnormalities increases when Tei index is abnormal (Tei > 0.47).

Table 8 shows that only the strain according to the circumference, the longitudinal-perimeter index, and the systolic index correlated with the LVEF. Global longitudinal strain and global longitudinal strain rate, global circumferential strain and global circumferential strain rate, global radial strain and global radial strain rate, the longitudinal-perimeter index, and the systolic index are correlated with the LVEF.

Discussion

We found that both the GLS and GLSR were decreased in HFpEF patients compared with the hypertensive non-HFpEF patients and the control group. Similar to our study, Krainer et al. [10] studied 219 hypertensive patients with HFpEF and 50 controls and also found

Table 4. Abnormal cut-off of cardiac function evaluation parameters (cut-off threshold 2.5th)

Parameter	Abnormal cutoff
GLS (%)	–14.364
GLSR [1/s]	–0.633
GCS (%)	–14.703
GCSR [1/s]	–0.834
GRS (%)	8.369
Radial vel [cm/s]	1.03
Torsional peak angle [º]	3.742
Torsional speed [º/s]	27.9
Time reaching peak torsion [s]	0.317
Longitudinal-perimeter index	–15.033
Systolic index	13.035

GLS — global longitudinal strain; GLSR —global longitudinal strain rate; GCS — global circumferential strain; GCSR — global circumferential strain rate; GRS — global radial strain

Table 5. Rate of systolic dysfunction in the hypertensive group

Parameter	Abnormal rates	
GLS	143	(94.7%)
GLSR	53	(35%)
GCS	98	(64.9%)
GCSR	66	(43.7%)
GRS	48	(31.8%)
Radial vel	9	(6%)
Torsional peak angle [º]	8	(5.3%)
Torsional speed [º/s]	4	(2.6%)
Time reaching peak torsion [s]	4	(2.6%)
Longitudinal-perimeter index	122	(80.8%)
Systolic index	102	(67.5%)

GLS — global longitudinal strain; GLSR —global longitudinal strain rate; GCS — global circumferential strain; GCSR — global circumferential strain rate; GRS — global radial strain

Table 6. Rate of systolic dysfunction by cardiac function

Parameter	Abnormal rates in patients without HfpEF		Abnormal rates in patients with HfpEF	
	n	%	n	%
GLS	84/90	93.3	59/61	96.7
GLSR	17/90	18.9	18/61	29.5
GCS	56/90	62.2	42/61	68.9
GCSR	36/90	40	30/61	49.2
GRS	25/90	27.8	23/61	37.7
Longitudinal-perimeter index	71/90	78.9	51/61	83.6
Systolic index	58/90	64.4	44/61	72.1

HfpEF — heart failure with preserved ejection fraction; GLS — global longitudinal strain; GLSR — global longitudinal strain rate; GCS — global circumferential strain; GCSR — global circumferential strain rate; GRS — global radial strain

Table 7. Rate of abnormal systolic strain parameters according to Tei index

Parameter	Abnormal rate when Tei ≤ 0.47		Abnormal rate when Tei>0.47	
	n	%	n	%
GLS	23/26	88.5	118/123	95.9
GLSR	3/26	11.5	32/123	26
GCS	15/26	57.7	82/123	66.7
GCSR	10/26	38.5	56/123	45.5
GRS	7/26	26.9	41/123	33.3
Longitudinal-perimeter index	19/26	71.3	102/123	82.9
Systolic index	13/26	50	89/123	72.4

GLS — global longitudinal strain; GLSR — global longitudinal strain rate; GCS — global circumferential strain; GCSR — global circumferential strain rate; GRS — global radial strain

that GLS was decreased in hypertensive patients with HFpEF compared with hypertensive patients without HFpEF and the control group ($p < 0.001$). The chronic increase of end-systolic pressure on the cardiac wall promotes collagen synthesis in myocardium layer, together with myocardial fibrosis which contributes to the longitudinal axial impairment of left ventricular function in hypertensive patients [11]. Galderisi et al.'s study also showed that GLS decreased from the very early stage of hypertensive [12], even in the pre-hyper-

Table 8. Correlation between the systolic strain parameters with left ventricular ejection fraction (EF)

Parameter		EF (M-mode)	EF (Simpson)
GLS	r	0.099	–0.208
	p	> 0.05	< 0.05
GLSR	r	–0.26	–0.25
	p	< 0.05	< 0.05
GCS	r	–0.178	–0.13
	p	< 0.05	> 0.05
GCSR	r	–0.14	–0.188
	p	> 0.05	< 0.05
GRS	r	0.12	0.191
	p	< 0.05	< 0.05
Radial vel	r	0.042	0.12
	p	> 0.05	< 0.05
Torsional peak angle	r	0.13	0.344
	p	> 0.05	< 0.05
Torsional speed	r	0.08	0.25
	p	> 0.05	> 0.05
Time reaching peak torsion	r	0.08	0.049
	p	> 0.05	> 0.05
Longitudinal-perimeter index	r	–0.2	–0.21
	p	< 0.05	< 0.05
Systolic index	r	0.2	0.21
	p	< 0.05	< 0.05

GLS — global longitudinal strain; GLSR — global longitudinal strain rate; GCS — global circumferential strain; GCSR — global circumferential strain rate; GRS — global radial strain

tensive stage. Thus, Kosmala et al. concluded that GLS was an early indicator parameter for preclinical left ventricular dysfunction [13].

In our study, it was found that GCS, GCSR, GRS and radial vel were lower in patients with HFpEF compared with non-HFpEF patients and the control group (Tab. 3). The changes in systolic function in the radial axis and circumferential are different in many studies. The study of Egidi Imbalzano in hypertensive patients whose left ventricular structure have not changed shown that GRS and GCS were conserved. However, in patients with left ventricular thickening, GRS decreased, while GCS increased [14]. Research by Krainer et al. [10] on 313 people (including 44 hypertensive patients, 219 hypertensive patients with HFpEF and 50 controls), showed decreased GCS in hypertensive patients with HFpEF compared with hypertensive patients without HF-pEF and the control group.

Our study showed that both longitudinal-perimeter index and systolic index were decreased in both hypertensive patients with and without HFpEF (Tab. 3). Chunyan and Morris et al. [9, 15] also showed similar results. Likewise, Kouzu et al. showed that global systolic function was the result of myocardial contraction in different directions such as longitudinal, radial axis and circumferential [16]. The decline in these parameters is also related to the left ventricular filling pressure, so assessing cardiac function in many directions is very important because it assesses the function of the entire left ventricular.

Results of our study, Torsional peak angle, torsional speed and Time reaching peak torsion did not change in these groups. Many studies also showed that left ventricular torsion was preserved in patients with HFpEF [14, 17, 18]. This is likely due to the compensatory mechanism of the heart to maintain a normal ejection fraction in patients with HFpEF [18, 19].

In our study we recruited the control group to define the reference range of myocardial strain parameters. We determined that the reduction in myocardial strain was the 2.5th percentile value ≤ percentile from the control group [9]. For negative values such as GLS, GLSR, GCS, GSR, longitudinal-perimeter index, we took the uppercut as an abnormal threshold (value approaches 0), for the positive sign value such as GRS, radial velocity, Torsional peak angle, torsional speed and time to reach peak torsion, systolic index, we took the lower threshold (value approaching zero) as abnormal threshold (Tab. 4). Based on this cut-off, we had the rates of preclinical systolic dysfunction in the hypertensive group as follows: GLS 94.7%, GCS 64.9%, GRS 31.8% (Tab. 5). This proves the high sensitivity of the STE technique.

In patients with HFpEF we saw a 96.7% decrease in GLS, while in hypertensive patients, although there were no clinical signs of heart failure, there was a 93.3% decrease in GLS. Likewise, GCS, systolic index and longitudinal-perimeter index in hypertensive patients with and without HFpEF were 62.2% and 68.9%, respectively; 78.9% and 83.6%; 64.4% and 72.1% (Tab. 6). Krainer's multicenter study [10] on 313 people (44 hypertensive patients, 219 hypertensive patients with HFpEF and 50 controls) determined the threshold of abnormal GLS and GCS based on cut-off > mean + 2SD. In the control group, the rates of abnormal GLS and GCS in hypertensive patients with HFpEF were 66.7% and 40.4%, respectively. Although GLS and GCS were significantly associated with EF, it was significantly reduced in patients with HFpEF. More than 1/2 of patients with HFpEF had decreased GLS. On the other hand, GLS is independently related to NT-proBNP. This indicates a contribution of systolic function to the clinical manifestations of heart failure with preserved ejection fraction.

In addition, the myocardial function index (Tei index) in cardiac Doppler ultrasound provides reliable results in the evaluation of cardiac function. However, through table 7 in the group with normal Tei index (Tei ≤ 0.47) there was a decrease in strain parameters and this rate is higher when the Tei index is abnormal (Tei > 0.47) (Tab. 7). The study of Ta Manh Cuong [20] showed no difference between hypertensive patients with HFpEF and the normotensive group in Tei index. It shows that the sensitivity of the Tei index is limited.

We also found a correlation between strain parameters and EF index (Tab. 8). Although 100% of hypertensive patients in our study sample had preserved EF (> 50%), most of them had reduced systolic function by strain parameters. This can be said that the sensitivity of the STE technique is higher than the classic echocardiography technique (M-Mode and Simpson).

Limitations and implementations

STE has shown that it is more effective than ordinary ultrasound methods in detecting LVH in the subclinical stage. The limitation of the study is the fact that measurements were not directly validated by MRI. However, Amundsen et al. [4] demonstrated a good correlation between STE technique and MRI. STE could be practical in our country with an echocardiogram machine which is installed online or offline software.

Although our study result has been relatively old, these results are still applicable because in the period of 2013 up to now there are not many studies on this technique in the Vietnamese population. Besides, our study was performed on one center with a small number of control groups due to objective limitations and financial problems, so its reliability was not relatively high. However, these results could be used as a reference value for further multicenter studies.

Conclusions

2D STE technique bears the potential to detect signs of early damage of the LV in patients with no clinical symptoms of HF. This method is associated with high sensitivity, especially at the global longitudinal strain index. The mean values of strain along the longitudinal axis, circumference, radial axis and torsional peak angle are –16.52 ± 1.19, –17.92 ± 2.39; 12.33 ± 1.94 and 11.33 ± 4.51, respectively. The threshold of abnormal systolic strain along the longitudinal axis is — 14.364; circumference is — 14.703; the horizontal axis is 8.369; Torsional peak angle 3.742. These values could be the reference basis for the next study. The sensitivity of the EF index and Tei index by ordinary echocardiography techniques (M-Mode and Simpson) is limited compared to the STE method.

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