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RESEARCH ARTICLE

STUDY OF RIGHT VENTRICULAR FUNCTION IN PATIENTS WITH PULMONARY HYPERTENSION BY SPECKLE TRACKING

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ABSTRACT

Objective: The aim of this study was to evaluate RV function by speckle tracking in patients with pulmonary hypertension.

Background: Right ventricular failure is the main cause of death in patients with pulmonary hypertension. 2D speckle tracking imaging allows noninvasive measurement of RV strain and strain rate.
Patients and methods: RV strain and strain rate analysis in 40 patients with pulmonary hypertension. 20 age and sex matched healthy volunteers free from any cardiovascular risk factors were enrolled as a control group.

Results: A highly significant increase was present in PHT patients (group I) compared to control group (group II) as regard TR GR.and PASP (P-value <0.001) and a highly significant decrease was present in group I as regard TAPSE (P-value <0.001). There was a highly significant reduction in group I as regard average right ventricular (septal and lateral walls) peak longitudinal systolic strain (S%) in apical 4 view (P-value <0.001). Also, there was a highly significant reduction of Average right ventricular (septal and lateral walls) peak longitudinal strain rate at systole , early diastole and late diastole (1/sec) in apical 4 view (P-value <0.001).

Conclusions: PHT is associated with development of RV dysfunction.RV strain and strain rate were highly significantly depressed in patients with PHT.

INTRODUCTION

Pulmonary hypertension is a serious clinical condition which is known to be progressive and to result in significant damage to the right heart function. Pulmonary hypertension which imposes pressure overload on the right ventricle, through elevated pulmonary artery pressure can cause premature death in severe cases [1].

So evaluation of RV function is considered very important especially in cases of PHT. Conventional RV function parameters, such as tricuspid annular plane systolic excursion (TAPSE) are widely used in clinical practice and can be considered validated indices of global RV contractility [2]. But, it has a number of limitations, such as angle- dependence. These parameters provide information about RV global function and do not afford important regional changes in myocardial performance. For RV global function assessment, TAPSE assumes that the function of a single segment represent the function of the entire right ventricle. speckle tracking is a novel technique that enables the accurate quantitative assessment of myocardial function. Speckle tracking echocardiography (STE) quantitatively analyzes the displacement and velocity of the myocardium by tracking myocardial movement from frame to frame throughout the cardiac cycle, and affords a new method to assess myocardial function [3–5].

STE-derive global strain and strain rate were based on the average of the RV 6 segmental strain and strain rate, Therefore, STE-derived indices are superior to TAPSE because it is not only allows the regional analysis of RV contractility and contraction synchronicity, but also allow the global analysis of RV function [6–8]. The aim of the work was to detect changes in RV function in pulmonary hypertension patients using speckle tracking echocardiography (RV strain and strain rate).

Subjects and methods

Study group

This is a study that enrolled 60 individuals after obtaining their written informed consent and approval of Ethics Committee of Menoufia University. They were divided into two groups; group I (cases group): 40 pulmonary hypertension patients,

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Group II (control group):20 healthy age and sex matched volunteers free from any cardiovascular risk factors.

Inclusion criteria included patients with pulmonary hypertension. Exclusion criteria included patients with pulmonary artery stenosis, RV outflow tract obstruction, Atrial Fibrillation (AF), Presence of Pacemaker wires in the right ventricle, History of coronary artery disease, previous myocardial infarction, Wall motion abnormalities, and Cardiomyopathy.

METHODS

Each patient was subjected to full history taking, thorough clinical examination, 12-lead ECG, plain chest x-ray and:

A. 2D echocardiography with Vivid 9 GE:measuremet of the gradient of the tricuspid regurge,pulmonary artery systolic pressure and tricuspid Annular Plane Systolic Excursion .
B. Speckle tracking strain and strain rate imaging of the right ventricle in apical 4 view, Off-line analysis was made using the commercially available EchoPac analysis system (GE, version 8.0.1, US). The software is based on real time tracking of natural acoustic markers, present in the ultrasound tissue images, which allows the derivation of 2D strain and strain rate (frame rate = 50 - 54 f/s) by comparing displacement of speckles in relation to one another throughout the cardiac cycle (Figures 1-4).

Statistical analysis

Data were collected, tabulated, and statistically analyzed with an IBM compatible personal computer with SPSS statistical package version 17.

Descriptive statistics: such as percentage (%), mean (x), and SD were determined.

Analytical statistics: these were ascertained using the X^2 -test, student's t-test, and analysis of variance (F), with a level of significance as follows: p-value less than 0.05 was considered significant, p-value less than 0.001 as highly significant, and p-value greater than 0.05 as nonsignificant.

RESULTS

Regarding conventional echocardiography, **a highly significant increase in** tricuspid valve regurge gradient and Pulmonary artery systolic pressure **was present in group** I **when compared with group** II **(p-value <0.001) and a highly significant decrease was present in group** I **when compared with group** II **as regard** tricuspid annular plane systolic excursion **(p-value <0.001)** (table 1)**.**

There was a highly significant reduction of average right ventricular (septal and lateral walls) peak longitudinal systolic strain (S%) in the apical 4 view in cases group **(p-value <0.001) (table 2).**

Table 1 Comparison between study groups as regard TR.GR., PASP and TAPSE

	Cases (n = 40)	Control (n = 20)	Test of sig.	p
TR.GR. (mmhg)				
Min. – Max.	40.0 – 85.0	19.0 – 26.0		
Mean ± SD	53.78 ± 10.82	23.05 ± 2.01	t = 17.370*	<0.001*
Median	52.0	23.50		
PASP (mmhg)				
Min. – Max.	45.0 – 100.0	24.0 – 31.0		
Mean ± SD	63.30 ± 13.45	28.05 ± 2.01	t = 16.217*	<0.001*
Median	59.0	28.50		
TAPSE (mm)				
Min. – Max.	13.0 – 20.0	20.0 – 29.0		
Mean ± SD	18.12 ± 1.96	23.75 ± 2.61	t = 9.346**	<0.001*
Median	19.0	23.50		

t: Student t-test
Z: Z for Mann Whitney test
*: Statistically significant at p ≤ 0.05
TR.GR.:Tricuspid regurge gradient,PASP:Pulmonary artery systolic pressure,TAPSE: Tricuspid annular plane systolic excursion.

Table 2 Comparison between study groups as regard longtudinal RV peak systolic strain (S,%) (A4C)

		Cases (n = 40)	Control (n = 20)	t	p
Septum	**Basal**				
	Min. – Max.	6.63 – 21.50	19.57 – 39.57		
	Mean ± SD	15.29 ± 3.27	30.63 ± 6.08	10.552*	<0.001*
	Median	14.68	31.24		
	Mid				
	Min. – Max.	7.19 – 19.89	21.33 – 37.22		
	Mean ± SD	15.44 ± 2.87	29.13 ± 4.92	11.498*	<0.001*
	Median	15.36	27.65		
	Apical				
	Min. – Max.	4.66 – 12.23	25.36 – 39.65		
	Mean ± SD	9.52 ± 2.94	33.68 ± 4.17	26.005*	<0.001*
	Median	9.58	33.71		
	Average				
	Min. – Max.	8.02 – 18.20	22.61 – 38.33		
	Mean ± SD	13.41 ± 2.15	31.15 ± 4.43	16.943*	<0.001*
	Median	13.31	29.72		
Lateral Wall	**Basal**				
	Min. – Max.	10.56 – 26.56	25.36 – 44.60		
	Mean ± SD	19.46 ± 3.78	34.02 ± 5.71	10.330*	<0.001*
	Median	19.84	35.52		
	Mid				
	Min. – Max.	1.12 – 17.95	23.36 – 42.37		
	Mean ± SD	9.54 ± 4.41	32.29 ± 6.16	14.733*	<0.001*
	Median	8.49	32.14		
	Apical				
	Min. – Max.	6.59 – 19.36	21.36 – 43.02		
	Mean ± SD	13.75 ± 3.45	33.41 ± 6.36	12.915*	<0.001*
	Median	14.36	34.66		
	Average				
	Min. – Max.	8.64 – 17.71	23.36 – 41.91		
	Mean ± SD	14.25 ± 2.24	33.24 ± 5.09	15.916*	<0.001*
	Median	14.70	33.48		

There was a highly significant reduction of average right ventricular (septal and lateral walls) peak longitudinal strain rate at systole , early diastole and late diastole (1/sec) in apical 4 view in cases group **(P-value <0.001) (table 3).**

Table 3 Comparison between study groups as regard longitudinal RV peak strain rate (S) (1/sec) (A4C)

		Cases (n = 40)	Control (n = 20)	t	p
Septum	**Basal**				
	Min. – Max.	0.25 – 1.75	0.88 – 2.58		
	Mean ± SD	1.04 ± 0.36	1.48 ± 0.50	3.936*	<0.001*
	Median	1.03	1.38		
	Mid				
	Min. – Max.	0.25 – 1.69	0.98 – 2.36		
	Mean ± SD	0.97 ± 0.36	1.56 ± 0.32	6.211*	<0.001*
	Median	0.98	1.56		
	Apical				
	Min. – Max.	0.01 – 1.93	1.20 – 2.45		
	Mean ± SD	0.92 ± 0.47	1.80 ± 0.37	7.299*	<0.001*
	Median	0.90	1.80		
	Average				
	Min. – Max.	0.49 – 1.74	1.26 – 2.12		
	Mean ± SD	0.98 ± 0.29	1.62 ± 0.23	8.650*	<0.001*
	Median	0.90	1.57		
Lateral Wall	**Basal**				
	Min. – Max.	0.52 – 2.67	1.25 – 2.84		
	Mean ± SD	1.66 ± 0.45	2.05 ± 0.47	3.140*	0.003*
	Median	1.66	1.92		
	Mid				
	Min. – Max.	0.25 – 2.08	1.14 – 2.74		
	Mean ± SD	1.18 ± 0.50	2.03 ± 0.49	6.292*	<0.001*
	Median	1.19	2.22		
	Apical				
	Min. – Max.	0.32 – 1.98	1.52 – 2.78		
	Mean ± SD	1.08 ± 0.44	2.28 ± 0.27	12.905*	<0.001*
	Median	1.04	2.34		
	Average				
	Min. – Max.	0.71 – 2.05	1.69 – 2.61		
	Mean ± SD	1.31 ± 0.30	2.12 ± 0.22	12.004*	<0.001*
	Median	1.33	2.17		

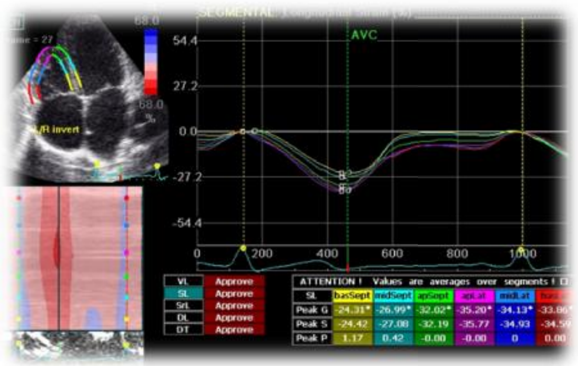

Figure 1 Right ventricular (septal and free walls) peak longitudinal systolic strain (S%) by two dimensional speckle tracking in a healthy subjects in apical four chamber view

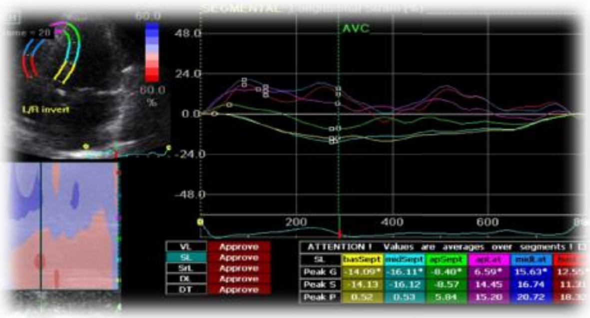

Figure 2 Right ventricular (septal and free walls) peak longitudinal systolic strain (S%) by two dimensional speckle tracking in a Patient with pulmonary hypertension in apical four chamber view.

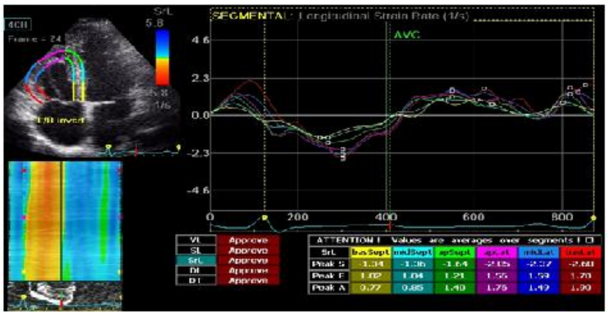

Figure 3 Right ventricular (septal and free walls) peak longitudinal strain rate in systole,early diasole and late diastole by two dimensional speckle tracking in a healthy subjects in apical four chamber view

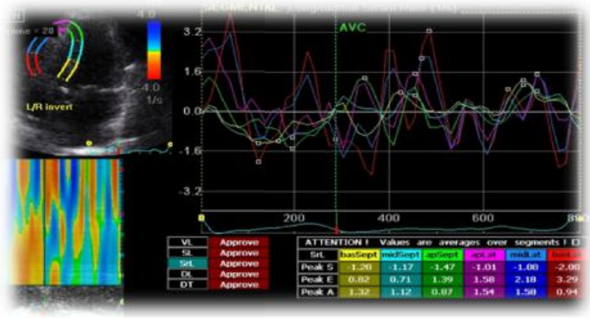

Figure 4 Right ventricular (septal and free walls) peak longitudinal strain rate in systole,early diasole and late diastole by two dimensional speckle tracking in a patient with pulmonary hypertension in apical four chamber view

DISCUSSION

The purpose of the study is to evaluate right ventricular function in patients with pulmonary arterial hypertension by 2-dimensional ultrasound speckle tracking echocardiography and detect the effect of pulmonary artery systolic pressure on right ventricle function.

40 patients with pulmonary arterial hypertension and 20 healthy controls were included in this study. Right ventricle longitudinal strain and strain rate were measured at the basal, mid and apical segments of the right ventricle lateral wall and septum using speckle tracking echocardiography.

The present study concluded that increasing in the pulmonary artey pressure is associated with right ventricle strain and strain rate reduction.

The results of this study were consistent with the results of Meris *et al*. [9] they found that right ventricle free wall and interventricular septum longtudinal strain measured by STE were impaired in patients with Pulmonary arterial hypertension compared with normal subjects.

Also the results of this study are consistent with the study of Yuman Li *et al*. that conducted on 42 patients with Pulmonary arterial hypertension and 31 healthy controls, right ventricle longitudinal peak systolic strain and strain rate were measured at the basal, mid and apical segments of the right ventricle free wall and septum by STE. Right ventricle global longitudinal peak systolic strain and strain rate were also measured by STE. And this study investigated that right ventricle global strain and strain rate were lower in patients with varying degrees of

Pulmonary arterial hypertension than in normal subjects, and concluded that STI-derived right ventricle strain and strain rate can be used as novel indices for assessment of right ventricle systolic function from 2-dimensional echocardiographic images.

Also the results of this study are consistent with the study of Li *et al.* who compared 42 patients with pulmonary hypertension to 31 healthy controls by assessing multiple parameters thought to be predictive of right ventricle changes [10]. These parameters included right ventricle global and longitudinal peak systolic strain and strain rates at basal, mid and apical segments of right ventricle free wall and septum, and the study concluded that strain imaging predicted the impaired right ventricle global and regional systolic function in patients with Pulmonary arterial hypertension.

Also the results of this study are consistent with the study of Calcutteea *et al.* compared 35 patients with pulmonary hypertension to 20 controls [11]. and noted reduced basal and mid-cavity strain rate, reduced time to peak systolic strain rate at multiple right ventricle levels: basal, midcavity and RVOT.

Finally the results of this study are concordant with the study of E.L. Hardegree *et al*.**[12]** studied right ventricle longitudinal systolic strain and strain rate by echocardiography in 80 patients with World Health Organization group 1 pulmonary hypertension .Survival status was assessed over 4 years, and found that all patients had a depressed right ventricle systolic strain and strain rate and concluded that Noninvasive assessment of right ventricle longitudinal systolic strain and strain rate independently predicts future right-sided heart failure, clinical deterioration, and mortality in patients with Pulmonary arterial hypertension and suggested that Speckle-tracking-based strain has the advantage of being widely available, objective, cost effective, and safe ,also Emerging ultrasound technologies such as speckle-strain may play an important role in predicting prognosis, monitoring the efficacy of specific therapeutic interventions, and detecting preclinical stages of disease in Pulmonary arterial hypertension.

CONCLUSIONS

PHT is associated with development of RV dysfunction.RV strain and strain rate were highly significantly depressed in patients with PHT.

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