Effect of Exercise on Echocardiographic Parameters in Healthy and Hypertensive Patients

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Abstract

Introduction: Hypertension as a chronic cardiovascular disease, has major impact on global mortality and morbidity around the world. The effect of hypertension on human body is still under research. The present article emphasize the different effects of exercise on echocardiographic characteristics of healthy and hypertensive patients. Material and methods: Patients who were aged between 16 to 50 years and referred for stress echocardiography during the one year period enrolled in present case control study. The participants were grouped according to their blood pressure status to hypertensive or normotensive patients. The stress echocardiography was performed according to Bruce protocol and the exercise was performed on a treadmill. Parasternal long axis, para sternal short axis, apical 4 chamber and apical 2 chamber view were evaluated for each patient. Echocardiographic variables regarding ventricular functions, diastolic parameters, PAP as well as right and left atrium area and volume were evaluated according to the recent cardiology guidelines. After completing the stress echocardiography, and reaching the target heart rate of 85%, the mentioned variables have recorded again for all patient when the heart rate fall between 100 and 110 beat per minute. Results: Most of the participants were female and the mean \pm standard deviation of age was 44.72±.9.74 years. Exercise increased the E, Em, LAEF and E/e in hypertensive and also E, Em and LAEF among control groups (P=0.001 for all). E, A, STV, ETV and RAEF values were significantly increased in both hypertensive and control groups after exercise (P=0.001 for all). Also, after exercise, LA volume decreased in both groups (P=0.012). The LAEF at rest was significantly higher in control group and increased significantly by exercise in both groups (P=0.001 for all). Among hypertensive group after exercise only RA volume reduced significantly (P=0.002). RAEF in control group was greater than hypertensive group at rest and this parameter increase significantly in both groups after exercise (P=0.001 for all). Conclusion: The present study revealed that healthy patients at rest have fewer E/A ratio of mitral valve, right and left atrial volume while right and left atrial function were greater. In both groups after exercise, Em, ET, STV, LAEF and RAEF increases while the changes in Sm is not statistically significant.

Key words: Stress Echocardiography, Echocardiography, Hypertension

Introduction

Hypertension is considered as a disease with considerable morbidity and mortality around the world. We are expecting to face 60% increase in hypertension disease burden in the first quartile of the 21st century. Shifting from major mortality from communicable disease to non-communicable causes globally has highlighted the effects of high blood pressure complications and adverse health outcomes. Stroke, end stage renal disease and many other cardiovascular disease are taking affect from high blood pressure (Lackland and Weber, 2015). There are numerous preventive and treatment protocols available for reducing the disease burden (Lackland and Weber, 2015; Esfehani et al., 2012; Nerenberg et al., 2018). Most of the adverse effects of high blood pressure as well as better understanding of antihypertensive treatment regimens can be achieved by increasing our about the pathophysiological and anatomical effects of hypertension on the body organs. Hypertension can provide remodeling alteration in both great and small vessels as well as the cardia itself (Laurent and Boutouyrie, 2015). The herald role of inward remodeling mainly caused by pathological hypertrophy in arteries. However, the effect of hypertension on the cardia seems to be more complicated that blood vessels (Heagerty, Heerkens and Izzard, 2010). Both systolic and diastolic blood pressure depends on different factors including myocardial contractility, stroke volume, peripheral resistance and venous return and preload (Pavlíček et al., 2016). Echocardiography as a non-invasive tool which can visualize

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different aspects of the heart including its morphology, function and blood flow has been used to evaluate the effect of different disease on the cardia. Left ventricular hypertrophy (LVH) is one of the first adjustment mechanisms for overcoming pressure overload and maintain cardiac output (Pavliček et al., 2016). Left ventricular (LV) systolic and diastolic function as well as left atrial size are other important modalities which are altered in hypertensive patient and can be efficiently evaluated by use of echocardiography (Lee and Park, 2015). Alongside with echocardiography which provide functional information about the cardiac function in hypertensive patients, stress echocardiography is another diagnostic test which can evaluate the real-time effect of physical, pharmacological or electrical stress on hypertensive heart (Varga et al., 2006). Moreover, the information provided by exercise echocardiography can provide prognostic information as well. It has been demonstrated that patients with normal E/e' will have more favorable outcomes than those who experience increased E/e' after exercise even if they have unremarkable exercise test (Peteiro et al., 2019).

To the best of our knowledge, no study has evaluated the effect of physical stress on the both left and right side of the heart function in hypertensive adults. So, regarding to the gap of knowledge and also the growing burden of hypertensive disease, we have conducted the present research on hypotensive and normotensive adult patients undergoing stress echocardiography.

Material and Methods:

The present case control study took place in Ghaem hospital, Mashhad Iran. The study protocol was approved by Mashhad University of Medical Sciences ethic committee. The participants of present study were chosen from patients aged between 16 to 50 years and who were referred for stress echocardiography during the one year period (Jan 2018 - Jan 2019). Before performing the stress echocardiography test, every patients have provided with an informed consent from and those who didn't agree to enroll in present study have undergone their medical management and received the same medical service. Every patient who agree to enroll have received a brief physical examination as well as a complete medical history taking from a cardiologist. Those patients who have history of cardiac disease including any arrhythmias or valvular disease, positive history of any cardiac surgery or angiography, history of other disease including diabetes mellitus, dyslipidemia, peripheral vascular disease, cerebrovascular accidents, and those who were smokers or athletes didn't enrolled in present study. Then the participants were grouped according to their blood pressure status to hypertensive or normotensive patients. Only those who has hypertension according to American heart association guideline were included in present study (systolic and diastolic blood pressure greater than 140mmHg and 90mmHG) (Whelton Paul et al., 2018). The stress echocardiography was performed according to Bruce protocol and the exercise was performed on a treadmill. The echocardiography of all patients was performed by the same fellowship of echocardiography with the Philips echocardiography device (Siemens echocardiography device - Acuson SC2000, probe 4V1c 3 MHZ). Parasternal long axis, para sternal short axis, apical 4 chamber and apical 2 chamber view were evaluated for each patient. Any patient with valvular disease, increased pulmonary artery pressure and regional motion abnormality discovered during echocardiography as well as those who could not complete the stress echocardiography were excluded. Diastolic parameters including early diastolic mitral fellow (E), transmitral fellow velocity with atrial contraction (A), E/A ratio, deceleration time (DT) and isovolemic relaxation time (IVRT) of both left and right ventricle as well as right and left atrium area and volume were evaluated. Also, other parameters including systolic wave velocity (Sm), velocity of early diastolic mitral annular motion (Em), tricuspid regurgitation (TR) and pulmonary artery pressure (PAP) of left side as well as S tv, E tv, E/e tv ratio and S,D in HV of the right side of the heart were evaluated. After completing the stress echocardiography, and reaching the target heart rate of 85%, the mentioned variables have recorded again for all patient when the heart rate fall between 100 and 110 beat per minute.

Results:

Among 72 study participants who were divided into healthy and hypertensive groups 75% were female and the mean \pm standard deviation of age was 44.72 \pm .9.74 years. Distribution of other cardiovascular risk factors are summarized in table 1. The study groups were not significantly different according to Hyperlipidemia, diabetes mellitus and gender (P=0.289, P=0.836 and P=0.606 respectively) (table 2). The difference between echocardiographic variables before and after exercise is summarized in table 3 and 4. Among left side of the heart at rest; A, E, E/A ratio, DT, LA area, LA volume, E/e, TR and PAP in hypertensive patients were higher than control group. Among these variables, only E/A ratio, A and LA volume were significantly different among study groups (P=0.004, P=0.007, P=0.005 respectively). Em and LAEF values at rest were significantly different higher than control group (P=0.001 and P=0.007 respectively).

Among right side of the heart at rest; E, A, E/ETV, RA area and RA volume in hypertensive group were higher than control group. A, E/ETV, RA area and RA volume were significantly different among both groups (P<0.001, P=0.008, P=0.005 and P=0.007 respectively). STV and RAEF values at rest were significantly higher in control group (P=0.003 and P=0.009 respectively).

Exercise increased the E, A, Sm, Em, LAEF and E/e values in hypertensive groups. Among these variables only E, Em, LAEF and E/e increased significantly (P=0.001 for all). Also, the exercise increased the E, A, Sm, Em and LAEF as well as E/e ratio among control

group and only E, Em and LAEF increase significantly (P=0.001 for all). E, A, STV, ETV and RAEF values were significantly increased in both hypertensive and control groups after exercise (P=0.001 for all).

The LA are and LA volume at rest were significantly greater among hypertensive groups (P=0.049 and P=0.005). After exercise, these values decreases among both groups; however, only decrease in LA volume is statistically significant hypertensive group(P=0.012). The LAEF at rest was significantly higher in control group and increased significantly by exercise in both groups (P=0.001 for all). RA area and volume in hypertensive group was greater than control group (P=0.005 and P=0.007 respectively). Among hypertensive group after exercise, RA area, RA volume reduced and only RA volume reduced significantly (P=0.002). RAEF in control group was greater than hypertensive group after exercise (P=0.001 for all).

Discussion:

The present study has compared the exercise response in both hypertensive and normal heart by using stress echocardiography. While echocardiography can visualize the inner structure of the heart as well as determining its global function in a real time manner, it's considered as an effective and non-invasive tool for evaluating cardiac function. According to our results, there are some significant differences among post exercise echocardiography of hypertensive patients including LAEF and RAEF as well as A, E, E/A ratio and DT in both sides of the heart. Overall, such changes in hypertensive and control group shows that exercise will not provide notable diastolic function changes

Hypertension is now considered as a major cause of different cardiovascular problems. Blood pressure level is related to ventricular deformation and affect cardiac mechanistic and functions (Tadic et al., 2014). Hypertension may cause heart failure with preserved ejection fraction. Both LVH and LV diastolic dysfunction are the main precursor of heart failure. LV diastolic dysfunction is commonly seen in those with asymptomatic hypertension (Farag E-SM, Al-Daydamony and Gad, 2017). Determination of LV diastolic function and functional capacity in those with even asymptomatic hypertension is reasonable. Diastolic dysfunction in hypertensive patients is a contributor of developing further heart failure in those who are at early asymptomatic heart failure stages (Farag E-SM, Al-Daydamony and Gad, 2017). Different studies have evaluated the effect of hypertension on cardiac function during different exercise tests. Kim et al. has found that there is significant relation between diastolic dysfunction and obesity and/or hypertension. They have evaluated 4 groups of patients including hypertensive, obese, obese hypertensive and normal controls. According to their results, approximately 64% of their patients had diastolic dysfunction and such dysfunction couldn't confer the exercise capacity in their population. Their hypertensive patients have lesser E/A ratio than normal controls (1.00±0.33 versus 1.13±0.44) which is not as same as our study. Moreover, their hypertensive patients tend to have higher DT than normal controls (195.16±40.20 versus 188.06±46.01) which is as same as our study in the left side (Kim et al., 2016). The E wave shows the early filling of LV during diastole which is directly related to the LA pressure and inversely associated with LV compliance. Aging and ventricular diastolic dysfunction decreases the E wave amplitude and strengthen LA contracture; resulting in increasing A wave amplitude. Regarding to DT and E/A ratio, there was not any remarkable diastolic dysfunction in both groups. According to further results of Kim et al. study, obese hypertensive patients are 3 times more likely to develop diastolic dysfunction. Obese hypertensive were more likely to have decreased Ea and E/A ratio, high E/Ea and delayed DT (Kim et al., 2016). The Kim et al. study emphasizes the fact that weight loss and hypertension control can modify cardiac dysfunction (Kim et al., 2016). Tadic et al. is the other study which has evaluated both hypertensive and normal controls according to their exercise test results (Tadic et al., 2014). Their study has confirmed that hypertensive patients have deteriorated left ventricular diastolic function which is highlighted by decreased E/A ratio, increased DT and left atrial dilatation. They have demonstrated that E/A ratio, DT and LA area in left side is significantly different among controls, untreated, controlled and uncontrolled hypertensive patients. The LA area decreased from uncontrolled group toward untreated, controlled and normal control patients. Their healthy controls had the highest E/A ratio upon both left and right sides while the untreated and uncontrolled groups have the lowest. Moreover, the healthy control group has the lowest DT while the uncontrolled group has the highest in both left and right sides. Among the right side, RAEF didn't significantly differed among study groups (Tadic et al., 2014). Moreover, sahebjam et al. has demonstrated that mild hypertension will result in decreased early diastolic strain rate of LA even in those who have unchanged maximal left atrial volume and preserved peak systolic strain rate (Sahebjam et al., 2014). In our study, the LAEF was significantly higher among control group before and after exercise. The LA area and volume didn't significantly changed after exercise. The RAEF significantly increased after exercise in both groups. RAEF was significantly higher in controls in contrast to hypertensive group before and after exercise.

Diastolic dysfunction has been identified as a predictor of adverse outcome in heart failure patients (Linke et al., 2012). In those patients who have heart failure, exercise training can improve disease course (Alves et al., 2012). However, in some cases including dilated cardiomyopathies, the exercise should be carry out with more caution. Morikawa et al. has demonstrated that exercise induced diastolic dysfunction will present for a day after exercise of such patients (Morikawa et al., 1998). As same as our study, those with dilated cardiomyopathy has showed significant decrease in E/A ratio after exercise.

Limitations:

Although echocardiography is an inexpensive, non-invasive tool for assessing global cardiac function; however it has its own limitation. Echocardiography is an operator dependent technique. This fact make the reproducibility of some results more difficult. Moreover, effective visualization of cardiac chambers and especial views in some patients including obese patients is more difficult.

Conclusion:

The present study which have evaluated the effect of exercise on echocardiographic parameters in healthy and hypertensive patients revealed that healthy patients at rest have fewer E/A ratio of mitral valve, right and left atrial volume while right and left atrial function were greater. In both groups after exercise, Em, ET, STV, LAEF and RAEF increases while the changes in Sm is not statistically significant.

Study variable	Frequency (%)			
Male	18(25)			
Hypertensive	40(55.6)			
Diabetes mellitus	67(93.1)			
Hyperlipidemia	12(16.7)			
Left ventricular hypertrophy	38(52.8)			

Table 1. Frequency of study risk factors among study participants.

Table 2. Distribution of study variables among study groups

Study variable	Control group (%)	Hypertensive group (%)	P value
Male	8 (25)	10 (25)	0.606
Hypertensive	0 (0)	40 (100)	0.000
Diabetes mellitus	2 (6.3)	3 (7.5)	0.836
Hyperlipidemia	7 (21.9)	5 (12.5)	0.289
Left ventricular hypertrophy	0 (0)	38 (95)	0.000

Table 3. Left side parameters among hypertensive and control patients undergoing exercise echocardiography.

Variable	Hypertension		Control		Baseline vs final		Hypertension vs control	
	Baseline	Final	Baseline	Final	hypertension	Control	Baseline	Final
Е	69.08±22.90	94.35±25.28	66.50±13.77	87.09±11.80	<0.001**	< 0.001**	0.577	0.139
А	67.62±20.61	77.33±23.06	66.56±16.21	81.03±27.45	0.812	0.536	0.007**	< 0.001**
E A	1.54±0.43	1.52±0.39	1.28±0.29	1.41±0.35	0.777	0.108	0.004**	0.221
DT	204.00±58.31	194.30±40.20	182.66±29.33	169.96±49.80	0.199	0.03**	0.063	0.01**
IVRT	75.20±13.85	64.07±10.09	74.19±9.62	63.19±11.00	<0.001**	< 0.001**	0.731	0.727
SM	6.9±4.50	8.6±1.08	7.78±1.22	10.70±2.85	0.594	0.607	0.440	0.98
EM	7.18±1.91	8.88±3.27	9.80±2.51	12.23±3.17	<0.001**	< 0.001**	< 0.001**	< 0.001**
LA area	17.15±3.59	16.69±3.45	15.65±2.42	15.34±3.27	0.055	0.257	0.049*	0.101
LA volume	48.49±14.67	44.37±15.15	39.65±9.14	37.88±11.82	0.012**	0.325	0.005**	0.054
LA EF	0.53±0.04	0.66±0.05	0.56±0.02	0.69±0.03	<0.001**	< 0.001**	0.007**	0.003**
Еe	9.91±3.47	11.69±4.98	6.81±2.43	7.61±2.52	<0.001**	1.26	< 0.001**	< 0.001**
TR	22.10±6.58	24.74±7.50	19.67±3.64	21.73±3.08	<0.001**	< 0.001**	0.073	0.043*
PAP	27.05±6.56	29.77±7.53	24.43±3.63	26.53±3.04	<0.001**	< 0.001**	0.054	0.030*

Variable	Hypertension		Control		Baseline vs final		Hypertension vs control	
	Baseline	Final	Baseline	Final	hypertension	Control	Baseline	Final
Е	62.90±25.30	80.87±20.98	49.78±20.48	66.19±19.58	<0.001**	<0.001**	0.021*	0.004**
А	88.03±25.90	101.74±29.25	53.56±31.53	66.75±33.92	<0.001**	<0.001**	< 0.001**	<0.001**
ΕA	1.60±0.45	1.61±1.25	1.37±0.29	1.36±0.27	0.938	0.914	0.018*	0.260
DT	172.02±36.37	156.10±31.55	187.45±30.38	173.35±51.79	0.018*	0.064	0.061	0.087
IVRT	29.05±12.19	16.10±6.75	29.97±13.16	22.16±19.06	<0.001**	<0.001**	0.762	0.066
STV	12.32±2.23	15.13±3.22	14.44±3.51	19.28±5.26	<0.001**	<0.001**	0.003**	<0.001**
ETV	11.11±1.82	13.31±2.49	12.09±3.48	15.03±4.05	<0.001**	<0.001**	0.134	0.030*
E ETV	5.66±2.06	6.26±2.14	4.40±1.75	4.71±1.73	0.010*	0.208	0.008**	0.002**
RA area	12.50±2.53	12.16±2.99	10.90±1.67	10.98±1.93	0.271	0.804	0.005**	0.071
RA volume	29.46±10.25	27.34±9.46	23.79±4.19	24.48±6.37	0.002	0.367	0.007	0.167
RA EF	0.48±0.04	0.59±0.03	0.50±0.02	0.62±0.04	<0.001**	<0.001**	0.009**	0.008**

Table 4. Right side parameters among hypertensive and control patients undergoing exercise echocardiography.

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