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Research Article

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Evaluating the Effect of Exercise Test on Pulmonary Artery Systolic Pressure in COPD Patients and its Comparison with Normal Subjects in Ahvaz Imam and Golestan Hospitals

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ABSTRACT

The pulmonary artery systolic pressure (PASP) can be accurately estimated, non-invasively, using continuous-wave Doppler (CWD) ultrasound measurement of the peak velocity of a tricuspid regurgitant (TR) jet. During exercise, PASP may increase. The purpose of this study was to examine the responses of PASP by Doppler echocardiography during exercise in normal subject and in patients with chronic obstructive pulmonary disease. Thirty eight participants in each group, aged 35-65 years old were evaluated using Doppler echocardiography at rest and during treadmill exercise test. PASP was calculated using Bernoulli formula (4 times the tricuspid regurgitant velocity squared). During exercise, PASP increased in both groups with higher values achieved by patients with COPD (27.42 vs 56.10 mm Hg, P< 0.05). None of the normal subjects reached abnormal PASP limit at peak exercise. The systolic pulmonary artery pressure change during exercise increased with age in both group but has no correlation with gender. Also, change of PASP during exercise increase with body mass index in normal subjects but no in COPD patients. COPD patient have higher PASP compared with healthy control subjects both at rest and during exercise. Despite normal resting values for PASP in 44% of study patients, half of them showed abnormal increases in PASP during exercise.

Keywords: Pulmonary Artery Systolic Pressure, Chronic Obstructive Pulmonary, Exercise, Doppler Echocardiography, Tricuspid Regurgitant Jet

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INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) causes symptoms such as chronic cough, increased sputum, and activity dyspnea and is partially reversible. Some of the known risk factors of it are smoking, air pollution, asthma and certain genetic problems (1).

COPD is the fifth leading cause of death in the world and many patients progressively go towards the final stage of the disease. In the final stages, it causes corpulmonale the increased pulmonary arterial pressure and eventually cardiac dysfunction (2, 3).

Increased pulmonary artery pressure leads to right ventricular afterload (RV). The causes of increase in pulmonary artery pressure are multiple and could be due to progressive pulmonary vascular disease or underlying disease or pulmonary artery pressure (PAP) in response to high pressure from the left part of the heart (4).

Increased pulmonary artery pressure is specified with mean pulmonary artery pressure higher than 25 mmHg in rest or over 30 mmHg in certain activities (5, 6). Pulmonary artery pressure gradually increases with age.

In the normal lung, cardiac output increase of about two or three times the resting value increases pulmonary artery pressure only a few mm Hg, but in the case of illness, pulmonary artery pressure increases drastically even in a slight increase in blood flow.

In COPD usually large ventricle and the right atrium, left ventricle with normal size, and thick ventricular septal are seen. In Doppler echocardiography, left ventricular systolic pressure is calculated by measuring Tricuspid Regurgitation Velocity (TRV) (TRV) and Bernoulli formula. In Radionucleotide ventriculography, useful information in 201 secondary wall thickening of the right ventricle pulmonary arterial pressure (7).

COPD patients with increased pulmonary artery pressure have more functional limitations than other patients.

There are two ways to search for patients susceptible to pulmonary artery pressure:

By increasing blood flow, dobutamine stress echo causes disproportionate increase in pulmonary artery pressure in patients who cannot change their lung capacity vessels (8, 9).

Exercise has recently been used to identify patients susceptible to pulmonary hypertension (10). If COPD patients have pulmonary hypertension, exercise leads to a severe increase in this pressure. Patients that suffer pulmonary hypertension during exercise are highly susceptible to increased pulmonary arterial pressure at rest (11, 12).

Increase in pulmonary artery blood pressure during exercise is usually obtained higher than that predicted by equation pulmonary vascular resistance (PVR), which shows an increase in vasoconstriction (13). This unexpected increase may be due to reduced blood mixed venous oxygen partial pressure, vasoconstriction induced by stimulation of the sympathetic nervous system, or pH reduction due to decrease in blood carbon dioxide concentration.

COPD initially leads to hidden increase of pulmonary artery pressure (PAP), which is less than mmHg 20 in resting. This rate increases with exercise and reaches up to mmHg 30 (14). As hidden increase in pulmonary arterial hypertension is associated with increased mortality, to find a way to identify these patients, we studied the effect of exercise in increasing pulmonary artery blood pressure in patients with COPD by measuring the pulmonary artery pressure by transthoracic echocardiography before and after exercise test.

MATERIALS AND METHODS

In this study that was conducted in 2010, a number of 38 patients (35 to 65 years of age), in whom COPD was confirmed with pulmonary function tests, chest x-ray and so on, were studied.

Inclusion criteria included patients with COPD who do not have other known lung or heart disease or physical limitations in doing exercise, and they should not have pericarditis, hypertrophic obstructive cardiomyopathy, and myocardial infarction, history of heart failure and acute pulmonary attack in the last 3 months.

Demographic characteristics (age, sex, weight and height) were recorded and echocardiography was done using a Vivid 3 US with 3MHz probe in TTE form by cardiovascular assistant. Healthy people who have not have any known heart or lung diseases, have not been treated with any medication or supplement, are consistent with COPD patients regarding age and sex, and do not have increased pulmonary artery pressure entered the study.

In both groups, criteria such as EF, end-systolic and diastolic volume, the maximum amount of TRV and SPAP [4 (TRV) 2 + RAP] where TRV is the rate of valve regurgitation, left atrium size were measured from different views and then by Bruce Test exercise test was performed and maximum heart rate for each individual was calculated with (age -220) × % 85 formula.

One minute after exercise test, echo test was done again and the results were recalculated, and data analysis was done using t-test with SPSS software.

Sample size:
The sample size of this study was estimated using the Eq. (1). The confidence of interval was considered as 95% for this study, then the the minimum sample size was 38 as follows:

$$\frac{(S_1^{\,2} + S_2^{\,2})(Z_{1-a/2} + Z_{\beta})^2}{(M_1 - M_2)^2} \qquad \textbf{(1)}$$

$$38 \simeq \frac{(144+529)7/8}{144} = \frac{(23^2+12^2)7/8}{(44-32)^2}$$

RESULTS

Using statistical tests Paired t-test, Tukey post hoc test and ANOVA ratios and means were compared before and after the exercise test. The significance level for all tests was considered 0.5 and the data analysis was performed using SPSS17.0. For the relationship between age and pulmonary arterial systolic pressure, Pearson correlation coefficient was used.

Tricuspid regurgitation velocity (TRV) and systolic pulmonary artery pressure (SPAP) were determined in all the subjects. Age and BMI were investigated. According to the independent T-test test P> 0.05, no significant differences are seen between the two groups in terms of BMI and age. In terms of TRV and SPAP mean in rest time there is no significant difference between healthy men and women (P> 0.05).

After the initial echocardiography, the patients reached maximum heart rate through exercise and then a minute after disconnecting the test, echocardiography was repeated and SPAP and TRV parameters changes were compared. According to paired T-test, TRV and SPAP mean changes are significant after exercise test in healthy individuals (P <0.05).

SPAP and TRV mean difference in patients with COPD before and after the exercise test is significant according to P <0.05.

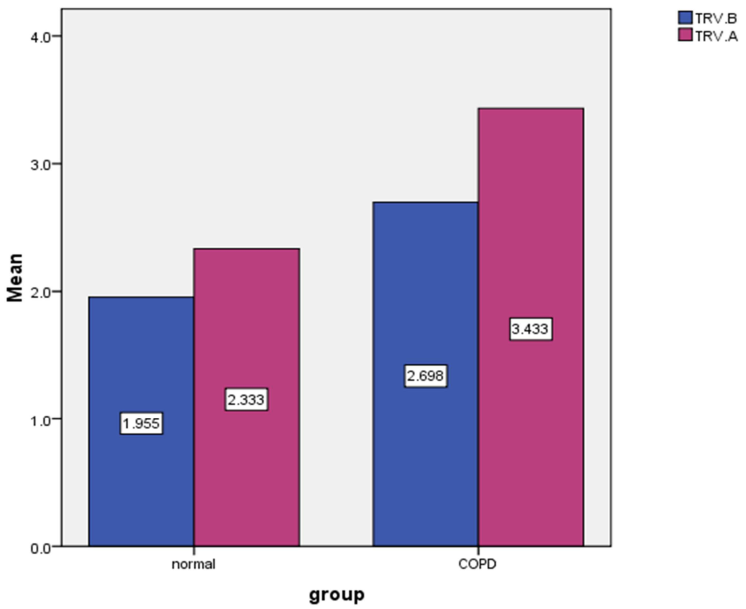

Figure 1. Comparison of TRV before and after exercise test in healthy and sick people

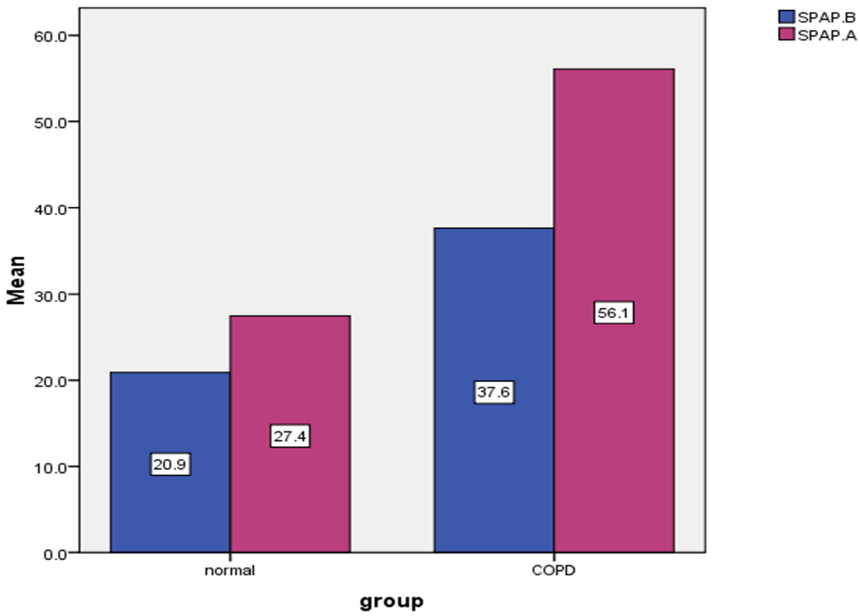

Figure 2. Comparison of SPAP before and after exercise test in healthy and sick people

There was no significant relationship between gender and SPAP and FRV after exercise test in healthy subjects P> 0.05. In addition, there was no significant relationship between gender and exercise after exercise test according to P> 0.05. However, there are significant differences between the genders in COPD patients in TRV after exercise testing according to P< 0.05.

There is a significant differences between healthy and COPD patient women in terms of indicators of TRV and SPAP before and after exercise test (P< 0.05).

There is a significant difference between healthy and COPD patient men in terms of SPAP and TRV indices before and after exercise testing (P< 0.05).

The mean difference of SPAP Difference and TRV Difference between healthy and patient groups was significant (P< 0.05).

There was no significant difference between healthy men and women in both TRV Difference and CPAP Difference (P> 0.05). In both indexes of TRV Difference and SPAP Difference, there is no significant difference between male and female with COPD (P> 0.05).

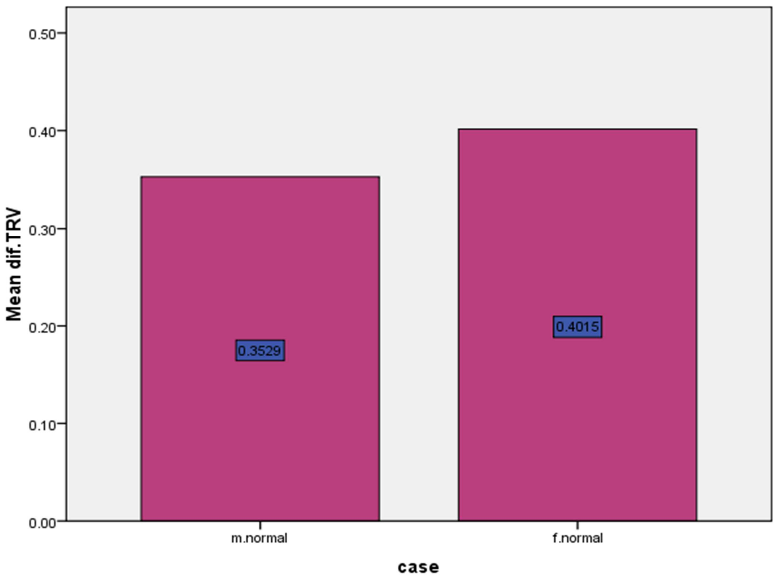

Figure 3. Comparison of TRC Difference in healthy men and women

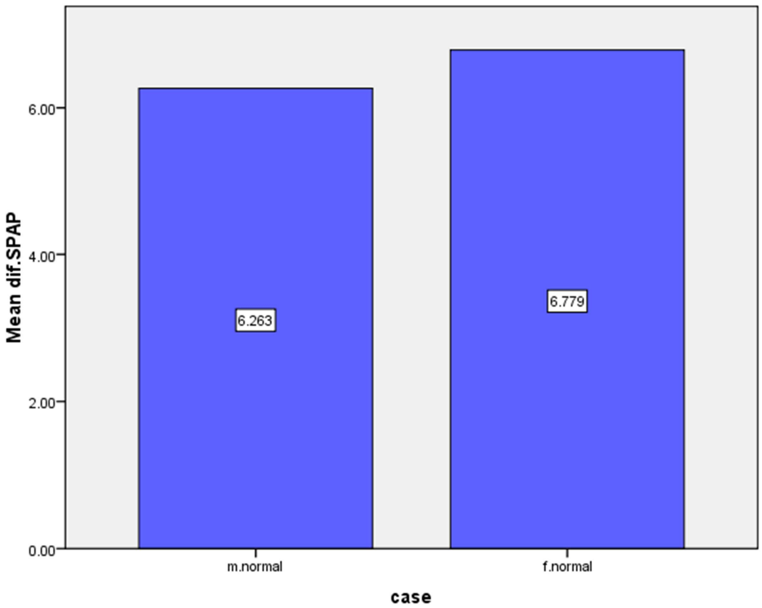

Figure 4. Comparison of SPAP Difference in healthy men and women

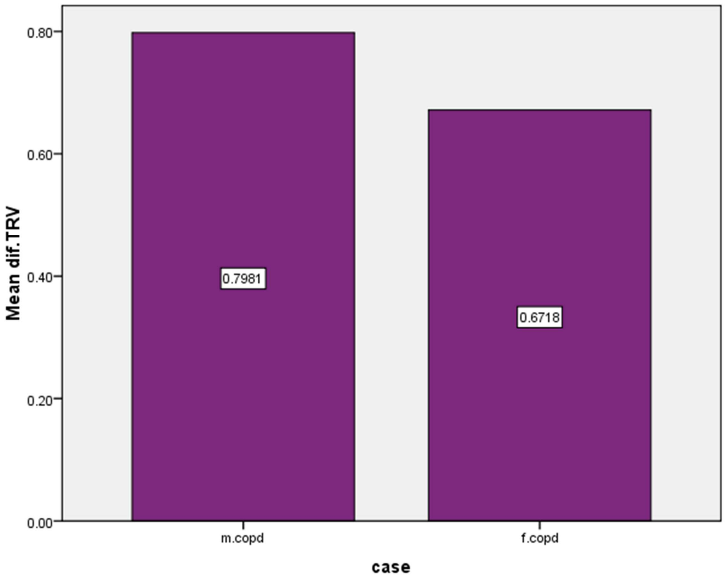

Figure 5. Comparison of TRC Difference in male and female patients

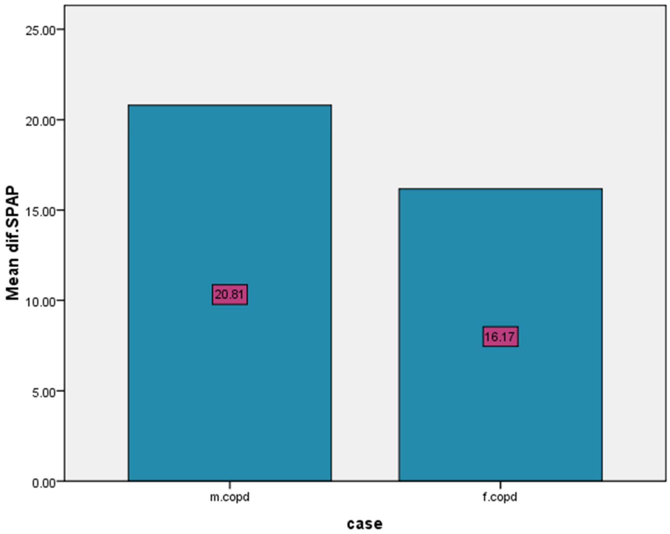

Figure 6. Comparison of SPAP Difference in male and female patients

In general, a significant relationship was observed in healthy subjects between TRV Difference and BMI (P< 0.05), this is also true for the relationship between BMI and SPAP Difference in healthy subjects (P< 0.05).

TRV Difference in the mean of the group with BMI less than 25 and the one with BMI= 25-30 was not significant (P> 0.05). The mean TRV Difference between BMI below 25 and above 30 was significant (P< 0.05). Regarding SPAP difference between the mean the group with BMI= 25-30 and BMI lower than 25, there are no statistically significant differences, but in the groups with BMI less than 25 and more than 30, this difference is significant (P< 0.05).

Regarding TSV Difference and SPAP Difference in COPD patients, there was no significant relationship with BMI (P> 0.05).

In healthy people, there was no significant relationship between TRV Difference and age (P> 0.05). A significant relationship was found between age and SPAP Difference in this group (P< 0.05).

SPAP difference between the first and the second group was not significant (P> 0.05), but the difference between first and third groups was significant (P< 0.05). Comparison of TRV Difference and SPAP Difference in different age groups in healthy subjects was made and provided in Figure 7 and 8.

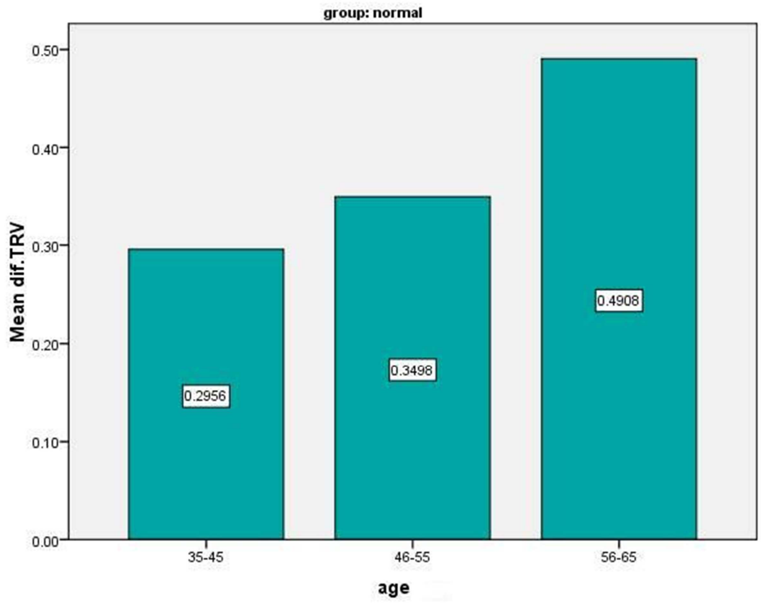

Figure 7. Comparison of TRV Difference in age groups of healthy subjects

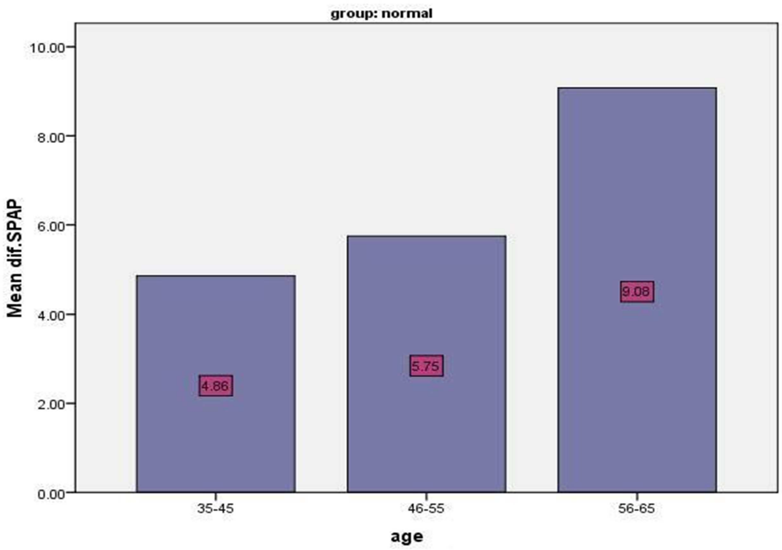

Figure 8. Comparison SPAP Difference mean in age groups of healthy subjects

There was no significant relationship in COPD patients between TRV Difference and age ($P > 0.05$). Correlation between age and SPAP Difference in this group is significant ($P < 0.05$).

SPAP Difference between the first group (35-45 years) and second (46-55 years) is not significant ($P > 0.05$), but the difference between first and third groups (56-65 years) is significant ($P < 0.05$).

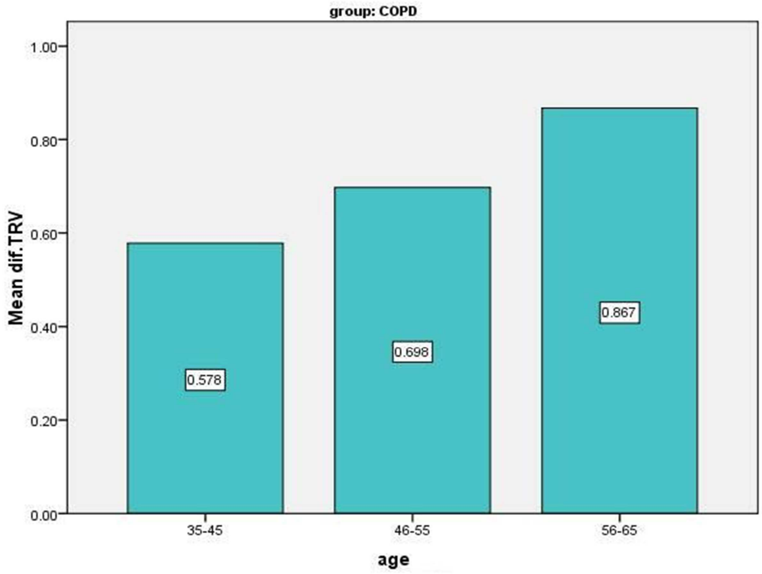

Figure 9. Comparison of TRV Difference mean in COPD patients in different age groups

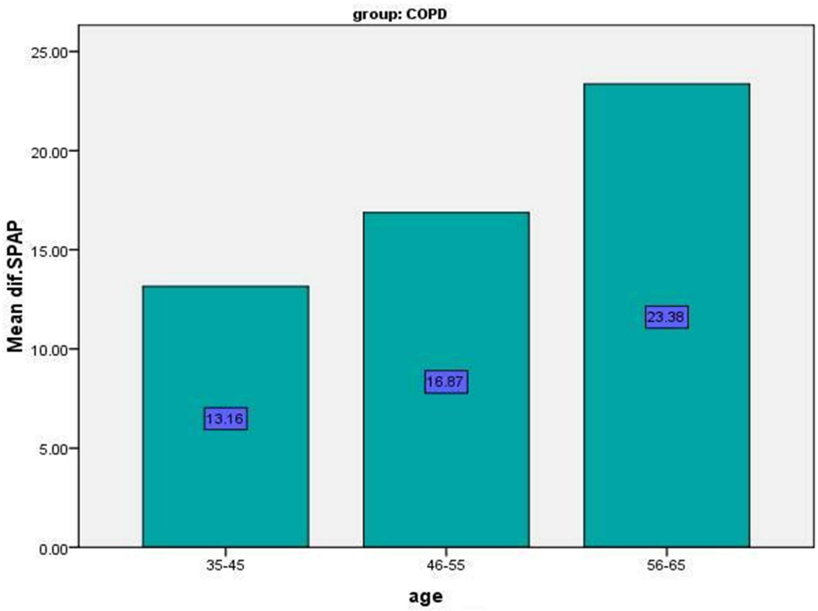

Figure 10. Comparison of mean SPAP Difference in COPD patients in different age groups

DISCUSSION

None of the healthy subjects in this study were in the definition of pulmonary hypertension at rest and even after exercise did not enter this area. Systolic Pulmonary Artery Pressure (SPAP) mean in patient group at rest was in the range of abnormal increase rate, increased with exercise test, and was significantly different from that in the control group.

TRV and SPAP values in this study were more than the amount raised in the previous investigations so that in the athletes SPAP reached even higher than 60 (15). According to the previous study, TRV and SPAP in normal subjects is in the limit of 2.46 m/s and 29.20 mmHg respectively that is slightly different from the results of the current study that is perhaps due to the use of Bossone in Recumbent bicycle method for exercise test.

In this study, pressure difference between the right ventricle to the right atrium at the peak of exercise with contrast was higher compared with non-contrast echocardiography. Thus, this method has a reliable clinical value in the diagnosis of pulmonary artery pressure. Moreover, in our study, exercise test was with treadmill and transmission of the patient from exercise location to echo room was time consuming and caused reduction in heart rate and SPAP, but in Bossone and Himelman study, SPAP is measured at peak of the exercise.

The mean values of SPAP and TRV during the rest time in healthy subjects and patients are independent of gender. According to the results, SPAP mean has no significant relationship with gender even after exercise test in healthy subjects and patients, although TRV mean after exercise testing in patients with COPD was higher in men.

In TRV mean changes after exercise test, no significant differences are seen in mean change between the genders in any of the two, and in SPAP mean changes, there is no relationship.

In healthy individuals studied, there is a positive relationship between SPAP changes during exercise testing with BMI and TRV, but in patients, the changes of the mentioned indices are independent of BMI.

In healthy subjects and patients, TRV changes are independent of age, but SPAP changes in exercise test corresponded with age

CONCLUSION

The SPAP mean changes in healthy subjects were 6.52 and 18.48 in patients, which is a significant difference.

In this study, which was conducted by treadmill exercise and then echo while lying on the left side, SPAP mean in non-athlete healthy subjects at rest was normal and did not enter abnormal range after exercise.

In patients, the mean SPAP at rest was greater than normal and had more increase after exercise. SPAP increase in both groups is independent of gender but is related age and this difference in age group between 56-65 years of age and less than 45 years is statistically significant.

SPAP increase during exercise in healthy subjects was consistent with BMI, but in COPD patients, no significant relationship was found. 44% of SPAP patients had normal resting, but half of them suffered abnormal increase in SPAP after the exercise test, this means that normality of SPAP at resting cannot rule out abnormal pulmonary artery.

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