

Study the effect of exercise on systolic pulmonary artery pressure in healthy subjects

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ABSTRACT

Introduction: As no data are available concerning the cut-off value defining abnormal pulmonary artery systolic pressure (PASP) response in subjects of various ages, the aim of this study is to assess physiological PASP response to exercise in healthy individuals of various ages. **Material and methods:** One hundred and twenty three healthy volunteers, aged 30 to 70 years, underwent Doppler echocardiographic measurements at rest and after treadmill exercise test. Pulmonary artery systolic pressure was estimated at rest, and immediately after peak exercise using Bernoulli formula (four times tricuspid valve regurgitation velocity squared adding an estimated right atrial pressure). **Results:** Lower and upper limits of PASP during rest was 7 and 28 mmHg and after peak exercise was 14 and 48 mmHg respectively. After exercise, PASP increased from rest (14 ± 4 mmHg) to peak (25 ± 7 mmHg). Pulmonary artery systolic pressure during rest and peak exercise, increased with age, but has no correlation with body mass index or gender. **Conclusion:** Pulmonary artery systolic pressure at peak exercise can frequently reach values ≥ 30 mmHg in healthy individuals with good exercise capacity, especially in elderly individuals, which goes beyond pathologic definitions of pulmonary hypertension.

Keywords: Pulmonary Arterial Hypertension; Pulmonary Arterial Systolic Pressure; Exercise; Doppler Echocardiography

1. INTRODUCTION

Pulmonary arterial hypertension (PAH) is known to diminish exercise capacity by decreasing right ventricular performance, pulmonary blood flow, and oxygen delivery to peripheral musculature during exercise [1]. Al-

though a number of studies showed that pulmonary artery systolic pressure (PASP) slightly increase with exercise in healthy volunteers and reaches to a value of 35 or 40 mmHg, [2-5] some authors believe that because these findings are based on evaluation of young healthy subjects, PASP at exercise may reaches to higher value in healthy older people [1]. As it is not a definition for lower and upper limits of normal PASP fitting to all individuals and all exercise levels, and according to introduction of Doppler quantification of tricuspid regurgitation peak velocity as a reliable instrument to assess PASP at rest and exercise, we sought to explore the range of pulmonary artery systolic pressure at rest and with exercise in healthy individuals of various ages.

2. MATERIAL AND METHODS

All of the subjects in this cross sectional study were healthy volunteers, without cardiopulmonary disorders, aged 30 to 70 years. At the beginning of study, subjects were weighted and their height was measured. So their body mass index (BMI) was deliberated. Regarding the BMI, subjects divided into four groups: lean (BMI < 20), Normal (BMI 20 - 25), Overweight (BMI 25 - 30), and Obese (BMI > 30) volunteers. Electrocardiogram and chest x-ray of all subjects were recorded and their serum electrolytes were measured. Subjects were excluded from the study regarding to have history of chronic cardiopulmonary disorders, signs or symptoms of cardiopulmonary disease, abnormal ECG (including old MI, AV block), abnormal chest x-ray, electrolyte imbalance, and mental or physical deficit that make the subject unable to do the exercise test. Also subjects were excluded if they had systolic blood pressure > 200 mmHg or diastolic blood pressure > 110 mmHg Just before the echocardiographic assessments. All of the subjects underwent Trans thoracic 2 dimension and color Doppler echocardiography (using the GE Vivid 3 Export GE 2007) at rest and If any abnormality (including right ventricle dilatation, left ventricle diastolic dysfunction, more than trivial valvular insufficiency, pulmonary arterial hyper-tension with

sever tricuspid regurgitation) was found, subject was excluded. Also if ischemic changes were observed during exercise test, subject was disqualified for this study.

In this way, 123 healthy volunteers enrolled in to this study. Continues wave Doppler echocardiography in multiple views was carried out at rest and in supine position to find the peak tricuspid regurgitation velocity. Right atrial pressure (RAP) was estimated regarding the diameter of inferior vena cava, tricuspid regurgitation, and right atrium size (**Table 2**).

Using the Bernoulli formula (four times tricuspid valve regurgitation velocity squared adding an estimated right atrial pressure) the PASP of subjects at rest were estimated.

Then each healthy subject, carried out the treadmill exercise test and after they reach the target heart rate (eighty five percent of (220-age) for each subject) the treadmill exercise was stopped and subjects underwent Doppler echocardiography immediately and PASP of each subject was estimated again. Each experiment performed one time, then data recorded by physician in the questionnaires.

Data are presented as the mean \pm standard deviation (SD) or percentage as appropriate. Chi-square test or Fisher's exact test was used for comparisons of dichotomous data. Pearson coefficient was used for correlation of quantitative data. Assessment of mean between the 2 groups was performed using the one sample independent t test. A p value less than 0.05 was considered significant. all data were analyzed by SPSS 17 software.

The Research Ethics Committee of the Ahwaz Joun-dishapour University of Medical Sciences approved this study at 2010/12/5 and with the identification number of 2726/d/20/8/p.

3. RESULTS

One hundred and twenty three healthy volunteers, 58

men and 65 women (mean age 47 ± 11 years), with at least 20 subject in each range of age (30 - 40, 40 - 50, 50 - 60, and 60 - 70) enrolled into this study. Mean BMI of subjects was 25 ± 4 m/kg², showing no differences between two genders ($p = 0.68$). There were seventy lean, 48 normal, 48 overweight, and 10 obese subjects (**Table 1**).

Mean PASP at rest was 14.5 ± 4.5 mmHg (ranging from 7 to 28 mmHg) among the subjects with no differences between two genders or various BMI. PASP at rest increased simultaneously with age ($r^2 = 224$, $p < 001$). After peak exercise PASP increased to 25.5 ± 7 mmHg (ranging from 14 to 48 mmHg). It shows no differences between 2 genders or various BMI, but increased with age concurrently ($r^2 = 356$, $p < 001$).

PASP difference before and after exercise test had a positive linear correlation with age ($r^2 = 21$, $p < 001$) and also PASP at rest ($r^2 = 05$, $p = 015$), but not with gender or BMI (**Figure 1**).

As you can see in **Figure 1**, elevated PASP before exercise leads to more elevation of PASP after exercise.

4. DISCUSSION

Previous invasive studies described mild increases in pulmonary pressure with exercise in the normal population [6]. Dokainish *et al.* assumed that PASP may reaches the value of more than 40 mmHg in the healthy elderly people (>90 years) [7]. Mahjoub *et al.* showed that PASP more than 60 mmHg in old peoples (>60 years old) could be considered normal [1]. In our study that included healthy men and women of various ages, PASP at peak exercise reach values ≥ 30 mmHg (like Kovacs study). As age increase, pulmonary blood flow decrease, mean pulmonary pressure increase, and an increase occur in pulmonary resistance, supposed that related to reduced compliance of the pulmonary bed [8]. So as suggested by Bossone *et al.*, one should put workload and age with PASP response together to decide if an increase in PASP is a pathologic occurrence or not [2]. Ha *et al.* showed

Table 1. Patients characteristics.

Patients		Number of patients	Male	Female	p value
		123	58 (47.2)	65 (52.8)	0.39
AGE	MEAN	47.3 ± 11 (years)	46.78 ± 110.4	47.7 ± 10.66	0.619
BMI	MEAN	25.2 ± 3.95 (kg/m ²)	25.83 ± 4.05	25.09 ± 3.88	0.689

Table 2. Estimation of right atrial pressure regarding the diameter of inferior vena cava, tricuspid regurgitation, and right atrium size.

Inferior vena cava diameter	Tricuspid regurgitation velocity	Tricuspid regurgitation	Right atrium size	Estimated right atrial pressure
Normal	Equal to or less than 2.5 m/s	None or mild	Normal	5 mmHg
Dilated	2.6 to 4 m/s	Moderate	↑	10 mmHg
Dilated, without respirator collapse	More than 4 m/s	Severe	↑↑	15 mmHg

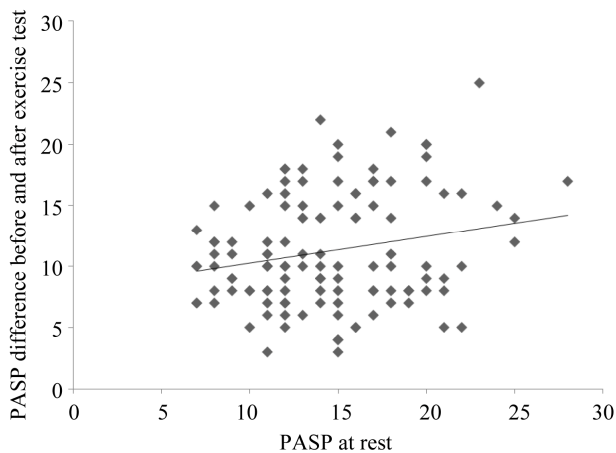


Figure 1. Correlation of PASP difference before and after exercise and PASP at rest.

that resting TR velocity, E/E', age and gender are the strongest predictors of PASP during exercise. They also proposed a value of 50 mmHg for a workload of 50 W to define pulmonary hypertension at exercise [9].

In our study, there were no correlations between gender, BMI and PASP at rest or PASP at peak exercise ($p < 0.05$). The data of our review, like Kovacs research, do not support the current threshold of PASP during exercise and it was shown that, exercise PASP is age related and frequently exceed 30 mmhg, especially in elderly individuals, which make it difficult to define normal PASP during exercise [10,11]. PASP after exercise had correlation with age and PASP before exercise (**Figure 1**) and subjects with more PASP before exercise had more elevation of PASP after exercise. In a large study on 3790 echocardiographically normal subjects by McQuillan *et al.* results showed that PASP was associated with age, BMI, sex, wall thickness, and ejection fraction. It is a fact that our sample size is smaller than McQuillan study, therefore our study suffered from potential selection bias. Also it should be noted that in McQuillan study, right atrial pressure considered as a constant value of 10 mmHg, but we estimate it as 5, 10, or 15 mmHg regarding the diameter of inferior vena cava, tricuspid regurgitation, and right atrium size.

5. STUDY LIMITATIONS

Invasive measurement of PASP at rest and during exercise was not performed to match up to with our echocardiographic data. Although the assessment of PASP by Doppler echocardiography is reliable at rest, the accuracy of this method is not fully established during exercise. We just evaluated the PASP at rest and peak exercise and did not perform our assessment during treadmill exercise test. Thus raise of PASP in early stage of exercise test in individuals can be suggestive for pulmonary

hypertension. We did not use any contrast (such as air and saline) to define the tricuspid regurgitation velocity better.

6. CONCLUSION

Pulmonary artery systolic pressure at peak exercise can reach values ≥ 40 mmHg in healthy individuals, especially older peoples. Further studies in large populations are required to determine the abnormal range of PASP at various level of exercise, and also compare the result of echocardiography and invasive methods during exercise.

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