

Electrocardiographic right ventricular hypertrophy predicts the severity of pulmonary hypertension in patients with mitral stenosis

Elektrokardiyografik sağ ventrikül hipertrofisi mitral darlığı olan hastalarda pulmoner hipertansiyonun ciddiyetini belirler

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ABSTRACT

Objectives: Rheumatic heart disease is still common in developing countries. Mitral stenosis impedes left atrial emptying, increases left atrial and pulmonary venous pressure, and thus causes pulmonary hypertension. Pulmonary hypertension results in right ventricular hypertrophy (RVH), implying that the disease is long lasting and needs interventional treatment. The aim of our study was to predict the severity of pulmonary hypertension in patients with mitral stenosis by evaluating electrocardiographic RVH.

Study design: Patients admitted to our hospital with mitral stenosis were evaluated. Their clinical, electrocardiographic, and echocardiographic parameters were recorded. Electrocardiographic RVH was diagnosed when at least 2 of the following criteria were present at the same time: V1R+V5S or V6S >10.5 mm, V1R >6 mm, R >S in V1, V1 S <2 mm, V6 R/S <0.4, V5.6 R <3 mm, aVR R >4 mm, and right axis deviation.

Results: Sixty-seven patients (13 males, 54 females; mean age: 44.9±14.5 years; range 18 to 80 years) were included in the study. One male patient and 14 female patients were diagnosed as having electrocardiographic RVH. Pulmonary arterial pressure, right atrial and ventricular dimensions, peak and mean transmitral gradients were higher, and mitral valve area was lower in patients with RVH. The presence of RVH predicted pulmonary arterial pressure as 60 mmHg or higher with the sensitivity of 93% and specificity of 92%.

Conclusion: Electrocardiographic RVH was found to be related to more severe mitral stenosis, higher pulmonary arterial pressure, and larger right heart chambers. RVH can be a simple and useful parameter to predict the severity of pulmonary hypertension.

ÖZET

Amaç: Romatizmal kalp hastalığı gelişmekte olan ülkelerde hala yaygındır. Mitral darlığı sol atriyum doluşunu engelleyerek sol atriyum ve pulmoner venöz basıncı artırır ve pulmoner hipertansiyona yol açar. Pulmoner hipertansiyon ise hastalığın uzun süredir var olduğunu ve girişimsel veya cerrahi tedavi gerektiğini gösteren sağ ventrikül hipertrofisine (SVH) yol açar. Bu çalışmada, elektrokardiyografik (EKG) SVH değerlendirilerek mitral darlığının yol açtığı pulmoner hipertansiyonun ciddiyeti araştırıldı.

Çalışma planı: Hastanemize başvuran ve mitral darlığı tanısı alan hastalar çalışmaya alındı. Klinik, EKG ve ekokardiyografik veriler kaydedildi. Elektrokardiyografik olarak SVH tanısı şu bulgulardan en az ikisinin varlığı ile koyuldu: V1R+V5S veya V6S >10.5 mm, V1R >6 mm, V1'de R >S, V1 S <2 mm, V6 R/S <0.4, V5.6 R <3 mm, aVR R >4 mm ve sağ eksen sapması.

Bulgular: Altmış yedi hasta çalışmaya alındı (13 erkek, 54 kadın; ort. yaş: 44.9±14.5, dağılım 18-80 yaş). Bir erkek ve 14 kadın EKG ölçütlerine göre SVH tanısı aldı. Elektrokardiyografik SVH bulunan grupta pulmoner arter basıncı, sağ atriyal ve sağ ventriküler boyutlar, zirve ve ortalama transmitral basınç gradiyenti yüksek, mitral kapak alanı düşük olarak bulundu. Elektrokardiyografik SVH'nin %93 duyarlılık ve %92 özgüllük ile sistolik pulmoner arter basıncını 60 mmHg veya üzeri olarak öngördüğü saptandı.

Sonuç: Elektrokardiyografik SVH'nin, daha ciddi mitral darlığı daha yüksek pulmoner arter basıncı ve sağ kalp boşluklarında genişleme ile ilişkili olduğu bulundu. Bu nedenle elektrokardiyografik SVH klinik pratikte pulmoner hipertansiyon ciddiyetini belirlemede basit ve kullanışlı bir yöntem olarak değerlendirilebilir.

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Since the prevalence of rheumatic fever is high in developing countries,^[1] mitral stenosis is still common and causes substantial morbidity. In a retrospective analysis of the data acquired from transthoracic echocardiography of almost 44,000 subjects screened between 2003-2008 in the southeastern region of Turkey, 4.3% of the patients were found to have rheumatic heart disease.^[2] In mitral stenosis, leaflet thickening, calcification, and commissural and chordal fusion result in narrowing of the valve area and impedance of left atrial emptying, therefore increasing left atrial pressure. Pulmonary hypertension, and subsequently right ventricular overload, follow left atrial pressure elevation. Although these pathophysiological consequences of mitral stenosis are well known, the quantitative relationship between right ventricular hypertrophy (RVH) in ECG and pulmonary hypertension has not been well studied in patients with mitral stenosis.

The main purpose of our study was to predict the severity of pulmonary hypertension measured by echocardiography in patients with mitral stenosis by evaluating the presence or absence of electrocardiographic RVH.

PATIENTS AND METHODS

Sixty-seven patients with mitral stenosis and sinus rhythm admitted to our hospital were reviewed retrospectively. Their clinical, electrocardiographic, and echocardiographic parameters were evaluated. Electrocardiographic RVH was diagnosed when at least 2 of the following criteria were present at the same time: V1R+V5S or V6S >10.5 mm, V1R >6 mm, R >S in V1, V1S <2 mm, V6 R/S <0.4, V5.6 R <3 mm, aVR R >4 mm, and right axis deviation.^[3] Patients were categorized as having RVH or not. All patients were examined in the left lateral and supine positions by precordial M-mode, two-dimensional, and Doppler echocardiography. Left ventricle end-diastolic, left ventricle end-systolic, and left atrial end-systolic diameters were measured from M-mode in the parasternal long-axis views. Planimetric mitral valve area was measured in the parasternal short axis view by tracing the restrictive mitral orifice in middiastole. Mitral valve area and transmitral gradients were also evaluated by Doppler echocardiography for determining the severity of the mitral stenosis. Systolic pulmonary artery pressure was evaluated by tricuspid regurgitation velocity. Doppler echocardiographic parameters were measured according to the standards

of American Society of Echocardiography.^[4] Left ventricular ejection fraction, left atrial diameter, mitral valve area, peak and mean gradients of the mitral valve, the degree of valvular regurgitations, the dimensions of right heart chambers, and pulmonary artery systolic pressure were compared with the electrocardiographic RVH.

Statistical analysis

Distribution of the data was assessed using a one-sample Kolmogorov-Smirnov test. Continuous variables with a normal distribution are expressed as mean±SD, while categorical variables are expressed as percentage. For comparison of categorical variables or percentages we used Fisher's exact and chi-square tests. Continuous variables were compared by Student t tests. Correlation was tested with the Pearson correlation coefficient. A *p* value below 0.05 was considered to be statistically significant.

Abbreviations:

AF	Atrial fibrillation
ECG	Electrocardiography
RVH	Right ventricular hypertrophy

RESULTS

Of the 67 patients with mitral stenosis, 15 (22%) had electrocardiographic RVH. One in 15 patients with RVH and 12 in 52 patients without RVH were males. The mean age of the patients with RVH in ECG was 38.1±13.7 years, and the mean age of those without RVH in ECG was 46.9±14.3 years (*p*=0.02). Mitral valve area was found to be lower in the RVH (+) group, while peak and mean transmitral gradients, right atrial and right ventricular dimensions, and systolic pulmonary arterial pressure were higher. The difference in the left atrial diameter between the groups was not statistically significant (*p*=0.26). The echocardiographic findings are summarized in Table 1. There were no aortic or tricuspid stenoses in the whole group. The presence of electrocardiographic RVH predicted systolic pulmonary artery pressure as 60 mmHg or higher with the sensitivity and specificity of 93% and 92%, respectively, and predicted the mean transmitral gradient as 10 mmHg or higher with the sensitivity and specificity of 87% and 73%, respectively.

DISCUSSION

The main finding of our study was the prediction of systolic pulmonary arterial pressure being 60 mmHg or higher in patients with electrocardiographic RVH

Table 1. Basic characteristics and echocardiographic findings of patients with and without RVH

Variable	RVH (+) (n=15)		RVH (-) (n=52)		p
	n	Mean±SD	n	Mean±SD	
Age (years)		38.1±13.7		46.9±14.3	0.02
Gender (male / female)	1 / 14		12 / 40		
Left atrial diameter (cm)		50±5		49±8	0.26
Ejection fraction (%)		62±4		63±5	0.29
Mitral valve area (cm ²)		1±0.2		1.4±0.3	0.01
Peak transmitral gradient (mmHg)		28±9		17±6	0.02
Mean transmitral gradient (mmHg)		15±5		9±4	0.02
Right atrial diameter (cm)		43±8		35±8	<0.001
Right ventricular diameter (cm)		38±7		31±4	<0.001
Systolic pulmonary artery pressure (mmHg)		79±20		44±12	<0.001

RVH: Right ventricular hypertrophy.

with a sensitivity and specificity of 93% and 92%, respectively. The quantitative relationship between electrocardiographic RVH and the severity of pulmonary hypertension has not been studied well in patients with mitral stenosis. It has been reported that approximately half of the patients with a right ventricular systolic pressure between 70 and 100 mmHg manifest the ECG criteria of RVH.^[5] Electrocardiographic RVH indicates a mean pulmonary pressure of 40 mmHg or higher, but the sensitivity of these criteria for the detection of pulmonary hypertension in mitral stenosis has not been evaluated.^[6,7] RVH causes electrocardiographic changes such as tall R waves in V1, V2 and aVR, and deep S waves and small r waves in lateral precordial leads. Although the sensitivity of each electrocardiographic RVH criteria is generally as low as 10%, the specificity is high, being greater than 90%.^[8] Because the sensitivity of each criteria has been stated to be low, hypertrophy should be severe enough to produce electrocardiographic changes. Therefore, electrocardiographic evidence of RVH may be valuable in assessing the severity of pulmonary hypertension, and thus that of mitral stenosis. Donoso et al.^[9] found that the QRS axis in the frontal plane correlated with the level of pulmonary vascular resistance in patients with pure mitral stenosis, with an axis greater than +60° suggesting a mitral valve area of less than 1.3 cm².

Acute rheumatic fever and rheumatic heart disease are still major health problems in developing

countries, and rheumatic fever is the leading cause of acquired heart disease in children and young adults.^[10,11] The diagnosis and determination of the severity of mitral stenosis should be based on clinical evaluation, and investigations including ECG, chest X-ray, echocardiography, and heart catheterization whenever needed. Although transthoracic echocardiography with Doppler evaluation is the mainstay for the diagnosis and also for the determination of the severity of mitral stenosis, ECG is the most easy and primary tool for cardiac evaluation. ECG findings such as left atrial abnormality and RVH are not specific for mitral stenosis, but the presence of these abnormalities in a patient with known mitral stenosis may imply that the disease is at least in a stage of moderate severity.

Pulmonary arterial hypertension is often found in symptomatic patients with mitral stenosis, and it could have prognostic implications and trigger the need for therapeutic interventions.^[12] Chronically elevated left atrial pressure leads to pulmonary venous hypertension and remodeling of the pulmonary arterial vasculature. Pulmonary hypertension leads to RVH, right ventricular dilation, and eventual right heart failure. Right ventricular dysfunction, which may be caused by pulmonary hypertension, has been shown to be a major determinant of clinical outcome.^[13,14]

The main limitation of this study is the relatively low number of patients due to the exclusion of patients with atrial fibrillation (AF). The reasons for the exclusion of AF patients were the diversity of heart

rate in patients with AF and the variability of tricuspid regurgitation from beat to beat, which may cause errors in the determination of systolic pulmonary arterial pressure.

In conclusion, we demonstrated that there is a correlation between RVH in ECG and the degree of pulmonary hypertension, which is also correlated with the severity of mitral stenosis. Since systolic pulmonary arterial pressure greater than 50 mmHg is considered to be an indication for intervention in patients with mitral stenosis, electrocardiographic RVH may imply that interventional treatment should be considered soon. We think that these ECG criteria may also be useful for general practitioners, because ECG is a simple and widely available diagnostic tool.

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Key words: Developing countries; electrocardiography; mitral valve stenosis/complications; rheumatic heart disease/epidemiology.

Anahtar sözcükler: Gelişmekte olan ülkeler; elektrokardiyografi; mitral kapak stenozu/komplikasyonlar; romatizmal kalp hastalığı/epidemioloji.