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The Value of P-Pulmonale as an Electrocardiographic Criterion for Detection of Right Atrial Dilatation

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Abstract

Background and objectives: There are many electrocardiographic (ECG) criteria for detection of right atrial dilatation (maximum diameter of more than 5.3 mm), the most common one is P- pulmonale which is manifested by a tall P- wave in the inferior leads mainly lead II (P- wave equal or more than 2.5 mm), although this criteria is subjected to criticism regarding its sensitivity, specificity and predictive values, but it is still regarded as a main criteria. This study was designed to estimate the sensitivity, specificity, predictive values and accuracy of P- pulmonale in the detection of right atrial dilation. Methods: Two hundred patients with different pathologies that can lead to right atrial dilatation had been included in the study from 2013-7-1 to 2015-9-1. ECG and two dimensional chocardiography had been performed for all patients, P- wave in lead II of 2.5 mm or more had been regarded as P- pulmonale, right atrial maximum dimension in apical four chamber view transthoracic two dimensional echocardiography of more than 5.3 mm had been regarded as dilated right atrium. The patients accordingly were divided into four groups (true positive, true negative, false positive and false negative). **Results:** The study included patients of different ages, male to female ratio was 3:2, and the patients had different pathologies that could lead to dilated right atrium. Sensitivity of P-pulmonale was %49, specificity %79, positive predictive value of %51, negative predictive value of 77 % and accuracy] of %70.5. **Conclusions:** P-pulmonale is a reliable criterion for the detection of right atrial dilatation although it has variable sensitivity. It is more specific than being sensitive. The negative predictive value of P-pulmonale is higher than its positive predictive value.

Keywords: P-pulmonale; dilated right atrium.

Introduction

The forces generated by right atrial depolarisation are directed anteriorly and inferiorly and produce the early part of the P wave. Right atrial hypertrophy or dilatation is therefore associated with tall P- waves in the anterior and inferior leads, though the overall duration of the P- wave is not usually prolonged, a tall P- wave (height ≥2.5 mm) in leads II, III, and aVF is known as the P- pulmonale[1-2]. P-wave height more than or equal 2.5 mm in inferior leads is regarded as a criterion for right atrial enlargement firstly by Friedman [3]. Dilated right atrium is defined as a right atrium with maximum dimension of more than 53 mm in apical four chamber view 2- dimensional echocardiography [4]. The ability of ECG to detect right atrial enlargement had been the subject of many investigations; in these studies methods of validating right atrial dimensions included radiographic, autopsy and hemodynamic data [3]. Quantitative 2- dimensional echocardiography had been shown to be reliable method of evaluating normal and enlarged right atrium 3,5.Reliable ECG criteria for right atrial enlargement could offer a simple and inexpensive way to detect the presence of tricuspid valve diseases, pulmonary valve diseases, cardiomyopathies, pulmonary hypertension and various forms of congenital heart disease[5]. Einthhoven is credited with being the first to recognize that P- wave abnormalities on the electrocardiography (ECG) reflected altered atrial depolarization, since then numerous criteria for the ECG recognition of right atrial enlargement (dilatation and or hypertrophy) had been proposed 1. The most enduring and commonly taught criteria is that of P- pulmonale used to describe peaked P wave in leads II, III and aVF [5]. New criteria had been proposed for the recognition of right atrial overloading in children, and some previously proposed criteria such as "P- pulmonale" or the Macruz index' had been found to be lacking sensitivity or specificity or both[6]. P- Pulmonale as criteria for right atrial enlargement had been increasingly criticized as insensitive and non-specific3. In spite of the marked right atrial dilatation that is known to occur in patients with

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atrial septal defect, P-wave abnormalities are uncommon in Leads II and III [7]. The aim of this study was to determine the sensitivity, specificity, predictive values and accuracy of P- pulmonale in the detection of right atrial dilatation.

Patients and methods

The data of this study had been collected from outpatient clinics, inpatients and cardiac care units of Erbil Teaching Hospital and Rizgary Teaching Hospital from 1-7-2013 till 1-9-2015, 200 patients whom had pathologies that can lead to right atrial dilatation were included in the study; they were of different age groups, and of both genders. Exclusion criteria were atrial fibrillation, atrial flutter and those with unsatisfactory transthoracic echocardiography views because of obesity and abnormal chest contours. For all patients standard 12 leads resting electrocardiography had been performed using Cardio line machines, the height of P- wave in inferior leads mainly lead II was estimated. P- Wave height equal or more than 2.5 mm had been considered as P- pulmonale [1-5]. Two dimensional transthoracic echocardiography in left lateral position had been performed for all patients using Philips Envisor and Vivid 3 machines. In all cases apical four chambers view optimized for estimation of maximum right atrial dimension. A maximum right atrial dimension of more than 53 mm had been regarded as dilated right atrium [4]. The Echocardiography finding of dilated right atrium had been regarded as reliable standard [3, 5].

The patients were divided into four groups.

1. True positive group (TP) (those with P- pulmonale in their ECG and dilated right atrium by echocardiography).
2. True negative group (TN) (those with normal P-wave height and normal right atrium maximum dimension).
3. False positive (FP) (those with P- pulmonale in their ECG and normal right atrial maximum dimension).
4. False negative (FN) (those with normal P- wave height but dilated right atrium).

The sensitivity, specificity, positive and negative predictive values and accuracy had been estimated as follows[4]:

Sensitivity=True positive/True positive+ False negative

Specificity=True negative/True negative+ False positive.

Positive predictive value (PPV) = True positive /True positive+ False positive

Negative predictive value (NPV) =True negative/ True negative+ False negative

Accuracy= True positive +True negative/total number of patients.

Results

Table 1 shows that age limit from 15 year to 85 year included in the study, especially ages between 66 and 75 years.

Table (1): Age distribution of the patients

Age limits	No of cases	%
25-15	20	10
35-26	30	15
45-36	20	10
55-46	30	15
65-56	35	17.5
75-66	45	22.5
85-76	20	10
Total	200	100

Table 2 shows male to female ratio. It's seen that more male patients included in the study.

Table (2): Gender distribution of the patients

Male	Female	Total	Ratio
120	80	200	3:2

The two most common diseases included in the study are cases of chronic obstructive lung diseases and heavy smoker, Table 3.

Table (3): Distribution of the patients according to the diseases

Diseases	No of cases	%
Chronic obstructive lung diseases	50	25
Heavy smoker	40	20
Tricuspid valve disease	20	10

Pulmonary hypertension	20	10
Atrial septal defect	20	10
Tetralogy of Fallot	20	10
Pulmonary embolism	10	5
Restrictive lung diseases	10	5
Dilated cardiomyopahy	10	5
Total	**200**	**100**

Table 4 shows that the number of true negative cases is the most frequent.

Table (4): Grouping the patients according to the ECG and Echo findings

TN	FN	TP	FP	Total
109	32	31	28	200

Sensitivity= 31/31+32=49%
Specificity= 109/109+28=79%
Positive predictive value (PPV) =31/31+28=52%
Negative predictive value (NPV) =109/109+32=77%
Accuracy=31+109/200=70.5%.

Discussion

P- Pulmonale is the most widely accepted criteria for right atrial enlargement, this criteria was exposed to many studies3. In 1962, Caired and Wilcken found right atrial abnormalities in autopsy of 20 patients with obstructive lung diseases, 11 of them had right atrial dilatation, P- pulmonale found in 7(TP) of them, while 4 (FN) of them had dilatation in right atrium with normal P- wave, so the sensitivity was 63% , they also found P- pulmonale in 2 (FP) of 9 cases with normal right atrial volume the rest 7 (TN) has normal P-wave , so the specificity is 77 %, the PPV is 77%, and the NPV is %63 [3,5], the results of the current study (sensitivity= 49%, specificity= 79%, PPV= 52%, NPV= 77%) were near to these results. The small differences may be related to the differences in the sample sizes (200 versus 20), as well as the fact that the patients taken in Caired et al study were checked by autopsy, while in our study the patients assessed by 2- dimensional echo study that can only detect abnormalities in right atrium in two planes [4].
In 1965, Gordon et al found no correlation between P-wave amplitude and right atrial volume, however in children with various types of congenital heart diseases which can lead to right atrial volume and/or pressure overload; some correlation was found between the right atrial volume and amplitude of P- wave [3].
In 1978, electrocardiographic task force reported that the PPV of P- pulmonale was only 18% [5], and this is significantly less than the figure in the current study which was 52%.

Chon and Helen used the term pseudo P- pulmonale to explain P- pulmonale in normal RA and may be due to left atrial forces contributing to the increased P- wave height; this can explain the pseudo positive cases [5, 10]. Jeffry and associates showed in their study that the sensitivity of P- pulmonale was only 6%, but 100% specific [5], this is quite different from the results of the current study, though it had been shown that the result of P- pulmonale specificity is more than its sensitivity (79% versus 49%) in the detection of right atrial dilatation, as well it has higher negative predictive value 77% versus 52%). The P- pulmonale was detected in only 8% of patients with right atrial enlargement with sensitivity of 24-34% and it was associated with ECG features of right ventricular enlargement [8], this figure is different from the figure in this study (49%). Peaked P- wave is one of the accepted criteria for right atrial dilatation, but the positive predictive value is around 20% [9], this is significantly lower if compared with the current study (52%). Hideki Hayashi et al showed that the sensitivity of P-pulmonale is variable from 30 to 60 %, however it is highly specific 90% [10], in the current study it had been shown that P- pulmonale is specificity is (79%) and sensitivity is (49%). The differences in the results of their study with current one, is related to the fact that they included in their study only patients with chronic obstructive pulmonary disease in advance stages, while in the current study different pathologies were included in the study in variable stages.
Taso et al showed that the sensitivity of P- pulmona-

le reaches around 50%, and it's of very high specificity [11], in the current study the sensitivity was exactly very near to this figure (49%).

Conclusions

Although P- pulmonale has variable sensitivity, it is a reliable criterion for the detection of right atrial dilatation. P- Pulmonale is more specific than being sensitive. The negative predictive value of P- pulmonale is higher than its positive predictive value.

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