

Diagnostic electrocardiographic dyad criteria of emphysema in left ventricular hypertrophy

Swapnil S Lanjewar¹
Lovely Chhabra¹
Vinod K Chaubey¹
Saurabh Joshi¹
Ganesh Kulkarni¹
Chandrasekhar
Kothagundla¹
Sudesh Kaul¹
David H Spodick²

¹Department of Internal Medicine,

²Department of Cardiovascular
Medicine, Saint Vincent Hospital,
University of Massachusetts Medical
School, Worcester, MA, USA

Background: The electrocardiographic diagnostic dyad of emphysema, namely a combination of the frontal vertical P-vector and a narrow QRS duration, can serve as a quasidiagnostic marker for emphysema, with specificity close to 100%. We postulated that the presence of left ventricular hypertrophy in emphysema may affect the sensitivity of this electrocardiographic criterion given that left ventricular hypertrophy generates prominent left ventricular forces and may increase the QRS duration.

Methods: We reviewed the electrocardiograms and echocardiograms for 73 patients with emphysema. The patients were divided into two groups based on the presence or absence of echocardiographic evidence of left ventricular hypertrophy. The P-vector, QRS duration, and forced expiratory volume in one second (FEV₁) were computed and compared between the two subgroups.

Results: There was no statistically significant difference in qualitative lung function (FEV₁) between the subgroups. There was no statistically significant difference in mean P-vector between the subgroups. The mean QRS duration was significantly longer in patients with left ventricular hypertrophy as compared with those without left ventricular hypertrophy.

Conclusion: The presence of left ventricular hypertrophy may not affect the sensitivity of the P-vector verticalization when used as a lone criterion for diagnosing emphysema. However, the presence of left ventricular hypertrophy may significantly reduce the sensitivity of the electrocardiographic diagnostic dyad in emphysema, as it causes a widening of the QRS duration.

Keywords: emphysema, electrocardiogram, left ventricular hypertrophy, chronic obstructive pulmonary disease, P-vector, QRS duration

Introduction

Chronic obstructive pulmonary disease is a syndrome in which chronic inflammatory changes of the lung airways and parenchyma cause progressive airflow limitation which is not fully reversible.¹ To date, the association between various electrocardiographic abnormalities in emphysema has been well reported in prior studies, and a vertical P-vector (>60°) has been found to be the most sensitive lone electrocardiographic criterion for diagnosis of emphysema.²⁻⁸ Previous studies have shown that the vertical P-vector is not only the most sensitive but also a highly specific criterion for rapid bedside screening for emphysema in the general hospitalized population.⁴⁻⁶ Moreover, a vertical P-vector also bears an inverse correlation with the severity of obstructive lung dysfunction (forced expiratory volume in one second, FEV₁) and radiographic severity of emphysema.^{9,10} A vertical P-vector has a sensitivity and specificity ranging

Correspondence: Lovely Chhabra
Saint Vincent Hospital, University
of Massachusetts Medical School,
123 Summer Street, Worcester,
MA 01608, USA
Tel +1 508 667 5052
Fax +1 888 598 6647
Email lovids@hotmail.com

from 82.1% to 96% and from 86.4% to 96%, respectively, for diagnosing emphysema.^{4,6,11–13}

A narrow QRS is also a characteristic of emphysema.¹¹ A QRS duration <90 msec has almost 100% sensitivity and a QRS duration of <70 msec has almost 100% specificity in electrocardiographic screening for emphysema.¹¹ The narrow QRS complex in patients with emphysema was first described in 1974.¹⁴ This observation was also correlated with computerized measurements of the QRS duration subsequently in 1999.⁶ In one of the recent investigations, a vertical P-vector and narrow QRS duration were utilized as an electrocardiographic diagnostic dyad for emphysema, and revealed a specificity close to 100% when the QRS duration was <75 msec in combination with a vertical P-vector.¹¹ We postulated that the presence of left ventricular hypertrophy (LVH) in emphysema may perturb the sensitivity of the diagnostic dyad criterion, given that LVH generates prominent left ventricular forces and may increase the QRS duration. Our current study aimed to investigate the same hypothesis in a clinical setting by testing the effects of LVH on the vertical P-vector and QRS duration in patients with emphysema.

Materials and methods

We reviewed 12-lead electrocardiograms for 100 unselected, consecutive emphysema patients who received treatment for chronic obstructive pulmonary disease/emphysema at the pulmonary clinic, Saint Vincent Hospital, after application of initial selection criteria. Inclusion criteria were age >45 years and an established diagnosis of emphysema based on clinical history, pulmonary function tests, and radiologic investigations, including chest computed tomography or roentgenogram. Patients aged <45 years and those with poor quality electrocardiographic tracings, non-sinus rhythm, paced rhythms, or bundle branch blocks were excluded. Patients younger than 45 years were excluded because a vertical P-vector may be a normal physiologic finding in such patients.^{2,4} Of the 100 emphysema patients screened based on the initial selection criteria, 27 were excluded because they did not have an echocardiogram available in our database in the previous year. Thus, a total of 73 patients were finally enrolled in the study. Of these, 30 patients had LVH on echocardiography and 43 patients did not have LVH. A left ventricular posterior wall diameter and/or interventricular septal wall thickness >11 mm was used as the echocardiographic criteria for diagnosis of LVH.¹⁵ Computer-generated P wave axes and QRS durations were noted and inspected manually by the authors independently using a handheld 10× loop magnifier. In the event of any

discrepancy or suspected error in automated reading, manual readings were used. Manual calculation of frontal P-vectors was performed using the vector method, based on the amplitude of the P waves in leads I and III.^{2,4,16}

The duration of the QRS complex generated via computer was noted and corroborated manually by measuring the QRS duration from the beginning of the Q wave to the J point. Any differences in manual computations were subsequently resolved in a conference consensus.

Demographic variables including age, sex, and smoking history (pack-years) were reviewed from the medical charts of all patients and were then compared for any statistically significant difference between the subgroups, ie, emphysema patients without and with LVH. Mean P-vector, QRS duration, and FEV₁ were also computed in all patients and then compared between the subgroups. The data were checked for skewness using the Mann–Whitney *U* test. The P-vector, QRS duration, and FEV₁ were compared in the subgroups using the unpaired Student's *t*-test for any statistically significant difference. Correlation between the P-vector and FEV₁ was determined using the Pearson's correlation test. All calculations were done using GraphPad Prism 6 statistical software (GraphPad Software, San Diego, CA, USA). *P*-values (two-sided) <0.05 were considered to be statistically significant.

Results

The baseline demographics of the study population are shown in Table 1. The total number of patients in the study was 73. The mean age (\pm standard deviation) of the patients was 69.21 \pm 9.37 years and their average smoking history was 60.81 \pm 29.98 pack-years. The mean frontal P-vector for all patients was 67.71 \pm 11.36 $^\circ$ and their average QRS duration was 83.88 \pm 10.68 msec. The mean FEV₁ for all patients in the study was 48.55 \pm 17.85%. The 73 patients were then subdivided into two groups, ie, emphysema without LVH and with LVH, as shown in Table 2. There was no statistically significant difference in mean frontal P-vector between the

Table 1 Patient demographic characteristics

Variable (for all patients)	Emphysema patients (n=73)	P-value (two-sided)
Age (years)	69.21 \pm 9.37	
Smoking history (pack-years)	60.81 \pm 29.98	
Frontal P-vector	67.71 \pm 11.36 $^\circ$	
QRS duration (msec)	83.88 \pm 10.68	
FEV ₁ (%)	48.55 \pm 17.85	
<i>r</i> (P-vector and FEV ₁)	-0.56	<i>P</i> <0.001*

Notes: Data are presented as the mean \pm standard deviation; *r* indicates Pearson's correlation coefficient; *statistically significant *P*-value.

Abbreviation: FEV₁, forced expiratory volume in one second.

Table 2 Comparison of electrocardiographic diagnostic criteria and lung function variables in patients with and without LVH

Variable	No LVH	LVH	P-value	Description
Frontal P-vector	68.42°±11.24°	66.7°±11.65°	0.53	Two-tailed
QRS duration (msec)	81.56±10.87	87.67±10.97	0.02*	Two-tailed
FEV ₁ (%)	49.14±19.11	47.7±16.16	0.74	Two-tailed
r (P-vector and FEV ₁)	-0.546	-0.599		

Notes: Data are presented as the mean ± standard deviation; r indicates Pearson's correlation coefficient; *statistically significant P-value.

Abbreviations: FEV₁, forced expiratory volume in one second; LVH, left ventricular hypertrophy.

subgroups, ie, 68.42°±11.24° in the group without LVH versus 66.7°±11.65° in the group with LVH ($P=0.53$). The mean QRS duration was significantly wider in the emphysema patients with LVH as compared with those without LVH, ie, 81.56±10.87 msec versus 87.67±10.97 msec ($P=0.02$). The severity of obstructive lung dysfunction (percent FEV₁) was comparable between the subgroups (49.14%±19.11% in patients without LVH versus 47.7%±16.16% in those with LVH, $P=0.74$). FEV₁ and P-vector verticalization showed an inverse correlation in the subgroups ($r=-0.546$ in patients without LVH and -0.599 in patients with LVH).

Discussion

The electrocardiographic diagnostic dyad of emphysema, namely a combination of the frontal vertical P-vector and a narrow QRS duration, can serve as a ready diagnostic marker for emphysema, with a specificity close to 100%, as demonstrated in previous studies.¹¹ Although several theories have been postulated previously to explain these electrocardiographic changes, none have been proven conclusively so far. Among these, the most plausible explanation for narrowing of the QRS segment is “left ventricular disuse atrophy”.¹⁷ Under normal physiologic circumstances, ie, in the absence of significant right ventricular hypertrophy, the left ventricle is the main generator of the electromotive forces of the heart. However, in emphysema, the equidominance or predominance of right ventricular forces may lead to a tendency toward “less of left ventricular forces”, leading to more rapid completion of ventricular depolarization, resulting in a narrow QRS duration on the surface electrocardiogram.¹¹

To the best of our knowledge, our study is the first thus far to investigate if the presence of LVH in patients with emphysema could affect these electrocardiographic diagnostic criteria in a practical clinical setting. One may conceptually project that the atrial vector may also shift relatively leftward

as a result of left ventricular disuse atrophy in emphysema. However, this does not appear to be the case in actual practice, as evident from the results of this study. Thus, P-vector verticalization can still effectively serve as a lone diagnostic criterion even in the presence of left ventricular disease. However, should the diagnostic dyad be used, a prior history of left ventricular disease must be accounted. This may practically apply to many patients, including a major subset of those with pre-existing hypertensive heart disease.

Although verticalization of the P-vector can be independently affected by the severity of obstructive lung disease, this did not appear to be a limiting/confounding factor in our study because patients in both subgroups had comparable pulmonary function test results when compared using FEV₁.

We acknowledge some limitations to this study. Many patients did not have a high resolution computed tomography (CT) scan of the chest, which is currently the gold standard for diagnosis of emphysema. Further, our investigation lacked a control group, in that all patients had a diagnosis of emphysema.

Conclusion

The electrocardiographic diagnostic dyad (P-vector verticalization with an axis >60° and a narrow QRS duration <80 msec) can be effectively used to diagnose emphysema. However, one must take into consideration the presence or absence of left ventricular disease, mainly LVH. The presence of LVH may not affect the sensitivity of P-vector verticalization when used as a lone criterion for diagnosing emphysema. However, when used in combination with a narrow QRS duration (diagnostic dyad), it may significantly reduce the sensitivity as LVH causes widening of the QRS duration even in the setting of pre-existing emphysema.

Disclosure

The authors report no conflicts of interest in this work.

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