NEW CORRELATION BETWEEN ANGLES OF WIDE QRS COMPLEX IN ELECTROCARDIOGRAM AND ECHOCARDIOGRAPHIC INDICES

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Abstract

BACKGROUND: Heart failure (HF) due to left ventricular (LV) systolic dysfunction has lesser survival than diastolic HF .We examined the correlation of two new angles(α and β) of QRS complex in the electrocardiogram (ECG) with indices including left ventricular ejection fraction (LVEF),left ventricular end systolic dimension (LVESD) and left ventricular end diastolic dimension (LVEDD) for predicting LVEF.

METHODS: In this cross–sectional study,159 subjects with clinical signs of LV systolic dysfunction who presented to the Al-Zahra hospital in Isfahan, Iran , underwent echocardiography .First ,on the ECG ,two new angles defined and then these two angles compared manually and with computerized analysis by two different observers blinded to the another data. After confirmation of excellent correlation between these two forms, then two angles measured manually with protractor in 159 patients (wide QRS complex in 59 and normal in 100 patients). Then, correlation between these angles and echocardiographic indices were assessed.

RESULTS: Statistical analysis revealed that in normal QRS complex, there was no correlation between any of two angles and echocardiographic indices. In contrast, in wide QRS complex,β angle and β/α ratio was correlated with any three echocardiographic indices (negative correlation with LVEF and positive correlation with LVESD and LVEDD) i.e. with decrease in LVEF and increase in LVESD and LVEDD, β angle is widened and β/α ratio increases.
A LVEF of 30% corresponded to β/α ratio of 2 in wide QRS complex patients on the regression line. Linear regression analysis generated the regression line equation for predicting the LVEF. The equation is LVEF = 60.6 – (14.5 ×β/α ratio).

CONCLUSION: β angle and β/α ratio can predict LVEF in patients with suspected HF and wide QRS complex.

Keywords: Left ventricular systolic dysfunction, QRS angle, Electrocardiogram, ejection fraction.

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Introduction

Heart failure (HF) is a relatively common disorder. It is estimated that 4.9 million patients are under treatment for HF in U.S and 550000 new cases in year diagnosed.[1] HF can be systolic or diastolic .Systolic HF is with lower survival than diastolic HF[2] and correct diagnosis and treatment can be lifesaving.

The most prominent symptom in systolic HF is dyspnea and in patients that presented with dyspnea in emergency department(ED), discrimination of cardiac dyspnea from other causes of dyspnea is important.

LV systolic dysfunction is common and assessment of LV function routinely perform with echocardiography but echocardiography has limitations because of unavailability in some ED centers and poor echo window and unfavorable position in significant percent of patients with acute dyspnea.BNP has high sensitivity but cannot differentiated systolic from diastolic HF. Thus for this reason, combination of BNP and QRS duration in some studies has performed[3] but cost-effectiveness analysis has limited his use in comparison with echocardiography alone.[4] In multiple studies normal ECG has been with high sensitivity and specificity for normal ejection fraction,[2,5] thus ECG can be helpful for estimation of normal ejection fraction.

Although, ECG with wide QRS duration has been with high specificity for systolic LV dysfunction but its sensitivity is low.

Because ECG is a safe, simple, available and cheap instrument and can be helpful for assessment of

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LVEF, we examined whether two new angles in ECG (α and β according to the definition) have correlation with echocardiographic indices (LVEDD: Left ventricular end-diastolic diameter; LVESD: Left ventricular end-systolic diameter; LVEF: Left ventricular ejection fraction) and can predict LVEF (Figure 1).

On a medline search, no previous publication of these angles found.

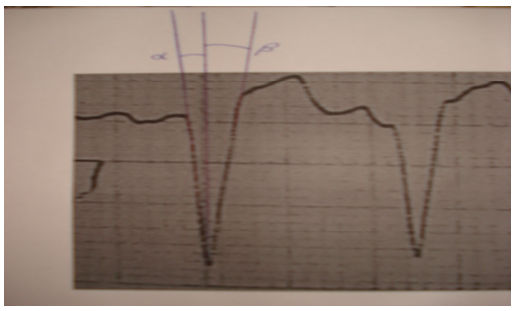

Figure 1. α and β angles in ECG according to the definition

Materials and Methods

This cross-sectional study was conducted on patients with clinical signs of LV systolic dysfunction who presented to the Al-Zahra hospital in Isfahan, Iran, from 6/2005 to 6/2007. They underwent echocardiography via single cardiologist in left lateral decubitus and 12 leads ECG taken from them. Echocardiography carried out with Powervision 6000 (Toshiba Inc, Tokyo) and 3.2 MH transducer and cardiac indices (LVEF, LVEDD and LVESD) calculated using Teichholz M-mode method.

Diagnosis of systolic LV dysfunction was based on American Society of Echocardiography (ASE) committee recommendation[6] that divided patients to three categories: Mild LV systolic dysfunction (LVEF = 45-54%); Moderate LV systolic dysfunction (LVEF = 30-44%); Severe LV systolic dysfunction (LVEF < 30%). Inclusion criteria consisted of all patients with LV systolic dysfunction .Exclusion criteria included patients on antiarrhythmic drugs, with pacemaker rhythm, RBBB and electrolyte disturbances including hyperkalemia.

First, on the ECG, two new angles defined (α and β). α-angle is the angle between the descending limb of the S wave and vertical line on QRS nadir relative to isoelectric line. β-angle is the angle between the ascending limb of the S wave and the same vertical line(fig1).This angles measured in leads V_1 or V_2.

Initially in 10 patients after scanning of ECGs, these two angles measured with computerized analysis (Vista Metrix. Ver 1.3 Skill Crest, LLC) with accuracy of one tenth degree and also in manual form (with protractor) via two different observers blinded to another data and then, comparison between this two forms carried out. Because of excellent correlation between these two forms and because of practical purposes,then angles measurement, done manually. Data were analyzed with SPSS statistical package, version 13.0 for windows. Correlation between variables was assessed with pearson's coefficient of correlation and linear regression tests. Variables were presented as mean ± SD. Two tailed P value of .05 or less were considered to be statistically significant.

Results

In first step, correlation between manual and computerized forms compared. Excellent correlation was evident and Pearson's coefficient of correlation for α and β was 0.98 and 0.94 respectively.

Then in 159 patients, angles calculated manually for practical purposes with protractor. Table 1 shows study variables. The average age of patients was 64 ± 14.3 years and 62% of patients were male.

59 patients had wide QRS complex (QRS duration greater than 100 ms) and 100 subjects had narrow (normal) QRS complex .Data analyzed in 159 patients and also separately in wide and narrow QRS complexes (Table 2 and Table 3).

Table 1. Patients characteristics

Variable	Mean ± Std. Deviation		
	All pts.	Narrow QRS complex	Wide QRS complex
α angle	3.97 ± 1.44	4.06 ± 1.45	3.42 ± 1.13
β angle	5.34 ± 2.21	4.87 ± 2.08	5.96 ± 2.14
β/α ratio	1.38 ± .50	1.20 ± .37	1.78 ± .51
LVEF	39.91 ± 11.35	41.32 ± 10.97	34.68 ± 9.86
LVESD	41.94 ± 11.30	40.63 ± 11.35	45.67 ± 10.73
LVEDD	55.10 ± 10.91	53.53 ± 11.32	58.83 ± 9.75

Pts: patients; Std.: standard; LVEDD: Left ventricular end-diastolic diameter. LVESD: Left ventricular end-systolic diameter. LVEF: Left ventricular ejection fraction.

Table 2. Correlation between α angle ,β angle and β/α ratio with echocardiographic indices in all 159 patients

Angles and their ratio	All patients		
	LVEF	LVESD	LVEDD
α angle			
Pearson correlation	0.064	0.022	- 0.012
P value	0.424	0.784	0.876
β angle			
pearson correlation	-0.183*	0.140	0.127
P value	0.021	0.081	0.111
β/α ratio			
pearson correlation	-0.316**	0.187*	0.220**
P value	< 0.001	0.019	0.005

* correlation is significant at the 0.05 level (2 tailed)
** correlation is significant at the 0.01 level (2 tailed)
LVEDD: Left ventricular end-diastolic diameter. LVESD: Left ventricular end-systolic diameter. LVEF: Left ventricular ejection fraction.

Table 3. Correlation between α angle, β angle and β/α ratio with echocardiographic indices in narrow and wide QRS complex patients.

Angles and their ratio	Narrow QRS complex			Wide QRS complex		
	LVEF	LVESD	LVEDD	LVEF	LVESD	LVEDD
α angle						
pearson correlation	-0.099	0.159	0.133	-0.033	-0.074	-0.103
P value	0.325	0.115	0.186	0.826	0.624	0.484
β angle						
pearson correlation	-0.080	0.088	0.044	-0.616**	0.311*	0.310*
P value	0.430	0.382	0.666	< 0.001	0.035	0.032
β/α ratio						
pearson correlation	0.018	-0.071	-0.093	-0.761**	0.558**	0.566**
P value	0.859	0.481	0.356	< 0.001	< 0.001	< 0.001

* correlation is significant at the 0.05 level (2 tailed)
** correlation is significant at the 0.01 level (2 tailed)
LVEDD: Left ventricular end-diastolic diameter. LVESD: Left ventricular end-systolic diameter. LVEF: Left ventricular ejection fraction.

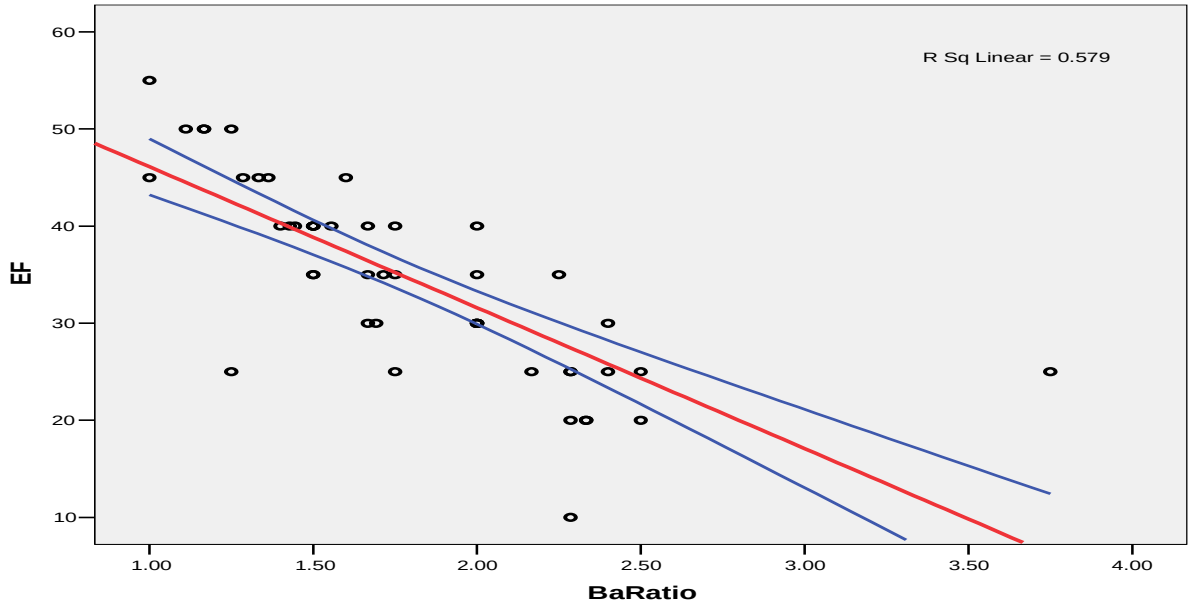

Figure 2. Plot of LVEF vs β/α ratio associated with regression line.
Linear regression analysis generated the regression line equation LVEF =60.6 – (14.5 × β/α ratio). Upper and lower curved lines represent the 95% confidence limits around the mean predicted values.
For predicting the LVEF, linear regression analysis generated the regression line equation: LVEF = 60.6 – (14.5 × β/α ratio)

Significant correlation was not existed between any of three variables, with echocardiographic indices in narrow (normal) QRS complex patients (Table 3). In all cases (narrow as well as wide QRS complex), there was significant correlation between β angle and β/α ratio with LVEF and between β/α ratio with LVESD and LVEDD (Table 2). Thus, these relations are due to effects of wide QRS complexes.

A significant inverse relation existed between LVEF and β angle or β/α ratio (all $P < 0.001$; Table 3). Additionally, a direct relation between any two echocardiographic dimensions with β angle and β/α ratio was found (Table 3).Greatest correlation found between β/α ratio and LVEF ($r = -.761$, Table 3). Because of greatest correlation between LVEF and β/α ratio, regression line depicted. A LVEF of 30% corresponded to β/α ratio of 2 on the regression line (Figure 2).

Discussion

Significant correlation was found between β angle and β/α ratio with LVEF, LVEDD and LVESD and but not any correlation in narrow QRS complexes. Correlation between β angle and β/α ratio with LVEF are greatest and negative whereas other correlations are positive. So, when LVEF decreases, β/α ratio and β angle will increase. LVEF can predict by regression line equation: LVEF = 60.6 – (14.5 × β/α ratio).

This study has several limitations. First although ECGs assessed in normal range of heart rate (60-100), but because of variable heart rate between the patients, it may causes some difference and may need to be adjusted with heart rate. Second, this angles was not compared with normal population .Third, the number of patients with wide QRS complex is little.

Despite of these limitations, because ECG is easily available and safe and rapidly perform in patients and because of good correlation of β angle and β/α ratio with LVEF, if next studies with exclusion of above limitations confirm correlation of these angles, this angle and ratio can be undertaken in initial evaluation or even screening of patients suspicious to LV systolic dysfunction and then other accurate tools such as echocardiography confirm this initial estimation.

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