Prediction of Left Ventricular Dysfunction on the Basis of Ventricular Depolarization Time and Electrical Axis in Patients with Left Bundle Branch Block

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Abstract

Background- Prolongation of ventricular depolarization time (QRS duration), particularly in left bundle branch block (LBBB), is commonly associated with many cardiac diseases. We posit that the QRS duration and degree of left-axis deviation (LAD) identify significant left ventricular (LV) systolic dysfunction in patients with LBBB.

Methods- In this prospective study, 150 patients with diagnosis of LBBB were divided into two groups (QRS≥160 and QRS<160 milliseconds). Then the relationships between QRS duration, left axis deviation (LAD: axis between –30° and –90°), and echocardiographic LV ejection fraction (EF) were derived by t-test, chi-square, and linear regression analysis in a step-wise method.

Results- There was no significant difference in age and sex among the patients with or without LAD and QRS duration less or more than 160 ms (p>0.05). The EF of patients with LAD (n=64) and without LAD (n=86) was 48.64±14.63% and 52.10±13.98%, respectively (p=0.143). The mean±SD EF (54.5±10.54%) of the patients with a QRS duration of ≥160 milliseconds (n=19) was significantly more than the mean ± SD EF (23.89±5.46%) of the patients with a QRS duration of <160 milliseconds (n=131, p<0.001). The QRS duration also had a significant (p<0.001) inverse correlation with EF (R = 0.926, adjusted R^2 = 0.857, SE of estimate = 5.42). However, the QRS axis was not significantly correlated with EF and did not have added predictive values.

Conclusion- The QRS duration has a significant inverse relationship with EF. Furthermore, the prolongation of QRS duration (≥160 milliseconds) in the presence of LBBB is a marker of significant left ventricular systolic dysfunction. The presence of LAD in LBBB does not signify a further decrease in EF ***(Iranian Heart Journal 2006; 7 (4):17-25)***.

Keywords: QRS duration■ electrical axis■ LV dysfunction■ ejection fraction■ left bundle branch block

Left bundle branch block (LBBB) is commonly associated with coronary artery disease (CAD), cardiomyopathy, and hypertension.[1,2]

Echocardiographic studies have revealed that patients with even mildly prolonged QRS duration (≥120 milliseconds) resulting from intraventricular conduction delay have left ventricular (LV) dysfunction.[3-9]

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LBBB is responsible for a greater degree of asynchrony in LV contraction as a result of alteration in LV depolarization sequence.[1,2,5,10-16] Therefore, LBBB may be a marker of both LV systolic and diastolic dysfunction due to alteration in LV depolarization and prolongation of QRS duration. LBBB is also associated with increased mortality in patients with congestive heart failure (CHF)[3,4,17-27] and carries a poor prognosis.[1,2,10]

It has also been suggested that left axis deviation (LAD) in the presence of LBBB may be associated with either left anterior fascicular block (LAFB) or loss of inferiorly directed forces from myocardial scarring(5;12). It has also been shown to have a higher incidence of cardiomegaly, CHF, diffused conduction system disease, and sudden cardiac death(18;28-30). Accordingly, it is the impression among clinical cardiologists that LAD with LBBB identifies patients with severe LV systolic dysfunction. This study was designated to prove or refute this clinical observation, and we postulated that LAD and/or prolonged QRS duration (QRS ≥160 milliseconds) in the presence of LBBB is associated with poor LV function.

Methods

In this prospective cross-sectional research, we studied 150 patients with LBBB in the cardiac ward, CCU, and out-patient clinic of Shaheed Beheshti Hospital, Babol Medical University from September 2000 to December 2003. Patient demographics, including age and sex, were collected. The criterion for LBBB was a QRS duration of ≥120 milliseconds.[3-5,23] An RSR pattern in leads I, V5, and V6 with secondary ST-T wave changes was a supportive finding for LBBB. Acute prolongation of QRS duration was a strong indicator of LBBB.

LAD was defined as a QRS axis between –30 degrees and –90 degrees.[1,5,14,16] Heart rates >100 beats/min were excluded from the study because of the possibility of tachycardia-related disorders. The patients with intraventricular conduction defects, right bundle branch block, or pacemaker rhythm were also excluded. The ejection fraction (EF) was determined by Simpson’s method on a Hewlett-Packard model Sonus 1500.

Statistical analysis

The demographic parameters among the patients with a QRS duration of ≥160 milliseconds and the patients with a QRS duration of <160 milliseconds were analyzed by 2 methods, and their EFs were compared by the 2-tailed type II Student *t*-test. Descriptive statistics were also calculated for each variable (QRS duration and LAD). Medians, quartiles, and ranges were derived for the QRS duration, QRS axis, and EF in these patients. Simple linear and multiple regression analysis were used to compare relationships among variables (QRS duration and LAD). Raw data were input into a case-wise multiple regression model.

Results

One hundred fifty patients were found to have LBBB, most of them being male (56.7% vs. 43.3%). The mean (±SD) age of the patients was 53.39 (±8.29) years, and there was no significant difference between males and females (p>0.05).

Of the 150 patients included in the analysis, a prolonged QRS duration (≥160 milliseconds) was found in 19 patients (12.7%), and a short QRS duration (<160 milliseconds) was found in 131 (87.3%). There was no significant difference in age and sex among the patients with or without prolonged QRS durations (respectively, p=0.908; p=0.964, OR (95%CI) = 0.944 (0.356-2.501). The mean (±SD) EF of the patients with a QRS duration of ≥160 milliseconds was significantly lower than that of the patients with a QRS duration of <160 milliseconds (54.5% ± 10.54% vs. 23.89% ± 5.46%, P<0.001). Also, this difference was reported between males and females (P<0.001).

The mean (±SD) EF (48.64%±14.63%) of the patients with LBBB and LAD (n= 64) was not significantly different compared with the mean (±SD) EF (52.1%±13.97%) of the patients with LBBB and without LAD (n=86, P=0.143). There was no significant difference in age and sex among the patients with or without LAD (P>0.05).

Relationships uncovered among the variables (QRS duration, QRS axis, and EF) are illustrated in Table III. According to first model [EF= 182.059 - 936.759 QRS duration + .046 LAD] and final model [EF= 185.279 - 966.87 QRS duration] we found that the QRS duration had a significant (P<0.001) inverse correlation with the EF (R = 0.926, adjusted R^2= 0.857, SE of estimate = 5.42). However, the axis was not significantly correlated with EF and added no predictive value to the model.

Discussion

Heart failure is often misdiagnosed or under-diagnosed in primary care. Assessment of left-ventricular function in patients with suspected heart failure leads to more effective diagnosis and treatment of this disorder.[20-22,25,26,31] Intraventricular conduction disturbance is common in congestive heart failure (CHF), which is characterized by a wide QRS complex.[23,24,27,32] Up to half of advanced CHF patients have prolonged QRS durations, which has been identified as an independent prognostic factor.[4] Left ventricular dysfunction predicted by standard 12-lead electrocardiography would be clinically useful. Left bundle branch block is commonly associated with structural heart disease and LV dysfunction.[5,10,12]

In our study, we found that the role of age and sex is not correlated to QRS duration and LAD (P>0.05), but there is a significant difference between left ventricular ejection fraction (LV EF) and prolonged QRS duration. Our findings in similar roles of age and sex between patients with and without prolonged QRS duration are consistent with reports by Nastasiou et al.,[30] Pastore et al.,[2] and Recke et al.[15]

In our study, we divided QRS duration into two groups (≥160 or <160 millisecond), but Sandhu et al.[32] divided this duration on the basis of 120 milliseconds, and Bode-Schnurbus et al.,[18] 150 milliseconds. The probable cause of this difference is due to different sample sizes and measurement methods.

Tabuchi et al. estimated LV systolic function based on the ECG in cases with LBBB and reported that patients with underlying mild hypertensive heart disease may have a favorable LV systolic function. Thus, LV systolic function in patients with LBBB may be suspected by observing these electrocardiographic findings.[33]

Usefulness of the spatial dispersion of QRS duration in predicting mortality in patients with mild to moderate chronic heart failure was studied by Yamada, et al.[27] They studied 114 consecutive stable outpatients with radionuclide left ventricular ejection fraction <40% and concluded that spatial dispersion of QRS duration is a powerful prognostic marker of the mortality in patients with mild to moderate CHF.[27] Our results in LAD and LVEF do not agree with the findings of Yamada and coworkers. It is mentioned that they divided QRS duration on a scale of 120 milliseconds.

Furthermore, several studies of QRS duration have shown that a prolonged QRS (>170 milliseconds) is associated with LV dysfunction.[3-5,7-9,18,21,23,24,27,29] Our data indicate that the presence of complete LBBB is related to LV dysfunction and that prolonged QRS durations are correlated with poor systolic function. Das and coworkers[5] analyzed the data of 300 patients to determine the relationship between prolonged QRS duration (QRS ≥170 ms) and left axis deviation (LAD) in the presence of LBBB. They concluded that there was no significant difference in age, sex, presence of valvular heart disease, and EF among the patients with or without LAD.[5] As in our study, Das et al.

concluded that the QRS duration has a significant inverse relationship with EF and prolongation of QRS duration (≥170 milliseconds) in the presence of LBBB. The presence of LAD in LBBB does not signify a further decrease in EF.[5]

Murkofsky et al.[8] studied 270 consecutive patients who referred for radionuclide ventriculography, and concluded that prolonged QRS duration (>0.10s) obtained from a standard resting 12-lead ECG is a specific, but relatively insensitive indicator of decreased LV systolic function. Further prolongation of the QRS had a higher specificity for decreased LV EF and a higher positive likelihood ratio for predicting abnormal LVEF.

In our study, LAD in the presence of LBBB was not associated with further deterioration of LV function. With complete LBBB, the right ventricle is activated by the right bundle branch in its usual fashion. The impulse to the LV crosses the interventricular septum at one or more sites and then appears to enter the LV distal Purkinje system and is distributed throughout.[13,33] The mean frontal QRS axis in LBBB presumably reflects the site or sites of impulse crossing the septum and the distribution of the impulse within the left ventricle.[14]

LAD in patients with LBBB presumably reflects the abnormality in the activation of the LV, which could reflect septal, distal Purkinje system, or LV tissue abnormalities. The thinner left anterior fascicle could be more prone to injury because of ventricular stretch, which might be more severe in the group with LAD.[1,5]

Thus the proposed mechanism of LAD in the presence of LBBB is partial LAFB or loss of inferiorly directed forces from myocardial scarring that interfere in some way with the distribution of the impulse.[14,16] However, our study confirms that there is no significant difference in the severity of LV dysfunction in patients with LBBB in association with either LAD or a normal QRS axis.

We speculate that it simply signifies the anisotropy of impulse propagation in a myopathic ventricle or the presence of decreased inferoposterior depolarization, leading to the left superior orientation of the main vector force.[34]

Similarly to this conclusion, Spurrell et al.[16] performed study of intraventricular conduction times in patients with left bundle-branch block and LAD using His bundle electrograms. Our conclusion is similar to Parharidis's findings.[14] The aim of their study was to elucidate the diagnostic significance of LAD in patients with LBBB. They concluded that the presence of LAD had a low sensitivity for the presence of organic heart disease.[14]

Conclusion

In the presence of LBBB, QRS duration has a significant inverse relationship with EF and a prolongation of QRS duration (≥160 milliseconds) is a marker of significant LV systolic dysfunction. However, the degree of LAD in LBBB does not correlate with EF and also does not signify a further decrease in EF.

Table I. Comparison among QRS duration with age, gender, and EF in presence of complete LBBB

		QRS duration (millisecond)				
		< 160 (n= 131)	≥ 160 (n= 19)	Total (n= 150)	p-value	OR (95% CI)
Age (year) *		53.38±8.43	53.47±7.538	53.39±8.299	0.964 **	
Gender	Male	74 (56.5%)	11 (57.9%)	85 (56.7%)	0.908 ***	0.944 (0.356-2.501) †
	Female	57 (43.5%)	8 (42.1%)	65 (43.3%)		
Ejection Fraction (%)*	Male	54.77±9.947	23.91±4.949	50.78±14.053	0.000 **	
	Female	54.16±11.356	23.88±6.468	50.43±14.763	0.000 **	
	Total	54.5±10.545	23.89±5.466	50.63±14.317	0.000 **	

* Mean±Std. deviation, ** Estimate from independent sample T-test and p-value less than .05 is significant
*** Estimate from Pearson Chi-square test and p-value less than .05 is significant † OR (95% CI) estimate from Mantel-Henszel for QRS duration < 160 millisec/ QRS duration ≥ 160 millisec

Table II. Comparison among LAD with age, gender, and EF in presence of complete LBBB

		Left Axis Deviation (degree) *				
		No (n= 86)	Yes (n= 64)	Total (n= 150)	p-value	OR (95% CI)
Age (year) **		53.58±7.974	53.14±8.774	53.39±8.299	0.749 ***	
Gender	Male	49 (57%)	36 (56.2%)	85 (56.7%)	0.929 †	1.03 (0.536-1.979) †*
	Female	37 (43%)	28 (43.8%)	65 (43.3%)		
Ejection Fraction (%) **	Male	51.94±13.874	49.14±14.336	50.78±14.053	0.377 ***	
	Female	52.32±14.304	47.93±15.244	50.43±14.763	0.237 ***	
	Total	52.10±13.978	48.64±14.635	50.63±14.317	0.143 ***	

* LAD = (axis between -30 degrees and -90 degrees), ** Mean±Std. deviation, *** Estimate from independent sample T-test and p-value less than .05 is significant , † Estimate from Pearson Chi-square test and p-value less than .05 is significant †* OR (95% CI) estimate from Mantel-Henszel for LAD- / LAD+

Table III. Multivariate analysis showing correlations of prolonged QRS duration and LAD in presence of LBBB with EF

Models *	**First Model** **			**Final Model** ***	
	(Constant)	QRS duration	LAD	(Constant)	QRS duration
Coefficients					
Unstandardized					
B	182.059	-936.759	.046	185.279	-966.870
Std. Error	4.576	33.430	.016	4.531	32.379
Standardized					
Beta		-.897	.090		-.926
T-test†	39.782	-28.021	2.801	40.892	-29.861
Sig. †	.000	.000	.006	.000	.000
Pearson Correlation	r (EF, LAD)= 0.378 ; sig. = 0.006			r (EF, QRS dur.)= 0.926; sig. = 0.000	
(N=150)	r (EF, QRS dur.)= 0.926; sig. = 0.000				
ANOVA ††					
Mean Square	13206.927			26193.553	
F	470.392			891.687	
Sig.	.000(b)			.000(a)	
Model Summary †*	EF= 182.059- 936.759 QRS dur.+.046 LAD			EF= 185.279- 966.87 QRS dur.	
R	.930			.926	
R Square	.865			.858	
Adjusted R Square	.863			.857	
Std. Error of the Estimate	5.299			5.420	

* Estimate from linear regression analysis with stepwise method, ** Predictors in linear regression model are: (constant), LBBB, LAD
*** Predictors in linear regression model are: (constant), LBBB, † Estimate from t-test among correlation coefficients and p-value less than .05 is significant, †† The ANOVA table tests the acceptability of the model from a statistical perspective. The significance value of the F statistic is less than 0.05, which means that the variation explained by the model is not due to chance. Dependent variable in linear regression models is: EF
†* The model summary table reports the strength of the relationship between the model and the dependent variable. *R*, the multiple correlation coefficient, is the linear correlation between the observed and model-predicted values of the dependent variable. Its large value indicates a strong relationship. *R Square*, the coefficient of determination, is the squared value of the multiple correlation coefficient. It shows what proportion of the variation in *time* is explained by the model. Dependent variable in linear regression models is: EF

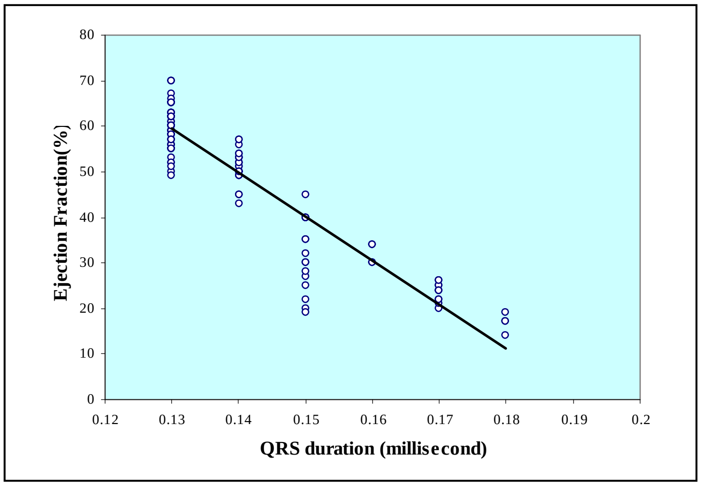

Fig.1. EF= 185.279- 966.87*QRS duration Pearson correlation: r (EF, QRS dur.)= 0.926; sig. = 0.000. Multivariate analysis showing negative correlation of prolonged QRS duration in presence of LBBB with EF.

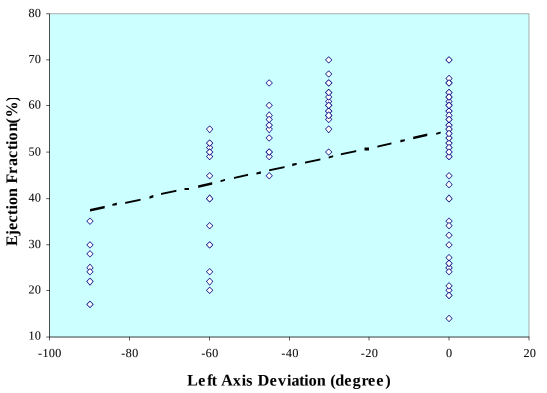

Fig. 2. EF= 54.73+ 0.194*QRS duration Pearson correlation: r (EF, LAD)= 0.378 ; sig. = 0.006 Correlation of QRS axis in presence of LAD with EF derived by multivariate regression analysis.

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