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

Farzad Jalali MD,[a] Seyyed Mohammad Miri MD[b] and Pegah Karimi Elizei [c]

Abstract

Background- Prolongation of ventricular depolarization time (QRS duration), particularly in left bundle branch block (LBBB), is commonly associated with many cardiac diseases. We propose 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 conducted in the cardiac ward, CCU and out-patient clinic of our department in Babol from 2000 to 2003, 150 patients with a diagnosis of LBBB were divided into two groups (QRS ≥160 and QRS<160 milliseconds). Then the relationship 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 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 greater than 160 milliseconds (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±10.545%) of the patients with a QRS duration of ≥160 milliseconds (n=19) was significantly more than the mean±SD EF (23.89±5.466%) 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 value.

Conclusion- The QRS duration has a significant inverse relationship with EF and 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 2008; 9 (2):29-36).***

Key words: 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 is

Received April 16, 2007; Accepted for publication May 4, 2008.
a; Associate Professor of Cardiology, Department of Internal Medicine and Cardiology, Babol University of Medical Sciences, Babol, Iran,
b; Research Assistant, MD, Department of Internal Medicine, Baghiatollah Hospital, Baghiatollah University of Medical Sciences, Tehran, Iran
c; Research Assistant, MD, Babol University of Medical Sciences, Babol, Iran.
Address for correspondence: 11th West Floor, Baghiatollah Hospital, Department of Internal Medicine, Baghiatollah University of Medical Sciences, Tehran, Iran. Tel: +98 21 88211000 Fax: +98 21 88055752 Email: sia_miri@yahoo.com

Associated with left ventricular (LV) dysfunction.[3-9] LBBB is responsible for a greater degree of asynchrony in LV contraction as a result of alteration in the sequence of LV depolarization.[1,2,5,10-16] Therefore LBBB may be a marker of both LV systolic and diastolic dysfunction because of alteration in LV depolarization and prolongation of the QRS duration. LBBB is also associated with increased mortality in patients with congestive heart failure (CHF).[3,4,17-27] Overall, LBBB is associated with 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, diffuse conduction system disease, and sudden cardiac death.[18,28-30] Therefore 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 Sciences 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 were supportive findings for LBBB. Acute prolongation of QRS duration was a strong indicator of LBBB.

LAD was defined as a QRS axis between –30 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 echocardiography machine.

Statistical analysis

The demographic parameters among the patients with a QRS duration ≥160 milliseconds and the patients with a QRS duration <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, of which most of them were male (56.7% vs. 43.3%). The mean (±SD) age of patients was 53.39±8.29 years, of which there was no significant difference between males and females ($p>0.05$).

Of the 150 patients included in the analysis, prolonged QRS duration (≥160 milliseconds) was found in 19 patients (12.7%) and 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 duration (respectively: p=0.908; p=0.964, OR (95% CI) = 0.944 (0.356-2.501). The mean (±SD) EF of the patients with 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 had been 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.

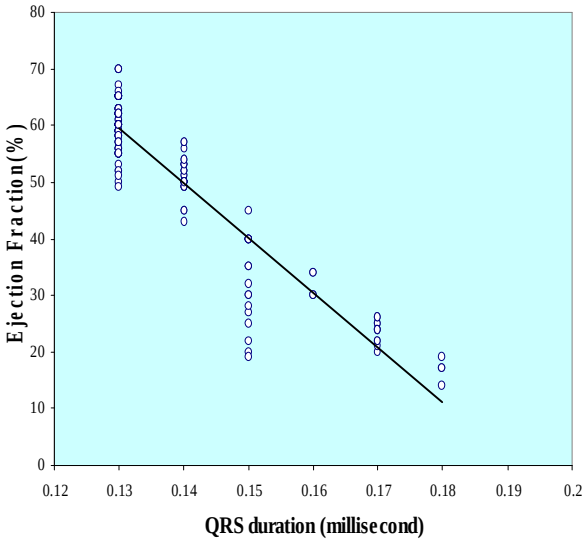

Fig. 1. Multivariate analysis showing negative correlation of prolonged QRS duration in presence of LBBB with EF. EF= 185.279- 966.87*QRS duration Pearson correlation: r (EF, QRS dur.)= 0.926; sig. = 0.000.

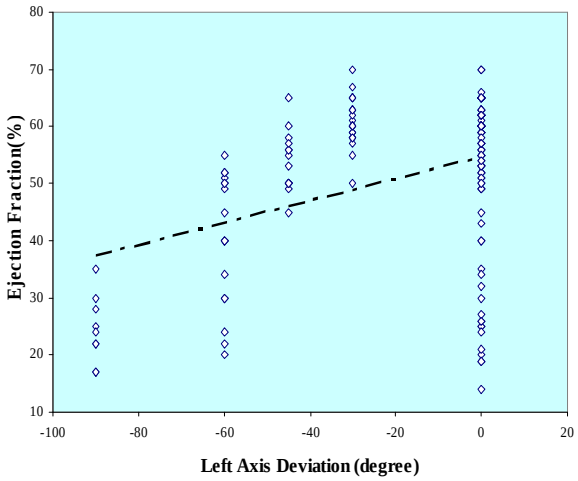

Fig. 2. Correlation of QRS axis in presence of LAD with EF derived by multivariate regression analysis. EF= 54.73+ 0.194*QRS duration Pearson correlation: r (EF, LAD)=0.378 ; sig. = 0.006.

Discussion

Heart failure is often misdiagnosed or underdiagnosed 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, which is characterized by a wide QRS complex.[23,24,27,32] Up to one-half of advanced CHF patients have prolonged QRS duration, 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 and prolonged QRS duration. Our findings in similar roles of age and sex between patients with and without prolonged QRS duration are consistent with the findings of 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 milliseconds), but Sandhu et al.[32] divided this duration on the basis of 120 milliseconds, and Bode-Schnurbus et al.,[18] on the basis of 150 milliseconds. The probable cause of this difference is due to different sample size 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]

The usefulness of 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 according to 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 prolonged QRS duration is 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 referred for radionuclide ventriculography, and concluded that prolonged QRS duration (>0.10 s) 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 LVEF 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 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 left superior orientation of the main vector force.[34] Similarly to this conclusion, Spurrell et al.[16] performed a 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, the QRS duration has a significant inverse relationship with EF and prolongation of the 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 0.05 is significant
***Estimate from Pearson Chi-square Test and p-value less than 0.05 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 0.05 is significant; †Estimate from Pearson Chi-square test and p-value less than 0.05 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 0.05 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

References

1. Gressard A. Left bundle branch block with left-axis deviation: an electrophysiologic approach. Am J Cardiol 1983; 52(8): 1013-1016.

2. Pastore CA, Moffa PJ, Tobias NM, de Moraes AP, Kaiser E, Cuoco MA et al. Left bundle branch block analysis by body surface mapping. Comparison with electrocardiographic and vectocardiographic findings. Arq Bras Cardiol 1996; 66(5): 253-256.

3. Aranda JM, Carlson ER, Pauly DF, Curtis AB, Conti CR, Ariet M et al. QRS duration variability in patients with heart failure. Am J Cardiol 2002; 90(3): 335-337.

4. Bleeker GB, Schalij MJ, Molhoek SG, Verwey HF, Holman ER, Boersma E et al. Relationship between QRS duration and left ventricular dyssynchrony in patients with end-stage heart failure. J Cardiovasc Electrophysiol 2004; 15(5): 544-549.

5. Das MK, Cheriparambil K, Bedi A, Kassotis J, ES D, Reddy CV et al. Prolonged QRS duration (QRS >/=170 ms) and left axis deviation in the presence of left bundle branch block: A marker of poor left ventricular systolic function? Am Heart J 2001; 142(5): 756-759.

6. Ghio S, Constantin C, Klersy C, Serio A, Fontana A, Campana C et al. Interventricular and intraventricular dyssynchrony are common in heart failure patients, regardless of QRS duration. Eur Heart J 2004; 25(7): 5.٥٧٨-٧١

7. Hofmann M, Bauer R, Handrock R, Weidinger G, Goedel-Meinen L. Prognostic value of the QRS duration in patients with heart failure: a subgroup analysis from 24 centers of Val-HeFT. J Card Fail 2005; 11(7): 523-528.

8. Murkofsky RL, Dangas G ,Diamond JA, Mehta D, Schaffer A, Ambrose JA. A prolonged QRS duration on surface electrocardiogram is a specific indicator of left ventricular dysfunction [see comment]. J Am Coll Cardiol 1998; 32(2): 476-482.

9. Shamim W, Yousufuddin M, Cicoria M, Gibson DG, Coats AJ, Henein MY. Incremental changes in QRS duration in serial ECGs over time identify high risk elderly patients with heart failure. Heart 2002; 88(1): 47-51.

10. Haskell RJ, Ginzton LE, Laks MM. Electrocardiographic diagnosis of left ventricular hypertrophy in the presence of left bundle branch block. J Electrocardiol 1987; 20(3): 227-232.

11. Kang SJ, Song JK, Yang HS, Song JM, Kang DH, Rhee KS et al. Systolic and diastolic regional myocardial motion of pacing-induced versus idiopathic left bundle branch block with and without left ventricular dysfunction. Am J Cardiol 2004; 93(10): 1243-1246.

12. Kountouris E, Korantzopoulos P, Karanikis P, Pappa E, Dimitroula V, Ntatsis A et al. QRS dispersion: an electrocardiographic index of systolic left ventricular dysfunction in patients with left bundle branch block. Int J Cardiol 2004; 97(2): 321-322.

13. Mehta A, Jain AC, Mehta MC, Billie M. Usefulness of left atrial abnormality for predicting left ventricular hypertrophy in the presence of left bundle branch block. Am J Cardiol 2000; 85(3): 354-359.

14. Parharidis G, Nouskas J, Efthimiadis G, Styliadis J, Gemitzis K, Hatzimiltiadis S et al. Complete left bundle branch block with left QRS axis deviation: defining its clinical importance .Acta Cardiol 1997; 52(3): 295-303.

15. Recke SH, Esperer HD, Eberlein U, Gansser R, von der EJ. Assessment of left ventricular function from the electrocardiogram in left bundle branch block. Int J Cardiol 1989; 24(3): 297-304.

16. Spurrell RA, Krikler DM, Sowton E. Study of intraventricular conduction times in patients with left bundle-branch block and left axis deviation and in patients with left bundle-branch block and normal QRS axis using His bundle electrograms. Br Heart J 1972; 34(12):1244-12.

17. Bax JJ, Marwick TH, Molhoek SG, Bleeker GB, VAN EL, Boersma E et al. Left ventricular dyssynchrony predicts benefit of cardiac resynchronization therapy in patients with end-stage heart failure before pacemaker implantation. Am J Cardiol 2003; 10(92): 1038-40.

18. Bode-Schnurbus L, Bocker D, Block M, Gradaus R, Heinecke A, Breithardt G et al. QRS duration: a simple marker for predicting cardiac mortality in ICD patients with heart failure. Heart 2003; 89(10): 1157-1162.

19. Davies M, Hobbs F, Davis R, Kenkre J, Roalfe AK, Hare R et al. Prevalence of left-ventricular systolic dysfunction and heart failure in the Echocardiographic Heart of England Screening study: a population based study. Lancet 2001; 358(9280): 439-444.

20. Gupta SN, Jose VJ, Chandy ST. Heart failure: what proportion of patients satisfy the electrocardiographic criteria for cardiac resynchronization therapy? Indian Heart J 2003; 55(6): 619-623.

21. Kalra PR, Sharma R, Shamim W, Doehner W, Wensel R, Bolger AP et al. Clinical characteristics and survival of patients with chronic heart failure and prolonged QRS duration. Int J Cardiol 2002; 86(2-3): 225-231.

22. Kearney MT, Zaman A, Eckberg DL, Lee AJ, Fox KA, Shah AM et al. Cardiac size, autonomic function, and 5-year follow-up of chronic heart failure patients with severe prolongation of ventricular activation. J Card Fail 2003; 9(2): 93-99.

23. Molhoek SG, VAN EL, Bootsma M, Steendijk P, Van Der Wall EE, Schalij MJ. QRS duration and shortening to predict clinical response to cardiac resynchronization therapy in patients with end-stage heart failure. Pacing Clin Electrophysiol 2004; 27(3): 308-313.

24. Shenkman HJ, Pampati V, Khandelwal AK, McKinnon J, Nori D, Kaatz S et al. Congestive heart failure and QRS duration: establishing prognosis study. Chest 2002; 122(2): 528-534.

25. Tarantini L, Faggiano P, Senni M, Lucci D, Bertoli D, Porcu M et al. Clinical features and prognosis associated with a preserved left ventricular systolic function in a large cohort of congestive heart failure outpatients managed by cardiologists. Data from the Italian Network on Congestive Heart Failure. Ital Heart J 2002; 3(11): 656-664.

26. Varela-Roman A, Gonzalez-Juanatey JR, Basante P, Trillo R, Garcia-Seara J, Martinez-Sande JL et al. Clinical characteristics and prognosis of hospitalised inpatients with heart failure and preserved or reduced left ventricular ejection fraction. Heart 2002; 88(3): 249-254.

27. Yamada T, Shimonagata T, Misaki N, Asai M, Makino N, Kioka H et al .Usefulness of spatial dispersion of QRS duration in predicting mortality in patients with mild to moderate chronic heart failure. Am J Cardiol 2004; 94(7): 960-963.

28. Freudenberger R, Sikora JA, Fisher M, Wilson A, Gold M. Electrocardiogram and clinical characteristics of patients referred for cardiac transplantation: implications for pacing in heart failure. Clin Cardiol 2004; 27(3): 151-153.

29. Iuliano S, Fisher SG, Karasik PE, Fletcher RD, Singh SN. QRS duration and mortality in patients with congestive heart failure. Am Heart J 2002; 143(6): 1085-1091.

30. Nastasiou-Nana MI, Nanas JN, Karagounis LA, Tsagalou EP, Alexopoulos GE, Toumanidis S et al. Relation of dispersion of QRS and QT in patients with advanced congestive heart failure to cardiac and sudden death mortality. Am J Cardiol 2000; 85(10): 1212-1217.

31. Sparrow N, Adlam D, Cowley A, Hampton JR. The diagnosis of heart failure in general practice: implications for the UK National Service Framework. Eur J Heart Fail 2003; 5(3): 349-354.

32. Sandhu R, Bahler RC. Prevalence of QRS prolongation in a community hospital cohort of patients with heart failure and its relation to left ventricular systolic dysfunction. Am J Cardiol 2004; 93(2): 244-246.

33. Tabuchi H, Kawai N, Sawayama T] .Estimation of left ventricular systolic function based on the electrocardiograms in cases with left bundle branch block]. J Cardiol 1998; 31(1): 23-30.

34. Kong CW, Hsu TG, Lu FJ, Chan WL, Tsai K. Leukocyte mitochondria depolarization and apoptosis in advanced heart failure: clinical correlations and effect of therapy. J Am Coll Cardiol 2001; 38(6): 1693-1700.