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QRS duration and echocardiographic evidence of left ventricular dyssynchrony in patients with left ventricular systolic dysfunction

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ORIGINAL ARTICLE

QRS Duration and Echocardiographic Evidence of Left Ventricular Dyssynchrony in Patients with Left Ventricular Systolic Dysfunction

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ABSTRACT

Objective: To determine the association between left ventricular (LV) dyssynchrony assessed by tissue Doppler imaging (TDI) in patients with left ventricular ejection fraction (LVEF) < 35% and prolonged ventricular depolarization on electrocardiography.

Study Design: A cross-sectional study.

Place and Duration of Study: The Aga Khan University, Karachi, from June to September 2007.

Methodology: All patients with LVEF < 35% were included. Apical 2-D images were obtained in 4 chamber and 2 chamber views. TDI pulse wave Doppler parameters were measured from these 2 color-coded images. Time interval between the onset of QRS complex and the peak systolic velocity per region was derived. Patients with valvular heart disease, mitral annular calcification, atrial fibrillation and paced rhythm were excluded. Fischer's exact test was used to determine the association between QRS duration and left ventricular dyssynchrony.

Results: A total of 60 patients were included. Twenty one patients had QRS duration of > 120 msec. Out of those 21 patients, a total of 6 patients (28.6%) had evidence of dyssynchrony on TDI. Five patients (23.8%) had dyssynchrony on the basis of basal septal and basal lateral velocity difference (p=0.045) and 6 patients (28.6%) had evidence of dyssynchrony based on basal anterior and basal inferior velocity difference (p=0.018). Out of the remaining 39 patients with narrow QRS complex, only 2 patients (5.1%) had dyssynchrony on TDI.

Conclusion: The study demonstrates a significant association between prolonged QRS duration and left ventricular dyssynchrony on TDI. Therefore, such patients should be screened for prolonged QRS duration on ECG before cardiac resynchronization therapy (CRT).

Key words: *Left ventricular dyssynchrony. Tissue doppler imaging. Peak systolic velocity. Ejection fraction. QRS duration. Left ventricular dysfunction.*

INTRODUCTION

Cardiac resynchronization therapy (CRT) with biventricular pacing is a new invasive mode of therapy for severe drug-resistant heart failure. It improves the symptoms, quality of life, mitral regurgitation, ventricular remodeling and exercise capacity in patients with severe systolic heart failure. Previous studies used the morphology and duration of the QRS complex on ECG as a criteria for selecting the patients for this device therapy along with advanced NYHA class and low EF (< 35%).[1] However, some patients do not respond to biventricular pacing despite having prolonged QRS duration.[2,3] In this respect, studies observed that the left ventricular systolic dyssynchrony is a much better predictor of therapeutic response with biventricular pacing.[4] Tissue Doppler imaging (TDI) has been shown to be the best modality for determining the presence and severity of LV systolic dyssynchrony, and also helps to confirm the improvement in LV remodeling after biventricular pacing.[5]

The main purpose of this study was to determine the association between prolonged QRS duration on ECG and left ventricular dyssynchrony by TDI in patients having LV dysfunction (ejection fraction < 35%).

METHODOLOGY

This was a cross-sectional based study conducted at the Aga Khan University Hospital, Karachi, from June to September 2007. All patients found to have a left ventricular ejection fraction below 35% on echocardiographic evaluation were considered for inclusion in this study. Further inclusion criteria were age > 18 years, presence of sinus rhythm on ECG and prominent systolic velocity curve on tissue Doppler signal. Patients with organic valvular heart disease, mitral annular calcification, non-sinus rhythm including atrial fibrillation and paced rhythm and those with poor quality tissue Doppler signal were excluded. The indications for performing echocardiographic study and various

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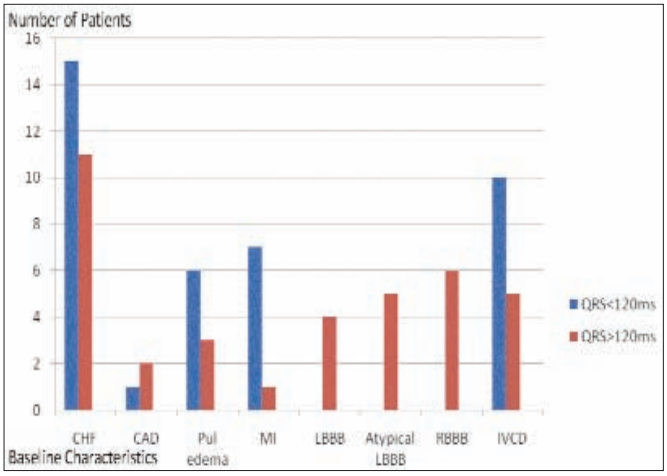

Figure 1: Showing the frequencies of various baseline characteristics in the study group.

CHF=congestive heart failure; CAD=coronary artery disease; MI=myocardial infarction; LBBB=left bundle branch block; RBBB=right bundle branch block; IVCD=intraventricular conduction disturbance.

electrocardiographic features found in studied patients are shown in Figure 1.

A 12-lead electrocardiogram was obtained in every patient. QRS axis, duration and morphology were noted in each ECG. A hand caliper was used to accurately measure the duration of QRS complex from the onset of either Q or R whichever present first on the complex to the end of the complex. The widest complex on the precordial lead was chosen. Premature ventricular ectopics (PVC) were ignored.

Echocardiographic studies were performed on GE Vivid 7 Dimension Machine. A senior technologist first performed the routine echocardiographic examination using a 3.5 MHz transducer. Left ventricular end systolic and end diastolic diameters were measured in parasternal long axis view in end systolic and end diastolic frames, respectively. Left ventricular systolic function was assessed visually by a cardiologist after detailed review of all the views obtained.

Patients with ejection fraction below 35% were included in the study and had a further detailed tissue Doppler and M-mode examination for dyssynchrony assessment.

For TDI, apical 2-D images were obtained in 4 chamber and 2 chamber views. Color Doppler was superimposed on these images. Color Doppler frame rates were set at > 80 frames per second and aliasing velocities between 16 and 32 cm/s. The highest possible frame rates were achieved by narrowing the 2- and 4-chamber apical TDI views down to the left ventricle (i.e., excluding the right ventricle and atria). TDI pulse wave Doppler (PW) parameters were measured from these 2 color-coded images. To determine LV dyssynchrony, the sample volume (6x6 mm) was placed in the basal parts of the anterior, inferior, septal, and lateral walls adjusting the point where the systolic and the diastolic 'E' and 'A' were well formed. The images which had a systolic wave with a prominent spike were selected for measurement. The time interval between the onset of the QRS complex and the peak systolic velocity per region was derived (electro-systolic delay). LV dyssynchrony was defined as the maximum delay between peak systolic velocities among the basal lateral and basal anterior septal region and the basal anterior and basal inferior regions. On the basis of established data (1), a cutoff value of 65 ms was used as a marker of LV dyssynchrony.

The data was entered and analyzed using SPSS (Statistical Package for Social Sciences) version 15.0. Frequencies of variables like gender of the patient, duration of QRS, differences of time distance on M-mode and difference of velocity interval on TDI in various basal regions were generated. Mean and standard deviation were reported for age of the patient, LV end diastolic dimension and other variables as shown in Table I. Independent samples t-test was used to see the mean difference between QRS duration and variables including LV ejection fraction, ventricular dimensions and ventricular dyssynchrony between different defined regions (Table I). Fisher's exact test was used to observe the association between QRS complex duration and left ventricular dyssynchrony by M-mode and TDI (Table II).

RESULTS

A total of 60 patients were selected who had ejection fraction below 35% on echocardiography with well formed tissue Doppler signals for tissue velocity assessment. Among these, 47 (78.3%) were men. The average age of the patients was 60 years ranging from 21 to 85 years. Four patients had typical LBBB (left bundle branch block) pattern, 5 patients had atypical LBBB pattern, 5 had non-specific IVCD (Intraventricular conduction disturbance) and 4 patients had RBBB (right bundle branch block) pattern as shown in Figure 1. Narrow QRS duration (< 120 msec) was found in 39 patients and the remaining 21 patients had > 120 msec QRS duration on ECG. Mean LV end diastolic dimension was greater in the group who had broad QRS complex (56 mm) than in the group with narrow QRS complex (53 mm). The mean difference of M-mode derived time delay between septal and posterior wall was found to be greater in the group with broad QRS complex (63 msec) as compared to those with narrow QRS complex (39 msec). The same was true for TDI derived basal velocities as shown in Table I.

Assessment of M-mode based time delay between septum and posterior wall was possible in 40 patients only because of poor echo windows and difficult alignment. A significant association was seen between broad QRS complex and M-mode derived dyssynchrony (p=0.005) where 5 out of 15 patients with broad QRS complex had evidence of dyssynchrony (33.3%), while

Table I: Echocardiographic parameters including 2D, M-mode and tissue Doppler imaging.

	QRS duration (< 120 and 120+)							
	< 120 (n=39)				120 and above (n=21)			
	Mean	Standard error of mean	Min	Max	Mean error of mean	Standard	Min	Max
2-D echo LVEF (visual)	26	1	10	35	24	1	15	35
2-D echo LVEDD	53	1	40	75	56	2	44	74
2-D echo LVESD	42	1	30	65	47	2	30	63
Onset of QRS to maximum of septal motion on M-mode	294	11	180	450	303	30	110	500
Onset of QRS to maximum of posterior wall motion on M-mode	335	11	200	420	366	12	300	430
Difference of two M-mode motions	39	12	90	110	63	35	180	310
Onset of QRS to peak of basal septal velocity	171	6	105	255	164	10	59	229
Onset of QRS to peak of basal lateral wall velocity	190	10	95	460	204	12	145	327
Difference of two TDI	19	10	40	355	40	16	74	233
Onset of QRS to peak of basal anterior wall velocity	194	10	80	486	194	11	105	285
Onset of QRS to peak of basal inferior wall velocity	183	7	125	275	180	12	70	265
Difference of two basal wall velocities	11	10	65	353	13	13	85	155

Table II: Association between QRS duration and evidence of dyssynchrony on M-mode and tissue Doppler imaging by Fischer's exact test.

	QRS duration (< 120 and 120+)				Total	
	< 120		120 and above			
	n	%	n	%	n	%
Difference of two M-mode motions (< 130 and 130+)					p=0.005	
< 130	25	100.0%	10	66.7%	35	87.5%
130 and above	0	0.0%	5	33.3%	5	12.5%
Difference of TDI values between basal septal and lateral wall velocities (< 65 and 65+)					p=0.045	
< 65	37	94.9%	16	76.2%	53	88.3%
65 and above	2	5.1%	5	23.8%	7	11.7%
Difference of TDI values between basal anterior and inferior wall velocities (< 65 and 65+)					p=0.018	
< 65	37	94.9%	15	71.4%	52	86.7%
65 and above	2	5.1%	6	28.6%	8	13.3%
Total	39		21		60	

no patient with narrow QRS complex had dyssynchrony as shown in Table II. A significant association was observed between broad QRS complex and TDI derived left ventricular dyssynchrony. Out of 21 patients with broad QRS complex, a total of 6 patients had evidence of LV dyssynchrony on TDI. Of those, 5 patients (23.8%) had dyssynchrony on the basis of basal septal and basal lateral velocity difference (p=0.045) and 6 patients (28.6%) had evidence of dyssynchrony based on the difference between basal anterior and basal inferior velocities (p=0.018) as shown in Table II. However, out of 39 patients with narrow QRS complex, only 2 patients (5.1%) had evidence of dyssynchrony on TDI.

DISCUSSION

Cardiac resynchronization therapy (CRT) is an important technological advancement in the treatment of drug-refractory heart failure patients. The mechanism of benefit of biventricular pacing is attributed to the improvement of intraventricular systolic synchrony.

Many studies have revealed that intra-ventricular dyssynchrony correlated poorly with QRS duration, being absent in about one-third of patients with intermediate to broad QRS complex and present in many patients with narrow QRS complex.[6-9] Conventional M-mode technique is no longer used while among newer modalities tissue Doppler imaging is the most widely used technique for the assessment of dyssynchrony. Dohi *et al.* demonstrated that the extent of LV dyssynchrony was the only pre-implantation parameter which was different between responders and non-responders to CRT.[10] Eighty five percent of the patients selected on the basis of LV dyssynchrony were shown to respond to therapy after CRT implantation.[5] In patients undergoing biventricular pacing, systolic asynchrony, but not QRS complex duration, proved to be a better predictor of haemodynamic, echocardiographic and clinical response to CRT.[4] In this study, 17 patients (28.3%) had bundle branch block pattern on ECG. The incidence of bundle branch pattern has been reported in literature from 20% in general heart failure patient to 35% in patients with severe LV dysfunction.[11,12] Out of the 40 patients screened for M-mode based dyssynchrony criteria, 5 patients (12.5%) had evidence of LV dyssynchrony while 35 patients (87.5%) had no evidence of dyssynchrony and all these 5 patients had broad QRS complex on their ECG.

Overall 8 patients (13.3%) had dyssynchrony on TDI based criteria in the study group. Among the patients with broad QRS complex, 28.6% had evidence of LV dyssynchrony on TDI. A small subset of patients (5.1%) with narrow QRS complex also had evidence of dyssynchrony. These observations suggest that prolonged QRS duration is still one of the best method of screening patients for CRT therapy as a significant association was demonstrated between broad QRS complex and LV dyssynchrony on TDI.

Different studies have noted an incidence of 60-70% of left ventricular dyssynchrony in patients who had severe heart failure with NYHA class III-IV, LVEF < 35% and broad QRS complex.[13-15] A study from Tehran reported 45.1% incidence of LV dyssynchrony.[16] However, our study showed a lesser incidence of 28.6%, probably because our study population was slightly different in the manner that they had less severe heart failure with most patients being NYHA I-II. However, further larger regional studies are necessary to establish the incidence of LV dyssynchrony in the local population with cardiac failure.

The main limitations of the study were small number of patients and that left ventricular dyssynchrony were only determined at basal regions, however, some studies have used 8-16 segments model. In this study, visual estimation of ejection fraction was used instead of the quantitative method.

CONCLUSION

Broad QRS complex on ECG should be used as first selection criteria for cardiac resynchronization therapy, because of significant association with TDI based left ventricular dyssynchrony.

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