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Electrocardiography, Echocardiography, and Tissue Doppler Imaging Manifestations in Left Bundle Branch Block

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ABSTRACT

Background and Objective: One-third of heart failure cases also represent conduction disorders, such as Left Bundle Branch Block (LBBB), which leads to mechanical defects and ventricular dyssynchrony. This study aims to investigate the correlation between the degree of LBBB and other electrocardiographic parameters, along with the severity of ventricular dysfunction and mitral regurgitation (MR).

Methods: In this cross-sectional study, 40 patients (20 women/20 men) with non-ischemic LBBB were selected by continuous sampling from the patients of Fatemeh Zahra Sari Hospital in 2019. Electrocardiography (including QRS duration, R voltage of organ leads, S voltage in precordial leads, Cornell index, Sokolow-Lyon index, QRS axis deviation and Notched QRS in lateral leads), echocardiography (including Left Ventricular Ejection Fraction (LVEF)) and MR degree) and Tissue Doppler Imaging were investigated in selected patients.

Findings: The mean age of the patients was 64±13.5 years. 77.5% had LVEF less than 35%, 57.5% had intraventricular dyssynchrony>60 and 60% had interventricular dyssynchrony>40. There was a significant correlation between the level of LVEF (r=-0.464, p=0.003) and MR severity (r=0.332, p=0.037) and the severity of intraventricular dyssynchrony. In addition, septal to lateral wall motion delay in patients with LVEF less than 35% was significantly related to the level of intraventricular dyssynchrony (r=0.6712, p=0.000). Among the ECG parameters in patients with LVEF less than 35%, there was only a significant relationship between the maximum R range and the degree of interventricular dyssynchrony (r=0.438, p=0.014).

Conclusion: Our results indicated that LVEF and MR were correlated with the degree of ventricular dyssynchrony and they could be considered as valuable markers for LBBB. Septum to lateral wall delay, and septum to posterior, were also correlated.

Keywords: *Tissue Doppler (TD), Left Bundle Branch Block (LBBB), Electrocardiography, Dyssynchrony.*

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Introduction

Heart failure is a major global health problem with a rising prevalence due to lifestyle changes leading to increasing prevalence of certain risk factors such as obesity, diabetes, and hypertension, particularly in countries with greater post-myocardial infarction life expectancy, as well as global aging (1, 2). Electromechanical synchrony is an essential indicator of normal cardiac function; however, it can be impaired by either intraventricular or interventricular conduction disturbances. These disturbances are accompanied by an increased risk of morbidity and mortality in patients with prior heart conditions, such as heart failure or myocardial infarction (3, 4).

There are various conduction disorders occurring in chronic heart failure, that can lead to electromechanical dyssynchrony and affect the timing and pattern of ventricular contraction. Intraventricular blocks are a group of conduction disorders manifested with interrupted or delayed conduction of electrical impulses in ventricles that can affect the shape and duration of the QRS complex on the ECG and lead to ventricular asynchrony. These disorders include left bundle branch block (LBBB), right bundle branch block (RBBB), and fascicular blocks (5). LBBB is one of the most prominent and also pathogenic conduction disorder of this group. This condition is considered malignant as it can lead to dilatation and dysfunction of left ventricle (6-8). It can also cause incomplete ventricular filling, decreased ventricular contraction, prolonged functional Mitral Regurgitation (MR), and inconsistent motions of the ventricular septal, all resulting in reduced cardiac output (9, 10).

Intraventricular conduction defects with wide QRS, especially LBBB, occur in 25-30% of patients with heart failures (11). Due to the discordance between the times of left and right ventricular function, this condition leads to an increased risk of heart failure, functional MR, and cardiac death (12). Due to the high burden of the disease as well as its prevalence knowing the exact ECG and echocardiographic manifestations (as the most common non-invasive evaluation methods in cardiologic disorders) seems necessary. This study aims to investigate the correlation between the degree of LBBB and other electrocardiographic parameters, along with the severity of ventricular systolic dysfunction and functional MR.

Methods

This cross-sectional study was approved by the ethics committee of Mazandaran University of Medical Sciences with the code IR.MAZUMS.REC.1391.91277 and conducted on 40 patients with cardiovascular disease (20 men and 20 women) who referred to Fatemeh Zahra Hospital in Sari, Iran, through continuous sampling. Inclusion criteria included LBBB rhythm on EGC and absence of cardiac ischemia on previous angiography or cardiac nuclear scan. There were no age restrictions. The history of heart failure, severity of symptoms, and patients' performance rating were not considered in the inclusion criteria. However, patients who showed more than 30% coronary artery disease or heart ischemia in the results of angiography were excluded from the study. Demographic data, including age and gender, were recorded after obtaining informed consent.

The standard 12-lead ECG was performed by trained technicians on patients in a supine position with a careful determination of the precordial lead markers. The ECG findings were magnified and analyzed by a trained heart assistant who was not aware of the clinical conditions and ECG manifestations of patients. The findings were defined as:

QRS duration of >120ms and/or existing rS wave in the right-sided leads (V1, V2) and wide, notched, or slurred R wave in left-sided leads (I, V5, or V6) were considered as LBBB. The QRS duration was calculated in milliseconds by maximum QRS duration in every 12 leads from the first QRS starting point until it was restored to its basic limit. The QRS axis was specified in the frontal axis from limb leads. A deviation of <-30˚ was specified for the left axis, and a deviation of <+90˚ was specified for the right axis. The notched QRS in lateral leads (i.e., the leads facing ventricles such as I, aVL, and V5-V6) was recorded in at least 2 out of 3 leads.

The following voltages were checked (and measured using a multimeter unit): maximum R wave amplitude in each limb lead, maximum size of S wave in precordial leads: horizontal surface, R wave in V5-V6 (whichever is higher), Sokolow-Lyon index: sum of S in V1+R in V5 or V6, Cornell index: sum of S in V3+R in aVL.

Echocardiography was performed by a trained heart assistant and supervised by an echocardiography fellowship using a GE Vivid S5 Ultrasound machine equipped with 3-5 MHz probes. M-Mode and 2-dimensional examinations were performed based on the units provided by the American Society of Echocardiography (ASE) and the European Society of Cardiology (ESC). The measurements were recorded as the average of 3 findings at the end of exhalation. TD imaging was performed to examine the basal segment of lateral, septum, posterior, anteroseptal, anterior, and inferior walls of the left ventricle in apical 4-chamber and apical 2-chamber views.

An electromechanical delay was defined as the time between the onset of the QRS complex and the peak systolic wave recorded by TDI. The intraventricular dyssynchrony was defined in the form of a difference of ≥60 ms in the intervals of electromechanical activity between the two opposite walls of LV. The pulmonary Pre-Ejection Period (PEP) was recorded by measuring the time between the QRS start time and the pulmonary flow velocity start time in the left parasternal long-axis view. Furthermore, Aortic PEP was recorded by Doppler as the time between QRS complex start time and the Aortic flow velocity startup. In the 5-chamber view, interventricular dyssynchrony was specified as the difference of ≥40ms between these two values.

Septum to posterior wall motion delay was measured using M-mode as the time between the displacement of the maximum septum and the posterior wall in the left parasternal long-axis view. The septum to lateral wall delay was defined as the difference in the electromechanical activity intervals between the septum and lateral walls of LV.

Left Ventricular Ejection Fraction (LVEF) was evaluated using the Simpson method. The systolic heart failure was specified by echocardiography as a mild heart failure with LVEF of 40-50%, moderate heart failure with LVEF of 35-40%, and severe heart failure with LVEF of less than 35%. Functional MR was determined using CDI. The presence of MR in echocardiography with a normal valve shape and the coronary artery was considered functional MR.

The obtained data were recorded in the SPSS 16 statistical software. Spearman correlation coefficient (for ordinal variables) and Pearson correlation coefficient (for quantitative variables) were employed to assess the association of ECG manifestations, tissue doppler, and echocardiographic indices. Moreover, the t-test was used to compare variables with normal distributions (parametric), and the Mann-Whitney test was applied to variables with abnormal distributions. The significance level was considered as p-value≤0.05.

Results

In this study, 40 patients (20 females and 20 males) with LBBB manifestations in ECG were examined. The median age of patients was 64 years old (the maximum age was 89, and the minimum was 35). The average LVEF in the subjects was 28.6%. Among the studied patients, 31 (77.5%) had LVEF<35%, 23 (57.5%) had intraventricular dyssynchrony>60, and 30 had interventricular dyssynchrony>40. Moreover, 21 patients (52.5%) were detected with both intraventricular and interventricular dyssynchrony. Based on the echocardiographic data, LVEF was 25% in patients with intraventricular dyssynchrony, while in patients without intraventricular dyssynchrony, it was 40% (p=0.019), indicating a significant difference. Furthermore, there was a statistically significant correlation between the LVEF rate and intraventricular dyssynchrony intensity in the Pearson correlation test (r=-0.464, p=0.003) (Figure 1).

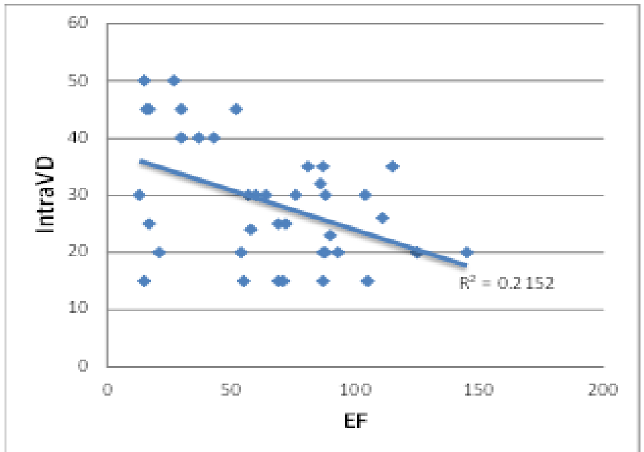

Figure 1. The relationship between left ventricular ejection fraction (EF) and intra-ventricular dyssynchrony

Moreover, the MR intensity in subjects with intraventricular dyssynchrony was found at +2, while it was +1 in others. However, this difference was not statistically significant (r=0.95, p=0.609). Nevertheless, there was a significant correlation between the degree of intraventricular dyssynchrony and MR intensity in the Pearson correlation test (r=0.332, p=0.037) (Figure 2).

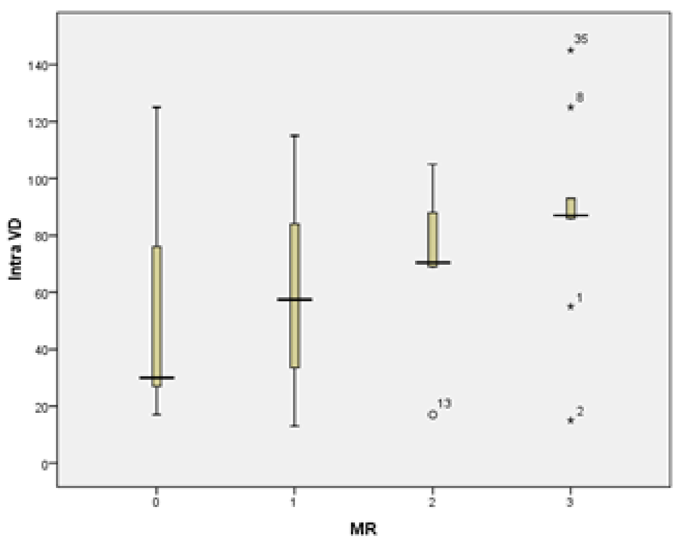

Figure 2. The relationship between secondary mitral regurgitation and Intra-ventricular dyssynchrony degree

In addition, the degree of the septum to lateral delay in patients with LVEF<35% was significantly associated with the degree of intraventricular dyssynchrony in the Pearson correlation test (r=0.6712; p=0.000) (Figure 3).

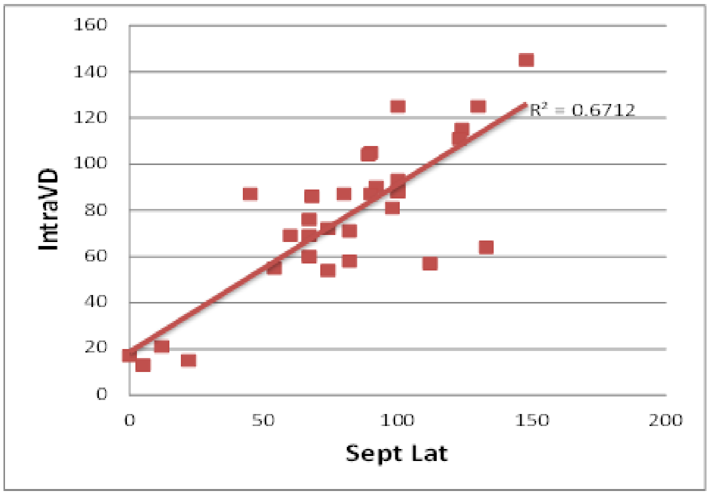

Figure 3. Relationship between septum to lateral delay degree and intraventricular dyssynchrony degree in patients with LVEF<35%

There was no relationship between QRS duration (r=193, p=0.234), R wave amplitude (r=-0.16, p=0.923), S wave amplitude (r=0.117, p=0.471), Sokolow index (r=0.220, p=0.172), and Cornell index (r=0.009, p=0.957), and the intensity of intraventricular dyssynchrony in the Pearson Correlation test.

Non-parametric findings, including axis deviation (mean difference=-0.627, p=0.964) and the current lateral notches (mean difference=-17.035, p=0.410), were not significantly correlated with the degree of intraventricular dyssynchrony. In subjects with LVEF<35%, no significant relationship was found in the Pearson correlation test between QRS duration (r=0.188; p=0.311), max R wave amplitude (r=0.184, p=0.323), max S wave amplitude (r=0.102, p=0.584), Sokolow index (r=0.277, p=0.132), and Cornell index (r=-0.057, p=0.760), and the degree of intraventricular dyssynchrony. However, in the same group of patients, there was a significant relationship between max R wave amplitude and interventricular dyssynchrony degree in the Pearson correlation test (r=0.438, p=0.014) (Figure 4).

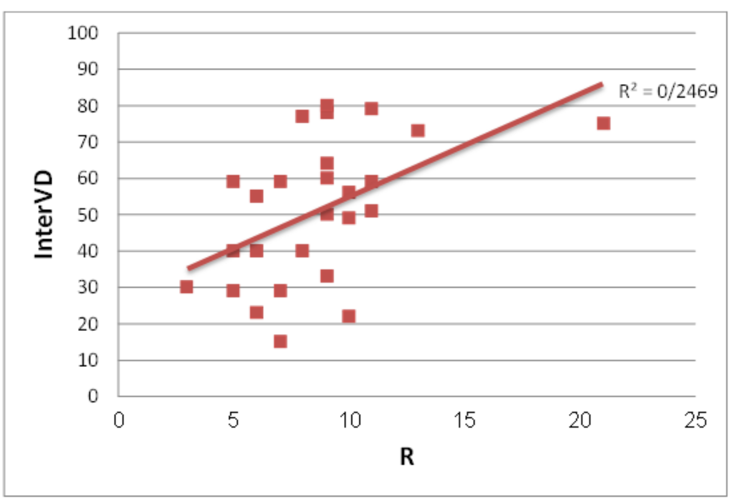

Figure 4. Relationship between R wave amplitude in limb leads and Inter-ventricular dyssynchrony degree in patients with LVEF<35%

The QRS duration (r=0.258, p=0.108), max R wave amplitude (r=0.285, p=0.075), max S wave amplitude (r=-0.157, p=0.333), Sokolow index (r=0.080, p=0.625), and Cornell index (r=-0.231, p=0.152) showed no significant relationship with the level of interventricular dyssynchrony degree in the Pearson correlation test. Furthermore, no relationship was observed in patients with LVEF<35% between QRS duration (r=0.313, p=0.086), S wave amplitude (r=0.060, p=0.747), Sokolow index (r=0.146, p=0.433), and Cornell index (r=0.009, p=0.960) with the degree of interventricular dyssynchrony. In patients with LVEF<35%, no significant relationship was observed between axis deviation (p=0.252) and lateral lead notches (p=0.291) with the degree of interventricular dyssynchrony. However, there was a significant relationship between the LVEF value (r=-0.515, p=0.001) and MR intensity with interventricular dyssynchrony degree in all tested subjects.

A significant relationship was found in patients with LVEF<35% between LVEF value (r=-0.593; p=0.092) and MR intensity (r=-0.303, p=0.098) with the interventricular dyssynchrony degree. Moreover, the degree of interventricular dyssynchrony was significantly correlated with the septum to posterior delay values (r=0.393, p=0.012) (Figure 5).

No significant relationship was found in the Pearson Correlation test between other values, including intraventricular dyssynchrony degree (r=0.292; P=0.068), Septum to lateral delay (r=0.301, p=0.059), LVEF value (r=-0.210, p=0.193), and QRS duration (r=0.152, p=0.350), and septum to posterior delay values.

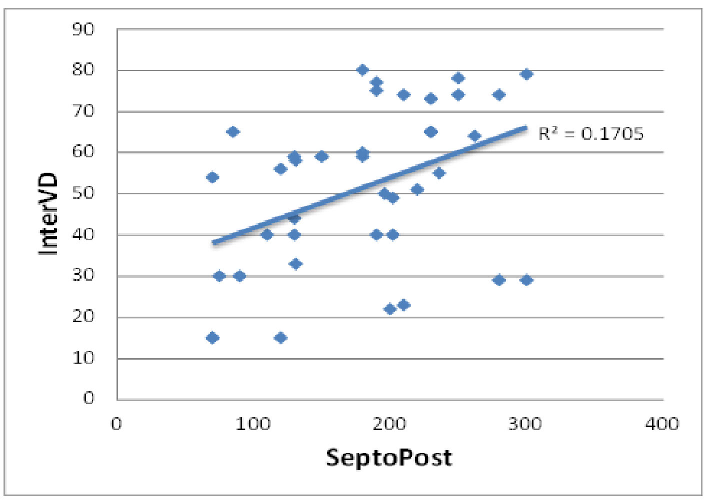

Figure5. Relationship between septum to posterior delay values and interventricular dyssynchrony degree

Discussion

The results represented a highly significant relationship between septum to lateral delay with intraventricular dyssynchrony, while other ECG parameters showed no significant correlation. This notion indicates that intraventricular dyssynchrony could be demonstrated by the examination of only two septal and lateral segments of the left ventricle. The findings for 31 patients with LVEF<35% were rechecked separately, and only R wave amplitude in limb leads was shown to be correlated with the degree of interventricular dyssynchrony. All other ECG parameters (including QRS duration, max S wave amplitude in precordial leads, Cornell index, Sokolow index, axis deviation, and lateral lead notches) showed no relationship with the degree of intraventricular and interventricular dyssynchronies. Septum to lateral delay in patients with LVEF <35% was significantly correlated with interventricular dyssynchrony, which highlights the advantage of studying these two segments to evaluate their association with intraventricular dyssynchrony.

Moreover, a relationship was observed between septum to lateral delay and interventricular dyssynchrony in the M-mode view. Many studies have been previously performed on ECG parameters and their relationship with ventricular mechanical dyssynchrony, most of which suggested a poor or moderate relationship between the QRS duration and dyssynchrony degree (13, 14). These studies were carried out on patients with LBBB rhythm with visible symptoms of heart failure and Cardiac Resynchronization Therapy (CRT). The main reason for the difference between our results (regarding the relationship between QRS duration and dyssynchrony degree) and the mentioned studies may be the inclusion criteria dissimilarities.

In a similar study by Neto et al., 50 patients (i.e., CRT candidates), including 75% non-ischemic cardiomyopathy cases, were studied, and their results showed a poor association between the QRS duration and notched QRS with mechanical dyssynchrony. Moreover, subjects with mechanical dyssynchrony had a higher S wave in precordial leads (15). In our study, R wave amplitude in limb leads was correlated with the degree of interventricular dyssynchrony only in patients with LVEF<35%. In a study by Emkanjoo et al., the degree of interventricular and intraventricular dyssynchronies was evaluated based on the QRS duration. Their conclusion indicated that a majority of patients with a long QRS duration had no interventricular and intraventricular dyssynchrony, which indicated the limitation of the QRS duration in identifying ideal patients for CRT placement (16). In our investigation, no relationship was found between QRS duration and interventricular and intraventricular dyssynchrony. In addition to ECG parameters, some echocardiographic parameters, and their relationship with mechanical dyssynchrony, were also investigated in our study. There was an inverse relationship between LVEF and the degree of intraventricular dyssynchrony (i.e., patients with less LVEF had more intense intraventricular dyssynchrony). In a study by van Dijk et al., the relationship between left ventricle function and mechanical dyssynchrony was evaluated in asymptomatic patients with LBBB rhythm. It was found that asymptomatic LBBB patients had less overall left ventricle function compared to healthy subjects, and they experienced moderate mechanical dyssynchrony (17). This notion can predict improved ventricular systolic function following the reduction of dyssynchrony through CRT placement. In the study carried out by Porciani et al., patients showed a decreased intensity of functional MR in response to CRT and a considerable reduction of left ventricle dyssynchrony (18). In our study, MR intensity was correlated with intraventricular dyssynchrony, indicating that the CRT placement and dyssynchrony reduction reduce MR intensity and improve the patient’s symptoms.

Considering the relationship between LV systolic function and functional MR intensity with intraventricular dyssynchrony and the fact that most previously conducted studies (this study included) have a limited number of ECG parameters, poor relationships for the identification of ventricular dyssynchrony, CRT placement issue, and MR reduction, and disregarded the role of successful ventricular synchronization in the improvement of ventricular function, further research is suggested for patients with heart failure symptoms for the diagnosis of the mechanical dyssynchrony. This also helps identify the advantages of CRT placement using a diagnostic device such as TDI or Strain rate. This suggestion aims to avoid excluding patients without prolonged QRS and decrease the absence of response to CRT due to the absence of visible mechanical dyssynchrony in patients with wide QRS. In addition, it may be useful to use septum to lateral delay and septum to posterior delay to diagnose intraventricular and interventricular dyssynchronies.

Conflict of interest: The authors declare no conflict of interest.
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