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Left Ventricular Torsion, Rotation, Twist and Circumferential Strain in Patients with Left Bundle Branch Block versus Normal Individuals by Speckle Tracking Echocardiography

Running Title: Left Ventricular Torsion, Rotation, Twist and Circumferential Strain

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ABSTRACT

Introduction: To compare left ventricular torsion, rotation, twist, and circumferential strain in patients with left bundle branch block (LBBB) as compared to normal subjects. **Materials/Methods**: In this study 23 patients with LBBB and 14 normal subjects were enrolled. In short-axis view of the left ventricle, basal, midportion, apical and global circumferential strain were measured by off-line analysis. The basal, midportion and apical LV segments rotation were measured and subsequently, in both groups, LV twist and torsion were calculated. **Results**: The mean LVEF in the LBBB group was significantly lower than the normal group. The basal, midportion and global circumferential strain(GCS) were significantly lower in patients with LBBB as compared to normal subjects. The mean LV apical rotation in the LBBB group was significantly lower than the normal group (-0.28±1.59 vs 0.78 ± 2.59 vs) and P was 0.04. As compared with normal subjects, the mean basal and midportion LV rotation in LBBB patients had no significant difference. LV torsion was lower in LBBB compared to the normal group but the difference was not statistically significant. **Conclusion**: LV apical rotation was significantly lower in the LBBB group compared to normal. Global, basal, and midportion circumferential strain were lower in LBBB than normal subjects.

INTRODUCTION

Since 40 years ago, it has been recognized that an altered cardiac electrical activation puts deleterious effects on the mechanical functions of ventricles but this topic has gained more importance in recent years (1). Although the most accessible method for detecting left bundle branch block (LBBB) is ECG, whereas not all LBBBs appear in the same way on ECG or even do not appear on echocardiography (2-4). It is essential to assess the location and extension of ventricular conduction delay to find pathogenesis but ECG cannot do it precisely. On the other hand, LBBB is a complex electrical disease resulting from conduction delay located at several anatomic levels (5) that needs new evaluation methods. The epidemiological studies have described LBBB as an independent mortality risk factor due to cardiovascular disorders (6). As patients with LBBB have a poorer prognosis than those without any conductive disorders whether having an underlying cardiovascular disorder or not (7). Conductive disorder in patients with heart failure can be associated with a reduction in cardiac contractility such as left ventricle (LV) torsion, rotation, and circumferential strain which are the main components of cardiac function(8, 9). Although LBBB is critical in the prognosis of patients with cardiac problems, it can lead to a reduction in the total left ventricular ejection fraction (LVEF) and reduced cardiac output (10).

Patients with underlying heart failure and concomitant conductive disorders have more mortality rate than patients with narrow QRS (6, 11) which may be due to the effect of LBBB on decreasing ejection fraction. Therefore patients with mild to moderate systolic or diastolic dysfunction and LBBB have poorer clinical outcomes than patients without conductive disorders (7). It has been proven that LVEF may be influenced by any defect in LV but will not be severely affected till the advanced stages of the underlying disease (12). Therefore more sensitive parameters, especially the circumferential strain can be used for more accurate evaluations. Regional strain measured by echocardiography can be used as a more sensitive indicator than LVEF (firstly affected in a cardiac disorder) for monitoring myocardial function (13).

Although the main advantage of CRT has been seen among patients with QRS of more than 150 ms. Recent electrical mapping studies have indicated that the patients diagnosed with severe LBBB by ECG and have abnormal echocardiography strain, get more benefit from CRT (16, 17). Speckle echocardiography (SECHO) is an emergent diagnostic modality and an affordable and low-cost tool. Previous studies on LBBB have focused mainly on the left ventricular strain pattern, and other mechanical parameters have not been studied much (18). For this reason, the need for other parameters to describe the mechanical left ventricular defect by SECHO can be helpful in predicting the exact response to the CRT. Therefore, we tried to describe the pattern of left ventricular contraction by three parameters of Rotation, Torsion, twist, and Circumferential strains in patients with LBBB and LV dysfunction and normal subjects.

MATERIALS AND METHODS

This cross-sectional study was performed in Dr. Shariati Hospital, Tehran, Iran. In this study, 23 patients with LBBB and 14 subjects with normal ECG and normal echocardiography were enrolled. The exclusion criteria consisted of atrial fibrillation, acute coronary syndrome, a history of CRT within the last three months, the existence of an associated conductive impairment, the patients' dissatisfaction about attending or continuing the study, and insufficient resolution of echocardiography. Speckle tracking echocardiography was performed with Epic Philips machine. The left ventricular rotation, torsion, and twist, and circumferential strains were recorded by the speckle tracking echocardiography with the parasternal view and in the short axis through three levels of basal, mid, and apical level.

This study was started after getting the approval by the medical ethics code and the confirmation of the ethical committee of Azad university of medical sciences. Patients' information was not disclosed and no one was forced to participate in the study. In all stages of the research, the identification of participants remained confidential. All stages of the study were based on the Helsinki Ethics principles. The patients' data were gathered in a structured checklist by the researcher. Demographic characteristics (age and sex) were extracted from patient records and basic echocardiographic reports. Off-line analysis was performed to obtain basal, midportion, and apical rotation(degree). LV twist was calculated as follows: LV apical rotation-LV basal rotation (degree). LV torsion was calculated as follows: LV twist/ LV length (°/cm). The collected data was recorded in version 22 of SPSS software. The descriptive analysis was reported as a percentage and numbers for qualitative variables and mean (standard deviation) for quantitative variables. Then, for comparison of each variable in two groups of patients, an Independent-sample T-test was performed for quantitative variables and a Chi-Square test for qualitative variables. The significant value was calculated with the level of 0.05.

RESULTS

The mean LVEF in the LBBB group was significantly lower than the non-LBBB group (table1). LVDd, and LA size were significantly higher in LBBB as compared to the non-LBBB group (table1). The mean TAPSE in LBBB patients was significantly lower than that of the non-LBBB group. PAPs were significantly higher in patients with LBBB versus non-patients (table 1). Basal, mid-portion and global circumferential strain (GCS) were significantly lower in patients with LBBB vs the normal group. Apical CS was lower in LBBB as compared to normal but statistically was not significant. In normal subjects mean basal and mid-portion LV rotation were negative (counterclockwise) and apical rotation was positive (clockwise). In LBBB, mean LV basal and mid-portion were negative, and mean apical rotation was also negative and so in one direction. The mean LV apical rotation in LBBB was significantly lower than the normal group, P<0.04. The mean basal and midportion LV rotation in LBBB patients had no significant difference with normal subjects. LV twist and torsion were lower in LBBB patients as compared to normal subjects but the difference was not significant.

Table 1: Comparison of cardiac parameters between two groups

Demographic data	LBBB	Normal	p-value
LVEF	33.9(10.8)	55.35(2.37)	<0.001
LV length	7.30(0.84)	6.51(0.84)	0.008
QRS duration	161.78(17.39)	108.714(26.91)	<0.001

DISCUSSION

This study showed that the mean LV apical rotation was positive (clockwise) in normal subjects and negative in LBBB. Indeed in LBBB, LV rotation in basal, midportion, and apical is in one direction and counterclockwise. Basal, midportion, and global circumferential strain were lower in LBBB as compared to the normal subjects. In our study, torsion was lower in LBBB than normal such as P=0.089, which may be due to a relatively limited number of patients. This point was discussed along with the results in the study of Pavlyukova and colleagues in 2015 (19) that elaborated a reduction of the torsion and rate of rotation at the apical regions. One of its applications in the clinical examination is the evaluation of conduction disorders such as LBBB. However, it is not clear which of the strain types are used to recognize LBBB (21). While Miyazaki et al. (22)have indicated Longitudinal strain preference for the diagnosis of dyssynchrony. Wang et al. (21)revealed radial or circumferential as important in diagnosis as well. We didn't use the longitudinal strain in our study because of its dependence on the Doppler angle and its inability to check if LV is enlarged or not. Whereas we tried to use the circumferential strain in this study because it is vitally important in determining the prognosis of many cardiovascular events, as mentioned in Choi et al. study(23). The higher the CS level in the mid-portion, the more vitality it will attain than other sections. Because in the study by Choi et al.(23), it was proven that CS at the middle of the wall, is an independent factor and it can play a more important role as a predictor of cardiovascular events. This finding was consistent with the study by Tecelão et al. In 2007 by CMR,(24) which resulted in a marked decrease in mid-circumferential shortness in LBBB patients. In this study, the rate of reduction of apical C.S was also significantly increased in LBBB patients, which was not the case in our study. In a study by Han et al. (25) in the three groups (LBBB group, not decreased-EF-treated LBBBs group, and the healthy control group), the measurement of CS shortening at each of the three mid-ventricular, apical, and basal sections showed a significant decrease in CS of people with LBBB. On the other hand, there was a significant decrease in C.S in patients with cardiomyopathy, regardless of the juvenile disorder. Therefore, the circumferential strain parameter is inadequate to evaluate this asynchrony in patients with cardiomyopathy. Because myocardial contractility is reduced in these patients, regardless of conduction impairment, this leads to the conclusion that a conduction disorder can appear with different mechanical contraction patterns that must be distinguished depending on the structure of the heart and underlying illness.

The higher global circumferential strain in LBBB patients than non-affected patients is therefore important, which can be decisive as an important indicator of LV function alongside EF as the standard clinical practice, in Onishi (26) et al. GCS measurements by CMR and STE have a very close relationship with EF. Unlike EF, however, because of its renewability, cost savings, and the lack of dependence on individual experience in the use and analysis of imaging tools, it has been suggested as an effective tool in myocardial evaluation, especially in cases of chemotherapeutic cardiotoxicity changes. In their study, Cho and colleagues also proved that GCS can be used to predict cardiovascular events in patients with acute coronary artery disease. However, in a meta-analysis by Yingchoncharoen (27), natural GCS levels ranged from -20.9% to -27.8%, but in this study, the mean non-LBBB group was -11.1%. However, because of previous studies, the effects of such factors as age, sex, race, and physical characteristics, hemodynamic factors (such as heart rate and blood pressure), and cardiac factors such as left ventricular size and wall thickness in measuring strain has been proven.

Determining the natural range for this index requires additional studies. The lower apical rotation rate in LBBB patients, as compared to non-LBBB patients with negative values, the calculation of torsion in the apical region showed a decrease in LBBB patients compared to non-affected patients. Due to the fact that the LV rotation index is susceptible to local and general changes in LV (28) which can be a sign of a change in mechanical performance among LBBB patients. For the sake of being natural, it needs to coordinate all parts of the LV and therefore is a specific but insensitive indicator for assessing the response to the CRT(29). This is in line with the results of Pavlyukova et al., 2015 (30) which implies a reduction in the amount of rotation and torsion in the apical region. Monroe et al.(10) also concluded that torsion levels in patients with LBBB with EF are decreased, as compared with non-LBBB patients. To evaluate the mechanical ventricular rotation using the speckle tracking strain and calculating the curvature, in the study of Notomi (31) et al., the natural pattern of motion from the apical view was seen in the form of a slight clockwise rotation. Moreover, a larger circulation of the tip of the heart in the direction of the counterclockwise was observed. When clocked from the apex, the counter clock is reported with positive values and clockwise movements with negative values, so in normal cases, the rotation of the base is recorded negatively and the tip of the heart is recorded with positive values.

In the apical region, the negative rotation rates in patients with LBBB compared with the positive values in non-affected patients of this study can confirm the inversion of the tip of the heart from the anti-clockwise (positive) to a clock with negative values. It is the result of the Torsion at the apical level, which is obtained by dividing the apical rotation over the LV length. In the study of Helle-valle (28) et al. the anti-clockwise movement of the tip of the heart in the LV discharge phase was recorded in normal subjects and in the animal model (dog) by SEC and sonomicrometry. However, left ventricular circulation in the systolic phase is mainly counter-clockwise, but a small rotation of the clock was observed during the isovolumic contraction by SEC and sonomicrometry at the tip of the heart. This rotation was probably not detected in tagging MRI with a low-resolution time. Additionally, a decrease in the apical rotation rate with the obstruction of the LAD and the development of ischemia were other issues of this study. By comparing SEC with two MRI and sonomicrometry modalities, the accuracy of STE was confirmed by correlation of the results with these two methods. Following the decreased apical rotation in the study on animal samples, the reduced diastolic function (32) can lead to EF and SV impairment. It suggests that the presence of this disorder in LBBB patients can be a root cause of mechanical disorders and inadequacies. By examining it with imaging methods, it was more accurately diagnosed than the patients with heart failure. In other comparative studies such as Teceloa (33) et al. and Han (25) et al., the LV length, more significant LVDD and LVSD, and greater LA size in LBBB patients are consistent with the history of this concomitant disorder with structural heart deficiencies, such as valve disease and DCM.

CONCLUSION

LBBB group had a wide QRS and lower ejection fraction. In patients with LBBB, the mean LV circumferential strain in mid, basal, and GCS portion were lower than normal subjects. The mean LV apical rotation was significantly lower in the LBBB group, as compared to the normal group.

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AUTHOR CONTRIBUTIONS

All authors contributed equally

CONFLICT OF INTERESTS

The authors declare no conflict of interest in this study

ETHICAL STANDARDS

This study was approved by Islamic Azad University, Tehran Medical Branch

Table 2: Comparison of Echocardiographic Parameters Between LBBB and Normal Subjects

Apical CS	**Normal**	-11.17	7.52	0.15
	LBBB	-7.73	7.54	
Midportion CS	**Normal**	-11.97	4.08	**0.003**
	LBBB	-7.04	4.91	
Basal CS	**Normal**	-12.92	5.54	**0.001**
	LBBB	-6.74	4.62	
GCS	**Normal**	-11.10	7.61	**0.013**
	LBBB	-6.74	4.90	
Apical rotation	**Normal**	0.78	2.59	**0.04**
	LBBB	-0.28	1.59	
Midportion rotation	**Normal**	-1.08	2.04	0.67
	LBBB	-1.52	1.78	
Basal rotation	**Normal**	-1.39	0.96	0.67
	LBBB	-1.29	1.63	
torsion_m	**Normal**	-0.15	0.30	0.914
	LBBB	-0.21	0.25	
torsion_a	**Normal**	0.11	0.40	**0.033**
	LBBB	-0.04	0.23	
torsion_b	**Normal**	-0.21	0.13	0.506

	LBBB	-0.18	0.24	
LVDD	**Normal**	45.57	4.58	**0.001**
	LBBB	55.91	11.58	
LA	**Normal**	31.92	4.10	**0.042**
	LBBB	37.26	9.11	
AO	**Normal**	28.78	6.47	0.914
	LBBB	28.21	3.04	
RVD	**Normal**	27.5	2.92	0.107
	LBBB	29.69	4.44	
TAPSE	**Normal**	19.06	2.78	**0.005**
	LBBB	23.07	3.44	
PAPs	**Normal**	30.08	5.15	**0.026**
	LBBB	26.28	5.93	

REFERENCES

1. De Boeck BW, Kirn B, Teske AJ, Hummeling RW, Doevendans PA, Cramer MJ, et al. Three-dimensional mapping of mechanical activation patterns, contractile dyssynchrony and dyscoordination by two-dimensional strain echocardiography: rationale and design of a novel software toolbox. Cardiovascular ultrasound. 2008;6(1):22.
2. Scherbak D, Hicks GJ. Left Bundle Branch Block (LBBB). StatPearls. Treasure Island (FL)2019.
3. Strauss DG, Selvester RH, Wagner GS. Defining left bundle branch block in the era of cardiac resynchronization therapy. The American journal of cardiology. 2011;107(6):927-34.
4. Risum N, Strauss D, Sogaard P, Loring Z, Hansen TF, Bruun NE, et al. Left bundle-branch block: the relationship between electrocardiogram electrical activation and echocardiography mechanical contraction. American heart journal. 2013;166(2):340-8.
5. Auricchio A, Fantoni C, Regoli F, Carbucicchio C, Goette A, Geller C, et al. Characterization of left ventricular activation in patients with heart failure and left bundle-branch block. Circulation. 2004;109(9):1133-9.
6. Leeters IP, Davis A, Zusterzeel R, Atwater B, Risum N, Søgaard P, et al. Left ventricular regional contraction abnormalities by echocardiographic speckle tracking in combined right bundle branch with left anterior fascicular block compared to left bundle branch block. Journal of electrocardiology. 2016;49(3):353-61.
7. Witt CM, Wu G, Yang D, Hodge DO, Roger VL, Cha Y-M. Outcomes with left bundle branch block and mildly to moderately reduced left ventricular function. JACC: Heart Failure. 2016;4(11):897-903.
8. Kerkhof PL. Characterizing heart failure in the ventricular volume domain. Clin Med Insights Cardiol. 2015;9(Suppl 1):11-31.
9. Yılmaz S, Kılıc H, Ağac MT, Keser N, Edem E, Demirtaş S, et al. Left ventricular twist was decreased in isolated left bundle branch block with preserved ejection fraction. Anatol J Cardiol. 2017;17(6):475-80.
10. Mornos C, Petrescu L, Cozma D, Pescariu S, Mornos A, Ionac A. The influence of left bundle branch-block and cardiac dyssynchrony on 2D-strain parameters in patients with heart failure complicating ischemic cardiomyopathy. Romanian journal of internal medicine = Revue roumaine de medecine interne. 2011;49(3):179-88.
11. Risum N, Tayal B, Hansen TF, Bruun NE, Jensen MT, Lauridsen TK, et al. Identification of typical left bundle branch block contraction by strain echocardiography is additive to electrocardiography in prediction of long-term outcome after cardiac resynchronization therapy. Journal of the American College of Cardiology. 2015;66(6):631-41.
12. Rigolli M, Whalley GA. Heart failure with preserved ejection fraction. J Geriatr Cardiol. 2013;10(4):369-76.
13. Smiseth OA, Torp H, Opdahl A, Haugaa KH, Urheim S. Myocardial strain imaging: how useful is it in clinical decision making? Eur Heart J. 2016;37(15):1196-207.
14. Spartalis M, Tzatzaki E, Spartalis E, Damaskos C, Athanasiou A, Livanis E, et al. The Role of Echocardiography

in the Optimization of Cardiac Resynchronization Therapy: Current Evidence and Future Perspectives. Open Cardiovasc Med J. 2017;11:133-45.
15. Strik M, Regoli F, Auricchio A, Prinzen F. Electrical and mechanical ventricular activation during left bundle branch block and resynchronization. Journal of cardiovascular translational research. 2012;5(2):117-26.
16. Khan SG, Klettas D, Kapetanakis S, Monaghan MJ. Clinical utility of speckle-tracking echocardiography in cardiac resynchronisation therapy. Echo Res Pract. 2016;3(1):R1-R11.
17. Costa SP. Echocardiographic Predictors of Response to Cardiac Resynchronization Therapy in 2016: Can Quantitative Global Parameters Succeed Where Segmental Parameters of Dyssynchrony Have Fallen Short? Circulation: Cardiovascular Imaging. 2016;9(6):e004953.
18. Leenders GE, Cramer MJ, Bogaard MD, Meine M, Doevendans PA, De Boeck BW. Echocardiographic prediction of outcome after cardiac resynchronization therapy: conventional methods and recent developments. Heart Fail Rev. 2011;16(3):235-50.
19. Pavlyukova EN, Kuzhel DA, Matyushin GV, Lytkina VS. [LEFT HIS BUNDLE BRANCH BLOCK ASSOCIATED WITH LEFT VENTRICULAR TORSION AND REDUCED EJECTION FRACTION]. Klinicheskaia meditsina. 2015;93(11):15-21.
20. Collier P, Phelan D, Klein A. A test in context: myocardial strain measured by speckle-tracking echocardiography. Journal of the American College of Cardiology. 2017;69(8):1043-56.
21. Wang C-L, Wu C-T, Yeh Y-H, Wu L-S, Chan Y-H, Kuo C-T, et al. Left bundle-branch block contraction patterns identified from radial-strain analysis predicts outcomes following cardiac resynchronization therapy. The international journal of cardiovascular imaging. 2017;33(6):869-77.
22. Miyazaki C, Powell BD, Bruce CJ, Espinosa RE, Redfield MM, Miller FA, et al. Comparison of Echocardiographic Dyssynchrony Assessment by Tissue Velocity and Strain Imaging in Subjects With or Without Systolic Dysfunction and With or Without Left Bundle-Branch Block. Circulation. 2008;117(20):2617-25.
23. Choi E-Y, Rosen BD, Fernandes VRS, Yan RT, Yoneyama K, Donekal S, et al. Prognostic value of myocardial circumferential strain for incident heart failure and cardiovascular events in asymptomatic individuals: the Multi-Ethnic Study of Atherosclerosis. European Heart Journal. 2013;34(30):2354-61.
24. Tecelao SR, Zwanenburg JJ, Kuijer JP, de Cock CC, Germans T, van Rossum AC, et al. Quantitative comparison of 2D and 3D circumferential strain using MRI tagging in normal and LBBB hearts. Magnetic resonance in medicine. 2007;57(3):485-93.
25. Han Y, Chan J, Haber I, Peters DC, Zimetbaum PJ, Manning WJ, et al. Circumferential myocardial strain in cardiomyopathy with and without left bundle branch block. Journal of cardiovascular magnetic resonance : official journal of the Society for Cardiovascular Magnetic Resonance. 2010;12:2.
26. Onishi T, Saha SK, Delgado-Montero A, Ludwig DR, Onishi T, Schelbert EB, et al. Global longitudinal strain and global circumferential strain by speckle-tracking echocardiography and feature-tracking cardiac magnetic resonance imaging: comparison with left ventricular ejection fraction. Journal of the American Society of Echocardiography. 2015;28(5):587-96.
27. Yingchoncharoen T, Agarwal S, Popović ZB, Marwick TH. Normal ranges of left ventricular strain: a meta-analysis. Journal of the American Society of Echocardiography. 2013;26(2):185-91.
28. Helle-Valle T, Crosby J, Edvardsen T, Lyseggen E, Amundsen BH, Smith H-J, et al. New noninvasive method for assessment of left ventricular rotation: speckle tracking echocardiography. Circulation. 2005;112(20):3149-56.
29. Ashikaga H, Leclercq C, Wang J, Kass DA, McVeigh ER. Hemodynamic improvement in cardiac resynchronization does not require improvement in left ventricular rotation mechanics: three-dimensional tagged MRI analysis. Circulation: Cardiovascular Imaging. 2010;3(4):456-63.
30. Pavlyukova E, Matyushin G, Lytkina V. Left His bundle branch block associated with left ventricular torsion and reduced ejection fraction. Klinicheskaia meditsina. 2015;93(11):15-21.
31. Notomi Y, Shiota T, Popović ZB, Weaver JA, Oryszak SJ, Greenberg NL, et al. Measurement of ventricular torsion by two-dimensional ultrasound speckle tracking imaging. Journal of the American College of Cardiology. 2005;45(12):2034-41.
32. Iwasaki M, Masuda K, Asanuma T, Nakatani S. Effects of mechanical limitation of apical rotation on left ventricular relaxation and end-diastolic pressure. American Journal of Physiology-Heart and Circulatory Physiology. 2011;301(4):H1456-H60.
33. Tecelão SR, Zwanenburg JJ, Kuijer JP, de Cock CC, Germans T, van Rossum AC, et al. Quantitative comparison of 2D and 3D circumferential strain using MRI tagging in normal and LBBB hearts. Magnetic Resonance in Medicine: An Official Journal of the International Society for Magnetic Resonance in Medicine. 2007;57(3):485-93.