Section: Cardiology

Original Research Article

A STUDY OF SIGNIFICANCE OF TISSUE DOPPLER IMAGING IN ASSESSING VENTRICULAR DYSSYNCHRONY IN PATIENTS WITH LBBB

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Received : 07/06/2025
Received in revised form : 21/07/2025
Accepted : 12/08/2025

Keywords:
Aortic preejection delay, Pulmonary preejection delay, Intraventricular delay, Septum to posterior wall motion delay(SPWMD), Tissue Doppler Imaging.

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DOI: 10.47009/jamp.2025.7.4.261

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (4); 1372-1380

ABSTRACT

Background: Left bundle branch block (LBBB) generally associated with structural heart disease is a frequent conduction disorder. In patients with LBBB and structural heart disease, overall mortality is significantly increased.1 The incidence of cardiovascular disorders and subsequent mortality is increased in isolated LBBB 2. No recent data is available on regional systolic dyssynchrony in patients with LBBB and normal LV ejection fraction. In our study, we looked for the presence of intra and interventricular dyssynchrony using Tissue Doppler Imaging in patients with LBBB with both normal and compromised LV function. **Materials and Methods:** The study was conducted on 100 patients admitted in the Department of Cardiology in Coimbatore Medical College and Hospital, Coimbatore. Standard echocardiography and Tissue Doppler Imaging were done in study subjects according echocardiographic protocol. **Result:** 100 patients with baseline ECG having LBBB divided into two groups as EF<50% and EF>50% with 50 patients each and intraventricular and interventricular dyssynchrony was assessed by ECHO parameters. Patients with LBBB and low ejection fraction had greater dyssynchrony than those with LBBB and normal ejection fraction. The QRS width was also significantly greater in those patients with LBBB who had a low EF. However it was not found to correlate well with the ECHO parameters evaluating dyssynchrony. TDI is better for evaluating dyssynchrony than other methods because SPWMD cannot be obtained, either if the septum is akinetic after extensive anterior infarction or if the maximal posterior motion is ill-defined. In addition, it is often not possible to obtain perpendicular M- mode sections of the proximal LV. **Conclusion:** The criteria for cardiac resynchronization therapy was satisfied by 15 out of 50 patients with LBBB on baseline ECG and low ejection fraction on Echo. Patients with LBBB and low ejection fraction had greater dyssynchrony than those with LBBB and normal ejection fraction. Tissue Doppler is a better technique than ECG in detecting dyssynchrony.

INTRODUCTION

Left bundle branch block (LBBB) generally associated with structural heart disease is a frequent conduction disorder. In patients with LBBB and structural heart disease, overall mortality is significantly increased.[1] Moreover, it is also known that the incidence of cardiovascular disorders and subsequent mortality is increased in isolated LBBB.[2]

In the presence of LBBB, due to delay of left ventricular (LV) mechanical activity, interventricular dyssynchrony and abnormal interventricular septal movement occurs. As a result of abnormal septal movement, stroke volume, ejection fraction (EF), and LV filling are decreased.[3] Recently, cardiac resynchronization therapy (CRT) is advocated in heart failure in patients with NYHA class III, IV on maximum antifailure medication with wide QRS complex (≥ 130 msec) and decreased EF (≤ 35 %).[4] Results from mechanistic studies, observational evaluations and randomized control trials have constantly demonstrated significant improvement in quality of life, functional status and exercise capacity in patients with New York Heart Association (NYHA) class III and IV heart failure who are

assigned to active resynchronization therapy. The studies in such patient population have revealed the presence of intraventricular dyssynchrony among various LV segments together with interventricular dyssynchrony.[5] Furthermore different trials suggest that this treatment modality yields the best hemodynamic benefits in patients with documented intraventricular dyssynchrony irrespective of the QRS duration. Conversely no recent data is available on regional systolic dyssynchrony in patients with LBBB and normal LV ejection fraction. In our study, we looked for the presence of intra and interventricular dyssynchrony using Tissue Doppler Imaging in patients with LBBB with both normal and compromised LV function.

MATERIALS AND METHODS

This was a prospective observational study done in the Department of Cardiology, at Coimbatore Medical College and Hospital, Coimbatore over a period of 1 year from April 2024 to April 2025 after obtaining ethical committee approval. The study was conducted on 100 patients with LBBB on ECG admitted in Coimbatore Medical College and Hospital. Of these 50 patients – Group I had an ejection fraction less than 50% and 50 patients – Group II had a normal ejection fraction ≥ 50%.

Inclusion Criteria

1. LBBB on baseline ECG

Exclusion Criteria

1. Patients on CRT/Pacemaker
2. Atrial fibrillation with fast ventricular rate
3. Unwillingness of the patient to be enrolled
4. Poor acoustic window

Clinical Assessment: All patients were interviewed individually. Their history, duration and severity of the symptoms were ascertained. Then they were subjected to a thorough clinical examination. The drugs they were on and duration of therapy was noted. An ECG was done at the time of recruitment and this was used to determine the electrocardiographic variables. Patients were diagnosed to have ischemic cardiomyopathy if they had history of a prior MI, diagnosed by standard criteria or angiographic evidence of significant coronary artery disease.

Echocardiographic Protocol: After a standard echocardiographic study, these patients eligible for inclusion were informed about the study and informed consent was obtained. Standard Doppler echocardiography and Tissue Doppler Imaging were performed with the subjects in partial decubitus, by ultrasound system equipped with Doppler myocardial imaging capabilities. A frequency transducer of 4 MHz was used for two-dimensional, M-mode and Doppler imaging. All the measurements were obtained by taking the average of ≥ 3 cardiac cycles.

2D Echocardiogram: LV Ejection fraction was measured using a commercially available software program that applied modified Simpson's rule on this chamber and four chamber views.

M-Mode: The septum to posterior wall return delay was ascertained using the M-Mode short axis view taken at the level of the papillary muscles. It was obtained by measuring the shortest interval between the maximal posterior displacement of the septum and the posterior wall. A SPWMD longer than 130 milliseconds was considered as an interventricular dyssynchrony marker.

Standard Doppler: Using Pulsed Doppler time from the Q wave to the start of RV ejection as assessed at the level of the RV outflow tract from a short axis parasternal view was measured. The time from the q wave to the start of LV ejection as assessed by pulsed Doppler at the level of the LV outflow tract from a 4-chamber view was found out.

Interventricular Dyssynchrony Assessment: The difference between the time for LV activation (Q-A0) and time for RV activation (Q-pulm) determined the Doppler interventricular delay. A valve > 40 msec was considered an indication of dyssynchrony.

Pulsed Doppler Myocardial Imaging: In apical 4-Chamber and 2 chamber views, a 5mm pulsed Doppler sample volume was subsequently placed at the level of 5 different basal myocardial segments. LV posterior septum, LV inferior wall, LV anterior wall, LV lateral wall (at the level of mitral annulus) and RV lateral wall (at the level of tricuspid annulus). The apical view was chosen to obtain a qualitative assessment of the longitudinal regional wall motion at most simultaneous to Doppler inflow and outflow and to minimize the incidence angle between Doppler beam and longitudinal wall motion. By use of DMI the index of myocardial systolic activation in five different basal myocardial segments was calculated: Precontraction time (PCTm) (from the beginning of Q wave of ECG to the onset of Sm); intraventricular systolic synchrony was analyzed by the difference of PCTm between the most delayed.

Statistical Methods

Determination of sample size: To determine the sample size a similar study done by Pio Caso et al6 was chosen. One of the major outcomes of the study was a parameter called the intraventricular delay. The mean value of the intraventricular delay in those with normal ejection fraction was 20.8 ± 17.3 and in those with low ejection fraction was 35.6 ± 18.2. Based on this information we calculated the sample size of our study for two sample comparison of means by STATA software.

Analyses: All the analyses were performed by SPSS software. Variables were presented as Mean ± SD. T test for unpaired data and analysis of variance (ANOVA) test with Scheffe correction estimated differences among the groups. Linear regression analyses and partial correlation test by Pearson's method were done to assess univariate relations.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

RESULTS

During the period April 2024 to April 2025, 100 patients with LBBB on ECG were included in the study. Of these 50 patients – Group I had an ejection fraction less than 50% and 50 patients – Group II had a normal ejection fraction ≥ 50%. The two groups were comparable in age (69.62 ±9.73 in the low EF vs 62.80 ± 4.80 in the normal EF) (Table 1), sex male prevalence (27/50 in low EF vs 26/50 in normal EF). There were 47 female (47%) and 53 male (53%) subjects.

Table 1: Age distribution in years

	EF >50%		EF < 50%		Total	
	N	%	N	%	N	%
51 – 60	18	36%	12	24%	30	30%
61 – 70	32	64%	12	24%	44	44%
71 – 80	0	0%	17	34%	17	17%
81 – 90	0	0%	9	18%	9	9%
Total	50	100%	50	100%	100	100%
Mean ± SD	62.80 ±4.80		69.62 ±9.73		66.21 ± 8.37	
Chi square test = 36.29, p=<0.0001, Statistically significant						

36 subjects (36%) were diabetic, 42 (42%) were hypertensive and 68 (68%) were dyslipidemic. 48 (48%) were smokers and 10 (10%) were alcohol consumers.

The QRS duration was significantly greater in those with low EF (Mean = 148.36 ± 11.23) versus those with normal EF (Mean = 133.76 ± 8.66 p value 0.001). The mean LVIDd in those with low EF was 63.08 ± 6.42 which was significantly greater than those with normal EF (50.12 ± 3.71 p<0.001). The individuals with low EF had significantly higher LVIDs (50.24 ± 5.29 versus 30.42 ± 5.04 p<0.001), EDV (201.62 ± 22.38 versus 103.24 ± 12.46 p<0.001) and ESV (134.00 ±24.83 versus 50.34 ± 7.01) [Table 2].

Table 2: Echocardiographic variables in different patient groups

	EF >50	EF <50	P value
Ejection fraction	60.74 ± 7.77	39.34 ± 5.78	<0.0001*
Age	62.80 ± 4.80	69.62 ± 9.74	<0.0001*
QRS Duration	133.76 ± 8.66	148.36 ± 11.23	<0.0001*
LVIDd	50.12 ± 3.71	63.08 ± 6.42	<0.0001*
LVIDs	30.42 ± 5.04	50.24 ± 5.29	<0.0001*
EDV	103.24 ± 12.46	201.62 ± 22.38	<0.0001*
ESV	50.34 ± 7.01	134.00 ± 24.83	<0.0001*
Q to Basal lateral	101.56 ± 10.26	127.76 ± 13.85	<0.0001*
Q to Basal anterior	98.70 ± 9.13	123.06 ± 11.76	<0.0001*
Q to Basal inferior	50.46 ± 6.16	70.86 ± 11.07	<0.0001*
Q to Basal septal	46.98 ± 5.14	67.50 ± 11.15	<0.0001*
Q to RV Lateral	41.04 ± 4.79	60.32 ± 11.45	<0.0001*
Intraventricular desynchrony	54.18 ±6.42	59.86 ±9.69	0.0008*
IVMD	28.88 ± 10.15	37.46 ± 11.59	<0.0001*
APED	131.16 ± 6.93	135.00 ± 20.25	0.20
PPED	102.28 ± 11.31	97.54 ± 10.89	0.03*
SPWD	118.36 ± 6.90	127.78 ± 11.09	<0.0001*

APED: Aortic preejection delay in msec, PPED: Pulmonary preejection delay in msec, IVMD: Intraventricular delay in msec, SPMD: Septum to posterior wall motion delay in msec.

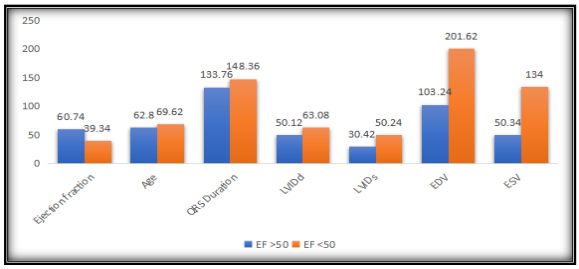

Figure 1: Bar diagram showing different Echocardiographic variables

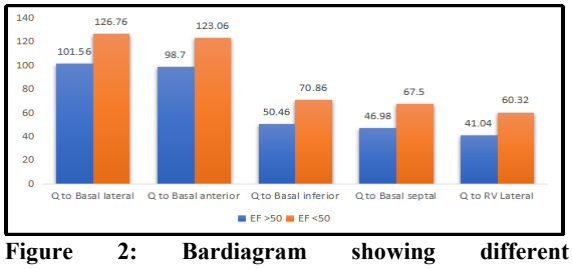

Figure 2: Bardiagram showing different Echocardiographic variables

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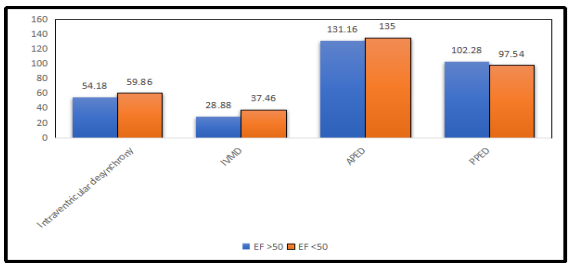

Figure 3: Bardiagram showing different Echocardiographic variables

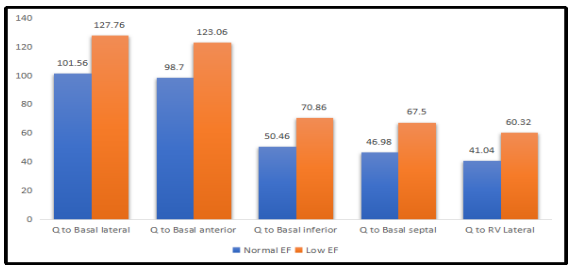

Figure 4: Bar diagram showing different TDI variables.

TDI analyses showed a prolonged precontraction time at the level of the LV lateral wall in those with low EF [Table 4]. The PCTm of the LV lateral wall was almost significantly higher in the group with low EF. The PCTm for the RV lateral wall, LV inferior wall and LV septum were significantly different between the two groups [Table 3&4]. Individuals of both groups showed a significant delay in activation of the LV lateral wall with consequent prolonged intraventricular delay. The group with normal EF were found to have significantly less intraventricular mechanical delay (p=0.0008); aortic pre-ejection delay (p=0.2). The septum to posterior wall motion delay was significantly different between the 2 groups (p<0.0001). [Table 5&6].

Table 3: TDI variables in Normal EF group

	Mean	SD	ST Error	95% Confidence interval	
				Lower	Upper
Q to Basal lateral	101.56	10.26	1.45	98.64	104.47
Q to Basal anterior	98.70	9.13	1.29	96.10	101.29
Q to Basal inferior	50.46	6.15	0.87	48.71	52.21
Q to Basal septal	46.98	51.3	0.72	45.52	48.44
Q to RV Lateral	41.04	4.79	0.67	39.67	42.40

Table 4: TDI variables in low EF group

	Mean	SD	St Error	95% Confidence interval	
				Lower	Upper
Q to Basal lateral	127.76	13.85	1.95	123.82	131.69
Q to Basal anterior	123.06	11.76	1.66	119.71	126.40
Q to Basal inferior	70.86	11.06	1.56	67.71	74
Q to Basal septal	67.50	11.14	1.57	64.33	70.66
Q to RV Lateral	60.32	11.44	1.61	57.06	63.57

Table 5: Echocardiographic variables in Normal EF group

	Mean	SD	St Error	95% Confidence interval	
				Lower	Upper
IVMD	28.80	10.15	1.43	25.99	31.79
APED	131.16	6.93	0.98	129.19	133.13
PPED	102.28	11.31	1.59	99.06	105.49
SPWD	118.36	6.90	0.97	116.39	120.32

Table 6: Echocardiographic variables in low EF group

	Mean	SD	St Error	95% Confidence interval	
				Lower	Upper
IVMD	37.46	11.59	1.63	34.16	40.75
APED	135	20.25	2.86	129.24	140.75
PPED	97.54	10.89	1.54	94.44	100.63
SPWD	127.78	11.08	1.56	124.62	130.93

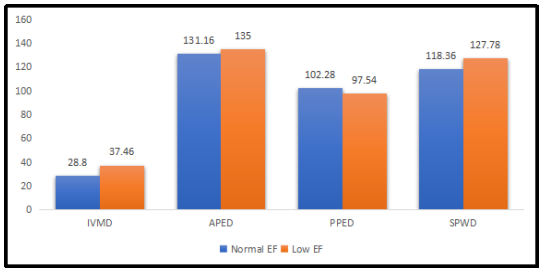

Figure 5: Bar diagram showing different TDI variables

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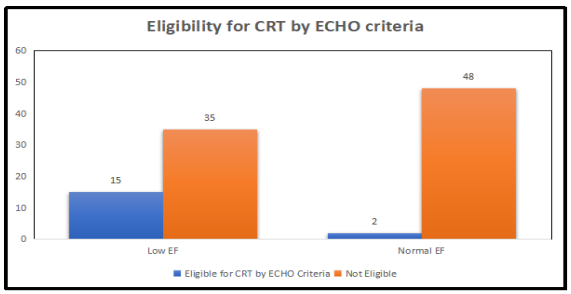

Figure 6: Bar diagram showing eligibility of CRT by ECHO criteria.

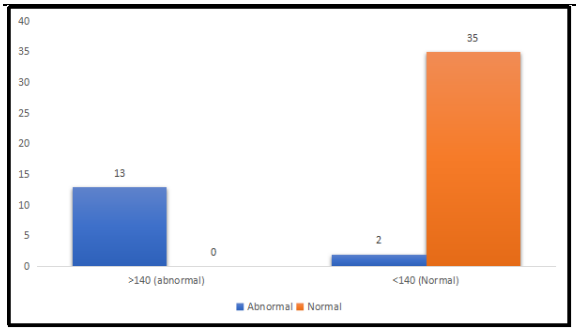

Figure 7: Bar diagram showing eligibility for CRT by QRS duration in Low EF group

The QRS width was significantly greater in those patients with LBBB who had a low EF. However, it was not found to correlate well with the ECHO parameters evaluating dyssynchrony.

Of the 100 patients, 17 individuals satisfied the ECHO criteria that deemed that they would benefit by resynchronization therapy (SPWMD > 130 msec, IVMD> 40 msec, APED > 140 msec, intraventricular activation delay > 65 msec and interventricular activation delay > 55 msec). 15 of these individuals had a ejection fraction less than 50%.

When compared to the Echo criteria, the ECG criteria (QRS ≥ 140 msec) to select patients who would benefit from CRT was only 86.6% sensitive and 100% specific [Table 8]. This proved beyond doubt that ECG criteria was grossly inadequate in selecting patients with dyssynchrony who would benefit from CRT.

Table 7: Eligibility for CRT by ECHO Criteria

	Eligible for CRT by ECHO Criteria	Not Eligible	Total
Low EF	15	35	50
Normal EF	2	48	50
Total	17	83	100

Table 8: Low EF group and QRS

QRS	Met criteria for CRT Abnormal	Doesn't met criteria for CRT Normal	Total
>140 msec	13	0	13
<140 msec	2	35	37
Total	15	35	50

Sensitivity = 86.6%, Specificity = 100%

PPV =100%, NPV =94.6%

Table 9: Normal EF group and QRS

QRS	Met criteria for CRT Abnormal	Doesn't met criteria for CRT Normal	Total
>140 msec	0	13	13
<140 msec	2	35	37
Total	2	48	50

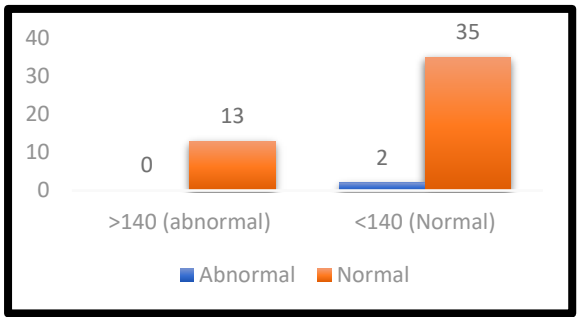

Figure 8: Bar diagram showing eligibility for CRT by QRS duration in Low EF group

DISCUSSION

Large number of patients with HF due to dilated cardiomyopathy had some intraventricular conduction defect in the majority of patients have left bundle branch block (LBBB). Patients with conduction delays or disturbances in electrical activity experience delay in contraction between right and left ventricles, which decreases cardiac output. Approximately 30% of patients with chronic HF have conduction pathway defects manifested by ventricular dyssynchrony. Mechanical dyssynchrony refers to abnormal prolongation of the timing of contraction or relaxation between atrium and ventricle (atrioventricular dyssynchrony), between the right ventricle and left ventricle (interventricular dyssynchrony) or between different left ventricular (LV) segments (intraventricular or LV dyssynchrony). Intraventricular dyssynchrony is probably the most important level of dyssynchrony evaluation.

The most precise methodology for identification and quantification of the intraventricular level of

ISSN (O): 2687-5365; ISSN (P): 2753-6556

dyssynchrony is probably tissue Doppler imaging (TDI). Detailed echocardiographic assessment using tissue Doppler echocardiography has shown that patients with LBBB have marked intraventricular dyssynchrony that can be improved by biventricular pacing.

Current American College of Cardiology guidelines consider cardiac resynchronization therapy (CRT) a Class I indication for patients with drug-refractory HF symptoms, LV ejection fraction (LVEF) 35% and wide QRS complex (>120 ms).

Multiple single-center trials and cardiac resynchronization in HF trial have demonstrated that LV mechanical dyssynchrony indices (most of which are based on echocardiographic measures) have superior accuracy compared with LV electric dyssynchrony (based on QRS duration) to predict response to CRT and long-term outcome.

The present study is done to compare LV mechanical dyssynchrony in LBBB patients with and without HF and to compare various methods of LV systolic dyssynchrony assessment by TDI.

Similar studies were done by Hygriv Rao et al,[7] Sambhaji Raut et al,[8] John Roshan et al.[9]

In our study protocol, we evaluated two useful indices of interventricular delay in patients with LBBB

- (Q-Ao)-(Q-Pulm) by standard echo- Doppler
- Inter ventricular Delay by TDI.
- Intra ventricular delay by TDI and SPWD

In the present study 100 patients with LBBB on ECG were included. Of these 50 patients – Group I had an ejection fraction less than 50% and 50 patients – Group II had a normal ejection fraction ≥ 50%.

John Roshan et al,[9] done their study in 69 patients with LBBB on ECG. Of these 38 patients had EF<50% and 31patients had EF>50%. In Hygriv Rao et al,[7] study a total of 128 patients with LBBB on ECG were recruited and divided into two groups, group A :103 patients with EF less than 50% and group B 25 patients with EF more than 50%.

In Sambhaji Raut et al,[8] 116 patients with a diagnosis of LBBB were included in study and divided into 4 classes according to their LV function and presence or absence of HF

Group A: Normal LV function without heart failure {50 patients}

Group B: Normal LV function with heart failure {8 patients}

Group C: LV Dysfunction with Heart Failure {50 patients}

Group D: LV Dysfunction without Heart Failure {8Patients}

In the present study the mean age of patients with EF > 50% is 62.80+_4.80 years and the mean age of patients with EF< 50% is 69.62+_9.73 years, where as in Hygriv Rao et al,[7] the mean age of patients in EF>50% is 61+_10 years and the mean age of patients in EF<50% is 55+_12 years. However in a study done by John Roshan et al,[9] the mean age of patients in EF>50% is 59.03+_11.58 years and the mean age of patients in EF<50% is 57.5+_12.48 years.In a study done by Pio Caso et al,[6] the mean age of patients in EF>50% was 55.3+_5.5 years and the mean age of patients in EF<50% was 57.2+_5.5 years.

In the present study the number of male and female patients in EF > 50% group is 26 and 24 and the number of male and female patients in EF< 50% group is 27 and 23, where in Hygriv Rao et al,[7] the number of male and female patients in EF>50% group are 17 and 8 and the male and female patients in EF<50% group are 70 and 33.However in a study done by John Roshan et al9 the male and female patients in EF>50% group is 20 and 11 and the male and female patients in EF<50% group is 24 and 14. In a study done by Pio Caso et al6 the male and female patients in EF>50% were 18 and 15 and the male and female patients in EF<50% were 30 and 12. In Sambhaji Raut et al8 study the number of male and female patients in EF>50% group were 38 and 20 and the number of male and female patients in EF<50% group were 35 and 23.

In the present study Mean QRS duration in EF > 50% is 133.76 +_8.66 ms and Mean QRS duration in EF < 50% is 148.36+_11.23 ms, whereas in Hygriv et al,[7] study Mean QRS duration in EF > 50% is 152 +_20 ms and Mean QRS duration in EF < 50% is 146+_25 ms and in John Roshan et al9 study Mean QRS duration in EF > 50% is 135.71 +_11.73 ms and Mean QRS duration in EF < 50% is 148.53+_18.56 ms.

Echocardiographic Variables in Different Studies

Mean EF: In the present study the mean EF in patients with EF > 50% is 60.04 +_7.77 and the mean EF in patients with EF< 50% is 39.34 +_ 5.78 ,where as in Hygriv Rao et al,[7] the mean EF in patients with EF>50% was 61 + 11 and the mean EF in patients with EF<50% was 32 +_6 .However in a study done by John Roshan et al9 the mean EF in patients with EF>50% was 55.9 +_ 2.7 and the mean EF in patients with EF<50% was 34.71 +_6.2 .In a study done by Pio Caso et al6 the mean EF in patients with EF>50% was 56.6 +_4.6 and the mean EF in patients with EF<50% was 31.3 +_4.8.

In Sambhaji Raut et al,[8] 116 patients with a diagnosis of LBBB were included in study and divided into 4 classes according to their LV function and presence or absence of HF

Group A: Normal LV function without heart failure

Group B: Normal LV function with heart failure

Group C: LV Dysfunction with Heart Failure

Group D: LV Dysfunction without Heart Failure

Mean EF Group A is 59.55 +_ 2.08

Mean EF Group B is 59.63 +_ 2.56

Mean EF Group C is 31.62 +_ 7.0

Mean EF Group A is 38.38 +_ 9.68

Echocardiographic Values in Different Studies

In the present study 2 patients in EF>50% group and 15 patients in EF<50% group with baseline ecg showing LBBB shown CRT eligibility ECHO criteria i.e, intraventricular dysynchrony > 65 msec by Tissue Doppler Imaging, interventricular mechanical delay > 40 msec i.e, (Q-Ao)-(Q-Pulm) by standard echo-

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Doppler, Aortic pre ejection time >140 msec and septum to posterior wall delay > 130 msec.

In Tissue Doppler Imaging in EF>50% group the mean time of Q to RV lateral is 41.04+_4.79 msec, mean time of Q to LV basal septal is 46.98 +_5.14 msec, mean time of Q to LV basal inferior is 50.46 +_6.16 msec, mean time of Q to LV basal anterior is 98.70 +_9.13 msec, mean time of Q to LV basal lateral is 101.56 +_10.26 msec. By the above values we know that there in delay in activation of various segments of left ventricle known as intraventricular dysynchrony and also there is delay in activation between right ventricle and left ventricle known as interventricular dysynchrony.

In Tissue Doppler Imaging in EF<50% group the mean time of Q to RV lateral is 60.32+_11.45 msec, mean time of Q to LV basal septal is 67.50 +_11.15 msec, mean time of Q to LV basal inferior is 70.86 +_11.07 msec, mean time of Q to LV basal anterior is 123.06 +_11.76 msec, mean time of Q to LV basal lateral is 127.76 +_13.85 msec.

Patients in EF<50% group also has intraventricular dysynchrony and interventricular dysynchrony. In both groups the last activated segment is LV basal lateral. Intra and inter ventricular dyssynchrony is more in EF<50% group than EF>50% group.

In John Roshan et al,[9] study 1 patient in EF>50% group and 9 patients in EF<50% group shown CRT eligibility ECHO criteria i.e, intraventricular dysynchrony >65 msec by Tissue Doppler Imaging, interventricular mechanical delay > 40 msec i.e, (Q-Ao)-(Q-Pulm) by standard echo- Doppler, Aortic pre ejection time >140 msec and septum to posterior wall delay > 130 msec.

In Tissue Doppler Imaging in EF>50% group the mean time of Q to RV lateral is 58.61 +_32.33 msec, mean time of Q to LV basal septal is 65.55 +_35.09 msec, mean time of Q to LV basal inferior is 73.23 +_35.72 msec, mean time of Q to LV basal anterior is 79.61 +_37.83 msec, mean time of Q to LV basal lateral is 103.16 +_46.01 msec.

In Tissue Doppler Imaging in EF<50% group the mean time of Q to RV lateral is 57.81 +_21.76 msec ,mean time of Q to LV basal septal is 79.13 +_33.93 msec, mean time of Q to LV basal inferior is 83.03 +_41.21 msec, mean time of Q to LV basal anterior is 97.71 +_37.64 msec, mean time of Q to LV basal lateral is 127.03 +_49.41 msec.

The results in John Roshan et al,[9] study is similar to the present study as it has both intraventricular dysynchrony and interventricular dysynchrony and the dyssynchrony is more in EF<50% group than EF>50% group.

Table 10: Echocardiographic Values in John Roshan et al study.[9]

Parameter	Group- I Low EF ≤50	Group II Normal EF > 50	P value
LVIDd	62.68 ± 9.36	48.35 ± 5.92	<0.001
LVIDs	51.5 ± 8.77	35.5 ± 9.33	<0.001
EDV	188.97 ± 59.89	108.39 ± 30.18	<0.001
ESV	126.05 ± 51.6	47.35 ± 13.5	<0.001
Q to Basal Lateral	127.03 ± 49.41	103.16 ± 46.01	0.043
Q to Basal Anterior	97.71 ± 37.64	79.61 ± 37.83	0.052
Q to Basal Inferior	83.03 ± 41.21	73.23 ± 35.72	0.301
Q to Basal Septal	79.13 ± 33.93	65.55 ± 35.09	0.108
Q to RV Lateral	57.81 ± 21.76	58.61 ± 32.33	0.913
Intraventricular Delay	68.82 ± 40.68	47.06 ± 32.64	0.03

Similar resuts were also seen in Pio Caso et al,[6] study i.e, In Tissue Doppler Imaging in EF>50% group the mean time of Q to RV lateral is 96.5 +_15.1 msec, mean time of Q to LV basal inferior is 108.3 +_12.1 msec, mean time of Q to LV basal anterior is 110.6 +_15.3 msec, mean time of Q to LV basal lateral is 121 +_ 13.6 msec.

In Tissue Doppler Imaging in EF<50% group the mean time of Q to RV lateral is 99.6 +_14.7 msec, mean time of Q to LV basal inferior is 144.7 +_12.5 msec, mean time of Q to LV basal anterior is 145.5 +_19.3 msec, mean time of Q to LV basal lateral is 168.3 +_15.3 msec. The above values in Pio Caso et al6 study shows that there is more interventricular and intraventricular dysynchrony in low EF patients.

Table 11: Echocardiographic values in Pio Caso et al study.[6]

Parameter	EF >50	EF <50	P value
Q to Basal Lateral	121.6 ± 13.6	168.3 ± 15.3	<0.0001
Q to Basal Anterior	110.6 ± 15.3	145.5 ± 19.3	<0.001
Q to Basal Inferior	108.3± 12.1	144.7 ± 12.5	<0.001
Q to RV Lateral	96.5 ± 15.1	99.6 ± 14.7	NS
Intraventricular Delay	20.8 ± 17.3	35.6 ± 18.2	<0.01

In Hygriv Rao et al,[7] study Prevalence of dyssynchrony in the HF group compared to Group B was 72% vs. 16%, (P< 0.01) while septal dyssynchrony was 16% vs. 16%. LV dyssynchrony is present in 72% of heart failure population with complete LBBB. The regional distribution patterns of dyssynchrony are heterogenous. Lateral wall delay is seen only in heart failure patients while septal delay is present similarly in heart failure patients and normal individuals with LBBB.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 12: Mean Interventricular Dysynchrony in Different Studies

SL. No		EF > 50 % Mean IVMD	EF < 50% Mean IVMD
1	Present Study	28.88 + 10.15	37.46 + 11.59
2	John Roshan et al9	47 + 35.52	74.68 + 43.90
3	Pio Caso et al6	20.8 + 17.3	35.6 + 18.2

ECG, Doppler and TDI assessment: The IVMD and interventricular delay by TDI were significantly more in those patients with LBBB who had low EF proving beyond doubt that of LBBB patients those with low EF had greater interventricular dyssynchrony. The qrs width was also significantly greater in those patients with LBBB who had a low EF. However it was not found to correlate well with the ECHO parameters evaluating dyssynchrony. In fact, no significant correlation was observed between TDI Interventricular delay and QRS duration. This result confirms that, despite similar QRS morphology, patients with CHF and LBBB may present heterogeneities of myocardial electromechanical coupling and different locations of mechanical dyssynchrony consequent to myocardial disease or subendocardial ischemia. There was only a 17% agreement beyond chance between ECG [qrsd >120msec] and Echo criteria in selecting patients for CRT. Though the ECG was reasonably sensitive it was far less specific in identifying patients with dyssynchrony. Thus Tissue Doppler Echo will help us in better selection of those cases that would benefit most from CRT.

TDI – to measure intraventricular dyssynchrony: In our study intraventricular dyssynchrony as assessed by M mode echo - septum to posterior wall motion delay was significantly different between the low and normal EF groups. However, frequently the SPWMD cannot be obtained, either because the septum is akinetic after extensive anterior infarction or because the maximal posterior motion is ill-defined. In addition, it is often not possible to obtain perpendicular M- mode sections of the proximal LV. Tissue Doppler assessment of intraventricular dyssynchrony showed there was significantly longer isovolumic contraction time to the LV basal lateral wall in patients with LBBB. This delay was much longer in those with low EF when compared to those with normal EF. The shortest and the longest ICTm were measured in the basal septal and lateral segments, respectively, thus resulting in 55 msec of delay between the LV septum and lateral wall. This data diverts from the normal, in the sense that the last segment to contract is the basal lateral, whereas it is the posterior segment in normal subjects.

Normally, LV contraction occurs without significant delay almost simultaneously in every LV segment that results in synchronous contraction.10 However, in patients with LBBB, contraction is delayed far more than the normal range.

TDI –RV basal lateral to LV basal lateral: In patients with LBBB there was a marked difference in the RV basal free wall to LV basal lateral wall in both the low and normal EF groups. This suggests that all patients with LBBB have some amount of inter and intraventricular dyssynchrony, those with low ejection fraction having greater dyssynchrony. These findings translated to a greater number of individuals with lower ejection fraction satisfying the echo criteria for cardiac resynchronization therapy; 15 out of 50 as against 2 out of 50 with normal ejection fraction. This suggests that in LBBB patients significant dyssynchrony could occur though it is much less frequent in those with normal ejection fraction.

In individuals with LBBB, the uncoordinated systole worsens the workload and the stress of the left ventricle. The interventricular septum, which is usually activated first, develops a small pressure load with low wall stress, and contributes minimally to intraventricular pressure increase. On the other hand, the LV lateral free wall is activated late, has a high presystolic stress, and is therefore affected by unbalanced load and stress. The final result is a worsening of LV global work with, with prolongation of presystolic ventricular time (i.e, PCTm), delay in the onset of LV systole, shortening of LV ejection and filling time, and further depression of LV ejection fraction

Why TDI is better?: In our study intraventricular dyssynchrony as assessed by M mode echo - septum to posterior wall motion delay was significantly different between the low and normal EF groups. However, frequently the SPWMD cannot be obtained, either because the septum is akinetic after extensive anterior infarction or because the maximal posterior motion is ill-defined. In addition, it is often not possible to obtain perpendicular M- mode sections of the proximal LV.

Our findings are consistent with several recent reports emphasizing the usefulness of TDI to support cardiac resynchronization therapy in patients with severe CHF and LBBB. In particular, as reported by Ansalone et al,[10] the extent of myocardium with asynchronous contraction at the LV base predicted the improvement in LV systolic performance and reversion of LV remodeling during short- and long-term biventricular pacing. Furthermore, individual tailoring of the pacing site, with accurate pre-activation of myocardial regions showing mechanical dyssynchrony, produced a significant reduction of the extent of Inter Ventricular delay, and consequent significant improvement of LV EF%. In other words, the delayed longitudinal contraction assessed by TDI represents mechanical LV dyssynchrony and thus contractile reserve, which can be recruited by means of optimized cardiac resynchronization therapy it was

ISSN (O): 2687-5365; ISSN (P): 2753-6556

also shown that after CRT, the delay between the contraction of septal and lateral walls was diminished. CRT improves coordination of contraction among LV segments due to homogeneous activation and serves to restore synchronous contraction. TDI enables the quantification of systolic and diastolic functions of separate LV segments and thus help us in appropriately planning the position of the coronary sinus lead and timing the activation of the different myocardial segments.

Study limitations:

1. The major limitation of our study is the Doppler technique used. It is angle dependent. Also there is the possible presence of artifacts. However we tried to overcome this by taking a minimum of 3 measurements for each parameter and calculating an average of the same.
2. Sample size: The number of subjects studied is only 100. A larger study needs to be done to confirm our findings.

Summary

1. 100 patients with baseline ECG having LBBB divided into two groups as EF<50% and EF>50% with 50 patients each and intraventricular and interventricular dyssynchrony was assessed by ECHO parameters.
2. Patients with LBBB and low ejection fraction had greater dyssynchrony than those with LBBB and normal ejection fraction.
3. The QRS width was also significantly greater in those patients with LBBB who had a low EF. However it was not found to correlate well with the ECHO parameters evaluating dyssynchrony.
4. TDI is better for evaluating dyssynchrony than other methods because SPWMD cannot be obtained, either if the septum is akinetic after extensive anterior infarction or if the maximal posterior motion is ill-defined. In addition, it is often not possible to obtain perpendicular M-mode sections of the proximal LV.

CONCLUSION

The main findings of our study are

1. The criteria for cardiac resynchronization therapy was satisfied by 15 out of 50 patients with LBBB on baseline ECG and low ejection fraction on Echo.
2. Patients with LBBB and low ejection fraction had greater dyssynchrony than those with LBBB and normal ejection fraction.
3. Tissue Doppler is a better technique than ECG in detecting dyssynchrony.

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ISSN (O): 2687-5365; ISSN (P): 2753-6556