Original Article

Outcomes of Cardiac Resynchronization Therapy on the Six-Minutes Walk Test in Patients with Heart Failure and Left Bundle Branch Block

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Abstract

Objective: To study the outcomes of cardiac resynchronization therapy (CRT) on the 6-minute walk test, in patients presenting with heart failure (HF) and left bundle branch block (LBBB).

Methodology: After getting approval from Institutional Ethical Board, this descriptive cross secitonal study was conducted at Cardiology Department of Hayatabad Medical Complex, Peshawar from 1st Jan 2023 to 30th June 2023. The study consisted of 50 patients, who met the inclusion criteria. Each patient underwent an extensive clinical assessment prior to cardiac resynchronization therapy (CRT) implantation. This consisted of a comprehensive clinical assessment involving detailed medical history taking, New York Heart Association (NYHA) functional class evaluation, and their documentation of their medications.

Results: A total of 50 heart failure (HF) patients with the left bundle branch block (LBBB) were enrolled, with a baseline average age of 50 ± 9.9 years. On 6-Minute Walk Test (6MWT), post-cardiac resynchronization therapy (CRT) the mean increase in the walk test distance was 60, 75 and 80 meters on 3 month, 6 month and 12 month follow-up, respectively. Post-CRT, there was a notable increase in mean Left ventricular ejection fraction (LVEF) from 35 ± 5% at baseline to 40 ±10.0 % at 6 months and to 50.0% at 12 months. The mean duration of the QRS complex also reduced from more than 135 msec to 110 msec at post-CRT 12 months. At the start of the study, 40 patients were in New York Heart Association (NYHA) functional class 3. Post CRT at 12 months,about 25 patients improved and shifted to NYHA functional class 2 and 10 patients shifted to NYHA functional class 1.

Conclusion: There is a substantial increase in the mean distance post-cardiac resynchronization therapy (CRT) on 6-Minute Walk Test (6MWT). It could markedly reduce the duration of prolonged QRS and improve Left ventricular LV function in patients presenting with heart failure (HF) and left bundle branch block (LBBB). These advantages can enhance patients' quality of life (QOL) and clinical outcomes.

Keywords: Cardiac resynchronization therapy, Heart failure, Bundle branch block, 6 minute walk test

Introduction

Heart failure with reduced Ejection Fraction (HFrEF) is a very common chronic disease characterized by impaired cardiac function and diminished exercise tolerance and patients remain symptomatic despite treatment.1 Cardiac resynchronization therapy (CRT) is the mainstay of treatment. Besides decreasing intraventricular conduction delay, CRT may also induce some cardiac reverse remodelling which may delay the subsequent mechanical dyssynchrony, and as a result, improve left ventricular (LV) function and decrease morbidity and mortality.[1] Accordingly, CRT is a class I recommendation in patients with HFrEF.[2]

In CHF patients who remain in NYHA classes II–IV despite optimal goal-directed medical therapy (GDMT), CRT gives an important benefit.[2] In such patients the QRS duration is usually wide (≥130 ms) and there is a reduced Left ventricular ejection fraction (LVEF) (≤35%).[3] As reported in current guidelines, large trial subgroup analyses show that the benefits of CRT are amplified by wider QRS durations and/or LBBB.[4]

Among the various causes of HF, LBBB is one that adds additional challenge as it creates a mechanical dyssynchrony of the ventricle leading to suboptimal force generation and decreased exercise performance.[5] CRT is one of the main treatment strategies in HF with LBBB and it aims to optimize ventricular timing and function. While a number of studies have examined CRT effect on clinical endpoints including LVEF and the NYHA functional class, its effect on exercise capacity, measured with the 6MWT is another important component of the holistic HF management.[6]

HF is one of the most common cardiovascular diseases, represents a major health burden.[7,8] HF patients with LBBB present with gradually worsening symptoms and outcomes than HF with a normal electrical conduction pattern.[9]

Over the past few decades, CRT has been identified as an effective treatment for patients with HF, especially in the presence of LBBB. With CRT, a specialized pacemaker will be implanted which helps to restore coordination between the electrical impulses of the heart's ventricles. It ameliorates signs and symptoms, reduces hospitalizations, and prolongs survival in HF patients.[10-12]

Clinical impact of CRT upon LVEF has been previously reported, but NYHA functional class, or quality of life, in HF patients has recently also been used as a clinical effect measures of CRT.[8,13] Higher symptom severity, higher hospitalization, and increased risk of adverse cardiovascular events are associated with reduced exercise capacity. This makes interventions to improve exercise tolerance a valuable clinical target.[14] This study aims to examine the potential impact of CRT on 6MWT performance in HF patients with LBBB. Analysis of the effects of CRT on exercise capacity may provide important information on the functional importance of this treatment.

Methodology

This descriptive cross sectional study was done at Cardiology Department, Hayatabad Medical Complex, Peshawar from 1st Jan 2023 to 30th June 2023. The study enrolled a total of 50 patients who met the inclusion criteria after approval from Institutional Ethical Board and informed consent of patients.

The patients with heart failure (HF) as per established clinical criteria and left bundle branch block (LBBB) confirmed by electrocardiography (ECG) undergoing cardiac resynchronization therapy (CRT) implantation based on clinical assessment and guideline recommendations were included in this study. Ability to complete the 6-Minute Walk Test (6MWT) without significant limitations was also included in criteria. Patients with contraindications to CRT, severe comorbidities limiting exercise capacity, or those who declined participation were excluded from the study.

Before CRT implantation, a comprehensive baseline assessment was conducted for each of the 50 enrolled patients. This included a thorough clinical evaluation, where detailed medical histories were recorded, New York Heart Association (NYHA) functional class assessments were performed, and medication histories were documented. Comorbidities that might impact exercise capacity were also noted. A 12-lead ECG was performed to confirm the presence of LBBB and assess baseline QRS duration. Transthoracic echocardiography was used to evaluate LVEF, left ventricular dimensions, and valvular function. CRT devices were implanted by experienced cardiac electrophysiologists following standard guidelines. Biventricular pacing leads were positioned in the right atrium and both ventricles to achieve optimal synchronization.

The 6MWT was conducted according to established protocols. Patients were asked to walk as far as possible in a straight corridor for 6 minutes, and the total distance covered was recorded. The test was done at baseline (pre-CRT) and repeated at 3 months, 6 months, and 12 months following CRT implantation.

Data was collected and analyzed using SPSS v29. Descriptive statistics were used to summarize patient demographics such as age and gender. Descriptive statistics were also done for etiology of HF, comorbidities, NYHA functional class, medications, Baseline LVEF and baseline QRS duration. Paired t-tests were utilized to compare continuous variables before and after CRT, depending on the normality of data distribution. A p-value of less than 0.05 was considered statistically significant.

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Results

This study recruited 50 patients with heart failure (HF) and left bundle branch block (LBBB) (mean age 50 ± 9.9 years at baseline). The baseline left ventricular function with mean Left ventricular ejection fraction (LVEF) was 35.0 ± 5.0. QRS duration > 135 msec, consistent with LBBB, was present at baseline in patients. Demographic data of the patients is given in table 1.

Cardiac Resynchronization Therapy (CRT) demonstrated a significant positive impact on patients' exercise capacity, as measured by the 6-Minute Walk Test (6MWT). After CRT implantation, 80% of patients (40 out of 50) showed improved performance, characterized by a substantial increase in the distance covered during the test. This improvement was evident at multiple time points, with the mean increase in walking distance progressively rising over time. At three months post-CRT, 35 patients improved with a mean increase of 60 meters, while at six months, 40 patients improved with a mean increase of 75 meters. By 12 months, 42 patients showed improvement, with an average increase of 80 meters. These results indicate that CRT not only provides immediate benefits but also supports sustained and progressive improvement in exercise capacity over time for the majority of patients.

Post-CRT, there was a notable increase in mean LVEF from 35 ± 5% at baseline, to 40 ±10.0 % at 6 months, and to 50.0% at 12 months. The mean duration of QRS complex also reduced from more than 135 msec to 110 msec at post-CRT 12 month. At the start of the study, 40 patients were in NYHA functional class 3. Post CRT at 12 months, about 25 patients improved and shifted to class 2 and 10 patients shifted to group NHYA class 1. At baseline Mean LV End-Systolic Volume was 160 ± 20 ml and mean LV End-Diastolic Volume 200 ± 25 ml. Post-CRT 12 months LVESV was 130 ± 15 ml and LVEDV was 160 ± 20 ml.

Table 1. Demographic data of patients

Characteristic	Baeline Value
Total	50
Mean Age (years)	50 ± 9.9
Gender (Male/Female)	30 Male, 20 Female
HF Etiology	Ishemic (n=35), Non-Ischemic (n-15)
Comorbidities	Hypertension (n=45), Diabetes (n=25),
	Coronary Artery Disease (n=35)
NYHA Functional Class	Class II (n=10), Class III (n=40)
Medications	ACE Inhibitors/ARBs (n=45), Beta-Blockers (n=40),
	Diuretics (n=30), Statins (n=25)
Baseline LVEF (%)	35.0 ± 5.0
Baseline QRS Duration (msec)	>135 msec
Coexisting Conditions	Atrial Fibrillation (n=10), Chronic Kidney Disease (n=8)
	Chronic Obstructive Pulmonary Disease (n=5)

Table 2. Six-Minutes Walk Test (6-MWT) results after Cardiac Resynchronization Therapy (CRT)

Time Point	Number of Patients Improved in 6MWT	Mean Increase in Distance (meters)
Post-CRT 3 monts	35	60
Post-CRT 6 months	40	75
Post-CRT 12 monhs	42	80

Discussion

The results of this study show a significant improvement in the6-Minute Walk Test (6MWT) performance after cardiac resynchronization therapy (CRT) implantation. Around 80% of patients exhibited better exercise capacity, as indicated by an increased distance covered during the test. This improvement is consistent with findings from previous studies and underscores the role of CRT in enhancing functional status in Heart Failure (HF) patients with left bundle branch block (LBBB).[15]

CRT not only improved exercise capacity but also had a profoundly improved left ventricular (LV) function. The mean increase in Left ventricular ejection fraction (LVEF) from 35.0 ± 5.0 before CRT to 50.0 ± 7.5 after CRT demonstrates the ability of therapy to improve cardiac performance.[16] The mean LVEF was 45.3% in the same single study, at 16 months follow up.[17]

This enhancement of LV function is crucial in HF as it may translate to symptomatic improvement and an improved quality of life. In fact, larger studies suggest better long-term prognosis after CRT in patients with the highest 6MWT distance.[18-22]

Among the pathophysiologic mechanisms involved behind the benefits seen, possible correction of electrical dyssynchrony secondary to LBBB is likely one of them.[17] Mean QRS duration decreased from >135 msec at baseline to 110 msec following CRT, demonstrating improvement of ventricular conduction with ventricular resynchronization. This is one of the corner stones of CRT since it allows for the optimal timing of contraction of the ventricle and makes the heart pumping more efficient. This has been partly validated for the management of HF patients with LBBB. Enhancing the capacity of exercise can contribute to improved activities of daily living, lesser dyspnea,fatigue symptoms and an overall improved quality of lifeIn addition to this, the increase in LV function may also reduce the need for hospitalization and rates of morbidity, which may improve long-term outcomes.[18]

In terms of exercise capacity, the increase in 6-Minute Walk Test (6MWT) distance by 80 meters at 12 months corroborates findings from the COMPANION trial, where CRT was associated with significant enhancements in functional capacity as measured by 6MWT and New York Heart Association (NYHA) classification.[23] Additionally, the reduction in QRS duration from >135 msec to 110 msec after CRT aligns with studies highlighting the role of QRS narrowing in improving ventricular synchrony and clinical outcomes in HF patients.[24]

Finally, the shift in NYHA functional class, with an increase in Class I patients from 0 at baseline to 15 after CRT, underscores the therapy's capacity to improve patients' quality of life. Similar functional class improvements have been documented in trials like CARE-HF, which emphasized CRT's role in reducing HF symptoms and hospitalizations.[25]

These findings collectively affirm CRT's efficacy in improving cardiac function, exercise tolerance, and ventricular synchrony, aligning with a robust body of evidence from previous clinical studies.

Our study has certain limitations. The findings may have limited generalizability due to the study being conducted at a single center. Additionally, the observational design may lead to selection bias, and the absence of a control group makes it challenging to solely attribute improvements to CRT. Lastly, the follow-up period, while substantial, could be extended to assess long-term outcomes and potential late complications.

Future research should focus on multicenter randomized controlled trials to validate these findings across diverse populations. Additionally, exploring the mechanisms underlying CRT's benefits could help refine patient selection and optimize therapy protocols. CRT requires long-term studies to assess its lasting effects and potential late-occurring consequences.

Conclusion

Cardiac resynchronization therapy (CRT) has the capacity, when irreversible factors related to heart failure (HF) are absent, to markedly reverse poor exercise capacity and left ventricular (LV) function in heart failure (HF) with left bundle branch block (LBBB). These advantages can positively affect the patients' quality of life and clinical outcomes.

References

1. Jastrzębski M, Moskal P, Huybrechts W, Curila K, Sreekumar P, Rademakers LM, et al. Left bundle branch–optimized cardiac resynchronization therapy (LOT-CRT): results from an international LBBAP collaborative study group. Heart Rhythm 2022;19(1):13-21.
2. Jurak P, Curila K, Leinveber P, et al. Novel ultra-high-frequency electrocardiogram tool for the description of the ventricular depolarization pattern before and during cardiac resynchronization. J Cardiovasc Electrophysiol 2020;31:300-7.
3. Zhang W, Huang J, Qi Y, ang F, Guo L, Shi X, et al. Cardiac resynchronization therapy by left bundle branch area pacing in heart failure patients with left bundle branch block. Heart Rhythm 2019;16(12):1783-90.
4. Chen K, Li Y, Dai Y, Sun QI, Luo B, Li C, et al. Comparison of electrocardiogram characteristics and pacing parameters between left bundle branch pacing and right ventricular pacing in patients receiving pacemaker therapy. Europace 2019;21(4):673-80.
5. Arnold AD, Shun-Shin MJ, Keene D, Howard JP, Sohaib SA, Wright IJ, et al. His resynchronization versus biventricular pacing in patients with heart failure and left bundle branch block. J Am Coll Cardiol 2018;72(24):3112-22.

6. Balla C, Cappato R. When to choose cardiac resynchronization therapy in chronic heart failure: type and duration of the conduction delay. Eur Heart J Suppl 2019;21(Suppl B):B31-5.
7. Domenichini G, Burri H, Valzania C, Gavaruzzi G, Fallani F, Biffi M, et al. QRS pattern and improvement in right and left ventricular function after cardiac resynchronization therapy: a radionuclide study. BMC Cardiovasc Disord 2012;12:27.
8. Wang S, Wu S, Xu L, Xiao F, Whinnett ZI, Vijayaraman P, et al. Feasibility and efficacy of His bundle pacing or left bundle pacing combined with atrioventricular node ablation in patients with persistent atrial fibrillation and implantable cardioverter-defibrillator therapy. J Am Heart Assoc 2019;8(24).
9. Su L, Cai M, Wu S, Wang S, Xu T, Vijayaraman P, et al. Long-term performance and risk factors analysis after permanent His-bundle pacing and atrioventricular node ablation in patients with atrial fibrillation and heart failure. Europace 2020;22(Suppl 2):ii19-26.
10. Caputo ML, van Stipdonk A, Illner A, et al. The definition of left bundle branch block influences the response to cardiac resynchronization therapy. Int J Cardiol 2018;269:165-9.
11. Derval N, Duchateau J, Mahida S, Eschalier R, Sacher F, Lumens J. Distinctive left ventricular activations associated with ECG pattern in heart failure patients. Circ Arrhythm Electrophysiol 2017;10(6).
12. Emerek K, Friedman DJ, Sørensen PL, Hansen SM, Larsen JM, Risum N, et al. Vectorcardiographic QRS area is associated with long-term outcome after cardiac resynchronization therapy. Heart Rhythm 2019;16(2):213-9.
13. Feeny AK, Rickard J, Trulock KM, Patel D, Toro S, Moennich LA, et al. Machine learning of 12-lead QRS waveforms to identify cardiac resynchronization therapy patients with differential outcomes. Circ Arrhythm Electrophysiol 2020;13(7).
14. Glikson M, Nielsen JC, Kronborg MB, Michowitz Y, Auricchio A, Barbash IM, et al. ESC guidelines on cardiac pacing and cardiac resynchronization therapy Eur Heart J. 2021;42:3427-3520.
15. Huang W, Su L, Wu S, Xu L, Xiao F, Zhou X, et al. A novel pacing strategy with low and stable output: pacing the left bundle branch immediately beyond the conduction block. Can J Cardiol 2017;33(12):1736.e1-1736.e3.
16. Huang W, Wu S, Vijayaraman P, Su L, Chen X, Cai B, et al. Cardiac resynchronization therapy in patients with nonischemic cardiomyopathy using left bundle branch pacing. JACC Clin Electrophysiol 2020;6(7):849-58.
17. Al Hennawi H, Khan MK, Ashraf MT, Sadiq U, Pavri BB. Improving survival and echocardiographic outcomes in heart failure with preserved ejection fraction using cardiac resynchronization therapy: a systematic review and meta-analysis. J Am Coll Cardiol 2024;83(13_Suppl):547.
18. Beatty AL, Schiller NB, Whooley MA. Six-minute walk test as a prognostic tool in stable coronary heart disease: data from the heart and soul study. Arch Intern Med 2012;172(14):1096-102.
19. Yazdanyar A, Aziz MM, Enright PL, Edmundowicz D, Boudreau R, Sutton-Tyrell K, et al. Association between 6-minute walk test and all-cause mortality, coronary heart disease-specific mortality, and incident coronary heart disease. J Aging Health 2014;26(4):583-99.
20. La Rovere MT, Pinna GD, Maestri R, Olmetti F, Paganini V, Riccardi G, et al. The 6-minute walking test and all-cause mortality in patients undergoing a post-cardiac surgery rehabilitation program. Eur J Prev Cardiol 2015;22(1):20-6.
21. Ajijola OA, Upadhyay GA, Macias C, Shivkumar K, Tung R. Permanent His-bundle pacing for cardiac resynchronization therapy: initial feasibility study in lieu of left ventricular lead. Heart Rhythm 2017;14(9):1353-61.
22. Allaw AB, Mittal S, Merchant FM, Besser SA, Beaser AD, Aziz Z, et al. Population-level impact of the guidelines update on patient selection and outcomes after cardiac resynchronization therapy. JACC Clin Electrophysiol 2022;8(5):651-61.
23. Ferté J, Boyer F, Taiar R, Pineau C, Barbe C, Rapin A. Impact of resistance training on the 6-minute walk test in individuals with chronic obstructive pulmonary disease: a systematic review and meta-analysis. Ann Phys Rehabil Med 2022;65(3).
24. Bazoukis G, Naka K, Alsheikh-Ali A, Tse G, Letsas KP, Korantzopoulos P, et al. Association of QRS narrowing with response to cardiac resynchronization therapy—a systematic review and meta-analysis of observational studies. Heart Fail Rev 2020;25:745-56.
25. Ponnamreddy P, Juggan S, Gilstrap L. Comparing the effect of CRT implantation on quality of life in older patients compared with younger patients: systematic review and meta-analysis. Circulation 2020;142.

Authors' Contribution Statement

HU contributed to the conception, design, acquisition, analysis, interpretation of data, drafting of the manuscript, and critical review of the manuscript. ZA contributed to the design, acquisition, analysis, interpretation of data, drafting of the manuscript, and critical review of the manuscript. All authors are accountable for their work and ensure the accuracy and integrity of the study.

Confilct of Interest

Authors declared no conflict on interest

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None

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.