A Left Hemiblock Improves Cardiac Resynchronization Therapy Outcomes in Patients With a Right Bundle Branch Block

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ABSTRACT

Background: The current recommendation for cardiac resynchronization therapy (CRT) in congestive heart failure (CHF) patients is based on QRS duration, not on QRS morphology. It is not known whether patients with right bundle branch block (RBBB) respond to CRT.

Hypothesis: This study was performed to compare the effects of CRT in CHF patients with pure RBBB vs those with a coexisting left hemiblock (LHB).

Methods and Patient Population: A total of 271 consecutive patients who underwent CRT at Montefiore Medical Center were analyzed. Baseline ECGs were analyzed by 2 reviewers for RBBB and further classified into those with a coexisting LHB. Response to CRT was defined to be, at ≥6 months after CRT, either an improvement in ejection fraction (EF) of at least 5%, or an improvement in New York Heart Association (NYHA) CHF class. A total of 44 patients were identified: 18 had pure RBBB and 26 had a coexisting LHB. The 2 groups were similar in respect to baseline characteristics ($P > 0.05$).

Results: Only 4 out of 18 patients with pure RBBB compared to 18 out of 26 with LHB ($P = 0.005$) had an improvement in EF ≥5%. The mean EF was −1% in the pure RBBB group, but +5.4% in those with LHB ($P = 0.0031$). Improvement in NYHA class was seen in 0 out of 18 with pure RBBB vs 7 out of 26 patients with LHB ($P = 0.03$).

Conclusion: If patients with RBBB also had LHB, their response to CRT was significantly better than if they had RBBB alone.

Introduction

Cardiac resynchronization therapy (CRT) has emerged as an effective therapy for congestive heart failure (CHF) patients who are on optimized medical therapy.[1–6] The current recommendations for CRT in CHF patients are based on QRS duration, not on QRS morphology. The majority of patients (85%–90%) in prior studies had a left bundle branch block (LBBB) morphology, with only a minority showing nonspecific conduction delays or a right bundle branch block (RBBB) pattern.[1–6] Some studies have suggested little or no benefit from CRT in patients with RBBB[7,8] while others have suggested a benefit only when a coexisting left anterior or posterior hemiblock (LHB) was present.[9,10]

This study describes our experience with the effects of CRT on CHF patients with a pure RBBB vs those with RBBB and a coexisting LHB.

Methods

Study Population and Patient Selection

A total of 271 consecutive patients who underwent CRT at Montefiore Medical Center were analyzed. In addition to the standard indications for CRT (left ventricular ejection fraction [LVEF] ≤35%, New York Heart Association [NYHA] functional class III or IV, QRS complex duration ≥120 ms), patients were divided into those with either a pure RBBB or RBBB with a coexisting LHB. Patients with LBBB or a nonspecific intraventricular conduction delay prior to CRT were excluded from the study.

Electrocardiogram Analysis

A baseline 12-lead electrocardiogram (ECG) was analyzed by 2 independent blinded reviewers according to well established criteria.[11]

The diagnosis of complete RBBB was made when the following were met: (1) QRS duration of 0.12 seconds or more; (2) a secondary R wave (R1) in right precordial leads, with R1 greater than the initial R wave (rsR1 or rSR1); (3) a peak R time in lead V_1 >0.05 second; (4) a wide deep terminal S wave in leads I, V_5, and V_6. Patients with true posterior wall myocardial infarction, right ventricular hypertrophy, and dilatation were excluded.

A coexisting left anterior hemiblock was based on the following: (1) a frontal-plane axis of the complex between 45° and 90°; (2) qR pattern in aVL; R peak time in lead aVL of 45 msec or more.

A coexisting left posterior hemiblock was based on the following after right ventricular hypertrophy, emphysema, vertical heart, and lateral wall myocardial infarction were excluded: (1) a frontal plane axis of at least +90

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degrees; (2) rS pattern in leads I and aVL; (3) qR pattern in III and aVF.

Assessment of Ejection Fraction

The ejection fraction (EF) was calculated using a 2-dimensional echocardiogram before and after implantation of CRT. Whenever possible, a manually traced EF was measured by the biplane-modified Simpson's method as described in standard references.[12]

Baseline Characteristics

Baseline characteristics included age, gender, comorbidities (atrial fibrillation, diabetes mellitus, hypertension, chronic renal failure), body mass index, current medication use (angiotensin-converting enzyme inhibitor/angiotensin receptor blocker [ACEI/ARB], β-blockers, spironolactone), NYHA class, LVEF, and ECG characteristics (rhythm, QRS duration, and type of block).

A total of 44 of 271 patients were identified to have RBBB. These 44 patients were divided into 2 groups: 18 had pure RBBB and 26 had a coexisting LHB (18 with a left anterior hemiblock and 8 with a left posterior hemiblock). The 2 groups were similar in respect to baseline characteristics ($P > 0.05$; Table 1).

CRT Implantation

All patients had a left ventricular lead implanted transvenously into a posterolateral branch of the coronary sinus, such that a wide separation of the RV and LV electrodes on a lateral chest x-ray was seen. The RV lead was placed in a septal location away from the RV apex. AV delays were nominally programmed to 120 ms and LV-RV intervals were programmed to zero.

End Point

The end points for this study were, at ≥6 months after implant, either an improvement in LVEF of at least 5% above baseline or an improvement in NYHA class. Other echocardiographic markers of cardiac remodeling (a decrease in amount of mitral regurgitation or in end-systolic diameter) were also evaluated.

Statistical Analysis

Statistical analysis was done using SPSS 15 software (SPSS, Chicago, IL). Baseline characteristics were compared between the 2 groups using the χ^2 test or Fisher exact test for categorical variables, and independent *t* tests or Mann-Whitney test for continuous variables (depending on whether or not the data was normally distributed).

An analysis of end points which were categorical variables (improvement in LVEF by at least 5%, changes in NYHA class, decrease in systolic diameter by at least 2 mm, decrease in mitral regurgitation [MR]) was done using an χ^2 or Fisher exact test (depending on category size). Analysis of end points between groups, which were continuous variables, was done using a Mann-Whitney test as these data were not normally distributed. A Wilcoxon signed-rank test was used to compare the mean EF before and after CRT in the 2 groups.

Table 1. Baseline Clinical Characteristics (all P = ns)

	RBBB (n = 18)	RBBB + LHB (n = 26)	*P* Value
Ischemic/nonischemic	13/5	12/14	0.09
QRS duration (msec)	147.1 ± 5.7	151.8 ± 3.1	0.49
Age	70.07 ± 2.4	70.76 ± 2.6	0.85
Gender (male/female)	14/4	24/2	0.21
Hypertension (Y/N)	15/3	21/5	1.00
Diabetes mellitus	10/8	15/11	0.88
Chronic renal failure	6/12	14/12	0.18
ACEI or ARB	18/0	24/2	0.50
β-Blockers	18/0	24/2	0.50
Spironolactone	11/7	12/14	0.33
Body mass index	25.86 ± 1.5	29.00 ± 1.8	0.20
Atrial fibrillation	5/13	12/14	0.22

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; LHB, left hemiblock; ns, not significant; RBBB, right bundle branch block.

Results

Table 2 summarizes the findings of the study. Improvement in NYHA class was seen in 0 out of 18 in pure RBBB vs 7 out of 26 patients with LHB ($P = 0.03$). Only 4 out of 18 patients with pure RBBB compared to 18 out of 26 with LHB ($P = 0.005$) had an improvement in EF >5% (Figure 1).

In the pure RBBB group, the EF after CRT (mean = 30%) was not significantly different from the EF before CRT (mean = 29%; $P = 0.633$). In the LHB group, the EF after CRT (mean = 35%) was significantly higher than the EF before CRT (mean = 29%; $P = 0.0004$). Figures 2 and 3 show pre-CRT EF, post-CRT EF, and δ EF in all individual patients of both groups. There was no significant difference in echocardiographic parameters of remodeling (MR and end-systolic dimension) after 6 months (Table 2). Although the numbers were too small to comment on mortality, 5 out of 18 in the pure RBBB group vs 1 out of 26 in the LHB group had died during a mean follow-up of 6 ± 1 months.

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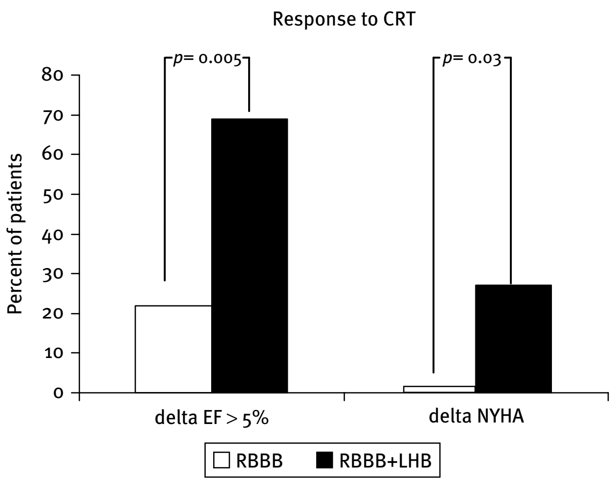

Figure 1. The percentage of responders to CRT based on improvement in LVEF by ≥5%, and by improvement in NYHA CHF class in patients with a pure RBBB and in those with a coexisting LHB.
Abbreviations: CHF, congestive heart failure; CRT, cardiac resynchronization therapy; LHB, left hemiblock; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; RBBB, right bundle branch block.

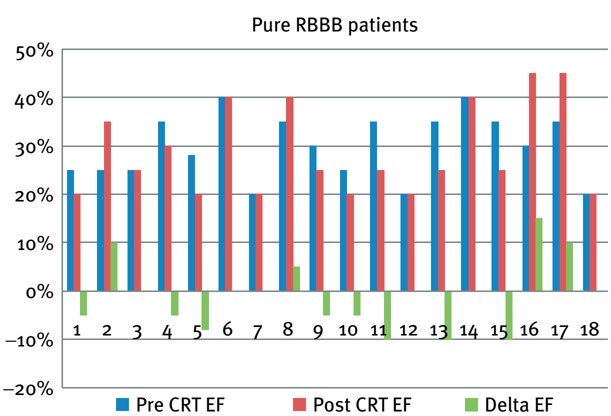

Figure 2. Ejection fraction before and after CRT placement and δ EF in individual patients with pure RBBB.
Abbreviations: CRT, cardiac resynchronization therapy; EF, ejection fraction; RBBB, right bundle branch block.

Discussion

The results of this study suggest that a coexisting LHB improves CRT outcomes at 6 months in patients with a RBBB. Cardiac resynchronization therapy has been shown to decrease symptoms and improve exercise capacity, quality of life, and ventricular function.[1–6] However, the majority of patients (85%–90%) in these studies had LBBB, with only a minority showing nonspecific conduction delays or RBBB. Current indications for CRT do not make a distinction between these patterns, and while patients

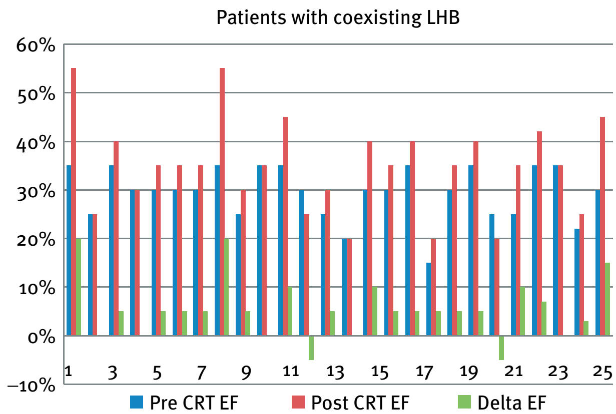

Figure 3. Ejection fraction before and after CRT placement and δ EF in individual patients with coexisting LHB.
Abbreviations: CRT, cardiac resynchronization therapy; EF, ejection fraction; LHB, left hemiblock.

with RBBB are not excluded from receiving CRT, it is not clear that all patients with RBBB benefit from CRT.

The results of this study are consistent with the findings of other studies; the response rates of patients with RBBB are lower than for those with LBBB. Only 7 of all 44 patients with RBBB (16%) had symptomatic improvement with CRT, though an improvement in LVEF was seen in 22 of 44 (50%).

Our results are concordant with 2 smaller studies that showed improvement in quality of life, functional class, and other measurements of functional capacity, but only when a coexisting LHB was present.[9,10] Although the numbers are too small to make any definitive comment, the lower number of deaths in patients with a coexisting LHB is intriguing.

Some authors have suggested that the benefit of CRT extends to patients with RBBB with a coexisting LHB because LHB is a marker of left intraventricular dyssynchrony. Fantoni et al described that the same delayed lateral wall activation of the LV was present in detailed electroanatomic maps of patients with RBBB as in LBBB.[13] In contrast, less mechanical dyssynchrony in a pure RBBB and a lower response to CRT has been demonstrated in an animal model.[14]

Though not all studies agree,[15] Fauchier et al demonstrated that LHB is a marker of dyssynchrony.[16] This might account for why more of the patients in this study with a coexisting LHB responded to CRT. It might also explain the differences between our study and others that failed to show benefit with CRT in patients with RBBB that did not account for a coexisting LHB.

The results of our study could also differ from those reported by others that did not show a benefit from CRT because of a lower number of patients with an

Table 2. Clinical and Echocardiographic Parameters of Response to CRT

Parameters	Pure RBBB	RBBB With LHB	*P* Value
Improvement in NYHA CHF class (responders/total)	0/18	7/26	0.03
Median δ EF at 6 mo	−1%	5.4%	0.003
Improvement in EF by ≥5% (responders/total)	4/18	18/26	0.005
Mean EF (before CRT vs after CRT)	30% vs 29%	29% vs 35%	0.57 (pure RBBB) 0.0004 (LHB)
Decrease in systolic diameter by at least 2 mm (responders/total)	8/18	9/26	0.54
Change in systolic dimension	−1	1.5	0.12
Improvement in MR	4/18	10/26	0.33
Change in grade of MR	0	0.5	0.08

Abbreviations: CHF, congestive heart failure; CRT, cardiac resynchronization therapy; EF, ejection fraction; LHB, left hemiblock; MR, mitral regurgitation; NYHA, New York Heart Association; RBBB, right bundle branch block.

ischemic etiology (15/44, 34%) in our study. In the 2 studies that have shown no difference in outcomes with RBBB, the majority of patients with RBBB had an ischemic etiology (76.5%[7], 71.2%[8]). Although the numbers are probably too small to make any definitive statement, there was no statistical difference when we compared the nonischemic patients in our study with the ischemic ones ($P = 0.09$).

Because of the limitation in the numbers, no definitive statement can be made, but there was also no difference when outcomes were compared between LAH ($n = 18$) and LPH ($n = 8$) patients. In the LAH group, 14 out of 18 were responders in terms of improvement in EF whereas 4 out of 8 in the LPH were found to be responders ($P = 0.19$). In terms of improvement in CHF class, 5 out of 18 in the LAH group whereas 2 out of 8 in the LPH group were responders ($P = 1.00$).

Limitations and Future Direction

Although this study is one of the larger single-center study of patients with RBBB with and without LHB, the number of patients is still small and all the limitations of a retrospective analysis apply. Some of these biases though are probably attenuated. For instance, since the echocardiographers and clinicians seeing the patients during follow-up had no knowledge of the patient groups, this should not have affected the echocardiography and NYHA results. AV and LV-RV optimization was also not performed on all patients. A prospective study designed to specifically enroll patients with RBBB would be needed to identify the criteria that predict which patients with RBBB will derive the greatest benefit from CRT.

Conclusion

If patients with RBBB also had LHB, their response to CRT was significantly better than if they had RBBB alone.

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