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Influence of QRS duration and axis on response to cardiac resynchronization therapy in chronic heart failure with reduced left ventricular ejection fraction: A single center study including patients with left bundle branch block

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Abstract

Background: *The aim of the study was to evaluate QRS duration and axis as predictors of response to cardiac resynchronization therapy (CRT) in order to reduce the proportion of non-responders.*

Methods: *Retrospective single-center study including 42 CRT recipients, with left bundle branch block (LBBB), left ventricular ejection fraction (LVEF) < 40%, in New York Heart Association (NYHA) class ≥ II. Response to CRT was declared as NYHA class improvement ≥ 1 (symptomatic) and LVEF improvement by ≥ 10% (echocardiographic) > 6 months post implantation.*

Results: *Symptomatic responders had longer pre- (172.3 ± 17.9 vs. 159.0 ± 18.3 ms; p = 0.027) and postimplantation (157.2 ± 24.1 vs. 136.7 ± 23.2 ms; p = 0.009) QRS duration. Preimplantation QRS < 150 ms predicted poor response (odds ratio [OR] for response vs. lack of response 0.04; 95% confidence interval [CI] 0.001–0.74). Predictors of symptomatic response included: postimplantation QRS > 160 ms (OR 7.2; 95% CI 1.24–41.94), longer QRS duration before (OR for a 1 ms increase 1.04, 95% CI 1.00–1.08) and post implantation (OR for a 1 ms increase 1.04; 95% CI 1.01–1.07). Area under the curve (AUC) for pre- and postimplantation QRS duration was 0.672 (95% CI 0.51–0.84) and 0.727 (95% CI 0.57–0.89), respectively, with cut-off points of 178.5 ms and 157 ms. For post implantation QRS axis, AUC was 0.689 (95% CI 0.53–0.85), with cut-off points of –60.5° or –38.5°. Preimplantation QRS axis was the only predictor of echocardiographic response (OR 0.98; 95% CI 0.96–1.00), with AUC of 0.693 (95% CI 0.54–0.85) and a threshold of –36°.*

Conclusions: *Marked pre- and postimplantation QRS prolongation and preimplantation negative QRS axis deviation are moderate predictors of response to CRT.* (Cardiol J XXX; XX, X: xx–xx)

Key words: cardiac resynchronization therapy, heart failure, left bundle branch block, QRS axis

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Introduction

Cardiac resynchronization therapy (CRT) is a well-proven beneficial treatment strategy for patients with chronic heart failure and reduced left ventricular ejection fraction (HF-rEF), and prolonged QRS duration [1]. Large studies have demonstrated that this therapeutic option not only reduces mortality and morbidity, but also improves symptoms and quality of life [2–4]. However, a significant proportion of patients treated with CRT do not achieve the desired response, emphasizing the need for better selection criteria [5]. Previous studies have recognized some simple electrocardiographic parameters, such as QRS morphology, duration and axis, as predictors of response to CRT [6–8]. However, the data are still sparse and inconclusive, particularly with regard to the predictive role of QRS axis in CRT candidates, and no threshold values for QRS axis have been established so far regarding positive response to CRT.

Thus, the aim of this study was to evaluate the potential usefulness of QRS duration and QRS axis orientation in predicting symptomatic (SR) and echocardiographic response (ER) to CRT in HF-rEF patients with left bundle branch block (LBBB).

Methods

Study design and patients

The study is a retrospective single-arm, single-center analysis including Caucasian patients implanted with cardiac resynchronization therapy-defibrillators (CRT-D) at the Department of Cardiology and Internal Medicine, Dr. A. Jurasz University Hospital No. 1 in Bydgoszcz from July 2010 through April 2016. All study participants were adults (> 18 years of age) with QRS duration > 120 ms, LBBB QRS morphology, left ventricular ejection fraction (LVEF) < 40%, and functional capacity of at least class II according to the New York Heart Association (NYHA) functional classification. Various transvenous delivery systems, left ventricle (LV) leads, and CRT-D devices from different companies were used. The most frequent target for LV lead placement was the posterolateral aspect of the LV. Apical positions were avoided. All LV leads were implanted intravenously. The VV interval was set between –20 and 0 ms, and the atrio-ventricular (AV) interval between 100–120 ms for sensed and 140–160 ms for paced atrial events. Presence of anodal LV pacing was excluded through programming LV pacing to bipolar or by confirmation of the presence of biventricular pacing morphology on electrocardiogram (ECG) in case of other configurations of LV pacing. No echocardiographic optimization of the device settings after implantation was implemented. LVEF was calculated by experienced echocardiographers using the modified Simpson rule. Pharmacotherapy in study participants was in line with the recommendations of the European Society of Cardiology. Patients undergoing an upgrade of conventional devices to CRT or a CRT replacement and those with incomplete data regarding electrocardiographic or echocardiographic parameters were excluded. All data were extracted from discharge cards, echocardiography and electrocardiography examinations. The study protocol was approved by the Bioethics Committee of the Nicolaus Copernicus University in Torun (Poland).

Electrocardiograms

A standard 12-lead ECG was recorded at a speed of 25 mm/s during the index hospitalization before and after the implantation procedure. Visual assessment of ECG recordings was performed by two independent researchers. The QRS duration was measured with a manual caliper in all 12 leads and the highest result was considered for further analysis. The preimplantation QRS duration was divided into three groups: < 150, 150–199, and ≥ 200 ms [6]. Similarly, postimplantation QRS duration was classified into three groups (< 120, 120–160, and > 160 ms) [6]. QRS axis was measured in leads I, II and aVF according to the method described in the literature [9]. QRS axis both as a quantitative value (expressed in degrees) and a qualitative category are presented. Normal axis was defined for values ranging between +90° and –30°, right axis deviation (RAD) for values between +90° and 180°, left axis deviation (LAD) for values between –30° and –90° and extreme axis deviation (EAD) for values between –90° and 180°. LBBB was diagnosed according to Polish Cardiac Society recommendations as: QRS duration ≥ 120 ms, with broad, slurred R-wave or R-wave with plateau at its peak in leads I, aVL, V5, and V6, with QS or rS morphology in leads V1–V3, intrinsicoid deflection in leads V5, V6 of > 60 ms, and secondary ST-T changes opposite to the major QRS direction [10].

Response to CRT

Response to CRT was independently evaluated using two parameters: NYHA class for SR and LVEF for ER. SR was defined as improvement in NYHA classification by ≥ 1 class [6, 8]. Improvement in absolute LVEF ≥ 10% was defined as ER.

The clinical and echocardiographic follow-up was performed at least 6 months after implantation.

Statistical analysis

The statistical analysis was performed with IBM SPSS Statistics version 23. P values < 0.05 were considered statistically significant. Normality of data distribution was tested with the Shapiro-Wilk test. Continuous variables were presented as mean ± standard deviation. Absolute frequency and percentages were reported for categorical data. The differences between paired variables were calculated with the appropriate Student t-test or Wilcoxon Signed Rank test according to normality of data distribution. Similarly, the differences between non-paired variables were calculated with the appropriate Student t-test or Mann-Whitney test according to normality. The χ^2 test was performed for all categorical data. Odds ratios (OR) were reported with 95% confidence intervals (CI). The parameters tested as potential predictors of response to CRT included: QRS duration, QRS duration reduction, QRS axis and QRS axis change. All parameters were analyzed for SR and ER. Receiver operator characteristic (ROC) curves with particular cut-off points, specificity, and sensitivity were calculated for parameters with significant impact on the response.

Results

Patients

Among all patients who received CRT-D within the study period, 42 met the inclusion criteria. The average age at implantation was 66.4 ± 8.3 years, with predominance of men (54%). The mean follow-up time was 29 ± 18.6 months. Baseline data for all patients including clinical parameters, preimplantation ECG and echocardiographic measurements are shown in Table 1.

Mean QRS duration at baseline exceeded 160 ms. The majority of patients (73.8%) presented native QRS duration between 150 and 199 ms. Wider QRS complexes (≥ 200 ms) were found in 9.5% of cases, while 16.7% of patients had QRS duration shorter than 150 ms, but not shorter than 130 ms. After the implantation a reduction in mean QRS duration by 19.5 ± 23.0 ms was observed. In 21.4% of patients QRS duration increased or remained unchanged.

Patients with normal QRS axis and LAD accounted for 95.3% of the study population. Detailed data on the distribution of QRS axis are presented in Table 1. Pre- and postimplantation mean QRS axis was –26.4 ± 41.7° and –47.9 ± 89.2°, respectively, corresponding to a mean change of –21.5 ± 97.2°. The direction of the change was towards more negative values in 69% of patients and towards more positive values in the remaining 31% of cases.

Table 1. Patient baseline characteristics (n = 42).

Variable	Value
Age [years]	66.4 ± 8.3
Sex:	
Female	19 (45.2%)
Male	23 (54.8%)
Etiology:	
Ischemic cardiomyopathy	31 (73.8%)
Non-ischemic cardiomyopathy	11 (26.2%)
Hypertension	28 (66.7%)
Diabetes mellitus	18 (42.9%)
Hyperlipidemia	10 (23.8%)
Obesity	8 (19.0%)
NYHA class:	
II	13 (31.0%)
II/III	15 (35.7%)
III	12 (28.6%)
IV	1 (2.4%%)
LVEF [%]	26.7 ± 5.5
QRS duration [ms]	164.0 ± 19.1
QRS axis:	
Normal	22 (52.4%)
LAD	18 (42.9%)
RAD	1 (2.4%)
EAD	1 (2.4%)
QRS axis [°]	–26.4 ± 41.7

Data are presented as numbers and percentages or means ± standard deviations. EAD — extreme axis deviation; LAD — left axis deviation; LVEF — left ventricular ejection fraction; NYHA — New York Heart Association; RAD — right axis deviation

At follow-up a reduction in mean NYHA class (2.55 ± 0.48 vs. 2.02 ± 0.44; $p < 0.001$), improvement in LVEF (26.7 ± 5.5 vs. 34.2 ± 10.3%; $p < 0.001$) and a reduction in QRS duration (164.0 ± 19.1 vs. 144.5 ± 25.4 ms; $p < 0.001$) were found. The numeric change in QRS axis was statistically insignificant (–26.4 ± 41.7 vs. –47.9 ± 89.2°; $p = 0.11$).

Symptomatic response

Symptomatic response was achieved in 16 (38%) patients. The responders, in comparison with non-responders, had a significantly higher baseline NYHA class, lower NYHA class at follow-

up and wider QRS complex before and after implantation (Table 2). The analysis of potential predictors of response to CRT revealed that patients with QRS < 150 ms before the procedure were less likely to respond well to CRT, while patients with QRS > 160 ms after the procedure had a greater chance to become responders to CRT (OR 7.2; 95% CI 1.24–41.94). Longer QRS duration was associated with a better response, when measured before as well as after implantation of the device. ROC curves calculated for parameters found to be predictors of SR are presented in Figure 1. Area under the curve (AUC) for QRS duration before the procedure was 0.672 (95% CI 0.51–0.84; p = 0.037) with an optimal cut-off point of 178.5 ms (sensitivity 31.3%, specificity 84.6%). AUC calculated for postimplantation QRS duration was 0.727 (95% CI 0.57–0.89; p = 0.005) with an optimal cut-off point of 157 ms (sensitivity 56.3%, specificity 73.1%). For postimplantation QRS axis, the AUC was 0.689 (95% CI 0.53–0.85; p = 0.025), with a cut-off point of –60.5° yielding sensitivity of 62.5% and specificity of 61.5%. Shifting the cut-off point to –38.5° resulted in a sensitivity drop down to 50%, with a concomitant increase in specificity up to 76.9%.

Echocardiographic response

Echocardiographic response was found in 19 (45%) patients. The responders, in comparison with non-responders, had significantly lower LVEF values at baseline and substantially higher LVEF at follow-up (Table 3). The QRS axis before the procedure was significantly more negative among responders as compared with non-responders. Postimplantation QRS axis trended to be more negative among responders. More negative QRS axis before CRT was associated with a better ER in univariate analysis (Table 3). ROC curve was calculated for QRS axis before the procedure and AUC for this parameter was 0.693 (95% CI 0.54–0.85; p = 0.018) with an optimal cut-off point of –36° (sensitivity 63.2%, specificity 69.6%).

Discussion

Cardiac resynchronization therapy remains the cornerstone of treatment for drug-refractory HF-rEF patients and wide QRS complex, particularly those with LBBB. This single-center study aimed to assess the role of pre- and postimplantation ECG for prediction of long-term response to CRT in patients with HF-rEF and LBBB. The main finding of this study is that simple electrocardiographic patterns can predict the SR and ER to this therapy. However, the predictive value of electrocardiographic parameters in this setting seems to be moderate. In detail, the present research indicates that: 1) SR is determined by QRS duration, 2) preimplantation QRS duration of more than 150 ms, but less than 178.5 ms predicts SR, 3) ER is determined by the QRS axis, 4) this relation is insignificant for qualitative estimates of the QRS axis, however in quantitative assessment preimplantation QRS axis of less than –36° predicts ER.

The true target for CRT is the mechanical dyssynchrony of the LV and QRS duration is considered the primary sign of this condition. Prolonged QRS duration is related to disease severity and increased mortality in HF-rEF patients [11] and remains an important factor determining enrollment for various studies assessing CRT. Based on large clinical trials and retrospective analyses [12–15], the current European Society of Cardiology guidelines for CRT restricted the highest class of recommendations to patients with QRS duration of > 150 ms are considered to achieve the most favorable response [1]. However, even though QRS duration was recognized as an important indicator of CRT effectiveness, a significant percentage of patients receiving this treatment still fail to benefit despite widened QRS [5]. A more precise analysis of prolonged QRS duration as a response predictor is required, however the data is limited. Kronborg et al. [6] reported an increased rate of SR to CRT in patients with QRS duration between 150 and 200 ms, compared with those with a shorter (< 150 ms) or longer QRS duration (> 200 ms). Sassone et al. [7] demonstrated that responsiveness to CRT in patients with LBBB decreases starting from QRS duration of around 180 ms onward. In the present study, the upper cut-off value of QRS duration to predict non-responsiveness was 178.5 ms. These similar results confirm that there is a limit of mechanical dyssynchrony of LV, visually represented in ECG, above which CRT fails to provide significant benefit.

In contrast to literature data showing that the extent of QRS duration reduction after CRT implantation is a marker of subsequent response to CRT (the higher the reduction, the better the response), this study demonstrated a higher likelihood of response to CRT in patients with QRS duration > 160 ms on biventricular pacing (OR 7.2, 95% CI 1.24–41.94). This unexpected finding perhaps might be explained by the fact that one of the response classifiers to be used in the present study was the NYHA classification — a method well

Table 2. Symptomatic response to CRT (NYHA class improvement ≥ 1): comparison of responders and non-responders, and electrocardiographic predictors of response to CRT in univariate analysis.

Variable	Non-responders (n = 26)	Responders (n = 16)	P
NYHA class at baseline	2.3 ± 0.31	2.9 ± 0.5	< 0.001
NYHA class at follow-up	2.2 ± 0.3	1.8 ± 0.5	0.006
LVEF preimplantation [%]	26.3 ± 5.5	27.5 ± 5.7	0.49
LVEF postimplantation [%]	32.7 ± 9.7	36.7 ± 11.0	0.22
QRS duration (preimplantation) [ms]	159.0 ± 18.3	172.3 ± 17.9	0.027
QRS duration (postimplantation) [ms]	136.7 ± 23.2	157.2 ± 24.1	0.009
QRS duration change [ms] (difference between post-implantation and preimplantation QRS duration)	–22.2 ± 21.2	–15.1 ± 25.8	0.33
QRS axis (preimplantation) [°]	–28.4 ± 43.4	–23.2 ± 40.0	0.7
QRS axis (post-implantation) [°]	–71.3 ± 76.8	–9.9 ± 97.0	0.028
QRS axis change [°] (difference between postimplantation and preimplantation QRS axis)	–42.9 ± 93.8	13.3 ± 95.3	0.068
Variable	**OR**	**95% CI**	**P**
Electrocardiographic predictors of response to CRT			
QRS duration (preimplantation)* [ms]			
< 150	0.04	0.001–0.74	0.033
150–199	3.69	0.82–16.65	0.49
≥ 200	5.77	0.54–61.13	0.15
QRS duration (postimplantation)* [ms]			
< 120	0.28	0.03–2.65	0.38
120–160	0.47	0.13–1.75	0.32
> 160	7.2	1.24–41.94	0.038
QRS duration (preimplantation) for a 1 ms increase	1.04	1.00–1.08	0.04
QRS duration (postimplantation) for a 1 ms increase	1.04	1.01–1.07	0.02
QRS axis (preimplantation)			
Normal	0.86	0.25–2.99	0.99
LAD	1.06	0.30–3.73	0.99
QRS axis (postimplantation)*			
Normal	0.69	0.13–3.74	0.99
LAD	1.23	0.31–4.83	0.99
RAD	4.0	0.64–25.02	0.18
EAD	0.33	0.08–1.30	0.2
QRS axis (preimplantation) for a 1° increase	1.00	0.99–1.02	0.69
QRS axis (postimplantation) for a 1° increase	1.01	1.00–1.02	0.04
No QRS axis change	1.91	0.45–8.05	0.47
QRS duration reduction	0.71	0.16–3.16	0.71
QRS axis decrease	0.39	0.10–1.50	0.19

*Asterisk signifies that each category of the parameter was compared against all remaining categories joined together. CI — confidence interval; CRT — cardiac resynchronization therapy; EAD — extreme axis deviation; LAD — left axis deviation; LVEF — left ventricular ejection fraction; NYHA — New York Heart Association Class; OR — odds ratio; RAD — right axis deviation

known for its subjectivity. Moreover, the majority of our patients (66.7%) presented with mild heart failure (NYHA class II), which is probably why the beneficial effect of CRT could be noticed primarily in patients with a high degree of underlying cardiac pathology and ventricular dyssynchrony as evidenced by largely widened QRS complexes, even on biventricular pacing. Unexpectedly, it was noted

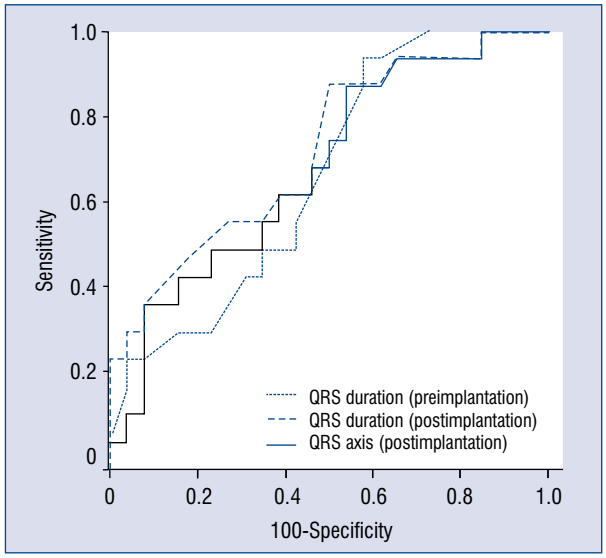

Figure 1. Receiver operator characteristic curves for predictors of symptomatic response to cardiac resynchronization therapy: preimplantation QRS duration (AUC 0.672 [95% CI 0.51–0.84]; p = 0.037), postimplantation QRS duration (AUC 0.727 [95% CI 0.57–0.89]; p = 0.005) and postimplantation QRS axis (AUC 0.689 [95% CI 0.53–0.85]; p = 0.025).

that there was no statistical difference in pre- and post implantation QRS duration in echocardiographic responders vs non-responders, however for symptomatic response assessment non-responders had significantly wider QRS duration, as expected. Possible explanations for this discrepancy might include a low number of participants enrolled in the study as well as a high percentage of patients with ischemic cardiomyopathy, with the latter being a risk factor of poorer resynchronization and response to CRT.

Previous studies provide consistent evidence of the importance of QRS duration in predicting response to CRT [2, 3, 6, 7, 12, 14, 15]. However, according to available research, only a few studies aimed to highlight the value of preimplantation QRS axis as a possible predictor of therapy success in LBBB patients, providing inconsistent results. In a study including 78 patients with LBBB receiving CRT, Garcia-Seara et al. [8] found that patients with LAD demonstrated a more favorable response (improvement in functional class, increase in LVEF of 5%, no hospital admissions for HF and remained alive throughout follow-up) than those with normal QRS axis. Also, Kronborg et al. [6] reported increased mortality and a lower likelihood of ER (improvement in absolute LVEF by 5%) in patients with RAD compared with normal axis or LAD. On the contrary, according to Brenyo et al. [16] the presence of LAD in LBBB is associated with less benefit from CRT. Similarly, Perotta et al. [17] suggest that the presence of LAD or RAD is associated with a significant risk of worse response.

In the present study, no significant differences were seen in response to CRT with respect to the qualitative categorization of the QRS axis. However, this study takes an important subsequent step in examining the efficacy of CRT in the LBBB population, relying on the quantitative value of QRS axis deviation. It was found that in a community-based cohort a more negative value of preimplantation QRS axis with a cut-off point of –36° was associated with a higher rate of response to CRT. Importantly, established herein was a successful cut-off point that distinguishes the predictive value of the QRS axis. It is believed that this finding is of particular interest, however further randomized controlled studies examining these conclusions with a greater number of patients in different environments are necessary.

Limitations of the study

The present study presents typical limitations of a retrospective single-center analysis. Therefore, the findings warrant confirmation in further larger prospective studies. Additionally, the investigated group was heterogeneous and there were different clinical and echocardiographic observers during the study period. It was not possible to define a specific point in time for the follow-up due to retrospective character of the study and lack of routinely scheduled long-term echocardiography examinations in patients treated with CRT. Thus, only patients with echocardiographic examination performed at least 6 months after the device implantation were included as this is the minimum period to observe changes in ejection fraction due to LV remodeling. Another major limitation is the small study group, which potentially exposed the results to type II error. Furthermore, due to a limited sample size the present study did not evaluate other causes for the lack of response to CRT, not associated with pacing, and multivariate analysis was not performed. There was also an inability to perform sub-analyses of the main study results. Only 2 patients in this study had axis other than normal or left deviated (one had RAD and one had EAD). However, the proportion of RAD patients in the present group (2.4%) is comparable to data presented in the literature (e.g. Kronborg et al. [6] reported 4% patients with RAD and LBBB). Finally, lower rates of responders to CRT were

Table 3. Echocardiographic response to CRT (absolute LVEF increased by ≥ 10%): comparison of responders and non-responders, and electrocardiographic predictors of response to CRT in univariate analysis.

	Non-responders (n = 23)	Responders (n = 19)	P
NYHA class at baseline	2.54 ± 0.54	2.55 ± 0.4	0.7
NYHA class at follow-up	2.02 ± 0.53	2.03 ± 0.31	0.94
LVEF preimplantation [%]	28.5 ± 5.0	24.6 ± 5.5	0.02
LVEF postimplantation [%]	27.8 ± 6.0	42.1 ± 8.8	< 0.001
QRS duration (preimplantation) [ms]	161.0 ± 20.3	167.6 ± 17.3	0.27
QRS duration (postimplantation) [ms]	142.8 ± 25.1	146.6 ± 26.2	0.63
QRS duration change [ms] (difference between postimplantation and preimplantation QRS duration)	–18.3 ± 25.4	–21.0 ± 20.4	0.71
QRS axis (preimplantation) [°]	–13.1 ± 34.7	–42.6 ± 44.6	0.021
QRS axis (postimplantation) [°]	–27.0 ± 98.1	–73.3 ± 71.4	0.09
QRS axis change [°] (difference between postimplantation and preimplantation QRS axis)	–13.9 ± 105.4	–30.7 ± 88.3	0.58
Variable	**OR**	**95% CI**	**P**
Electrocardiographic predictors of response to CRT			
QRS duration (preimplantation)* [ms]			
< 150	0.42	0.07–2.46	0.43
150–199	1.64	0.40–6.76	0.73
≥ 200	1.24	0.16–9.75	0.99
QRS duration (postimplantation)* [ms]			
< 120	0.56	0.09–3.45	0.67
120–160	0.75	0.21–2.72	0.75
> 160	2.38	0.49–11.62	0.43
QRS duration (preimplantation) for a 1 ms increase	1.019	0.99–1.05	0.27
QRS duration (postimplantation) for a 1 ms increase	1.01	0.98–1.03	0.62
QRS axis (preimplantation)			
Normal	0.31	0.09–1.10	0.12
LAD	2.08	0.60–7.22	0.35
QRS axis (postimplantation)*			
Normal	0.89	0.17–4.58	0.99
LAD	1.31	0.34–5.01	0.74
RAD	0.20	0.02–1.89	0.2
EAD	1.69	0.49–5.86	0.53
QRS axis (preimplantation) for a 1° increase	0.98	0.96–1.00	0.03
QRS axis (postimplantation) for a 1° increase	0.997	0.99–1.004	0.40
No axis change	1.29	0.31–5.35	0.99
QRS duration reduction	1.04	0.24–4.58	0.99
QRS axis decrease	1.49	0.39–5.66	0.74

*Asterisk signifies that each category of the parameter was compared against all remaining categories joined together. CI — confidence interval; CRT — cardiac resynchronization therapy; EAD — extreme axis deviation; LAD — left axis deviation; LVEF — left ventricular ejection fraction; NYHA — New York Heart Association Class; OR — odds ratio; RAD — right axis deviation; N — number of patients

reported when compared with other studies. This fact may have been caused by a high prevalence of established factors associated with poor response to CRT in the present study participants (i.e. ischemic etiology of HF-rEF, male patients and lower severity of symptoms).

Conclusions

The present study indicates that marked QRS prolongation in pre- and postimplantation assessment and preimplantation negative deviation of the QRS axis are moderate predictors of response to CRT in chronic heart failure patients with low LVEF and LBBB. In detail, substantial pre- and postimplantation QRS prolongation is associated with SR, while more negative pre-implantation QRS axis seems to predict echocardiographic response.

Conflict of interest: None declared

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