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New strict left bundle branch block criteria reflect left ventricular activation differences☆

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Abstract

Aims: Pacing lead electrical delays and strict left bundle branch block (LBBB) criteria were assessed against cardiac resynchronization therapy (CRT) outcome.
Methods: Forty-nine patients with LBBB and QRS duration >130 milliseconds underwent CRT-implantation. Sensed right ventricular to left ventricular electrical delay (RV-LV-IED) was measured. Response to CRT was defined as ≥15% decrease in left ventricular end-systolic volume.
Results: Eighteen of 20 (90%) patients with non-ischemic dilated cardiomyopathy (DCM) and 18 of 29 (62%) with ischemic heart disease (IHD) responded to CRT, $p < 0.01$. When applying new strict ECG criteria subsequent rates of response in DCM were 18/19 (95%) and in IHD of 18/23 (78%) respectively, $p < 0.05$ between IHD groups. Correspondingly, RV-LV-IED was longer in DCM compared to IHD patients and in responders compared to non-responders, $p = 0.017$ and $p < 0.001$, respectively.
Conclusion: Interventricular electrical delay predicts left ventricular remodeling after CRT and new, strict ECG criteria of LBBB are superior in predicting remodeling.

Keywords: Cardiac resynchronization therapy; Heart failure; Left bundle branch block; Interventricular electrical delay; Ischemic heart disease; Non-ischemic dilated cardiomyopathy

Introduction

Cardiac resynchronization therapy (CRT) of patients with activation-induced heart failure improves myocardial contraction coordination, global left ventricular (LV) performance and remodeling with subsequent improvement in morbidity and mortality [1–3]. However, more than one third of CRT recipients do not respond favorably. Recently, left bundle branch block (LBBB) morphology and QRS width, etiology, mechanical activation delay and electrical separation of the implanted right ventricular (RV) and LV leads have been identified as predictors of favorable outcome [4–9].

The substrate for CRT is to resolve a significant electrical activation delay in the LV. The electrical activation of the LV may be highly variable even in the presence of LBBB. Indeed around 1/3 of patients with LBBB by electrocardiogram (ECG) do not have a significantly delayed activation of the LV [10,11]. Recently, it has been proposed that the electrical delay measured between the Q-wave on the ECG and the sensed signal on the LV lead may be of value in predicting response to CRT [5,6]. However, the relation between current ECG criteria and the LV activation delay measured between the ventricular leads has not been described.

In the present study conducted in a group of CRT recipients with LBBB, we tested the hypothesis that sensed differences between the implanted RV and LV leads predicted response to CRT and if the sensed differences between ventricular leads were different between patients with ischemic heart disease (IHD) and patients with non-ischemic dilated cardiomyopathy (DCM). We also tested whether new, strict ECG criteria of LBBB were closer related to interventricular delays than

Abbreviations: CRT, cardiac resynchronization therapy; DCM, non-ischemic dilated cardiomyopathy; ECG, electrocardiogram; IHD, ischemic heart disease; LBBB, left bundle branch block; LV, left ventricular; pLV-sRV, interlead electrical delay from left ventricular pacing to right ventricular sensing; pRV-sLV, interlead electrical delay from right ventricular pacing to left ventricular sensing; RV, right ventricular; RV-LV-IED, right ventricular – left ventricular interlead electrical delay.

☆ Conflicts of interest: none.

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conventional LBBB criteria and thus superior in predicting CRT outcome.

Methods

Study population

Fifty-seven consecutive patients fulfilling the following criteria for CRT-implantation (LV ejection fraction ≤35%, LBBB, QRS ≥130 milliseconds, and New York Heart Association functional class II–IV despite optimal medical treatment) were prospectively enrolled in this study. Only patients in sinus rhythm at the time of examination who were implanted with a St Jude CRT-device were included. Patients were excluded if they had a previously implanted right ventricular pacing lead or CRT-device, significant primary valve disease, atrial fibrillation, coronary revascularization or acute coronary syndrome within 3 months of the baseline echocardiography. All patients had a coronary angiogram prior to implantation to rule out any need for revascularization and all patients categorized as having IHD had a history of myocardial infarction.

Written and informed consent was obtained from all patients prior to implantation, and the study conformed to principles of the Declaration of Helsinki. The local institutional committee on human research approved the study.

Definitions

Conventional ECG LBBB criteria

QRS duration ≥130 milliseconds and QS- or rS-configurations of the QRS-complex in leads V_1 and V_2.

Strict ECG LBBB criteria

QRS duration ≥140 milliseconds (men) or ≥130 milliseconds (women), QS- or rS-configurations of the QRS-complex in leads V_1 and V_2, and mid-QRS notching or slurring in ≥2 of leads V_1, V_2, V_5, V_6, I and aVL [12].

Interlead electrical delays

Interlead electrical delays were measured at baseline prior to CRT activation using the automatic Quick-opt function available on the device programmer Merlin Patient Care 3650 St Jude Medical. The intrinsic right ventricular – left ventricular interlead electrical delay (RV-LV-IED) was measured during spontaneous rhythm, while the paced IED was measured during either RV pacing and sensed LV (pRV-sLV) or LV pacing and sensed RV (pLV-sRV) at a pacing rate to avoid fusion beats and ensure complete ventricular capture. All values were averaged over 8 beats and given in absolute number (milliseconds) as well as percent of surface ECG width. Furthermore, threshold values for pacing output were determined prior to IED measurements and pacing was conducted at an output of threshold × 2.5.

Echocardiography

A full standard echocardiographic examination was performed on the day before CRT implantation and following six months of CRT. All echocardiographic studies were acquired with Vivid 7 Dimension or Vivid E9 using a 3.5 –MHz ultrasound probe (GE-Vingmed Ultrasound, Horten Norway). Off-line analysis was performed using EchoPAC PC version BT11 (GE-Vingmed Ultrasound). Two echocardiography specialists undertook all measurements. LV end-diastolic volume, LV end-systolic volume and LV ejection fraction were assessed using Simpson´s method of disks and each measurement was performed three times and averaged.

Device implantation and programming

All patients were implanted with a CRT device according to standard clinical practice. One lead was implanted in the high right atrium, a right ventricular lead was placed on the mid septum, and the LV lead was placed on the free wall in either a lateral or postero-lateral and mid-ventricular position. Lead positioning was documented from a 30° right anterior oblique and 60° left anterior oblique angulated fluoroscopy and using the clock definition as presented recently [13]. A venogram was performed in all patients, using a balloon catheter, from both the 30° right and 60° left anterior oblique projections to ensure correct LV lead positioning. CRT devices were programmed to the DDD mode with a lower rate of 40 beats per minute. Prior to discharge timing of atrio-ventricular and interventricular delays were performed according to standards as described previously [14,15]. A CRT delivery rate of 95% or higher should be obtained for inclusion in the final analysis.

Statistical analysis

Normal distributions were tested using visual inspection of histogram plots and are presented as either mean ± standard deviation or median with interquartile range. Differences were evaluated using a t-test for normally distributed continuous variables and Wilcoxon´s rank-sum test for continuous variables that did not show a normal distribution. Chi squared was used for all categorical data. A P-value of <0.05 was considered significant.

Results

Baseline clinical characteristics

The study included a total of 57 patients. Eight patients were excluded from the final analysis, 4 patients due to QRS-duration <130 milliseconds, 2 because of non-optimal lead positioning, and 2 due to pacing below 95%. Twenty-nine patients (59%) had IHD and 20 patients (41%) had DCM. The baseline characteristics are shown in Table 1. There were no statistically significant differences between the IHD and DCM patients in any of the baseline characteristics, including duration of the QRS complex. All of the 49 patients included in the final analysis received a right ventricular lead at a midseptal position and a left ventricular lead at a lateral or posterolateral and midventricular position. There were no differences in lead positions between patients with IHD and DCM.