Cardiac resynchronization therapy for electrical dyssynchrony with a narrow QRS duration and left anterior hemiblock

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Introduction

Cardiac resynchronization therapy (CRT) improves cardiac function by correcting electrical dyssynchrony in patients with symptomatic heart failure (HF). However, current guidelines focus on QRS interval alone with respect to electrical dyssynchrony. We implanted CRT in a patient with a QRS interval of 126 ms with left anterior hemiblock because a temporary pacing study before CRT showed correction of left anterior hemiblock with hemodynamic improvement via pacing at the electrically delayed left anterior site alone. The patient's HF symptoms improved from New York Heart Association (NYHA) class III to I with left ventricular (LV) reverse remodeling. A left anterior hemiblock is another category of electrical dyssynchrony, and the current new CRT system can accommodate to correct individual electrical dyssynchrony. Thus, patients with HF and left anterior hemiblock can be suitable candidates for CRT. CRT is a well-established treatment for symptomatic HF, depressed left ventricular ejection fraction (LVEF), and electrical dyssynchrony.[1] Current guidelines[2] support CRT use in patients with prolonged QRS intervals; however, its use is not recommended in patients with narrow or slightly prolonged QRS intervals (<130 ms).[3]

Electrical dyssynchrony can be evaluated using the QRS duration and QRS axis. This report presents a case of QRS axis deviation with a QRS interval of <130 ms and a left anterior hemiblock that was treated with CRT.

KEY TEACHING POINTS

- Cardiac resynchronization therapy (CRT) is a treatment for electrical dyssynchrony in patients with symptomatic heart failure.
- Although QRS duration is <130 ms, left anterior hemiblock is one of the electrical dyssynchronies eligible for CRT.
- Left ventricle–only pacing with fusion of intrinsic right bundle branch activation and automatic A-V interval programming could accommodate electrical dyssynchrony of left anterior hemiblock.

Case report

An 82-year-old woman with nonischemic cardiomyopathy was referred to the hospital because of exercise-induced dyspnea and leg edema. Her height, weight, and body mass index were 150 cm, 52 kg, and 23, respectively. A chest radiograph revealed bilateral pleural effusion and cardiomegaly. Transthoracic echocardiography showed an LVEF of 29%, severe mitral regurgitation (MR) (Supplemental Video 1), and an LV end-systolic volume of 147.1 mL, with a brain natriuretic peptide level of 1432 pg/dL. An electrocardiogram (ECG) showed a sinus rhythm, left anterior hemiblock, a QRS duration of 126 ms, and a QRS axis of -33°. The patient was admitted with a diagnosis of worsening HF.

Postadmission, diuretics and titration of neurohormonal blockades were not effective for the patient's HF, and she experienced persistent NYHA class III HF symptoms. Therefore, an invasive electrophysiological study was performed to evaluate the electrical dyssynchrony and its hemodynamic consequences and to evaluate whether the patient would benefit from CRT.[4]

For hemodynamic measurements, a dual transducer pressure catheter (Pressure Tip Catheter; CD Leycom, Hengelo, The Netherlands) was introduced into the left ventricle. Electrode catheters were placed into the high right atrium and right ventricular (RV) apex. The coronary sinus (CS) was cannulated with an 8.5F preshaped SL2 sheath (Abbott Medical, St Paul, MN). CS venography showed that the anterolateral and posterolateral CS branches were eligible for LV pacing; a 3.5F over-the-wire-type pacing catheter

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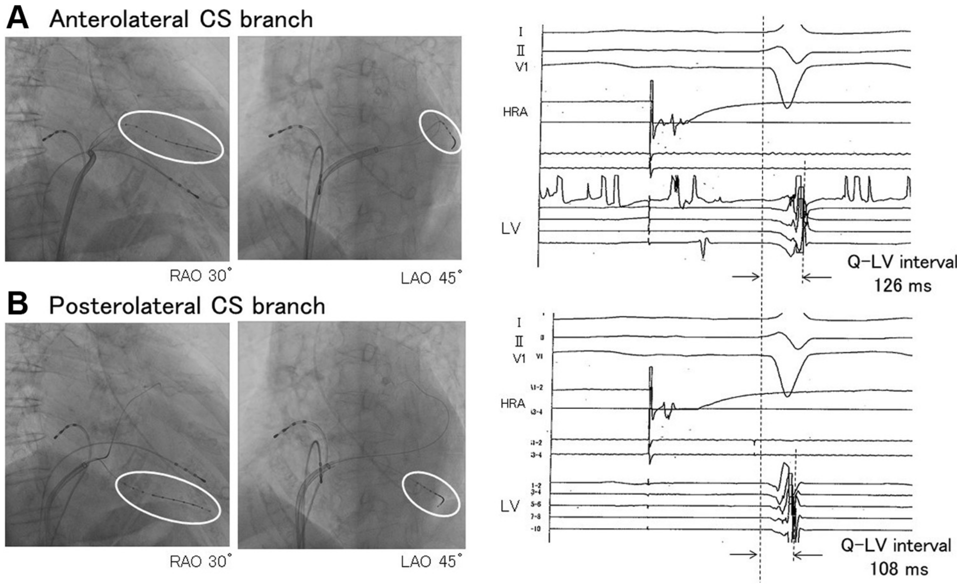

Figure 1 Invasive electrophysiological pacing study performed before cardiac resynchronization therapy device implantation. **A,B:** Electrode catheter locations during the study. **C,D:** Intracardiac electrocardiograms (ECG) recorded from each electrode catheter. The left ventricular (LV) pacing catheter was placed at the LV anterolateral (**A**) and posterolateral (**B**) sites (*white circle*). Intracardiac ECG revealed that the Q-LV interval was longer at the LV anterolateral site than at the LV posterolateral site (126 vs 108 ms). CS = coronary sinus; HRA = high right atrium; LAO = left anterior oblique; RAO = right anterior oblique.

(InterNova Monorail Catheter; InterNova, Tokyo, Japan) with a 0.014-inch guidewire was placed into each eligible branch. The electrical delay measured was calculated as the Q-LV interval.

The Q-LV interval was longer at the anterolateral site than at the posterolateral site (126 vs 108 ms) (Figure 1). In this case, the best pacing site was the mid-LV anterolateral region, because among the CS branches, it is the latest activated region. The Q-RV interval was 28 ms, suggesting preservation of intrinsic right bundle branch conduction. Therefore, the pacing study was conducted with only LV pacing synchronized with intrinsic RV activation.

The maximum LV pressure rate (LV-dP/dt$_{max}$) increase at baseline was 463 mm Hg/s, measured during pacing in the AAI mode (10 beats/min above the intrinsic rate). The interval between the atrial pacing spike and sensed signal at the RV apex was 310 ms; with the same baseline pacing cycle length, pacing in the DDI mode from the anterolateral CS branch site was performed sequentially using different atrioventricular (AV) intervals, with an LV-dP/dt$_{max}$ of 520, 664, 702, and 692 mm Hg/s for AV intervals of 150, 230, 280, and 300 ms, respectively (Figure 2). These findings indicated that an LV pacing advanced 30 ms from RV sensing (310–280 ms) achieved the best hemodynamic improvement.

Based on the temporary pacing study results, a CRT device (Quadra Allure MP CRT-P; Abbott) was implanted, with LV and RV lead positioning at the anterolateral CS branch and RV apex, respectively. The interventricular pacing delay was programmed with LV pacing advanced 30 ms from RV pacing using an interventricular delay optimization program (Sync AV; Abbott).[5] The RV pacing output was programmed at the minimum level (0.1 mV/0.1 ms) to avoid capturing the myocardium, indicating that the RV lead functions in sensing rather than pacing.

The QRS duration remained unchanged post–CRT device implantation; however, the QRS axis changed from a leftward deviation to a normal axis (-33° to 35°) (Figure 3). Thereafter, the patient's HF symptoms improved to NYHA class I, and she was discharged from the hospital. At 6 months post–CRT device implantation, the LVEF was 30%, with mild MR observed on transthoracic echocardiography (Supplemental Video 2). The LV end-systolic volume was 126.7 mL (13.1% reduction compared with that at baseline), and the brain natriuretic peptide level was 121.9 pg/dL. Her ECG findings showed a QRS duration of 126 ms and a QRS axis of 61°.

The patient provided written informed consent before receiving treatment. No consent was obtained for publication, as the data are anonymized.

Discussion

CRT is effective for many patients with systolic HF and electrical dyssynchrony caused by a damaged cardiac electrical conduction system. This report shows the effectiveness of CRT for patients with QRS axis deviation, a QRS interval of <130 ms, and left anterior hemiblock.

A left anterior hemiblock can quantitatively cause less electrical dyssynchrony than a bundle branch block. However, the left anterior fascicle connects to the LV anterior papillary muscle,[6] and a left anterior hemiblock can cause mechanical dyssynchrony between the anterior and posterior papillary muscles, causing MR. The patient developed severe MR before CRT, with post-CRT attenuation. Electrical dyssynchrony with a left anterior hemiblock is quantitatively

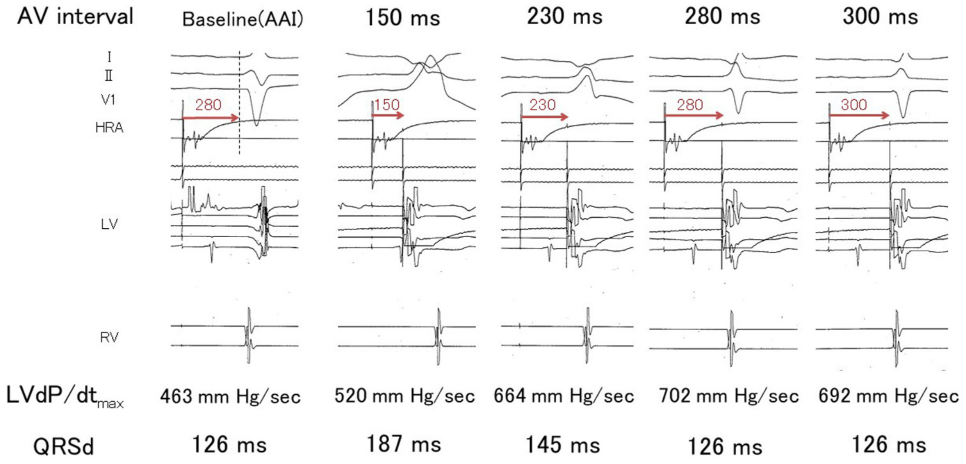

Figure 2 Invasive electrophysiological pacing study using different atrioventricular (AV) interval settings to evaluate the effects on the hemodynamic response. When the AV interval was set to 280 ms, the best hemodynamic response (LV-dP/dt_{max} of 702 mm Hg) was obtained. The narrowest QRS interval was similarly observed during the best hemodynamic response. Notably, right ventricular pacing was not performed, and sensing alone was conducted. LV = left ventricular; LV-dP/dt_{max} = maximal LV pressure rate; QRSd = QRS duration.

smaller than any other electrical dyssynchrony; thus, the post-CRT LVEF improvement in this case was insufficient. However, LV remodeling and NYHA class improvement sufficiently indicated a favorable response to CRT.

A recent study reported that CRT might be effective in patients with a relatively narrow QRS duration if they have a low body mass index because the QRS duration could be underestimated because of a small heart.[7] Therefore, in the Japanese Circulation Society guidelines, class III indication for patients with a QRS interval of <130 ms is not applicable.[8] Patients with a non–left bundle branch block and a QRS interval of <150 ms, similar to this case, have a class IIb indication according to the Japanese Circulation Society guidelines.[8] There are still controversies regarding classification. The QRS duration as a sign of quantitative electrical dyssynchrony is a crucial parameter to evaluate CRT eligibility. However, in patients with a relatively narrow QRS duration, we should consider the QRS axis as a sign of qualitative electrical dyssynchrony.

Shortening of the QRS duration after CRT is one of the predictive parameters to show good response to CRT.[9] However, patients with a relatively narrow QRS duration do not need to show narrower QRS duration after CRT because there is not enough quantitative electrical dyssynchrony at baseline. We should prioritize the QRS axis rather than the QRS duration in patients with a relatively narrow QRS duration to check whether CRT could correct qualitative electrical dyssynchrony.

This case suggested 2 important tips to maximize CRT effectiveness in patients with a left anterior hemiblock. First, the LV lead should be positioned at the LV anterolateral site rather than at the LV posterolateral site, as is typically

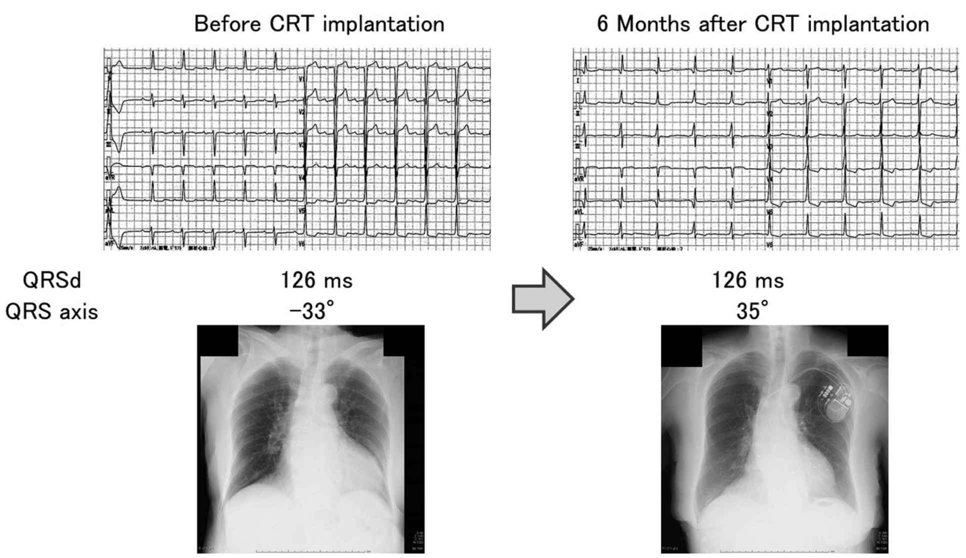

Figure 3 An electrocardiogram and a chest radiograph before and after cardiac resynchronization therapy (CRT) implantation. The QRS duration remained unchanged after CRT implantation. However, the QRS axis was normalized. QRSd = QRS duration.

recommended,[1,10] because the posterolateral site is not the latest activated region in patients with a left anterior hemiblock.[11] Second, LV-only pacing should be programmed in these patients because activation delays are present at the LV anterolateral sites alone. Therefore, RV pacing should be avoided to prevent new ventricular dyssynchrony.[12]

A speckle-tracking echocardiography study demonstrated that CRT is ineffective in treating patients with mechanical dyssynchrony and narrow QRS intervals[3]; especially, it is no longer recommended in this population. However, CRT aims to correct electrical rather than mechanical dyssynchrony.[13] As observed in this case, a left hemiblock can create electrical dyssynchrony with QRS axis deviation without QRS duration prolongation. CRT may be effective in patients with non–left bundle branch blocks and left axis deviations.[14,15] Therefore, it should similarly be considered for patients with QRS axis deviations but without prolonged QRS intervals.

Conclusion

CRT using LV anterolateral pacing synchronized with intrinsic RV activation can be considered in patients with HF and left anterior hemiblocks. Furthermore, CRT may be considered for QRS axis correction and might be beneficial in some patients without prolonged QRS durations.

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Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2021.09.001.

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