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Pressure-Volume Loop Analysis of Multipoint Pacing With a Quadripolar Left Ventricular Lead in Cardiac Resynchronization Therapy

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ABSTRACT

OBJECTIVES This study aimed to compare multipoint pacing (MPP) to optimal biventricular pacing with a quadripolar left ventricular (LV) lead and find factors associated with hemodynamic response to MPP.

BACKGROUND MPP with a quadripolar LV lead may increase response to cardiac resynchronization therapy.

METHODS Heart failure patients with a left bundle branch block underwent cardiac resynchronization therapy implantation. Q to LV sensing interval divided by the intrinsic QRS duration was measured. Invasive pressure-volume loops were assessed during 4 biventricular pacing settings and 3 MPP settings, using 4 atrioventricular delays. Hemodynamic response was defined as change in stroke work (Δ%SW) compared with baseline measurements during intrinsic conduction. Δ%SW of MPP was compared with conventional biventricular pacing using the distal electrode and the electrode with highest Δ%SW (BIV-OPT).

RESULTS Forty-three patients were analyzed (age 66 ± 10 years, 63% men, 30% ischemic cardiomyopathy, LV ejection fraction 29 ± 8%, and QRS duration 175 ± 13 ms). Q to local LV sensing interval corrected for QRS duration was 84 ± 8%, and variation between LV electrodes was 9 ± 5%. Compared with conventional biventricular pacing using the distal electrode, MPP showed a significant higher increase of SW (Δ%SW +15 ± 35%; $p < 0.05$) with a large interindividual variation. There was no significant difference in Δ%SW with MPP compared with BIV-OPT (−5 ± 24%; $p = 0.19$). Male sex and low LV ejection fraction were associated with increase in Δ%SW due to MPP versus BIV-OPT in multivariate analysis, while ischemic cardiomyopathy was only associated in univariate analysis.

CONCLUSIONS Optimization of the pacing site of a quadripolar LV lead is more important than to program MPP. However, specific subgroups (i.e., especially men) may benefit substantially from MPP. (J Am Coll Cardiol EP 2018;■:■-■) © 2018 by the American College of Cardiology Foundation.

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ABBREVIATIONS AND ACRONYMS

Δ%SW = change in stroke work

AV = atrioventricular

BIV-CONV = biventricular pacing with the distal electrode of a quadripolar lead

BIV-OPT = biventricular pacing with the electrode with highest increase in stroke work, of a quadripolar lead

DCM = dilated cardiomyopathy

ECG = electrocardiographic/electrocardiography

EP = electrophysiological

ICM = ischemic cardiomyopathy

LBBB = left bundle branch block

MPP = multipoint pacing

QLV/QRSd = Q to left ventricular sensing interval divided by the intrinsic QRS duration

PV = pressure-volume

RA = right atrial

RV = right ventricular

Cardiac resynchronization therapy (CRT) is an established therapy for patients with heart failure and left ventricular (LV) conduction delay (1). CRT aims to improve LV hemodynamic function by electromechanical resynchronization of LV contraction. Unfortunately, a considerable (30% to 40%) proportion of patients are considered nonresponders to CRT (2). Nonresponse has several causes, of which a suboptimal LV lead position is an important contributor (3). A suboptimal placed LV lead may reduce the effect of biventricular pacing on efficient electromechanical resynchronization (4). Several strategies have been suggested to optimize LV lead position, such as guided LV lead positioning, endocardial pacing, and multisite pacing (i.e., LV pacing in more than 1 vein) or multipoint pacing (MPP) (5,6). MPP implies pacing the LV free wall with 2 pacing stimuli, delivered by a single quadripolar LV lead. MPP may lead to a more homogeneous electromechanical activation and subsequently an additional improvement in LV function (4,7). MPP is proven to be beneficial compared with conventional biventricular pacing in terms of acute hemodynamic response, functional improvement, and reverse remodeling (5,8). Although these results are promising, most studies did not compare MPP with the most optimal setting of biventricular pacing, as obtained with a quadripolar LV lead. Moreover, hemodynamic response of MPP varies among patients (9), suggesting that patient specific differences (e.g., presence of ischemic cardiomyopathy or a low myocardial conduction velocity between electrodes) or therapy delivery (e.g., lead position) are factors contributing to the effect of MPP.

The aim of this study was to compare the short-term hemodynamic response of MPP, measured by invasive pressure-volume (PV) loops, with biventricular pacing using the electrode of quadripolar LV lead with highest increase in hemodynamic function. Patient characteristics as well as electrocardiographic (ECG) and electroanatomic parameters are correlated with MPP response. The hypothesis of this study is that patients with ischemic cardiomyopathy or those with a low myocardial conduction velocity between electrodes of a quadripolar LV lead will benefit from MPP because the additional pacing site may cause a faster or more homogeneous depolarization of the LV.

METHODS

PATIENT COHORT. The OPTICARE-QLV (Optimization of Cardiac Resynchronization Therapy with a Quadripolar Left Ventricular Lead) trial is a multicenter observational study, which was performed in 3 university medical centers (University Medical Center Utrecht; VU University Medical Center, Amsterdam; and Maastricht University Medical Center, Maastricht; all in the Netherlands). Fifty-one patients planned for CRT implantation were prospectively enrolled. Inclusion criteria were moderate to severe heart failure (i.e., New York Heart Association functional class II or III), LV ejection fraction ≤35%, optimal pharmacological therapy, sinus rhythm, and a left bundle branch block (LBBB) according to the Strauss criteria (10). Exclusion criteria were presence of LV thrombus, severe aortic valve stenosis, or a mechanical aortic valve replacement. The study was performed according to the Declaration of Helsinki and in agreement with the local medical ethics committees. All subjects gave written informed consent.

BASELINE CHARACTERISTICS. Before implantation baseline characteristics were collected, among which laboratory tests (creatinine and B-type natriuretic peptide levels), age, sex, New York Heart Association functional class, PR interval, QRS duration, and QRS morphology. All patients underwent an echocardiographic examination and cardiac magnetic resonance imaging before CRT implantation. Derived LV volumes were used to calibrate the conductance catheter-derived volumes. Type of cardiomyopathy was classified as dilated cardiomyopathy (DCM) or ischemic cardiomyopathy (ICM) using the definition of Felker et al. (11). Patients with history of myocardial infarction or revascularization (coronary artery bypass grafting or percutaneous coronary intervention), with ≥75% stenosis of left main or proximal left anterior descending artery, or with ≥75% stenosis of 2 or more epicardial vessels were categorized as ICM.

CRT IMPLANTATION. CRT implantation was performed under local anesthesia. The right atrial (RA) and right ventricular (RV) leads were placed transvenously at conventional positions. The quadripolar LV lead (Quartet 1458Q, St. Jude Medical, St. Paul, Minnesota) was placed transvenously in one of the coronary veins overlying the LV free wall. An anterolateral, lateral, or posterolateral position was preferred. After electrophysiological measurements, the 3 leads were connected to a St. Jude Medical CRT device.

ELECTROPHYSIOLOGICAL MEASUREMENTS. Electrophysiological (EP) measurements were performed