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FOCUS ON CARDIAC RESYNCHRONIZATION

A Possible Role for Pacing the Left Ventricular Septum in Cardiac Resynchronization Therapy

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ABSTRACT

OBJECTIVES The purpose of this study was to investigate whether stimulation at the left ventricular (LV) septum (LVs), alone or in combination with another site, could be an alternative way to apply cardiac resynchronization therapy (CRT) that avoids the coronary sinus and phrenic nerve stimulation and may create more physiological sequence of activation.

BACKGROUND In CRT, biventricular pacing is commonly performed from the right ventricle (RV) and the epicardium of the LV lateral wall (LVlat). In the left bundle branch block (LBBB), half of the electrical delay occurs due to impulse conduction across the septum.

METHODS Experiments were performed in 13 dogs with LBBB, 7 of them with chronic myocardial infarction (LBBB + MI). Pacing leads were positioned in the right atrium, RV, LVs, and at the LVlat epicardium. LV pump function was measured using conductance catheter and synchrony of electrical activation of the ventricles using epicardial mapping and from surface electrocardiogram. In 12 CRT patients, LV pump function was measured during temporary RV + LVs pacing and compared to RV + LVlat and RV + LVlat endo pacing.

RESULTS In the animals, electrical and hemodynamic benefits of LVs and RV + LVs pacing were comparable to those during conventional biventricular pacing and were comparable in LBBB and LBBB + MI hearts. Dispersion of repolarization was reduced by LVs stimulation, but not by LVlat pacing. In patients, hemodynamic benefits of RV + LVs, RV + LVlat and RV + LVlat endo pacing were similar.

CONCLUSIONS The use of the LVs as LV pacing site in CRT improves synchronization and acute hemodynamics comparably to conventional biventricular pacing in dyssynchronous canines and in patients. In addition, LVs stimulation may reduce dispersion of repolarization compared to epicardial pacing. (J Am Coll Cardiol EP 2016;2:413–22)

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ABBREVIATIONS AND ACRONYMS

BiV = biventricular

CRT = cardiac resynchronization therapy

EF = ejection fraction

LBBB = left bundle branch block

LBBB + MI = left bundle branch block plus myocardial infarction

LVs = left ventricular septum

LVlat = left ventricular lateral wall

LVlat endo = endocardial left ventricular lateral wall

Cardiac resynchronization therapy (CRT) improves pump function and clinical status, and reduces morbidity and mortality in patients with moderate-to-severe heart failure and left bundle branch block (LBBB) (1).

Commonly, pacing is performed at the lateral left ventricular (LV) wall, which is often the latest activated region. The LV lateral wall (LVlat) is generally approached through a coronary vein. In 5% to 10% of the patients, however, this route is difficult or impossible to access (2). Alternative approaches are endocardial LV lead positioning or (minimally invasive) surgical epicardial implant, using minithoracotomy (3) or (robotic) video-assisted thoracoscopy (4,5).

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From a physiological perspective, it makes sense to create the most physiological sequence of activation. This may be achieved by pacing the LV endocardium of the interventricular septum, referred to as LV septum (LVs), because this is the normal breakout side in physiological impulse conduction (6). Also, in LBBB the use of this site seems sensible because a considerable part of the total asynchrony in LBBB hearts originates from the delay in conduction across the interventricular septum (7,8). In synchronous canine hearts, LVs pacing resulted in superior acute and chronic LV pump function when compared to conventional right ventricular (RV) pacing and performed as least as good as biventricular (BiV) pacing (9). Recently, our group showed the feasibility and safety of positioning a LVs lead via the transvenous approach in patients with sinus node disease. Also, in these patients the hemodynamic performance during LVs pacing was comparable to that during natural sinus rhythm and better than during RV apical or RV septal pacing (10).

The aim of the present study was to explore a possible role of LVs pacing in CRT. To this purpose, we conducted experiments in the canine model of experimental LBBB, alone or in combination with myocardial infarction (MI). The effects of different pacing modes were assessed on electrical resynchronization and LV pump function. In addition, in 12 CRT candidates, temporary LVs (RV + LVs), LVlat (RV + LVlat endo) and conventional BiV (coronary sinus [RV + LVlat]) pacing was performed and their effect on LVdP/dtmax (the maximal rate of rise of left ventricular pressure) was assessed.

METHODS

Animal handling was performed according to the Dutch Law on Animal Experimentation (WOD) and the European Directive for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (86/609/EU). The protocol was approved by the Animal Experimental Committee of Maastricht University. Clinical experiments were approved by the medical ethical committee of the Catharina Hospital, and all patients provided informed consent.

ANIMAL STUDIES. Experimental setup. Experiments were performed on 13 adult mongrel dogs using protocols described in detail previously (11,12). In 7 of these animals severe transmural MI was created by embolization of either the left anterior descending artery (n = 4) or the left circumflex coronary artery artery (n = 3) (11). Post-mortem staining showed that infarct size was 20 ± 6% (range 14 - 32) of LV mass. LBBB was created by radiofrequency ablation. In the LBBB + MI animals, LBBB was induced 4 weeks after the infarction. The measurements mentioned below were performed after 2 weeks of LBBB.

Electrocardiographic and hemodynamic measurements. Surface electrocardiogram, right ventricle (RV) pressure, and LV pressure were measured and analyzed as described previously (13,14). Electrical activation of the ventricles was mapped using two multielectrode bands around the ventricles, an octapolar electrode catheter placed transvenously in the RV, and LV endocardial plunge electrodes (positioned at the midventricular level of the septum, anterior wall, lateral wall, and posterior wall). Also, mapping electrodes were positioned at the LV endocardial apicolateral wall and at the LV apex (12). LVlat pacing was performed from an electrode on the epicardial multielectrode band and LVs pacing using a plunge electrode, placed at the endocardial midlevel of the LV septum. In the LBBB + MI animals, pacing over scar tissue was avoided. Additional pacing leads were positioned transvenously in the right atrium and RV apex.

From all electrocardiograms acquired, the time of activation and repolarization was determined as the time of steepest negative and positive deflection of the signal, respectively. Total electrical activation time was calculated as the maximal difference in activation time between all RV and LV electrodes.

Protocol. Electrical mapping and hemodynamic measurements were performed simultaneously.