Optimizing Hemodynamics in Cardiac Resynchronization Therapy by Left Ventricular Pacing Site

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Cardiac resynchronization therapy (CRT) significantly improves the cardiac function, clinical outcomes, and survival of patients presenting with advanced, drug-refractory, congestive heart failure; left ventricular (LV) ejection fraction <35%; and a QRS duration $\geq 120$ ms. CRT is now recommended for selected patients with advanced, refractory heart failure due to systolic dysfunction and a wide QRS. However, individual results vary, and 20% to 40% of implanted patients do not respond to CRT.

Several strategies have been developed to address the issue of nonresponders in CRT, including a better selection of patients before implantation and optimization of device programming after implantation. However, the most promising approach seems to be a better selection of LV lead location.

In 2001, Butter et al. (1) demonstrated the role of the LV pacing site in determining response to CRT. Only 2 pacing sites were investigated (anterior and lateral), and positioning the LV lead at the lateral wall was superior to an anterior position. This corresponded to the intuitive concept that, in cardiomyopathy with left bundle branch block, the lateral wall is the site of latest activation and should be the optimal pacing location. To date, the current consensus is to position the LV lead in a lateral or posterolateral branch of the coronary sinus. However, recent studies have challenged this “one-size-fits-all” strategy by testing a larger number of LV pacing locations.

In 2001, Butter et al. (1) demonstrated in a small population of patients with severe ischemic cardiomyopathy initially referred for ventricular tachycardia ablation. By testing a large number of distributed endocardial LV pacing locations (51 ± 14 sites), they defined areas of optimal hemodynamic improvement and studied the relationship to LV activation sequence and areas of post-infarction dense scar. For this purpose, all pacing locations were tagged in a 3-dimensional mapping system. This novel approach allowed display of data collected in sinus rhythm (bipolar voltage and activation timing) as well as data relating to the efficacy of each pacing site (+dP/dt$_{\text{max}}$). In this way, the authors assessed: 1) the size and location of areas giving the optimal response; 2) the relationship between optimal pacing location and LV activation in sinus rhythm; and 3) the relationship between optimal pacing location and LV scar.

The authors showed that in this relatively heterogeneous population of patients with ischemic cardiomyopathy, after an extensive screening of the LV cavity to determine the optimal pacing location, all patients were improved by biventricular pacing (+36% of +dP/dt$_{\text{max}}$ vs. right ventricular apical pacing). In 9 of 11 patients, >2 optimal pacing locations were identified (i.e., sites yielding ≥85% peak increase in +dP/dt$_{\text{max}}$). Seven patients already had a CRT device in situ, allowing comparison of hemodynamics at the optimal LV location versus conventional pacing. The authors report a significant superiority of biventricular pacing at the optimal LV location over conventional pacing (+36% vs. +13% of +dP/dt$_{\text{max}}$, respectively). We reported similar results in a population of idiopathic dilated cardiomyopathy (+31% vs. +15% of +dP/dt$_{\text{max}}$, p < 0.001) (3), suggesting that even patients who are improved by conventional CRT may not be optimally improved. Of note, none of the LV leads of the implanted devices were located in the scar zone.

Even if this study demonstrates the complexity of lead location and CRT response in ischemic cardiomyopathy,
the results of this study suggest that more extensive electrophysiological and hemodynamic testing may improve CRT outcome. However, some limitations need to taken into consideration before translation of the results into routine clinical practice.

The population included was small (understandably because of the difficult inclusion criteria), and therefore conclusions must be drawn cautiously. The study was limited to patients with ischemic cardiomyopathy, and the activation sequence may be more heterogeneous than in patients with nonischemic cardiomyopathy. The hemodynamic improvement recorded at the optimal location was compared with right ventricular apical pacing, which has been previously demonstrated to have a detrimental impact on hemodynamics in heart failure patients, and was compared with conventional CRT in 7 patients only.

Although the study demonstrates important variability among patients, the authors report that in most cases (8 of 11 patients) an extreme basal lateral location was consistently associated with optimal hemodynamic response. The classic mid-lateral free wall was consistently associated with suboptimal improvement of $+dP/dt_{max}$. By systematically using a 3-dimensional electroanatomic map of LV activation, voltage, and hemodynamic response, the authors were able to analyze relationship between hemodynamics and pacing location in relation to post-infarction dense scar and baseline activation of the left ventricle. As observed in previous studies (5,6), the optimal pacing locations were found at a site in the healthy myocardium, remote from the dense scar (9.3 ± 3.6 cm). But, as provided in the Online Appendix, careful analysis of the different maps shows that the optimal site is not only determined by its location relative to the area of scar but is also inhomogeneously distributed in areas of “healthy” myocardium. Areas of latest activation were also insufficient to predict the optimal sites.

There is some debate over possible differences between endocardial and epicardial pacing. Recent animal data have suggested the superiority of endocardial pacing over epicardial pacing by producing a more homogeneous and rapid ventricular depolarization and repolarization and additional improvement in systolic LV pump function (7,8).

In this study, the authors did not find better results in hemodynamics when comparing endocardial pacing with adjacent coronary sinus pacing from the LV lead of the implanted device. We reported a similar result in patients with idiopathic dilated cardiomyopathy (3). However, the comparison was made at only 1 pacing site, and further experiments including a larger sample size are needed to conclude unresolved issues.

The study by Spragg et al. (4) depicts some of the clinical limitations to CRT in our daily practice. In line with a previous study on dilated cardiomyopathy, the results demonstrate the critical impact of the LV pacing site selection in optimizing hemodynamic results of CRT and the need to individualize the approach to CRT in current clinical practice. To date, there is no way to identify the optimal pacing site before implantation, and the protocol used in this study is lengthy and may not be practical for routine clinical practice. However, the results presented by Spragg et al. (4) are impressive in these end-stage heart failure patients for whom CRT is often the last therapeutic option. If LV pacing site selection can make a difference, we should do whatever is needed to ensure an optimal response. CRT in ischemic cardiomyopathy is not all about dodging scar but targeting the optimal site in “healthy” myocardium.

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REFERENCES


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