EDITORIAL COMMENT

Optimization of Ventricular Pacing: Where Should We Implant the Leads?*

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The original goal of implantable pacemakers was to prevent syncope and death due to prolonged periods of asystole from Stokes-Adams attacks and complete heart block (1). Subsequently, devices that were increasingly complex were developed to maintain atrioventricular (AV) sequential activation and to provide a better chronotropic response to exercise. Atrial based pacing (either AAI or DDD) has become standard for patients in sinus rhythm. Compared with ventricular pacing, atrial based pacing improves hemodynamic function and reduces the incidence of pacemaker syndrome, atrial fibrillation and congestive heart failure in patients with sick sinus syndrome. The effect of atrial based pacing on long term mortality is less clear (2-3). Rate responsive pacing improves functional capacity and exercise duration in subjects with chronotropic incompetence (4).

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With the safety and efficacy of permanent pacemakers now well established, research has been focused on optimizing hemodynamic and functional status. In patients with normal ventricular function and intact AV conduction, hemodynamic parameters are worse with atrial triggered right ventricular pacing (VDD mode) compared with ventricular activation through the native conduction system (5-6). In contrast, short AV delay right ventricular pacing has been proposed as a beneficial hemodynamic intervention in other groups of patients, even in the absence of symptomatic bradycardia. For instance, in subjects with hypertrophic cardiomyopathy and outflow tract obstruction, pacing from the right ventricular apex, but not outflow tract, reduces the magnitude of obstruction and improves functional status frequently (7,8).

The role of right ventricular pacing in patients with dilated cardiomyopathy and symptomatic congestive heart failure is more controversial. Early studies reported marked improvement of functional status with VDD pacing from the right ventricular apex (9,10). However, subsequent controlled studies failed to demonstrate any acute or long-term benefit of apical pacing in this cohort (11,12). There are several possible explanations for these disappointing results. First, only a subgroup of patients may improve hemodynamically with pacing, such as those with diastolic mitral regurgitation (13) or those with prolonged intrinsic AV delays (14). A second and more commonly used explanation is that any benefit of optimizing AV delay with pacing is offset by the discoordinated contraction resulting from right ventricular apical pacing. It has been proposed that ventricular activation is improved with right ventricular outflow tract pacing and that this will improve hemodynamic function (15,16). In this issue of the *Journal of the American College of Cardiology*, two important studies are reported evaluating the acute and chronic effects of right ventricular pacing site on hemodynamic and functional status.

**Effect of ventricular lead position.** In the study of Victor and colleagues (17), 16 patients with complete heart block and atrial fibrillation or flutter were evaluated. A dual chamber pacemaker was implanted with one lead in the right ventricular apex and the other in the outflow tract. In doing so, a comparison of the two pacing sites could be made chronically in each subject. Using a randomized, double blind, crossover design following an adequate observational period after AV node ablation and pacemaker implantation, multiple physiologic parameters were evaluated. There were no differences observed between apex and outflow tract pacing, despite measuring cardiac output, exercise duration, peak oxygen consumption, ejection fraction and functional status.

This is a well designed study that directly addresses the issue of the hemodynamic and functional effects of right ventricular lead position. By choosing patients in complete heart block with chronic atrial fibrillation, the confounding influence of atrial pacing and AV delay on outcomes was avoided. However, it remains possible, although unlikely, that a significant effect of pacing site would have been observed in the larger group of patients in sinus rhythm. In addition, only a few subjects had left ventricular dysfunction and congestive heart failure, which is the group that may show the most improvement with optimization of pacing function. Finally, the use of pacemakers with nonphysiologic sensors programmed to nominal values may have masked some functional improvements in this pacemaker dependent cohort. Despite these limitations, this study strongly indicates that routine right ventricular outflow tract pacing is unlikely to be of additional benefit compared with apical pacing. It also reemphasizes the need for properly controlled studies with appropriate endpoints to help guide clinical decision-making.

The question of why right ventricular outflow tract pacing is not superior to apical pacing is addressed in the...
study of Schwaab et al. (18). They evaluated a group of 14 subjects in sinus rhythm with complete heart block. A comparison of right ventricular apical and septal pacing was made in VDD mode, with the septal lead positioned to minimize QRS duration. Because QRS duration is primarily a measure of left ventricular activation time, the hypothesis tested was that left ventricular function would correlate inversely with QRS duration. This hypothesis was supported, because these authors showed that paced QRS duration and not anatomic lead location (apical versus outflow tract) correlated inversely with ejection fraction and directly with the phase distribution of left ventricular contraction. Of the nine patients with longer QRS durations with apical pacing, seven had better left ventricular function with septal pacing, as measured by radionuclide ventriculography. In contrast, all four patients with longer septal QRS durations had better function with apical pacing. As pointed out by the authors, these results are unlikely to have a large clinical effect, because detailed mapping of the right ventricle with precise measurements of QRS duration using orthogonal lead configurations is impractical. Moreover, the long term functional benefit of the changes observed are unknown. Nevertheless, this study establishes the importance of pacing activation patterns and times and not just anatomic lead position for assessing hemodynamic and functional improvement. It is noteworthy that biventricular pacing was reported to improve acute hemodynamic function without shortening paced QRS duration (19). Furthermore, in patients with left bundle branch block and congestive heart failure, the hemodynamic effects of biventricular pacing is not superior to left ventricular pacing alone (20). Thus, QRS duration may be less important than activation patterns when left ventricular pacing is employed.

**Clinical implications.** In patients with intact AV node conduction, right ventricular pacing does not improve hemodynamic or functional status (5,6), even in patients with left ventricular dysfunction (11,12,21). Thus, the programmed AV delay of pacemakers should be prolonged to minimize ventricular pacing in this patient group, and the implantation of pacemakers solely for hemodynamic indications is unwarranted. The only exceptions to this strategy are some patients with obstructive hypertrophic cardiomyopathy (7,8), and possibly those with dilated cardiomyopathy and significant diastolic and systolic mitral regurgitation (13). Right ventricular pacing site does not seem to be an important determinant of hemodynamic or functional performance, so the choice of lead placement should be based on other factors such as anatomic stability, operator preference and the location of other pacing or defibrillator leads in the ventricle. Further controlled studies are needed to assess the role of left ventricular and biventricular pacing, as well as to define whether there are other patient groups that benefit from pacing the right ventricular apex or outflow tract. Fortunately, several well designed multi-center trials are underway with the goal of addressing these issues. The outcomes of these studies will increase the understanding of patient populations most likely to benefit from pacing as well as the optimal position for ventricular leads.

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### REFERENCES


