Role of Permanent Pacing to Prevent Atrial Fibrillation

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Abstract—This advisory summarizes the current database on pacing modalities and algorithms used to prevent and terminate atrial fibrillation (AF). On the basis of the evidence indicating that ventricular pacing is associated with a higher incidence of AF in patients with sinus node dysfunction, a patient who has a history of AF and needs a pacemaker for bradycardia should receive a physiological pacemaker (dual chamber or atrial) rather than a single-chamber ventricular pacemaker. For patients who need a dual-chamber pacemaker, efforts should be made to program the device to minimize the amount of ventricular pacing when atrioventricular conduction is intact. Many pacemakers and implantable defibrillators have features designed to prevent AF and to terminate AF with rapid atrial pacing. The evidence to support their use is limited, although these algorithms appear to be safe and usually add little additional cost. For patients who have a bradycardia indication for pacing and also have AF, no consistent data from large randomized trials support the use of alternative single-site atrial pacing, multisite right atrial pacing, biventricular pacing, overdrive pacing, or antitachycardia atrial pacing. Even fewer data support the use of atrial pacing in the management of AF in patients without symptomatic bradycardia. At present, permanent pacing to prevent AF is not indicated; however, additional studies are ongoing, which will help to clarify the role of permanent pacing for AF. (Circulation. 2005;111:240-243.)

Key Words: AHA Science Advisory n fibrillation n pacing n pacemakers n electrophysiology

Rhythm control continues to be an appropriate strategy for the treatment of patients with symptomatic atrial fibrillation (AF). Because antiarrhythmic drug therapy has many limitations, nonpharmacological therapies have been developed. Pacing techniques that have been proposed as treatments for AF include standard atrial pacing, alternative single-site atrial pacing, multisite atrial pacing, pacing algorithms to increase the amount of atrial pacing and to prevent atrial pauses, and antitachycardia atrial pacing to terminate AF (Table). Despite the commercial availability of many of these options, the role of permanent pacing to prevent AF is controversial. Therefore, the Council of Clinical Cardiology believed that it would be useful to develop an advisory that summarizes the current database on pacing modalities and algorithms used to prevent and terminate AF.

Mechanisms of AF
AF is probably the result of several mechanisms.1 One theorized mechanism is that of the multiple reentrant wavelet,2,3 in which AF results from a critical number of randomly circulating reentrant wavelets. The pathways of these wavelets are not anatomically determined but rather are determined by local atrial refractoriness and excitability. In this mechanism, wavelets can collide and annihilate, divide, or fluctuate in size and velocity. A critical number of wavelets...
must be circulating to sustain the AF. A second mechanism is an atrial focus that generates a rhythm sufficiently rapid that some or much of the remainder of the atria cannot follow with 1:1 activation, resulting in fibrillatory conduction.\textsuperscript{1,4} Theoretically, atrial pacing could prevent AF resulting from reentry or fibrillatory conduction by preventing the changes in refractoriness caused by pauses or bradycardia, reducing intra-atrial conduction times, reducing dispersion of atrial refractoriness, or reducing atrial ectopy.

With regard to a relationship between the mechanism of AF and the potential role of pacing to terminate AF, mechanism by rapid pacing would make sense if the AF mechanism was such that pacing could interrupt the rhythm, because pacing can interrupt reentrant and triggered rhythms. The key, of course, is that the paced impulses must be able to invade the tissue that generates the rhythm. In a canine model of AF resulting from an apparent, stable, reentrant circuit of short cycle length, pacing in that region uniformly interrupts that rhythm (the driver), so that with termination of the burst pacing, the AF also terminates.

**Effect of Pacing on AF in Patients With Bradycardia**

Compared with ventricular pacing alone, atrial pacing is supported by both electrical and mechanical theory in preventing the onset of AF. Atrial pacing prevents potential triggers for AF such as bradycardic episodes and ectopic atrial beats, and atrial pacing avoids the atrial stretching caused by increased atrial pressure that is associated with atrioventricular (AV) dyssynchrony. Observational studies have suggested that the incidence of AF is between \textsuperscript{0} and \textsuperscript{3} per year in patients with dual-chamber pacemakers as compared with an incidence of \textsuperscript{6} to \textsuperscript{15} per year in patients with single-chamber ventricular pacemakers. These studies carry the numerous biases associated with nonrandomized and retrospective studies, however.

Five prospective randomized controlled trials comparing single- (atrial or ventricular) or dual-chamber pacing have evaluated the incidence of AF, usually as a secondary end point, in patients with a history of bradycardia.\textsuperscript{5–9} The evidence from these trials suggests that atrial pacing is superior to ventricular pacing in the prevention of AF in patients with sinus node dysfunction and normal AV conduction. In this group of patients, atrial pacing alone may be superior to dual-chamber pacing, but the data are limited. In the subgroup of bradycardic patients with AV conduction disease, including patients undergoing AV node ablation, the evidence is conflicting.

**TABLE 1. Device-Based Approaches for the Prevention of AF**

<table>
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<tr>
<th>Approach</th>
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<tr>
<td>Standard atrial pacing</td>
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<td>Multisite atrial pacing</td>
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<td>Pacing algorithms to increase frequency of atrial pacing</td>
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<td>Pacing algorithms to maximize native ventricular conduction</td>
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<td>Novel atrial pacing sites (Bachmann bundle, coronary sinus ostium)</td>
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<td>Combination of prevention/termination algorithms</td>
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<td>Hybrid approaches (device with medications or ablation)</td>
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**Multisite Pacing to Prevent AF**

The association between atrial tachyarrhythmias and inter- and intra-atrial conduction delay has led investigators to consider pacing therapies that could decrease the total atrial activation time.\textsuperscript{10,11} Two such options include biatrial pacing, which is accomplished by pacing simultaneously through leads placed at the high right atrium and at the coronary sinus ostium, and dual-site right atrial (RA) pacing.\textsuperscript{12} Studies of these 2 pacing modes have been performed in patients with a bradycardia indication for pacing and a history of atrial tachyarrhythmias. Both pacing modes have been shown to decrease atrial activation time. The only multicenter randomized controlled trial of long-term biatrial pacing, however, failed to show benefit compared with single-site or no atrial pacing.\textsuperscript{13} Several small studies have shown that dual-site RA pacing decreases the incidence of atrial tachyarrhythmias when compared with no pacing or single-site RA pacing; however, a multicenter randomized trial of dual-site atrial pacing versus high RA or support (DDI or VDI) pacing did not reveal a statistically significant benefit of dual-site atrial pacing.\textsuperscript{14} The requirement for 2 atrial leads and a Y connector may limit the usefulness of both biatrial and dual-site RA pacing. Furthermore, whether these pacing modes are superior to atrial septal pacing is unknown.

**Alternative Site Pacing to Prevent AF**

Pacing at RA sites at which preferential interatrial conduction exists will preexcite the left atrium to shorten the total atrial activation time and may reduce the susceptibility for AF. Bachmann’s bundle, a band of muscular fibers that crosses the roof of the atrial septum, and the low interatrial septum near the triangle of Koch or coronary sinus ostium have been studied as alternative pacing sites for AF prevention. Studies of atrial pacing at high or low seapal locations suggest that these sites are as feasible and as safe as conventional pacing from the RA appendage.\textsuperscript{15–18} During an intermediate period of follow-up, RA septal pacing may prevent the progression of AF in patients with bradycardia and AF who have indications for conventional pacing. Furthermore, the additional use of atrial overdrive pacing algorithms appears to further enhance the beneficial effect of septal pacing.\textsuperscript{16} As compared with multisite atrial pacing, these alternative pacing sites require less hardware. The relative efficacy of RA high versus low atrial septal pacing for AF prevention remains unknown; however, the use of high septal pacing is associated with a lower risk of ventricular far-field sensing. Despite these findings, it is important to note that no large multicenter clinical trial of alternative site pacing to prevent AF has been performed. Until these types of data are available, the use of alternative site pacing should be considered unproven and experimental.

**Pacing Algorithms to Prevent AF**

The observation that atrial (AAI) or physiological (DDDR) pacing in patients with sinus node dysfunction retards the development of AF as compared with ventricular (VVI) pacing has created an interest in increasing the “dose” of atrial pacing. To accomplish this while avoiding the continuously elevated heart rate that is associated with increasing the pacing lower-rate limit, a number of algorithms have been developed. Although variable in design, algorithms in general aim to prevent brady-
cardia and to avoid large atrial cycle length variations. Specific algorithms have included rate-adaptive pacing that periodically assesses the underlying intrinsic rate to pace just above it, elevation of the pacing rate after spontaneous atrial ectopy, transient high-rate pacing after mode switch episodes, and increased postexercise pacing to prevent an abrupt drop in heart rate. These algorithms have been added to the armamentarium of device-based approaches for preventing AF and have been shown to increase the frequency of atrial pacing compared with conventional rate-responsive pacing.19

The studies of preventive algorithms have yielded mixed results, possibly because they have used different trial designs, therapies, patient populations, and end points.19–21 Some trials have assessed multiple algorithms simultaneously, further clouding the role of the pacing algorithms themselves.21 Another limitation of these trials has been the absence of information about the frequency of ventricular pacing. Right ventricular apical pacing introduces elevated filling pressures, valvular regurgitation, and changes in ventricular geometry that may adversely affect the atria. An analysis of the MOST (MOde Selection Trial) study demonstrated a linear increase in the risk of AF in association with cumulative percentage of ventricular pacing.22 This suggests that the ventricular dyssynchrony introduced by ventricular pacing increases the risk of AF in sinus node dysfunction even when AV synchrony is preserved. Although algorithms to enhance intrinsic ventricular conduction have been developed, data about their efficacy are lacking. There-
References


Role of Permanent Pacing to Prevent Atrial Fibrillation: Science Advisory From the American Heart Association Council on Clinical Cardiology (Subcommittee on Electrocardiography and Arrhythmias) and the Quality of Care and Outcomes Research Interdisciplinary Working Group, in Collaboration With the Heart Rhythm Society
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