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Review

Current status of atrial pacing algorithms for the prevention of atrial fibrillation: Should algorithms be used?

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A B S T R A C T

Since the development of an atrial pacing algorithm for preventing atrial fibrillation (AF), approximately 20 years ago, many clinical trials have demonstrated the effectiveness of atrial pacing with respect to AF prevention. Nevertheless, the actual effectiveness of AF suppression via atrial pacing remains under debate, and no definitive conclusion has been reached. The AF suppression algorithms embedded in pacemakers have not demonstrated an unequivocal clinical efficacy that would support changing of the guidelines to recommend such algorithms. In this review of studies conducted since 2006, we discuss the efficacies of these AF suppression algorithms and their usefulness in patients requiring pacemaker implantation.

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1. Introduction

Atrial fibrillation (AF) is a highly prevalent atrial arrhythmia that affects approximately 10% of individuals older than 75 years of age and tends to increase in prevalence with advancing age [1–3]. Although AF itself is not life threatening, it is a risk factor for stroke, and the AF-associated stroke mortality rate is high [4–6]. Antiarrhythmic agents are usually effective for treating AF; however, some cases are refractory to pharmacological agents. Although various treatments for AF such as catheter ablation have been used, perfect rhythm control is not easily achieved.

An atrial overdrive pacing algorithm for the prevention of AF was initially reported by Murgatroyd et al. in 1994 [7], and other alternative pacing algorithms have since been developed, including post-premature atrial contraction (PAC) and post-exercise response algorithms and atrial overdrive pacing [8–10,33]. Although many clinical trials have been conducted, the usefulness of AF control algorithms has remained a matter of debate during the past 20 years [8–16]. Additionally, none of the pacemaker guidelines includes an AF suppression algorithm as a standard programming feature for AF prevention in pacemaker patients. The stated reason is that pacemaker-embedded AF suppression algorithms have not demonstrated unequivocal clinical efficacy. In this review, we summarize the previous clinical trials, characterize the efficacy of atrial pacing for AF prevention, and discuss the practical clinical applications of this algorithm.

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2. Prevalence and impact of AF in clinical practice

AF is the most common arrhythmia worldwide, and its prevalence increases with age; AF occurs in approximately 10% of the general population older than 75 years of age [1–3]. The prevalence of sick sinus syndrome or atrioventricular block, which requires pacemaker implantation, also increases with age [17,18]. Asymptomatic AF episodes are detected in approximately 10% of pacemaker recipients, an higher incidence than that observed in the general population [19–21]. AF poses a significant risk of stroke and systemic thromboembolism. Stroke resulting from a large cerebral infarction consequent to a left atrial appendage thrombus is the most severe complication of AF and is associated with a high mortality rate [22,23]. Annually, AF is responsible for 20% of all strokes. Strong evidence suggests that anticoagulant therapy could reduce the annual incidence of stroke in patients with AF; therefore, AF patients should certainly be treated with anticoagulation agents to prevent stroke [24]. However, anticoagulation therapy is underused in clinical practice because of the difficulty associated with drug administration and the risk of bleeding complications [25]. Nevertheless, AF prevention should be given the utmost priority.

3. Benefit of dual-chamber pacing for AF prevention

Several studies have demonstrated that dual-chamber pacing, through which ventricular pacing can be minimized, is superior to single-chamber ventricular pacing in terms of reducing the incidence of AF [26–31]. Atrial (atrial–atrial interval; AAI) and physiologic pacing (dual-chamber pacing, dual-chamber sensing, dual response, and rate-adaptive; DDDR) avoid atrioventricular dyssynchrony, which is associated with increased atrial pressure. The Mode Selection Trial (MOST) study [32] demonstrated a linear increase in the risk of AF up to cumulative ventricular pacing rates of approximately 80–85% in the DDDR and ventricular pacing, ventricular sensing, inhibition response and rate-adaptive (VVIR) modes (Fig. 1). Nielsen et al. [33] compared the AAI and DDDR modes by observing changes in the left atrial (LA) diameter and left ventricular fractional shortening (LVFS). In the DDDR mode, the LA diameter increased significantly ($p < 0.05$) and the LVFS decreased significantly ($p < 0.01$) [33]. Additionally, AF occurred significantly less often in the AAI mode. Therefore, by increasing the atrial stress associated with ventricular dyssynchrony, ventricular pacing might increase the risk of AF even when AV synchrony has been preserved. A large, randomized trial conducted by Connolly et al. [29] reported a significantly lower annual incidence of AF in the physiologic pacing group (5.3%) than in the ventricular pacing group (6.6%).

4. AF suppression algorithm and prevention mechanism

The atrial overdrive pacing algorithm is the most commonly used algorithm for AF prevention. Other pacing strategies have also been developed, including atrial pacing in response to atrial premature beats (post-PAC response), pacing in response to exercise (post-exercise rate control), and post-mode-switch pacing (Fig. 2) [34]. The suppression of potential AF triggers mechanisms, including long pauses after premature beats and atrial refractory period dispersion, through the elimination of pauses consequent to bradycardia or the reduction of premature beats is considered the mechanism responsible for overdrive pacing-mediated AF prevention. Atrial pacing has also been suggested to prevent AF by improving the synchronization of atrial depolarization. Therefore, alternative-site pacing such as Bachmann's bundle pacing, atrial septum pacing, and multisite pacing have been used to prevent AF in several pacing trials [16,35–39]. Several of these studies have demonstrated the efficacy of alternative site pacing versus conventional right atrial appendage pacing for reducing the incidence of AF; however, other studies have not demonstrated similar efficacies. Therefore, alternative-site pacing currently remains controversial in clinical settings.

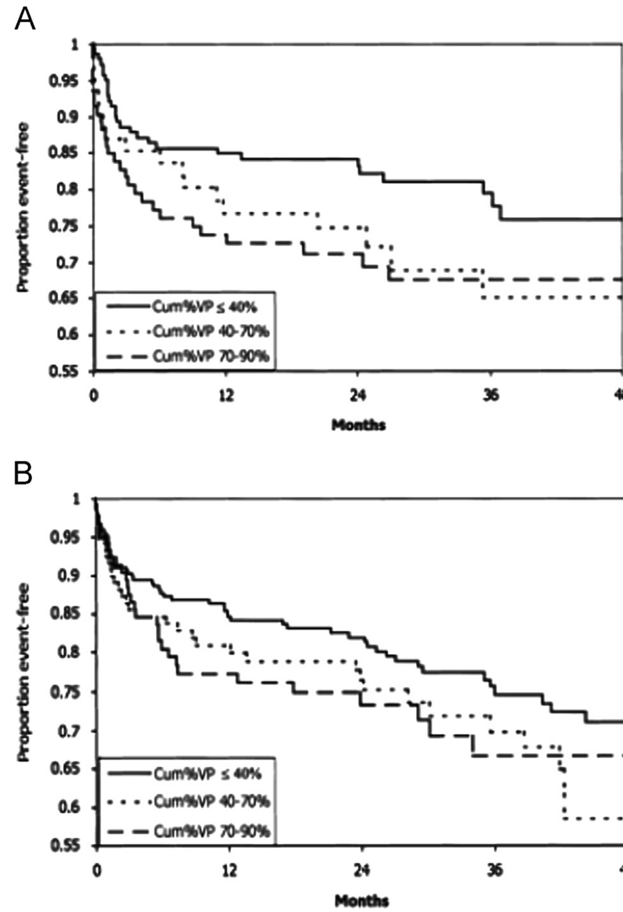

Fig. 1. Kaplan–Meier curves of freedom from documented incidences of atrial fibrillation (AF) as shown by the cumulative percentages of ventricular pacing (cum %VP) during the first 30 days. (A) DDDR mode; (B) VVIR mode (reproduced with permission: reference [31]).

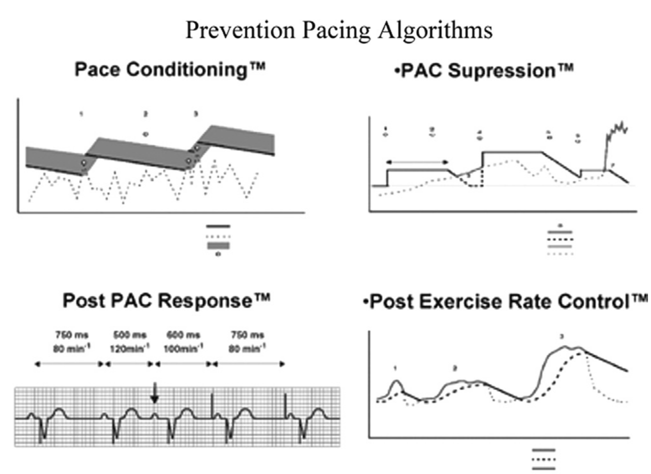

Fig. 2. Schematic view of 4 atrial fibrillation prevention pacing algorithms (reproduced with permission: reference [33]).