

Editorial Comment

Alternate Pacing Sites in the Atria and the Right Ventricle

GEORGE N. THEODORAKIS

2nd Cardiology Department, Onassis Cardiac Surgery Center, Athens, Greece

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Address:

George N.
Theodorakis

Onassis Cardiac
Surgery Center,
356 Sygrou Avenue
176 74, Athens, Greece
e-mail:
elbee@ath.forthnet.gr

More than forty years have passed since the first implantation of a pacemaker with a lead in the apex of the right ventricle.¹ Since then, for many years, whenever a pacemaker was needed pacing was from the right ventricular apex in almost all cases. The reason for choosing this site was that it ensured satisfactory stability of pacing because of the anatomy of the right ventricular apex. However, single-chamber pacing from the right ventricular apex, especially in patients with sick sinus syndrome under long-term follow up, proved to be associated with a clearly higher rate of heart failure, atrial fibrillation, and even total mortality in comparison to the more physiological AAI pacing mode.² Many subsequent studies confirmed the superiority of dual-chamber DDD pacing over single-site VVI.³ This knowledge was the spark that led to the widespread use of dual-chamber DDD pacing in daily clinical practice. However, many questions have arisen as to whether the right ventricular apex is the most suitable site for ventricular pacing. Both experimental data and clinical measurements of cardiac performance have shown that pacing from the right ventricular apex causes a deterioration in cardiac function and is inferior to cardiac depolarisation via the physiological conduction system.⁴⁻⁶ Recently, indeed, the DAVID study show-

ed that DDD pacing from the right ventricular apex in patients with a low ejection fraction causes an increase in mortality.⁷

Atrial pacing was found to reduce the incidence of atrial fibrillation in comparison with ventricular pacing—especially in patients with sick sinus syndrome—and was used to prevent episodes of that arrhythmia.^{3,8} In view of the fact that patients with sick sinus syndrome often have a pathological atrial myocardium and a prolonged intra-atrial conduction time, which pacing from the right atrial appendage prolongs even further, alternate pacing sites were sought. The following such sites are known today:⁹

- the interatrial septum, high (Bachmann's bundle) or low, close to the coronary sinus os;
- biatrial;
- at two sites in the right atrium.

The alternate pacing sites that have been used in the right ventricle are as follows:¹⁰

- the interventricular septum in or close to the His bundle;
- the right ventricular outflow tract.

This article will present a brief overview of the existing knowledge concerning these alternate pacing sites either in the atrium or in the right ventricle.

I) Pacing the atrium

A) Pacing from the interatrial septum, high (Bachmann's bundle) or low, close to the coronary sinus os

Pacing from the interatrial septum was inspired by the thought that stimulation of the interatrial septum would reduce the transatrial conduction time during right atrial pacing. Indeed, studies have shown that pacing from the interatrial septum reduces transatrial conduction time, the width of the P wave and atrio-ventricular conduction time in comparison with pacing from the right atrial appendage.^{11,12}

An initial study by Padeletti et al of 46 patients under septal pacing showed a reduction in the number of episodes of atrial fibrillation from 5 to 0.2 per month. This reduction was greater than in the case of pacing from the right atrial appendage (from 6 to 2 per month).¹³ In a recent, multicentre study involving 298 patients the same authors confirmed the positive effect in the prevention of atrial fibrillation only when the septal pacing used antitachycardiac algorithms (reduction from 2.5 ± 5.2 to 1.4 ± 3 episodes per month).¹⁴ It is interesting that the same study found no such effect on atrial fibrillation during simple anti-bradycardiac pacing from the right atrial appendage or pacing from the interatrial septum. Pacing high in the interatrial septum close to Bachmann's bundle, with continuation of previous antiarrhythmic therapy that had been considered ineffective, resulted in a significant improvement in the patients that reached 68%. In the same study, during 12 months' follow up, the percentage of patients who relapsed to chronic atrial fibrillation was less in the group paced from the interatrial septum at Bachmann's bundle (53% remained in sinus rhythm compared to 25% for the control group).¹⁵

However, a recent study (AFIST II) found that septal pacing was not superior to classical pacing from the right atrial appendage without concurrent administration of amiodarone.¹⁶

B) Batrial pacing

Simultaneous pacing of the right and left atria was proposed by Daubert et al in patients with intra-atrial conduction disturbances as a way of treating patients with sick sinus syndrome. Pacing of the left atrium may be accomplished via the coronary sinus. In Daubert's initial study, the great majority of patients treated with batrial pacing (35 out of 39) remained free of permanent atrial fibrillation. In 7 patients there was a problem with the coronary sinus

electrode.¹⁷ Larger studies with longer follow up showed that at least 30% of patients remained in sinus rhythm and another 30% suffered relapses, while the remainder fell back into chronic atrial fibrillation.¹⁸

Batrial pacing after the internal electrical cardioversion of atrial fibrillation appears to have a beneficial effect, according to one study with a rather small number of patients. After 3 months follow up 8 out of 11 patients remained in sinus rhythm.¹⁹

Prevention of postoperative atrial fibrillation has also been accomplished using batrial pacing, with varying results.²⁰⁻²⁴

At this point it must be stressed that the technical difficulties of implanting an electrode in the left atrium via the coronary sinus and the complications following lead placement mean that batrial pacing is of limited clinical use.⁹

C) Pacing from two sites on the right atrium

Pacing from two sites on the right atrium was proposed by Saksena's group and other researchers, based on the same thinking that prompted batrial pacing.^{25,26} The results of initial studies were positive as regards the prevention of atrial fibrillation. In contrast, a recent, multicentre study showed no statistical difference between dual-site right atrial pacing and single-site or rhythm support pacing. However, in a subgroup of patients who were taking antiarrhythmic medication and were paced from two sites in the right atrium, the authors observed a significant reduction in the episodes of atrial fibrillation compared to patients who were not receiving treatment.²⁷

In conclusion, it appears that alternate pacing sites in the atrium may contribute to the prevention of atrial fibrillation, especially in patients with intra-atrial conduction disturbance who are taking antiarrhythmic medication.

II) Alternate pacing sites in the right ventricle

Patients paced from the right ventricular apex show a reduction in left ventricular function, disturbances of myocardial wall motion and thickness, and also exhibit disturbances of myocardial perfusion and innervation.²⁸⁻³¹ Indeed, a recent study with a paediatric population and mean follow up of 9 years showed a deterioration of both systolic and diastolic left ventricular function as assessed by echocardiography with automatic detection of wall motion.³²

The problem appears to be greater in patients with heart failure, where it seems to have an unfavourable effect on their prognosis. Biventricular pacing is probably the solution for those patients.

The questions remain, however, as to whether young patients should be paced chronically from the right ventricular apex and whether in patients with biventricular pacing the right ventricular electrode should be placed at the apex. That is the reason why alternate pacing sites have been sought, such as the right ventricular outflow tract and the interventricular septum close to the His bundle.

1) Pacing from the His bundle

Attempts at pacing from the His bundle were made by Karpawich et al and were obviously aimed at depolarising the heart through the physiological conduction system.⁵ In fact, His bundle pacing in animals gave conduction times similar to those under sinus rhythm, whereas right ventricular apical pacing resulted in a prolongation of depolarisation with longer conduction times. In clinical practice His bundle pacing has been accomplished by one research group in 4 patients with dilated cardiomyopathy and gave results similar to those of Karpawich et al. In one patient there was electrode displacement.³³ Given the limited clinical experience from His bundle pacing and the likely disturbance of conduction, especially in older patients, this way of pacing has not found acceptance for wider clinical use.

2) Pacing from the right ventricular outflow tract

This is the main alternate site for right ventricular pacing. Many studies have seen the light of publication and have given varying results. In a recent meta-analysis of at least 9 studies that compared the effects of apical versus outflow tract pacing the results tended to favour pacing from the right ventricular outflow tract. Specifically, in a total of 217 patients included in the meta-analysis, there was a 34% benefit (odds ratio 0.35, confidence intervals 0.15-0.53) from outflow tract pacing.³⁴ From this analysis only two studies showed positive long-term results, while the others provided only immediate haemodynamic measurements. For example, Victor et al³⁵ found no benefit from right ventricular outflow tract pacing after 43 months' pacing, whereas Mera et al³⁶ found an improvement in left ventricular fractional shortening after 2 months. A recent study³⁷ examined the long-term difference

between outflow tract and apical pacing in 24 patients. It was immediately apparent that the 12 patients paced from the outflow tract had a shorter QRS complex than the 12 who were paced from the right ventricular apex (134 ± 4 ms versus 151 ± 6 ms, respectively).

After 18 months' follow up, the apical pacing group had greater perfusion defects and regional wall motion disturbances compared to the group paced from the right ventricular outflow tract. Furthermore, the apical pacing group showed a reduction in ejection fraction, which remained unchanged in the other group.

Therefore, pacing from the right ventricular outflow tract is likely to be a better approach, especially in children or in patients with heart failure in combination with biventricular pacing from the left ventricle.

The study by Manolis et al³⁸ in this issue supports this kind of move, namely towards alternate pacing sites in both the atria and ventricles, for the reasons presented above. The technological developments in pacing electrodes with drug-eluting capabilities will be a major contribution to the future.

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