Supplemental Material

Algorithms to Minimize RV Pacing

Two programming approaches have been developed to minimize RV pacing (Table 1). These include adaptive/dynamic algorithms permitting extension of the AV delay when intrinsic conduction is detected. The maximum AV delay permitted varies between the different device technologies and is determined by the programmed baseline AV delays and the programmed maximum allowed extension of the AV delays. The nuances of these adaptive algorithms have been recently described in detail.\(^1\) The second approach are mode switching algorithms that pace in the AAI mode when intrinsic AV conduction is detected but switches to dual chamber pacing when AV block occurs.

Several studies have compared the Managed Ventricular Pacing (MVP) mode switch algorithm to an AV search hysteresis algorithm.\(^2\)\(^-\)\(^4\) All three studies have reported a greater reduction in RV pacing with the MVP algorithm compared to the search AV hysteresis algorithm including in patients with intermittent AV block (Supplemental Figure 1). However, these differences have not been shown to impact clinical outcomes. The largest study conducted randomized 385 patients receiving dual chamber pacemakers to the MVP mode or search AV hysteresis programming. A significant reduction in % RV pacing was demonstrated in the group randomized to the MVP mode which persisted over one year of follow-up. Although the majority of patients enrolled had SND as the indication for pacing the overall burden of AF observed during follow-up was low and did not correlate with % RV pacing.\(^4\)
Anomalies of Mode Switching Functions

Overall the algorithms mode switching from AAI to DDD when AV block occurs have been demonstrated to be safe. Some unusual behaviors of the mode switching functions have been described in case reports.\textsuperscript{5,6} For example, the MVP algorithm is based on ventricular timing intervals which at times may allow longer pauses.\textsuperscript{5,6} Pause-dependent ventricular tachyarrhythmias have been reported as by design pauses in excess of just over twice the programmed lower rate may occur at onset of AV block prior to switching from AAI to DDD mode.\textsuperscript{6} Frequent VPBs have been reported to cause inappropriate mode switching from AAI to DDD mode.\textsuperscript{7} These examples are reminders that programming of devices must be individualized.
Supplemental References


## Supplemental Table 1: Studies Reporting Potential Deleterious Effects of Frequent Right Ventricular Apical Pacing

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients</th>
<th>Design</th>
<th>Outcomes</th>
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<tbody>
<tr>
<td>DAVID$^8$</td>
<td>506 Patients with ICD Indication</td>
<td>Prospective randomized DDDR lower rate 70 bpm vs Backup VVI Pacing lower rate 40 bpm.</td>
<td>1.61 increased relative risk of death or HF hospitalization.</td>
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<td>MOST Substudy$^9$</td>
<td>1339 Patients</td>
<td>SND Pacing Indication; QRS &lt; 120 ms; Retrospective analysis comparing DDDR vs VVIR pacing.</td>
<td>Cumulative % VP &gt; 40% in DDDR mode associated with 2.6 fold risk of HF hospitalization; Cumulative % VP &gt; 80% in VVIR mode associated with 2.5 fold risk of HF hospitalization; Risk of developing AF increased by 0.7% or 1.0 % for each 1% increment in cumulative % VP up to 80% in VVIR and DDDR groups respectively.</td>
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<tr>
<td>SAVE PACE$^{10}$</td>
<td>1065 Patients</td>
<td>SND Pacing Indication; Normal QRS duration and AV conduction</td>
<td>Prospective Randomized DDDR (AV delays 120-180 ms) vs DDDR with algorithms to minimize ventricular pacing.</td>
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<tr>
<td>PACE$^{11,12}$</td>
<td>177 Patients</td>
<td>Bradycardia Pacing Indication; LVEF ≥ 45%</td>
<td>Prospective Randomized BiV vs DDDR pacing.</td>
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<tr>
<td>BLOCK HF$^{13}$</td>
<td>691 Patients</td>
<td>High Grade AV Block Pacing Indication; LVEF ≤ 50%</td>
<td>Prospective Randomized BiV vs RV apical pacing (pacemaker or ICD based on clinical indications).</td>
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<tr>
<td>MADIT $^{14}$</td>
<td>567 ICD Patients</td>
<td>Retrospective analyses</td>
<td>During late phase of extended follow-up mortality increased in patients with % RV pacing &gt; 50% without baseline LBBB.</td>
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<tr>
<td>Extended Follow-up</td>
<td>65% RV paced ≤ 50%</td>
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SND – sinus node disease  
BiV – biventricular  
LBBB – left bundle branch block  
VP – ventricular pacing
% RV Pacing at 12 Mo

Supplemental Figure 1. Differences in median % RV pacing when pacemakers are programmed to either the MVP or search AV Hysterisis (SAV) algorithms based on underlying indication for pacing – sinus node disease (SND) or AV block and type of AV block. There were only 8 patients with intermittent complete AV block (i3°AVB) in the SAV group.

Data from Chen S et al Europace. 2014 Apr 4. [Epub ahead of print]
Supplemental Figure 2. Mean LVEF at baseline, 1 and 2 years follow-up in patients randomized to DDD or BiV pacing. LVEF decreased significantly over time in the RV apical pacing group. Data from Chan JY et al, Eur Heart J 2011;32:2533-2540.