Double-Counting of Intracardiac Electrogram During Biaatrial Pacing

Tsukasa Kobayashi, MD; Toshiyuki Ishikawa, MD; Shinichi Sumita, MD; Youhei Yamakawa, MD; Yasuo Ohkusu, MD; Kohei Matsusita, MD; Katsumi Matsumoto, MD; Tsuyoshi Nakagawa, MD; Ichirou Nakazawa, MD; Yasuyuki Mochida, MD; Toshiaki Ebina, MD; Kazuaki Uchino, MD; Kazuo Kimura, MD; Satoshi Umemura, MD

Background  Biaatrial pacing has a significant problem with memory function that misinterprets normal sinus rhythm as atrial tachyarrhythmias and in addition estimation of the atrial pacing thresholds (biaatrial and uniatrial pacing thresholds) is sometimes difficult because of small P waves.

Methods and Results  The intracardiac electrograms recorded by a pacemaker in 10 patients (age, 66.7±10.7 (SD) years) with implanted biaatrial pacemakers were analyzed. Atrial sensing within the atrial refractory period after atrial pacing was counted in 6 of the 10 patients (timing of the double counting was 143±64 ms) when pacing failed in the left or right atrium. Atrial sensing within the atrial refractory period after atrial pacing disappeared when biaatrial pacing was successfully performed. Atrial double-counts depend on interatrial conduction delay. The memory function of implanted pacemaker devices misinterpreted normal sinus rhythm as atrial tachyarrhythmias because of atrial double-counts. On the other hand, the biaatrial pacing threshold was easily recognized using this phenomenon.

Conclusions  The memory function of pacemaker devices is unreliable because of atrial double-counting during sinus rhythm in patients with biaatrial pacing. However, the biaatrial pacing threshold is easily checked using this phenomenon. (Circ J 2004; 68: 131–134)

Key Words:  Atrial fibrillation; Biaatrial pacemaker; Intraatrial electrogram; Pacing threshold

Although atrial fibrillation (AF) is the most commonly encountered arrhythmia and is associated with a high incidence of stroke and increased cardiovascular mortality,2 in many cases it is still difficult to treat. Previous studies argued that multisite atrial pacing may prevent the recurrence of AF,3–10 but in the application of biaatrial pacing, we have often found double-counting of the intracardiac electrogram in the atrium because of interatrial conduction delay. The slow conduction in the right atrium and retrograde left atrial activation result in inhomogeneous activation of the left atrium and intra- and interatrial asynchrony. This conduction delay is important relation to the mechanisms that underlie AF, and the majority of patients with interatrial conduction delay have a high incidence of atrial tachyarrhythmias.11 In the present study, we evaluated double-counting of the intracardiac electrogram in the atrium and used it to estimate the atrial pacing threshold.

Methods

Study Population  The study group comprised 10 patients (5 men, 5 women; mean ±SD age, 66.7±10.7 years, range 41–78 years) who were referred to hospital between October 2000 and August 2001. They underwent pacemaker implantation for sick sinus syndrome (SSS) and also had paroxysmal AF.

Pacemaker Implantation  Biaatrial dual-chamber pacemaker implantation was performed. The cephalic vein was used whenever possible, and the other 2 leads were inserted into the axillary vein by percutaneous puncture. First, the left atrial lead was introduced and positioned in the distal or mid site of the coronary sinus. After the lead was fixed, the ventricular lead and right atrial lead were introduced with passive fixation. We used the unipolar lead for the left atrium, and the bipolar leads for the right atrium and ventricle. The interelectrode distance of the bipolar lead was 17 mm. The coronary sinus lead was connected to the anodal port of the Y-connector and the distal electrode of the right atrial lead to the cathodal port. The connector was inserted into the atrial port of a DDR pacemaker (Thera DR™ or Kappa™, Medtronic, Minneapolis, MN, USA). The ventricular lead was inserted into the ventricular port. The generator was positioned in the prepectoral pocket and the pocket was closed.

Patient Follow-up  Arrhythmia control and device performance were assessed at outpatient visits. Intracardiac electrograms were recorded using the memory function of the implanted pacemaker devices, and the biaatrial pacing threshold was checked.
Device Performance
The mean pacing threshold was evaluated as output (V) × pulse width (ms). The mean pacing threshold was 2.0±2.0V×ms and 0.64±1.0V×ms for the left and right atrium, respectively. The sensed atrial amplitude was 2.4±1.4mV. The mean ventricular pacing threshold was 0.4±0.28V×ms, and the sensed ventricular amplitude was 12.5±6.2mV (Table 1).

Atrial Conduction Delay
Atrial sensing within the atrial refractory period after atrial pacing was recorded in 6 of the 10 patients when pacing failed in the left or right atrium. A representative case is shown in Figs 1 and 2. The interval between 2 atrial markers of the event counter in each P wave was measured as a timing of the double counting and was 143±64 ms (Table 1). Atrial sensing within the atrial refractory period after atrial pacing disappeared when biatrial pacing was successfully performed. In the other 4 patients, atrial sensing within the atrial refractory period after atrial pacing was not recorded even when pacing failed in the left or right atrium. The atrial blanking period was 50–100 ms, automatically determined by the pacemaker.

Results

Table 1 Demographic and Clinical Characteristics of the 10 Study Patients

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age (years)/ Sex</th>
<th>Etiology</th>
<th>Threshold of both atria (V/ms)</th>
<th>Threshold of one atrium (V/ms)</th>
<th>P sense (mV)</th>
<th>Amplitude of the double counting (mV)</th>
<th>Timing of the double counting (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>78/F</td>
<td>CAD</td>
<td>3.0/0.4</td>
<td>0.5/0.4</td>
<td>2</td>
<td>2</td>
<td>240</td>
</tr>
<tr>
<td>2</td>
<td>66/F</td>
<td>CAD</td>
<td>3.5/0.4</td>
<td>1.0/0.4</td>
<td>None</td>
<td>0.6</td>
<td>140</td>
</tr>
<tr>
<td>3</td>
<td>77/F</td>
<td>CAD</td>
<td>2.0/0.4</td>
<td>1.0/0.4</td>
<td>2</td>
<td>3</td>
<td>200</td>
</tr>
<tr>
<td>4</td>
<td>63/M</td>
<td>CAD</td>
<td>3.0/0.4</td>
<td>1.0/0.4</td>
<td>1.4</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>66/M</td>
<td>CAD</td>
<td>5.0/0.4</td>
<td>1.0/0.4</td>
<td>2.8</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>41/F</td>
<td>ATL</td>
<td>7.5/1.0</td>
<td>3.5/1.0</td>
<td>0.7</td>
<td>1.5</td>
<td>80</td>
</tr>
<tr>
<td>7</td>
<td>64/M</td>
<td>ATL</td>
<td>5.5/0.4</td>
<td>0.5/0.4</td>
<td>5.6</td>
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<td>2.8</td>
<td>4</td>
<td>100</td>
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<tr>
<td>9</td>
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<td>2</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>10</td>
<td>64/F</td>
<td>Polymyositis</td>
<td>7.5/0.34</td>
<td>1.0/0.4</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

CAD, coronary artery disease; ATL, adult T cell leukemia.

Fig 1. Electrocardiograms during biatrial pacing recorded in a 63-year-old man. (a) During sinus rhythm the P wave duration was 155 ms. (b) When the atrial pacing output was set at 2.5 V (0.4 ms), left atrial pacing failed and only the right atrium was captured. P wave duration was 157 ms. (c) When atrial output increased from 2.5 to 3.0 V (0.4 ms), biatrial pacing was successfully performed. P wave duration decreased to 120 ms.
Memory Function of Implanted Pacemaker Devices

In 6 of the 10 patients the memory function of the implanted pacemaker devices misinterpreted normal sinus rhythm as atrial tachyarrhythmias because of atrial double-counts (Fig 3).

Discussion

P wave duration and morphology are good markers of AF recurrence.2,3 Compared with sinus rhythm, conventional right atrial pacing prolongs P wave duration and can cause recording of split atrial intracardiac electrograms.5 Clinical studies have shown that multisite atrial pacing may be effective in preventing the recurrence of AF.4–10

There is marked shortening of the P wave duration with biatrial pacing in AF patients.16 However, during biatrial pacing in AF patients, estimation of the incidence of AF by the memory function of the pacemaker is sometimes difficult because the reliability of the memory function is not clear and there is not a specially designed pacemaker for multisite atrial pacing. A high right atrial lead and left atrial coronary sinus lead are usually connected by a Y-connector to achieve biatrial pacing and simultaneous left and right atrial intracardiac electrograms can be recorded. However, inter-atrial conduction delay may lead to atrial double-counts and in patients with markedly prolonged inter-atrial conduction delay the left and right atrial intracardiac electrograms are double-counted during sinus rhythm. It occurs when the inter-atrial conduction delay is longer than the atrial blanking period. As a result, the memory function of implanted pacemaker devices misinterprets normal sinus rhythm as atrial tachyarrhythmias. In the present study, atrial sensing within the atrial refractory period after atrial pacing was counted because of the markedly prolonged inter-atrial conduction time, which in 6 of the 10 patients was longer than the atrial blanking period when pacing failed in the left or right atrium. In the other 4 patients, atrial sensing within the atrial refractory period after atrial pacing was not recorded.

The following 3 reasons are suggested as mechanisms.

1. The inter-atrial conduction time was shorter than the atrial blanking period.
2. The amplitude of the double-counting was too small.
3. The atrial waves of the double-counting were in the atrial blanking after a ventricular event because of the short PQ interval.

Atrial double-counting needs to be eliminated when the incidence of atrial tachyarrhythmias is estimated by the
memory function of implanted pacemakers. Unipolar atrial sensing is required to avoid this phenomenon. In the current study, we eliminated atrial double-counting by changing from biatrial pacing to right atrial unipolar pacing and the problems will be ultimately solved when a specially designed pacemaker for multisite atrial pacing is used.

Biatrial pacing has 2 atrial pacing thresholds; one is for both the left and right atria (biatrial pacing threshold) and the other is for either the left or right atrium (uniatrial pacing threshold). Estimation of the atrial pacing threshold is sometimes difficult because of atrial double-counting during atrial fibrillation. Atrial sensing within the atrial refractory period after atrial pacing disappears when biatrial pacing fails in the left or right atrium. Atrial sensing within the atrial refractory period after atrial pacing is recorded when atrial double-counting. Atrial sensing within the atrial refractory period after atrial pacing disappears when biatrial pacing is successfully performed.

In conclusion, the memory function of pacemaker devices is unreliable because of atrial double-counting during sinus rhythm in patients with biatrial pacing. However, the biatrial pacing threshold is easily checked using this phenomenon.

References