Clinical Studies

Comparison of Susceptibility of Myopotential Inhibition between AAI and VVI Pacemakers

Hiroshi Ito, M.D., Yoshito Iesaka, M.D., Koichi Taniguchi, M.D., F.A.C.C., and Jugoro Takeuchi, M.D.

SUMMARY

Susceptibility of unipolar AAI pacemakers to myopotential inhibition (MPI) was assessed in 10 patients by provocative maneuvers and 24-hour Holter monitoring, and compared to that of unipolar VVI pacemakers in 12 patients. Five maneuvers were performed for each of four different sensitivity levels, and an MPI score of from 0–4 points was given according to the lowest sensitivity level at which MPI was provoked. The MPI score in patients with AAI pacemakers was significantly lower than that in patients with VVI pacemakers, 1.60±1.26 vs 2.83±1.03 (p<0.05). On Holter monitoring, no MPI was detected in any of the patients with AAI pacemakers, whereas myopotential inhibition was detected in 5/12 patients (42%) with VVI pacemakers. Intracardiac electrograms were of lower amplitudes for AAI pacing than for VVI pacing, 3.13±1.83 mV vs 11.20±5.95 mV (p<0.01). Although the amplitude of atrial signals was lower than that of ventricular signals, the AAI pacemakers were less susceptible to MPI than were the VVI pacemakers. However, when MPI occurs in AAI pacing, it may be more difficult to correct without undersensing because of the lower amplitude of the intracardiac signals.

Additional Indexing Words:
Unipolar pacemaker Provocative maneuvers Holter monitoring

It is well recognized that myopotentials, which arise from skeletal muscle activity, may inhibit the output of unipolar VVI pacemakers. Various reports concerning this complication have been published, including a report from our laboratory on the effectiveness of the maneuvers used to test for myopotential inhibition (MPI) in this study.1),2)
AAI pacemakers are currently used for the treatment of bradyarrhythmias without atrioventricular conduction disturbances. Oversensing of myopotentials may occur in unipolar AAI as well as in unipolar VVI pacemakers. However, there are only a few descriptions of MPI in the literature.

**Methods**

Ten patients with AAI pacemakers and 12 patients with VVI pacemakers were included in the study. The mean age of patients with AAI pacemakers was 66.5 years (range 42–85) and that of patients with VVI pacemakers was 71.8 years (range 54–85). All patients had Siemens Elema 668 or 688 pulse generators implanted in their right or left subclavicular area (Table I). Cordis endocardial unipolar J-leads were used for AAI pacemakers and Siemens Elema unipolar ventricular leads were used for VVI pacemakers. In all patients the indication for pacing was the sick sinus syndrome. Intracardiac signals were measured at the time of pacemaker implantation.

The following provocative maneuvers were performed by all patients (Fig. 1):

<table>
<thead>
<tr>
<th>Pacing System</th>
<th>No. of Patients</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Implant Pacemaker</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Siemens Elema</td>
</tr>
<tr>
<td>AAI</td>
<td>10</td>
<td>42–85</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>VVI</td>
<td>12</td>
<td>54–85</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>

(1) Hand Press Test  
(2) Pulling Test  
(3) Pushing Test  
(4) Teeth Brushing Test  
(5) Hand Clapping Test

Fig. 1. Provocative maneuvers: (1) hand press, (2) pulling, (3) pushing, (4) teeth brushing, and (5) hand clapping.
Fig. 2. ECG monitoring during the provocative maneuvers in a patient with an AAI pacemaker. MPI may be provoked by all five of the exercises.

1. Pressing both hands together in a praying motion.
2. Pulling the examiner’s hand using the hand on the implanted side.
3. Pushing the examiner’s hand using the hand on the implanted side.
4. Rhythmic motion like brushing teeth.
5. Rhythmic motion of clapping hands.

Each exercise was performed at maximum strength for a duration of more than 5 sec. Electrocardiograms were recorded during the exercise. MPI was defined as inappropriate prolongation of RR or PP intervals during the provocative maneuvers (Fig. 2), which were performed at four levels of sensitivity (very high, high, low, very low). An MPI score was assigned as follows:

- No MPI: 0 points
- Inhibition at “very high” setting: 1 point
- Inhibition at “high” setting: 2 points
- Inhibition at “low” setting: 3 points
- Inhibition at “very low” setting: 4 points

Mean MPI scores were compared between AAI and VVI pacemakers. T-test and Cochran-Cox tests were used for all statistical analysis.
RESULTS

*Intracardiac signals:*

For the AAI pacemakers intracardiac electrograms measured at the time of implant ranged from 2.0 to 7.5 mV with a mean amplitude of $3.23\pm1.83$ mV, while for the VVI pacemakers the electrogram amplitude ranged from 6.6 to 25.0 with a mean of $11.20\pm5.95$ mV. The signal amplitudes of the AAI pacemakers were significantly lower than that of the VVI devices ($p<0.01$).

*Provocative maneuvers:*

Provocative maneuvers were defined as being positive when MPI was caused by one or more of the exercises at any tested sensitivity. The results of provocative testing are shown in Fig. 3; the MPI score for each maneuver was lower for AAI pacemakers than for VVI pacemakers, but the difference

![Fig. 3. Results of provocative maneuvers for each exercise. MPI score (myopotential inhibition score) was lower in patients with AAI pacemakers for all exercises.](image-url)
in response between AAI and VVI pacemakers was only statistically significant for pulling and pushing (Fig. 3). However, the total MPI score was statistically significantly lower for AAI pacemakers, 1.60 ± 1.26, than for VVI pacemakers, 2.83 ± 1.03 (p < 0.05) (Fig. 4). During the maneuvers no symptoms due to pacemaker inhibition were encountered.

*Holter monitoring:*

Continuous 24-hour electrocardiographic monitoring detected MPI in 5 of 12 patients with VVI pacemakers (42%) and in none of the patients with AAI devices. In the 5 patients with VVI pacemakers who exhibited pacemaker inhibition, between 5 and 40 instances of inhibition occurred during the monitoring period. The maximum duration of RR interval prolongation varied from 1.48 to 1.66 sec. None of the patients complained of symptoms which could be ascribed to inappropriate pacemaker inhibition.

In our study population unipolar AAI pacemakers were less vulnerable to inappropriate MPI than were unipolar VVI pacemakers by both provoca-
Discussion

In 1972, Wirtzfeld originally demonstrated that myopotentials arising from pectoral muscle activity frequently inhibited unipolar ventricular demand pacemakers implanted in the subclavicular region. Since Wirtzfeld's report many papers have been published on this subject. We have also previously reported that a high incidence of MPI (70%) was provoked in VVI pacemakers using the same provocative maneuvers employed in this study.

In this study we employed five different maneuvers: (1) hand press, (2) pulling, (3) pushing, (4) teeth brushing, and (5) hand clapping. All these maneuvers may induce myopotentials from pectoral muscles. The first three maneuvers are similar to those used by Secemsky et al, who recorded skeletal muscle interference in 38% of VVI pacemakers while using those exercises. The last two maneuvers, to our knowledge, have not been previously described. These rhythmical movements are clinically useful in detecting MPI, because they are routinely used in daily life. We have had a patient who suffered an Adams-Stokes attack while brushing his teeth or clapping his hands in the course of daily life.

The reported frequency of MPI shows large variations, ranging from 11 to 85%. This variation may be due to differences in the provocative maneuvers which were employed by the different investigators. Gaita described the importance of a combination of several maneuvers. In our study the most effective exercise differed among individual patients. If only one exercise had been used, MPI would have been underestimated.

AAI pacemakers are used for the treatment of bradyarrhythmias without atrioventricular conduction disturbance. However, there are only a few descriptions of myopotential oversensing by atrial pacemakers. We believe the results of this study have implications not only for atrial pacing but also for physiological pacemakers (i.e. DDD pacemakers) which are implanted with atrial leads. Results of this study indicate that AAI pacemakers are less susceptible to MPI than are VVI pacemakers with unipolar lead systems. The following may be the reasons for this: (1) anatomic, the skeletal muscle mass located between the anode and cathode is smaller with AAI pacing than with VVI pacing, and (2) histologic, the endocardium of the atrium is thicker than that of the ventricle and may have different electrical conductivity.

The actual clinical relevance of MPI has not been fully investigated. Iesaka previously reported a case with bradycardia dependent ventricular
tachycardia facilitated by MPI. He emphasized the life-threatening effects of MPI. We believe that MPI is more hazardous than previously believed, and that, even if asymptomatic, MPI should be eliminated. MPI can be prevented by the following measures: (1) raising of the sensitivity level, (2) changing the pacing mode to an asynchronous or triggered mode, (3) placement of a silicon rubber boot between the pulse generator and muscles, and (4) use of a bipolar system. In the case of AAI pacemakers, raising the sensitivity level may induce undersensing because of the low amplitude of intracardiac signals in the atrium. Therefore to minimize MPI, bipolar systems are recommended for new implants.

CONCLUSIONS

MPI was provoked in some cases of AAI pacing, but susceptibility was lower than with VVI pacing. When MPI is provoked with AAI pacing, raising the sensitivity level without causing undersensing may be difficult because of the low amplitude of intracardiac signals in the atrium. The use of a bipolar system is the best resolution to this problem.

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REFERENCES

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