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Rate-Dependent Changes in Atrial Action Potential Duration After Short- Duration Rapid Atrial Pacing in Humans

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The effect of rapid atrial pacing on the rate adaptation of the atrial action potential duration was studied in humans. The right atrial monophasic action potential (RAMAP) of 5 patients was recorded before and after 30 min of rapid atrial pacing. The pacing cycle length (CL) was 146±9 ms, the shortest duration at which 1:1 capture was possible. The RAMAP duration at 90% repolarization (RMAPD) was measured. CL-dependent changes in RAMAPD (CL 600 ms – CL 300 ms) before and after rapid atrial pacing were 51.8±10.7 ms and 30.8±7.6 ms ($p<0.05$), respectively. (*Circ J* 2002; **66:** 874–875)

Key Words: Atrial fibrillation; Electrical remodeling; Monophasic action potential

Experimental studies in goats have shown that atrial fibrillation (AF) induces remodeling of the atria and that this effect is time dependent and may promote perpetuation of AF.[1] Experimental and clinical studies on the effects of short-term rapid atrial pacing on the atrial effective refractory period (ERP) have also been reported,[2–4] but no previous studies have assessed the rate-dependent changes in atrial action potential duration (APD) after short-duration rapid atrial pacing in humans. The purpose of this study was to assess these changes in humans.

Methods

Characteristics of the Study Population

The subjects in this study were 5 patients referred to the Nihon University Hospital for electrophysiological testing and radiofrequency catheter ablation (3 patients, manifest WPW syndrome; 1 patient, concealed Wolff-Perkinson-White (WPW) syndrome; 1 patient, atrioventricular node reentrant tachycardia; 2 men, mean age 45±16 (20–62) years [±SD]). None of the patients had a prior history of AF.

Electrophysiological Testing

Antiarrhythmic drugs, calcium-channel antagonists and β blockers were discontinued for 5 half-lives before the electrophysiological procedure. Informed consent was obtained from the patient and the patient's family. One quadripolar electrode catheter (EP Technology Corp, Sunnyvale, CA, USA) was positioned in the right atrial appendage for rapid atrial pacing. One quadripolar catheter and one Franz catheter (both from EP Technology Corp) were positioned in the high right atrium (RA) for pacing and monophasic action potential (MAP) recording, respectively.[5] Surface ECG leads I, II, III, V_1 and V_6, and the RAMAP waveform (filter: 0.05–500 Hz) were recorded.

Study Protocol

The study was approved by the Human Research Committee of Nihon University Hospital and was performed after completion of the clinically indicated portion of the electrophysiological study. Autonomic blockade was achieved by infusion of atropine (0.04 mg/kg) and propranolol (0.2 mg/kg) over a period of 5 min. RA pacing was performed at twice the late diastolic threshold. The RAMAP was measured at 90% repolarization time (RAMAPD90) at pacing CL of 600, 500, 400, 300, and 250 ms for 120 beats. RAMAPD90 was measured as the mean of the last 5 paced beats.

Rapid atrial pacing was performed at CL of 146±9 ms (140–160 ms), the duration at which the shortest 1:1 atrial capture was obtained at an output of 10 V with 2 ms pulse width, for 30 min. Electrical cardioversion was performed in one patient whose AF did not spontaneously convert after 5 min. Immediately after rapid atrial pacing or cardioversion, RAMAP measurements were repeated (Fig 1).

Statistical Analysis

All values were expressed as mean±SEM. The Wilcoxon signed-ranks test was used to compare the effects of rapid atrial pacing.

Results

RAMAPD90 measurements before rapid atrial pacing at pacing CL of 600, 500, 400, 300, and 250 ms were 232.8±13.9, 226.8±13.4, 216.2±11.7, 181.0±9.9, and 177.3±11.3 ms, respectively. RAMAPD90 measurements immediately after rapid atrial pacing or cardioversion at pacing CL of 600, 500, 400, 300, and 250 ms were 221.2±12.8, 214.6±12.7, 206.6±10.3, 190.4±9.2, and 170.3±5.8 ms,

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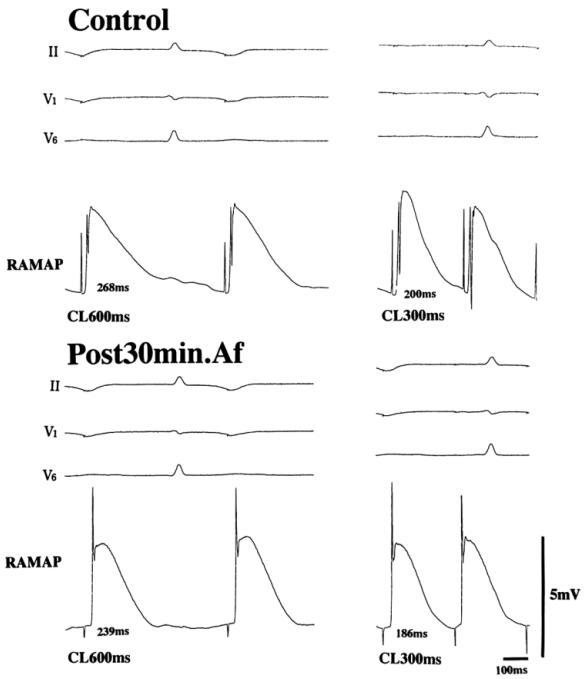

Fig 1. Right atrial monophasic action potentials recorded before (Upper panel) and after 30 min of rapid atrial pacing. Right atrial monophasic action potential duration (RAMAPD) at pacing cycle lengths of 600 ms before and after rapid atrial pacing was 268 ms and 239 ms, respectively, and of 300 ms before and after rapid atrial pacing was 200 ms and 186 ms, respectively. Note that RAMAPD after rapid atrial pacing was shortened by 29 ms at a pacing cycle length of 600 ms and by 14 ms at a pacing cycle length of 300 ms. RAMAP, Right atrial monophasic action potential; CL, cycle length; AF: Atrial fibrillation.

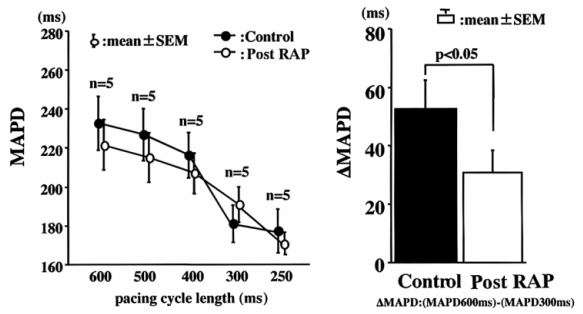

Fig 2. Rate-dependent changes in right atrial monophasic action potential duration before and after 30 min of rapid atrial pacing. Note that the rate-dependent decrease in the right atrial monophasic action potential duration was diminished after rapid atrial pacing. MAPD, monophasic action potential duration; RAP, rapid atrial pacing.

respectively (Fig 2, left). There was no statistically significant difference in RAMAPD90 at each pacing CL between before and after rapid atrial pacing. We then calculated the rate-dependent changes in RAMAPD90 (ΔRAMAPD90 = RAMAPD90 at pacing CL of 600 ms − RAMAPD90 at pacing CL of 300 ms). ΔRAMAPD90 before rapid atrial pacing was 51.8±10.8 ms and ΔRAMAPD90 after rapid atrial pacing was 30.8±7.6 ms ($p<0.05$).

Discussion

In this study, 30 min of high atrial pacing resulted in a decrease in the rate-dependent changes in RAMAPD90. This phenomenon was observed despite autonomic blockade. To our knowledge, this is the first study to report electrical remodeling of the atrial MAP by short-term rapid atrial pacing in humans. Goette et al reported that ERP shortening in the RA appendage was 24±2 ms/h in the canine heart during the first 30 min of high-frequency pacing[2] and Lee et al also reported MAPD and ERP shortening in the canine right atrium after high-rate atrial pacing at 800 beats/min for 30 min were 24 ms and 18 ms, respectively.[4] Daoud et al reported in humans that atrial ERP decreased by 31 ms at a basic CL of 350 ms and by 25 ms at a basic CL of 500 ms after spontaneous conversion of AF lasting 7.3±1.9 min and that the post-AF ERP returned to the pre-AF value after a mean of 8.4±0.3 min.[3] Yu et al also reported that the atrial ERP decreased by 30 ms at a basic CL of 500 ms after 10.4±1.0 min of pacing-induced AF.[6] Our results are consistent with those of previous studies showing a decrease in APD and ERP after short-term rapid atrial pacing. Furthermore, our results demonstrated that the rate-dependent changes in RAMAPD90 decreased after short-term rapid atrial pacing because of a slight decrease in RAMAPD at a pacing CL of 600 ms and a slight increase in RAMAPD at a pacing CL of 300 ms. Van der Velden et al reported that RAMAPD was rather increased at shorter pacing CL after chronic atrial fibrillation in the goat.[7] Thus, it is possible that the decrease in frequency-dependent changes in RAMAPD following short-term rapid atrial pacing results from not only a decease in RAMAPD at a longer pacing CL but also a decrease in the extent of RAMAPD shortening or ratheran increase in RAMAPD at a shorter pacing CL compared with the control. Finally, Kim et al recently reported the importance of recording atrial MAP to assess atrial action potential kinetics in human chronic AF.[8]

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