Clinical Significance of the Pre-Atrial Electrical Activity Recorded by the Catheter Electrode in High Right Atrium

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IN animal experiments, the sinus node activity is recorded from the excised atrium directly by microelectrode. In spite of the prediction of Hoffman and Cranefield, in situ recording of sinus node activity had been scarcely reported until several years ago. Some recordings have shown early activity preceding atrial deflection

in animal experiments.¹⁻⁴ Stopczyk et al.⁵ reported sinus node activity recorded by an intra-atrial monopolar electrode in man, however the tracing was not enough stable to be evaluated. We could record a small potential (pre-atrial activity; pre-A) of several decamicrovolts preceding an atrial wave by a bipolar catheter electrode

Fig.1. Schematic diagram of experiment (left) and representative tracings of simultaneous original recording by intraatrial and epicardial bipolar electrodes with standard ECG lead II (upper panel) and by intracellular microelectrode over the sinus node region and epicardial bipolar lead (lower panel).

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in high right atrium with the average technique, in canine experiments and in humans.⁶ A pre-atrial activity was also recorded in a patient with bradycardia by Hombach et al.⁷

The purpose of this report is 1) to examine the validity of our method by canine experiment, 2) to report the clinical experience in various diseases, 3) to compare pre-A interval with the sino-atrial conduction time by Strauss' method (SACT),⁸ and 4) to assess the clinical significance of the pre-A interval for the management of sick sinus syndrome.

MATERIAL AND METHODS

Canine experiment

In thoracotomized 20 mongrel dogs under artificial ventilation, electrical activity was recorded with epicardial bipolar electrode with a distance between the leads points of 0.1–0.2 mm. In five young canine (age less than 1 month) intracellular microelectrode was mounted and positioned over the sinus node region of the beating heart and could register the membrane potential of the area.⁹ A bipolar electrode catheter was introduced into the femoral vein and was placed at the junction of the right atrium and the superior vena cava. A 100 to 500 serial beats of atrial waves of high right atrial electrogram were averaged by using Nihon Koden ATAC 350. The intraatrial bipolar-recording was used for triggering, signal recording and averaging. The surface ECG lead II was recorded simultaneously and provided time reference. The data was recorded on Sony DFR 395 or mingograph at 7.5 inch/sec, 250–1000 mm/sec paper speed, respectively. The amplifier passband was 0.1–2 KHz. The recording was displayed on an oscilloscope and photographed with a Polaroid Camera.

Clinical study

During right heart catheterization in 153 patients, ranged between 16 to 76 years old, high right atrial electrogram by bipolar electrode and standard ECG lead II were simultaneously recorded for 10 to 20 minutes and the recordings were averaged by the same method as used in canine experiment. The interval between the beginning of the preatrial activity and the atrial deflection was designated as the pre-A interval. The sino-atrial-conduction time was measured by the "Strauss" method in dog experiments and humans.

Fig. 2. An example of an original tracing by epicardial and intraatrial bipolar leads and their averaging (x 200 beats) in a same experiment.

RESULTS AND DISCUSSION

Canine experiments (Simultaneous epi- and intra-cardiac recording)

Bipolar epicardial recording from the area of the sino atrial nodal region revealed the complex wave with multiple spikes (pre-atrial activity) preceding the atrial deflection and appeared earliest in the right atrial recording in sinus rhythm. The interval between the beginning of the multiple spike and the atrial deflection were 19 ± 6 msec in 20 dogs. The membrane potential at the point where the multiple spike was recorded, showed a slow diastolic depolarization. The rapid upstroke of the membrane potential was recorded at the time of multiple spike. (Fig. 1)

Sinus node activity was obtained by averaging technique in dog experiments. Recording by averaged (x 200) intraatrial electrogram at high right atrium showed pre-atrial activity (pre-A)

Fig.3. Four examples of pre-A tracings in clinical cases. Each graph consists of averaged intraatrial electrogram at high right atrium (upper) and standard ECG lead II (lower). SA: Pre-A interval

preceding the atrial deflection. (Fig. 2) The beginning of the low frequency, low amplitude potential coincided with the multiple spikes by epicardial atrial bipolar lead over sinoatrial nodal region and the rapid upstroke of the membrane potential.

The intervals between the beginning of pre-A and the atrial deflection (pre-A interval) were 21 ± 6 msec in 20 dogs. In dogs, the SACT were 40–50 msec.

Clinical experience of pre-atrial activity

By averaging 100 to 500 cosecutive beats of atrial waves of high right atrial electrogram in patients, a small potential (pre-A) was obtained 10 to 66 msec earlier than the atrial wave. The pre-A was recorded and evaluated in 114/153 clinical cases. Four representative tracings were shown in Fig. 3. In 16 cases, pre-A wave was not recognized after averaging. The average technique could not be applied in 23 cases because of poor recording and/or arrhythmia, e.g. atrial fibrillation, frequent atrial premature beats etc.

In order to obtain the sinus node potential by the technique, it is necessary to have sinus rhythm, no change of atrial wave configuration during recording, no shift of pacemaker site and a stable position of catheter electrode. The mean pre-A interval was 18 ± 4 msec in 23 patients without organic heart disease (control group). The pre-A interval ranged between 15 to 25 msec. It was shorter than the result of Stopczyk.⁵ Fig. 4 shows the pre-A interval in the individual patient with various heart disease and the value of mean pre-A interval in each group. The pre-A interval was significantly prolonged in cases with sick sinus syndrome 37 ± 11 msec, ischemic heart disease 34 ± 17 msec, and myocarditis 29 ± 8 msec. The pre-A interval was within normal limits in cases with paroxysmal atrial tachycardia, and was longer in 6 cases with atrio-ventricular block. In 9 cases with ischemic heart disease, the pre-A interval was longer than the normal range, however the severity of stenosis in the coronary arteries perfusing sinus nodal area was not significantly prominent in these patients. Three

Fig.4. Pre-A interval in clinical cases with various diseases.

variant angina treated with a calcium antagonist showed prolonged pre-A interval. We studied the SACT in 40 cases including 20 sick sinus syndrome using both averaging (pre-A) and the "Strauss" method. We were able to measure the SACT in 28/40 cases (70%) by the "Strauss" method, while the pre-A interval were recorded in 31/40 (77%). In 20 sick sinus syndrome, the SACT was obtained in 13/20 cases (65%) by the "Strauss" method and the pre-A was recorded in 16/20 (80%). The pre-A intervals were compared with the SACT by the "Strauss" method in 12 cases and significant correlation between them existed ($r = 0.80$, $p < 0.01$) (FIG. 5). The SACT by the Strauss' method was 2 to 3.7 times longer than the pre-A interval. Patients

with sinus node dysfunction show a chaotic pattern of the return cycles and in this situation the calculation of SACT by the "Strauss" method was not possible. In our study, four cases of sick sinus syndrome showed a chaotic pattern and in spite of this we were able to record the pre-A and the pre-A intervals were significantly prolonged. The discrepancy between the averaged pre-A interval and the SACT by "Strauss" was thought to be caused by several factors. When recording the sinus node activity at high right atrium, it is assumed that a certain current density builds up among the group of cells, so that the pre-A might not totally reflect the potential of a true pacemaker. However it is concluded by the canine experiment, that pre-A

Fig. 5. The relationship between the pre-A interval and the SACT (Strauss).

revealed the activity which related to the sinus node.

SUMMARY

- 1) In canine experiment, the averaging of high right atrial electrical activity revealed the pre-A preceding the atrial deflection, which was proven to be a part of the electrical activity of sinus nodal region.
- 2) The pre-A was obtained in 114 (75%) of 153 clinical cases.
- 3) The mean pre-A interval was 18 ± 4 msec in control group, and was prolonged in cases with sick sinus syndrome, ischemic heart disease and myocarditis.
- 4) The significant correlation existed between the pre-A interval and the SACT by Strauss' method ($r = 0.80$, $p < 0.01$).
- 5) The pre-A obtained by averaging technique is relatively simple, safe and reliable method, and is useful for evaluating the sino-atrial function.

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