The Vulnerability of the Right Atrium

III. Electrophysiologic Correlates of Atrial Vulnerability

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Untersuchungen über die Vulnerabilität des Vorhofes

III. Mitteilung. Beziehungen zwischen Vulnerabilität und die elektrophysiologischen Parameter des Vorhofes


Die statistische Auswertung ergab in der Vulnerabilitätsguppe signifikant längere Wellen ($p < 0.005$), kürzere effektive ($p < 0.001$) und längere relative Refraktärzeiten des rechten Vorhofes ($p < 0.001$), als in der Normalgruppe.

Mit zunehmender Stimulationsfrequenz traten Zeichen der gesteigerten Vorhofvulnerabilität in zunehmendem Maße auf. Dieses Phänomen wurde auf die frequenzabhängige Abnahme der effektiven und Zunahme der relativen Refraktärzeit des Vorhofes zurückgeführt.

Die oben beschriebenen Ergebnisse stützen das Konzept der Wiedererregung als Grundmechanismus der Vorhofvulnerabilität.


Summary. 70 patients were investigated by means of the atrial extrastimulus method at three different driving rates: 80, 100 and 120/min. At each rate the effective, the relative, the total and the functional refractory periods were measured. 30 patients who showed signs of atrial vulnerability at least one of the tested rates were included in the so called vulnerability group. The remaining 40 patients, who did not fulfill the criteria for atrial vulnerability, were included in the nonvulnerability group. When the two groups were compared to each other there were significant larger P waves ($p < 0.005$), shorter effective refractory periods ($p < 0.001$) and longer relative refractory periods ($p < 0.001$) in the vulnerability group.

With increasing driving rate there was an increased tendency to reentrant firing in the vulnerability group. The phenomenon of vulnerability correlated well with the rate-induced shortening of the effective and the lengthening of the relative refractory period.

The above described phenomena are compatible with the concept of re-entry as the electrophysiologic mechanism of atrial vulnerability in man.

Key words: Atrial fibrillation - Atrial flutter - Electrocardiography - Electrophysiology.

As early as 1930 Andrus, Carter and Wheeler [3] were able to demonstrate in the canine atrium that a single, appropriately timed suprathreshold stimulus delivered shortly after the completion of the effective refractory period is followed by several responses. The concept of vulnerability was introduced some years later by Wiggers and Wegria [42]. Although the phenomenon of atrial vulnerability was repeatedly investigated in animals [1, 2, 3, 5, 13, 27, 31, 38, 39, 40], little attention has been directed to the examination of this phenomenon in the human [18, 19, 34, 47].

In a previous paper we were able to demonstrate that there was a tendency of atrial vulnerability to
occurred with shorter effective and longer relative refractory periods of the right atrium [34]. However, the correlation between vulnerability and these parameters was significant from a statistical point of view only at a few heart rates tested. This finding was explained by the rather small number of patients studied at a given rate.

The purpose of this paper is: 1. to verify this hypothesis by studying the phenomenon of atrial vulnerability in a greater number of patients at three different heart rates, and 2. to extend the study of vulnerability investigating other electrophysiologic parameters of the atrium, too.

**Material and Methods**

70 patients underwent cardiac catheterization in the nonsedated postabsorptive state after giving informed consent. All cardioactive drugs had been withdrawn at least 48 hours before the study.

Under local anesthesia two electrode catheters were inserted percutaneously and positioned fluoroscopically in the right heart. The first catheter—a quadripolar one—was placed in the high right atrium at its junction with the superior vena cava. The two distal electrodes were used for stimulation, the proximal ones for recording a bipolar atrial electrogram. The second catheter—with two electrodes at the distal end—was positioned across the tricuspid valve according to the method of Scherlag et al. [37] to record the His bundle electrogram [16].

In all cases, premature right atrial stimulation was performed by means of the extrastimulus method [44] at three different driving rates: 80, 100 and 120/min. The premature test pulses were given during constant right atrial drive rhythm after every tenth beat. The test pulse interval was decreased by 5-10 ms steps until the effective refractory period of the atrium was reached. We used rectangular impulses of 1 ms duration and double threshold for driving and testing.

**Definition of Terms**

For purposes of this study, the following definitions of terms were used:

- PA interval is the interval from the onset of the P wave to the first high frequency component (intrinsic deflection) of the A wave in the His bundle lead.
- $S_1$ and $A_1$ represent stimulus artifact and atrial electrogram (recorded in the His bundle lead) of the tenth basic drive beat, respectively.
- $S_2$ and $A_2$ represent stimulus artifact and atrial electrogram (recorded in the His bundle lead) of the premature testing beat, respectively.
- Effective refractory period of the atrium (ERP) is the longest $S_2-S_3$ interval at which $S_3$ does not evoke an atrial response.
- Functional refractory period of the atrium (FRP) corresponds to the shortest attainable propagated $A_1-A_2$ interval.
- Total refractory period of the atrium (TRP) is the longest $S_1-S_3$ interval at which the $S_3-A_3$ interval becomes longer than the $S_1-A_1$ interval.
- Relative refractory period of the atrium (RRP) corresponds to the difference between the total and the effective refractory period of the atrium.

**Results**

The mean values with standard deviation and the result of the statistical analysis are listed in Tables 1 and 2.

There were no statistically significant differences concerning the mean values of the PA interval and the diastolic threshold when the two groups were compared one with another (Table 1). The P wave duration measured during spontaneous sinus rhythm was significantly longer in the vulnerability group than in the nonvulnerability group (Table 1).

The statistical analysis revealed in the vulnerability group significantly shorter effective and significantly longer relative refractory periods at all driving rates than the nonvulnerability group (Table 2). The quotient TRP/ERP had also significantly higher values in the vulnerability group. At no tested rate were there significant differences concerning the functional refractory period. Only at a driving rate of 120/min was the total refractory period significantly shorter in the nonvulnerability group than in the vulnerability group. For the other two rates, the differences were not significant.

With increasing rate, there was a significant shortening of the effective refractory period for both groups. The total refractory period shortened significantly only in the nonvulnerability group. While in the vulnerability group there was a significant prolongation of the relative refractory period with increasing rate, in the nonvulnerability group it showed a tendency to shorten. The functional refractory period decreased significantly and to a greater extent in the nonvulnerability group, as opposed to the vulnerability group. In the nonvulnerability group, the quotient TRP/ERP remained rather constant with increasing rate in contrast to the vulnerability group showing a significant prolongation of this parameter.

Finally, in the vulnerability group, the number of patients fulfilling the criteria for vulnerability increased with faster heart rate from 20 (66.6%) at a rate of 80/min to 23 (76.6%) and 29 (96.6%) respectively at rates of 100/min and 120/min respectively.