Atrial Fibrillation Produced by Atrial Stimulation

By Jacob I. Haft, M.D., Sun H. Lau, M.D., Emanuel Stein, M.D., Bernard D. Kosowsky, M.D., and Anthony N. Damato, M.D.

SUMMARY
Twenty-six episodes of atrial fibrillation and flutter-fibrillation, each lasting less than 23 sec, were recorded in three normal subjects during atrial pacing studies. The cause of these atrial arrhythmias was determined to be the result of stimulation within the atrial vulnerable period.

Additional Indexing Words:
Atrial vulnerable period Single and paired pacing Hazards of atrial pacing

Over the past few years, a number of clinical studies have been reported in which atrial pacing techniques were used. Although episodes of atrial fibrillation have previously been noted during atrial pacing studies in man, no demonstration of the mode of onset of these arrhythmias has been published. It is the purpose of this communication to report the results of a retrospective analysis of the records of three subjects in whom 26 brief episodes of atrial fibrillation or flutter-fibrillation were recorded during single and paired stimulation of the right atria.

Methods
Observations were made on three normal volunteer subjects whose atria were being paced during the course of other experimental studies. All subjects were in normal sinus rhythm and were studied in the postabsorptive state. The subjects were taking no prescribed drugs and no premedication was given prior to cardiac catheterization. Under fluoroscopic control, a bipolar or a tripolar electrode pacing catheter was advanced to the right atrium via an antecubital vein. The atria were paced at one and a half to three times threshold using impulses of 2 msec duration and up to 6 ma in magnitude generated from a battery-powered pacemaker (Medtronics Model no. 5837). A standard electrocardiographic lead II and intra-atrial electrograms were recorded during the procedure on an oscilloscopic photographic recorder at a paper speed of 50 to 100 mm/sec. As is routinely practiced in this laboratory, attention was paid to the grounding of all equipment in order to avoid the occurrence of random currents which of themselves may initiate atrial arrhythmias. It is important to note that all episodes of atrial arrhythmias occurred when atrial stimulation was the only procedure being performed. In every instance, the power supply for the fluoroscopy unit had been turned off and there was no physical contact between the patient and any other person in the laboratory. From the available records, the following measurements were made: (1) the time from the onset of the last normal P wave preceding arrhythmia to the impulse that initiated the arrhythmia, (2) the sinus rate prior to the onset of pacing, (3) the duration of the induced arrhythmia, and (4) the ventricular response rate during the atrial arrhythmia.

Results
A total of 26 episodes of atrial fibrillation and flutter-fibrillation were recorded in these three subjects. The data concerning these episodes are listed in table 1. Each episode lasted less than 23 sec whereupon normal sinus rhythm was reestablished. None of the subjects experienced any sensation of discomfort during the arrhythmia. Five episodes

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of atrial arrhythmias occurred during single atrial pacing; the remaining 21 episodes were recorded during paired atrial stimulation. The average interstimulus interval for the paired mode of stimulation which initiated the atrial arrhythmias was the same as the average P-stimulus interval for the single mode of stimulation.

In the first patient (Wi.), 15 short bouts of atrial fibrillation and flutter-fibrillation were recorded, all of which lasted less than 17 sec. Thirteen of the 15 recorded episodes of atrial arrhythmias occurred during paired atrial pacing. Figure 1 shows a typical episode that was recorded as the interstimulus interval was being shortened during paired atrial pacing. In this patient the period from the onset of the P wave to the stimulus spike that initiated fibrillation or flutter-fibrillation varied from 200 to 280 msec with a majority of the episodes occurring at 240 msec.

Eight episodes of atrial fibrillation or flutter-fibrillation were recorded in the second patient (W.A.). The P wave to spike interval varied from 180 to 240 msec (table 1). Figure 2 shows two short typical episodes of fibrillation in this patient.

Patient three (H.) had demonstrated atrial fibrillation or flutter-fibrillation on three occasions. The P-wave stimulus interval that led to the arrhythmias in this subject was determined to be between 220 and 240 msec. Figure 3 depicts a typical episode.

**Discussion**

Previous reports have called attention to the dangers of inducing cardiac arrhythmias during cardiac catheterization from the improper

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### Table 1

<table>
<thead>
<tr>
<th>Subject</th>
<th>Sinus rate* (beats/min)</th>
<th>Mode of pacing</th>
<th>P-stimulus interval (msec)</th>
<th>Interstimulus interval (msec)</th>
<th>Arrhythmia</th>
<th>Duration (sec)</th>
<th>Ventricular rate (beats/min)</th>
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<td>Flut-fib.</td>
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</table>

*Spontaneous sinus rate prior to pacing the atrium.

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Circulation, Volume XXXVII, January 1968
Patient W. An episode of atrial fibrillation that occurred when the interval between pairs of stimuli was progressively shortened to attain two atrial depolarizations for each ventricular depolarization. Atrial fibrillation terminated spontaneously after 16 sec. ECG II = standard lead II of the electrocardiogram; IAE = intra-atrial electrogram. Numbers represent milliseconds between pairs of stimuli.

Figure 1

Patient W. A. Two episodes of fibrillation or flutter-fibrillation are demonstrated on this record. The first episode occurred when atrial capture by the pacer was not complete. A normal P wave was interrupted by a noncaptured stimulus, followed by a stimulus that caused an atrial depolarization and started atrial fibrillation. The interval between the normal P wave and the inciting impulse was 220 msec. The second episode occurred during paired pacing at 180 msec interval. The intra-atrial electrogram was recorded from one of the electrodes of the bipolar pacer after pacing was stopped. The IAE shows flutter-fibrillation. The episode lasted 16 sec.

Figure 2

grounding of equipment used in such studies. In the present report, attention is focused on another cause of induced atrial arrhythmias which is attributed to electrical

8, 9
Figure 3

Patient H. This episode of flutter-fibrillation occurred during paired pacing at 240 msec. Following the third pair of stimuli, the base line becomes irregular and subsequent stimuli no longer capture the atrium. This episode lasted 13 sec.

Figure 4

A schematic representation of the period in the cardiac cycle during which electrical stimulation of the atrium elicited atrial fibrillation, or flutter-fibrillation. Each circle represents one episode of arrhythmia.

stimulation of the atrium during the atrial vulnerable period. The vulnerable period of the canine atrium has previously been defined. Data on the human atrial vulnerable period have thus far only included the recording of spontaneous atrial premature con-
tractions occurring immediately before the onset of atrial fibrillation. From an analysis of the data on these three cases, it would appear that the atrial vulnerable period in the human extends from 180 to 280 msec after the onset of the P wave (fig. 4). Since this report represents a retrospective analysis of the recorded data, attempts to define the manifest complete refractory period by shortening the coupling interval were not made. Although the limited number of observations made on this small series of cases does not allow for a more precise definition of the limits of the atrial vulnerable period, the authors have used these data to define working guidelines which have been applied in subsequent studies involving atrial pacing in man. As a consequence, by avoiding the delivery of electrical impulses during this period (that is, 180 to 280 msec after the onset of the P wave), we have encountered no instances of atrial arrhythmias in over 200 subsequent atrial pacing studies.

The frequency with which atrial pacing studies are now being performed in several cardiac catheterization laboratories makes these observations of more than academic interest. The atrial arrhythmias observed in these three subjects were of short duration and without complications, probably owing to the fact that these subjects had no significant cardiovascular disease.

References


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