Prolonged Atrial Conduction

A Major Predisposing Factor for the Development of Atrial Flutter

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SUMMARY Electrophysiological studies were performed during sinus rhythm on 21 patients who had demonstrated the spontaneous occurrence of sustained atrial flutter. The purpose was to determine if atrial conduction disease is a predisposing factor for the development of atrial flutter. Patients with atrial enlargement were excluded from the series. The control group consisted of 11 age-matched patients with normal electrocardiograms and electrophysiology studies. The flutter group showed prolongation of the mean right-intra-atrial conduction time at 50 msec (control of 37 msec, \( P < 0.05 \)), the mean intraatrial conduction time at 92 msec (control of 44 msec, \( P < 0.001 \)) and the mean P wave duration at 132 msec (control of 112 msec, \( P < 0.01 \)). The flutter group also demonstrated a higher incidence of sinus node dysfunction and ventricular conduction disease compared to the control group. These data indicate that patients who develop atrial flutter have atrial conduction disease. Atrial conduction disease appears to be 1) a major predisposing factor for the development of atrial flutter and 2) a part of the fibro-degenerative conduction disease spectrum.

ATRIAL FLUTTER has intrigued cardiologists and electrophysiologists for over a century. Despite the continued fascination for this dysrhythmia and the perpetual controversy regarding its mechanism (circus movement versus ectopic focus), the predisposing factors have not been clearly delineated. While it is generally appreciated that cardiac disorders associated with atrial enlargement show a higher incidence of atrial flutter,\(^1\) atrial enlargement itself is not the only predisposing factor in this patient population.\(^2\) Patients without detectable atrial enlargement or other contributory factors (metabolic, bronchopulmonary disease, etc.) also develop atrial flutter. This study was designed to compare atrial conduction of atrial flutter patients without atrial enlargement to a normal group, in order to determine if atrial conduction abnormalities are a major predisposing factor in the development of atrial flutter.

Materials and Methods

Subjects

The atrial flutter group consisted of 21 patients who had documented spontaneous atrial flutter. The dysrhythmia

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was sustained (duration exceeding 48 hours) in all of the flutter patients and did not deteriorate into atrial fibrillation in any of the patients. The A-V conduction (ventricular response) during the atrial flutter ranged from 2:1 to 6:1. The clinical diagnoses of the patients are presented in Table 1. Seven of the flutter patients had historical and cardiac catheterization evidence of arteriosclerotic heart disease. Two patients had a history of systemic hypertension with mild left ventricular wall thickening and normal left heart chamber sizes on their echocardiograms. We categorized six elderly patients as having a form of "degenerative" heart disease based on the presence of acquired cardiac conduction disease and normal findings at cardiac catheterization. Five patients were classified as having heart disease of unknown etiology because heart disease was suspected on the basis of the presence of conduction disease or symptoms but cardiac catheterization had not been performed. Mitral valve prolapse was an isolated anatomic finding during cardiac catheterization in one patient. Patients with cardiomyopathy and atrial enlargement by cardiac fluoroscopy or echocardiography were excluded from the study. Eleven age-matched patients with normal electrocardiograms and electrophysiologic studies served as the control group (Table 1).

All medication was discontinued a minimum of 48 hours prior to the electrophysiology study. Three patients in the control group and seven flutter group patients had received a digitals preparation (control: digoxin, 0.25 mg p.o. daily; flutter: five patients on digoxin, 0.25 mg p.o. daily and two patients on digoxin, 0.125 mg p.o. daily). Quinidine sulfate at 200–300 mg p.o. every six hours had been prescribed to nine patients of the flutter group. Two control patients and two flutter patients had received propranolol (20–30 mg p.o. every six hours). With the exception of one flutter patient (no. 21), who had a serum creatinine of 2.0 mg%, the serum creatinine and BUN levels of all patients were within normal limits.

### Procedure

Written informed consent was obtained from each patient prior to the electrophysiology study. No premedication was administered at the time of study. All patients in the atrial flutter group were studied during sinus rhythm within two months of the conversion of their atrial flutter to sinus rhythm (eight patients by DC cardioversion and 13 by rapid atrial pacing).

All catheters were placed with fluoroscopic assistance. A bipolar recording electrode was placed in the esophagus, 3 cm below the horizontal line extending from the junction of the superior vena cava and the right atrium. This catheter recorded the left atrial electrogram. A cut-down was performed over the right antecubital fossa and two bipolar catheters were introduced into the antecubital vein and positioned in the high right atrium. One catheter was used

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**Table 1. Electrophysiologic Data Obtained from Control and Atrial Flutter Groups**

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Age-sex</th>
<th>Clinical diagnosis</th>
<th>ECG</th>
<th>AA interval (msec)</th>
<th>P wave duration (msec)</th>
<th>HRA-LRA (msec)</th>
<th>HRA-LA (msec)</th>
<th>AERP (msec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>45-F</td>
<td>O</td>
<td>N</td>
<td>575</td>
<td>104</td>
<td>18</td>
<td>23</td>
<td>220</td>
</tr>
<tr>
<td>2.</td>
<td>47-M</td>
<td>O</td>
<td>N</td>
<td>900</td>
<td>134</td>
<td>37</td>
<td>40</td>
<td>—</td>
</tr>
<tr>
<td>3.</td>
<td>52-F</td>
<td>O</td>
<td>N</td>
<td>805</td>
<td>116</td>
<td>60</td>
<td>55</td>
<td>—</td>
</tr>
<tr>
<td>4.</td>
<td>55-M</td>
<td>H</td>
<td>N</td>
<td>1115</td>
<td>104</td>
<td>48</td>
<td>50</td>
<td>420</td>
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<tr>
<td>5.</td>
<td>55-M</td>
<td>O</td>
<td>N</td>
<td>1248</td>
<td>129</td>
<td>40</td>
<td>53</td>
<td>—</td>
</tr>
<tr>
<td>6.</td>
<td>58-F</td>
<td>O</td>
<td>N</td>
<td>816</td>
<td>110</td>
<td>28</td>
<td>32</td>
<td>270</td>
</tr>
<tr>
<td>7.</td>
<td>61-F</td>
<td>O</td>
<td>N</td>
<td>644</td>
<td>98</td>
<td>28</td>
<td>37</td>
<td>220</td>
</tr>
<tr>
<td>8.</td>
<td>62-M</td>
<td>O</td>
<td>N</td>
<td>609</td>
<td>107</td>
<td>30</td>
<td>36</td>
<td>280</td>
</tr>
<tr>
<td>9.</td>
<td>63-M</td>
<td>O</td>
<td>N</td>
<td>1164</td>
<td>112</td>
<td>43</td>
<td>60</td>
<td>310</td>
</tr>
<tr>
<td>10.</td>
<td>64-M</td>
<td>O</td>
<td>N</td>
<td>1342</td>
<td>127</td>
<td>20</td>
<td>59</td>
<td>460</td>
</tr>
<tr>
<td>11.</td>
<td>74-F</td>
<td>A</td>
<td>N</td>
<td>828</td>
<td>116</td>
<td>32</td>
<td>36</td>
<td>340</td>
</tr>
<tr>
<td>Mean</td>
<td>48</td>
<td></td>
<td></td>
<td>503</td>
<td>112</td>
<td>37</td>
<td>44</td>
<td>315</td>
</tr>
</tbody>
</table>

**Control Group** (N = 11)

**Atrial Flutter Group** (N = 81)

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**Notes:**
- **Sex:** M = male, F = female.
- **Clinical diagnosis:** O = no detectable cardiac disease; U = cardiac disease of unknown etiology; H = hypertension; A = arteriosclerotic; D = degenerative; MVP = mitral valve prolapse.
- **ECG:** N = no conduction disease; LIVCD = left intraventricular conduction defect; RBBB = right bundle branch block.
- **LAD** = left axis deviation; **PR** = increased PR interval.
- **AA interval** = basic cycle length.
- **HRA-LRA** = right intra-atrial conduction time.
- **HRA-LA** = interatrial conduction time.
- **AERP** = atrial effective refractory period.
for recording high right atrial electrograms and the other for pacing. A six-pole recording catheter was introduced into the right femoral vein, and placed across the tricuspid valve. This catheter was positioned to record the bundle of His electrogram as well as low right atrial and ventricular electrograms. Recordings were taken on an Electronics for Medicine DR-12 amplification and recording system at 100 mm/sec paper speed. The intracardiac and left atrial signals were amplified with a frequency range of 30-500 cycles per second. Three scalar ECG leads were recorded simultaneously with the intracardiac electrograms.

Measurements

A sample baseline recording is presented in figure 1. The basic cycle length (AA interval) is the time distance between the A waves of the high right atrial electrogram. The atrial conduction intervals were determined by measuring the right intra-atrial conduction time, interatrial conduction time and P wave durations. The right intra-atrial conduction time is the time interval from the onset of right atrial activation (the beginning of the P wave or the high right atrial deflection, whichever occurs first) to the low right atrial deflection (HRA-LRA, b. of fig. 1). The interatrial conduction time is the time interval from the onset of right atrial activation to the left atrial depolarization (HRA-LA, a. of fig. 1). P wave durations were taken from limb lead II or precordial lead V, whichever provided the P wave of longest duration. A-V node and bundle of His – proximal Purkinje conduction times were obtained by measuring the AH and HV intervals, respectively. Sinus node function was evaluated by the determination of the corrected sinoatrial recovery time (CRT) and sinoatrial conduction time (SACT). The final value for each of the above determinations on each patient is a mean of a minimum of 10 measurements. The effective refractory period of the atrium (AERP) was determined for the basic cycle length and was taken as the longest A-S interval at which S, (extrastimulus) failed to capture the atrium.

Statistical Analysis

Student's t-test was used to evaluate the statistical significance between the atrial flutter and control groups. The incidence of prolonged SACTs, CRTs, AH, and HV intervals between the two groups was analyzed with Fisher's exact test (chi-square).

Results

The atrial conduction intervals and effective atrial refractory period data are presented in table 1. The mean basic cycle length was not significantly different between the two groups. The measurements of atrial conduction showed significant prolongation in the atrial flutter group. The mean right intra-atrial conduction time was 50 ± 4.0 msec (mean ± SEM) for the flutter group and 37 ± 3.0 msec for the control group (P < 0.05). The mean interatrial conduction time of the flutter group was more than twice the control value with durations of 92 ± 6.0 msec and 44 ± 4.0 respectively (P < 0.001). It is noteworthy that there was no overlap of the HRA-LA data points between the two groups. The longest HRA-LA value for the control group was 60 msec and the shortest interval in the flutter group was 65 msec. P wave durations were also prolonged for the flutter group at 132 ± 5.0 msec with control P wave durations of 112 ± 4.0 msec (P < 0.01). The AERP was measured in 15 patients of the flutter group and eight patients of the control group and no significant difference was found between the mean values. The slightly shorter (but statistically insignificant) mean AERP of the flutter group is probably secondary to the slight (also insignificant) shortening of the basic cycle length.

The incidence of sinus node dysfunction was significantly increased in the atrial flutter group (table 2). Prolongation of the SACT (normal < 205 msec) occurred in eight of the 18 atrial flutter patients tested (P < 0.05). The CRT was prolonged (normal < 395 msec) in seven of the 19 atrial flutter patients tested (P < 0.05). The incidence of AH and

Table 2. Comparison of SA Node Function Studies, A-V Node and His-Proximal Purkinje Conduction of Control and Atrial Flutter Groups

<table>
<thead>
<tr>
<th></th>
<th>SACT</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>≤ 205 msec</td>
<td>&gt; 205 msec</td>
<td>x**</td>
</tr>
<tr>
<td>Flutter</td>
<td>11 patients</td>
<td>0 patients</td>
<td>P &lt; 0.05</td>
</tr>
<tr>
<td></td>
<td>≤ 395 msec</td>
<td>&gt; 395 msec</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>11</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Flutter</td>
<td>12</td>
<td>7</td>
<td>P &lt; 0.05</td>
</tr>
<tr>
<td></td>
<td>≤ 130 msec</td>
<td>&gt; 130 msec</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>11</td>
<td>0</td>
<td>NS</td>
</tr>
<tr>
<td>Flutter</td>
<td>10</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≤ 55 msec</td>
<td>&gt; 55 msec</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>11</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Flutter</td>
<td>12</td>
<td>1</td>
<td>NS</td>
</tr>
</tbody>
</table>

*x** = chi-square analysis.
HV prolongation was not significantly higher for the flutter group. Although no increased incidence of A-V node or His-proximal Purkinje conduction abnormalities was noted, eight of the 21 flutter patients (P < 0.05) had evidence of distal conduction disease (5 LIVCD, 2 LAD, 1 RBBB).

Discussion

The presence of prolonged atrial conduction intervals in the atrial flutter patients with normal sized atria strongly suggests the existence of atrial conduction disease. The presence of increased atrial mass secondary to atrial hypertrophy (without chamber enlargement) cannot be excluded as a potential explanation for the prolongation of atrial conduction. However, it is unlikely that a significant increase in the atrial wall musculature would occur without detectable chamber enlargement, or would account for the interatrial conduction times which are greater than two times the control value. The demonstration of an increased incidence of sinus node dysfunction and an increased frequency of distal ventricular conduction diseases supports the concept of the presence of atrial conduction disease. The disease process affecting the atria (more specifically, the preferential conduction system of the atria) probably involved the sinoatrial region and the ventricular conduction system as well. A diffuse fibrodegenerative conduction disease process akin to the processes described by Lev, Lenegre, and Legato et al. is the most plausible and unifying explanation for the conduction abnormalities found in the atrial flutter group. Other than one case report showing an increase in the fibrous tissue content of the SA node in a patient with atrial flutter, no histopathologic data are available on atria predisposed to the development of atrial flutter.

It is unlikely that the occurrence of atrial conduction disease in patients who develop atrial flutter represents the simultaneous development of two independent processes. Age-matched controls showed little to no delay of atrial conduction. Studies from our laboratory also showed that patients with paroxysmal atrial tachycardia (A-V re-entry and ectopic atrial focus varieties) did not have significant prolongation of the atrial conduction intervals. Preliminary data from our laboratory suggest that patients with atrial fibrillation also show evidence of prolonged atrial conduction, a physiologic manifestation of the histopathologic changes noted in chronic atrial fibrillation and a possible mechanistic link between atrial flutter and fibrillation. It appears that atrial flutter and fibrillation are dysrhythmias which depend on atrial conduction disease for their development, whereas other atrial dysrhythmias do not require the presence of extensive atrial conduction abnormalities.

How atrial conduction disease initiates and sustains atrial flutter is not explained by this study, nor does the study resolve the perpetual controversy of circus movement versus the ectopic focus mechanisms of atrial flutter. Conduction delay of a preferential atrial conduction pathway would shorten the length of loop necessary to sustain a circus movement loop. However, the presence of conduction disease also provides the milieu for the development of ectopic foci of small re-entry loops. Whatever the underlying mechanism may be, it is apparent that atrial conduction disease is a major predisposing factor for the development of atrial flutter.

References

Prolonged atrial conduction. A major predisposing factor for the development of atrial flutter.

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