CLINICAL PROGRESS

Atrial Tachysystole with Block

By Stuart Warren Rosner, M.D.

WHILE it is a clinical truism that the management of a patient should never be dictated by a single laboratory aid, at times the use of the electrocardiogram in the treatment of cardiac arrhythmias challenges this rule. The differential diagnosis of paroxysmal atrial tachycardia with atrioventricular block (PAT with block) versus atrial flutter, in the course of digitalis administration, is an example where remarkably different therapy may be indicated on the basis of the interpretation of the electrocardiogram. The appearance of PAT with block suggests the withholding of digitalis while atrial flutter may be an indication for increasing the dose of digitalis.

Some authors \(^1\)–\(^3\) believe that distinction between PAT with block and atrial flutter is possible on the basis of certain criteria. Others \(^4\)–\(^6\) contend that there is a continuum between atrial tachycardia and flutter with an intermediate zone that defies exact differentiation. Atrial tachysystole approximating 250 beats per minute associated with atrioventricular AV block, as in the cases to be presented, is of interest because of its location in this borderline region.

The term atrial tachysystole is used in this report in the broad sense of rapid atrial activity, without implying any special appearance of the baseline or atrial waveform. The use of this terminology has utility as long as a continuing electrocardiographic controversy awaits final definition.

Two patients are reported who exhibited episodic atrial tachysystole with block. The electrocardiographic criteria of PAT with block and atrial flutter are re-examined.

Case Reports

Case 1

M. S. is a 49-year-old white woman, with the complaints of intermittent dyspnea, fatigue, and ankle swelling for 20 years. She was thought to have rheumatic heart disease with mitral stenosis and regurgitation and aortic stenosis. She had been treated with digitalis for many years. Physical examination revealed clear lungs and no cardiomegaly. At the apex, the first sound was accentuated, and blowing holosystolic and rumbling presystolic murmurs were present. An opening snap was heard at the lower left sternal border. A coarse, ejection, basal systolic murmur radiated into the neck. An electrocardiogram (January 1962) showed sinus bradycardia, first-degree heart block, a prominently negative terminal deflection of the P wave in leads II, III, aVF and V\(_1\), suggesting left atrial enlargement, ST-segment depression, and inversion of the first portion of the T wave in leads I, aVF, and V\(_5\), considered due to digitalis effect. The patient gave no evidence of thyroid dysfunction. A protein-bound iodine determination and 24-hour \(^1\)\(^3\)\(^1\) uptake were normal. Hemogram, urinalysis, blood urea nitrogen, serum electrolytes, and pulmonary function tests were normal.

Case 2

H. S. is a 59-year-old white man with the complaints of dyspnea and cough productive of copious, green, occasionally blood-streaked sputum. He was diagnosed as having pulmonary emphysema and bronchiectasis. He had been taking digitalis for many years. Physical examination revealed persistent bibasilar inspiratory rales and scattered inspiratory and expiratory wheezes. There was no enlargement of the thyroid gland. The heart sounds were distant. Mild clubbing was present without cyanosis. Bronchography demonstrated bilateral lower lobe cylindrical bronchiectasis. Pulmonary function studies showed moderate...

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airway obstruction. Hemogram, urinalysis, blood urea nitrogen, and serum electrolytes were normal. An $^{131}$I uptake was normal. An electrocardiogram in March 1958 showed normal sinus rhythm with ST-T-wave changes consistent with digitalis effect.

**Discussion**

**Historical Review**

The concept of atrial flutter has had a gradual evolution since MacWilliam observed rapid regular mechanical atrial activity following faradic stimulation of the dog auricle. The movements appeared as a series of contractions originating in the stimulated area from which it spread over the remaining muscle. He labeled the phenomenon auricular flutter. Jolly and Ritchie adopted this term and applied it to an electrocardiographic entity.

Mayer produced a self-propagating excitation wave in a ring of contractile tissue from the jellyfish. Mines attempted to explain the observation of MacWilliam on the basis of a self-sustaining circulating rhythm, which he was able to induce in a ring of muscle composed of tortoise auricle and ventricle. Garrey, working independently, reached similar conclusions. The experiments of Lewis entrenched the circus movement theory in electrocardiographic thinking, although the studies of Rothberger and Winterberg and Scherf and Schott prevented its unanimous acceptance. The latter workers have offered a theory of repetitive focal discharge to explain the same phenomena. Using high-speed cinematography, Prinzmetal et al. have added evidence supporting the latter.

Mines and Iliescu and Sebastiani suggested that a circus rhythm may be responsible for some cases of paroxysmal tachycardia. In objecting to this, Lewis pointed out that there was insufficient tissue to maintain a simple circus movement on the assumption of a reasonable conducting speed and with atrial rates of 120 to 150. Furthermore, the complexes were separated by quiescent intervals. Ashman and Hull and subsequently, Barker et al. suggested that the circus rhythm concept might explain atrial tachycardia if one assumes that the re-entrant wave passes through one of the specialized nodes (SA or AV node). The latter group explained the isoelectric intervals as due to the impulse traversing the nodal tissue, which is too small to produce detectable electrical activity by the usual methods. The atrial rate would depend, in part, on the speed of conduction and the length of the path through the nodal tissue. This controversy awaits resolution.

PAT with block was originally described by Lewis from a polygraphic recording of the jugular and radial pulses. Reports incriminating digitalis in its etiology are numerous. Digitalis-induced atrial flutter is rare. PAT with block may also occur in the absence of digitalis administration in patients with or without organic heart disease. In these cases, digitalis has been reported to restore sinus rhythm and, in other instances, to exert a beneficial effect by controlling the ventricular rate. Recently, the arrhythmia has been noted with great frequency in patients with concomitant lump disease. The digitalis-induced and idiopathic forms cannot be distinguished electrocardiographically. Lown and Levine listed several contrasting features (table 1).

**Table 1**

<table>
<thead>
<tr>
<th>Diagnostic feature</th>
<th>PAT with block</th>
<th>Atrial flutter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usual atrial rate</td>
<td>150 to 200</td>
<td>Over 200</td>
</tr>
<tr>
<td>P wave (leads II and III)</td>
<td>Upright</td>
<td>Inverted</td>
</tr>
<tr>
<td>P-P baseline</td>
<td>Isoelectric</td>
<td>Mobile</td>
</tr>
<tr>
<td>P-P interval</td>
<td>Regular or irregular</td>
<td>Regular</td>
</tr>
<tr>
<td>AV response</td>
<td>Variable</td>
<td>Usually 2:1</td>
</tr>
<tr>
<td>Ventricular premature beats</td>
<td>In 40 per cent</td>
<td>In 20 per cent</td>
</tr>
<tr>
<td>Carotid sinus pressure</td>
<td>AV block increased</td>
<td>AV block increased</td>
</tr>
<tr>
<td>Onset and offset</td>
<td>Gradual</td>
<td>Abrupt</td>
</tr>
<tr>
<td>Potassium administration</td>
<td>Return to sinus rhythm</td>
<td>No effect</td>
</tr>
</tbody>
</table>
Atrial Rate

Lewis reported the rate limits for untreated flutter as 220 to 370 with an average of 300. He stated that paroxysms of tachycardia are usually recorded at about 150 beats per minute, but he was aware that faster rates could occur. Skilled electrocardiographers have interpreted tracings as PAT with atrial rates above 250, even as high as 400. Furthermore, typical flutter waves have been recorded at a rate as low as 134 per minute.

In a recent communication, Lown et al. suggested that 250 beats per minute be accepted as an arbitrary borderline. Of the many electrocardiograms recorded, the atrial rates in case 1 ranged from 214 to 300 and from 240 to 375 in case 2. The several atrial rates above and below this value, in these cases, demonstrate the limitations of this criterion. The use of atrial rate as the sole differentiating item appears hazardous as there is significant overlap of the rate limits, especially in the 230 to 270 range.

P Wave

Atrial flutter is held to originate at the caudal end of the atrium thereby accounting for the “negative P wave” in leads II and III.
ATRIAL TACHYSYTOLE WITH BLOCK

(69 per cent of Prinzmetal's cases). In classic 
PAT without block, the ectopic impulse is 
most commonly cephalic in origin, but P-wave 
morphology cannot be determined in the limb 
leads in two thirds of the records. In PAT 
with block, P II and P III are usually up-
right. In figure 1A from case 1, P II and 
and P III are upright; these waves, however, have 
been observed to be inverted in other 
episodes. The electrocardiogram in case 2 (fig. 2) 
illustrates that recognition of the initial from 
the terminal portion of the atrial wave form, 
in the presence of a continuously moving baseline, is not possible. One cannot speak with 
confidence of having identified an "inverted 
P wave" in those leads showing the typical 
undulation pattern of atrial flutter. Further-
more, determination of P-wave direction, 
when possible, does not offer conclusive means 
of separating PAT with block from atrial 
flutter.

P-P Baseline

Lewis stated that the most important cri-
terion of atrial flutter was the presence of a 
continuously moving baseline in most leads. 
By contrast, PAT is characterized by quiescent 
intervals being evident between P waves. The 
usefulness of this diagnostic point is under-
mined in those cases in which a mobile base-
line appears in only one or a few leads as 
noted in case 2 (fig. 2). Undulating waves 
are seen only in leads II, III, and aVF. Flutter 
waves are commonly best seen in these leads. 
This electrocardiogram also demonstrates that 
one lead (V1 in this case) may show P waves 
while others show flutter. It is unlikely that a 
paroxysm of PAT was recorded by chance at 
that time. It may be argued that there is a 
single lead line of derivation favorable for the 
 vecors responsible for the entire flutter wave. 
In the case noted, the horizontal plane might 
be isoelectric for initial or terminal atrial 
 vectors, thereby prohibiting the presence of 
undulation in the chest leads and in those 
standard and unipolar limb leads widely 
skewed from the vertical. In the example 
given, only lead aVF or an exploratory lead in 
that plane, e.g., an esophageal lead, may 
demonstrate the familiar undulatory pattern.

Prinzmetal and associates suggested that 
the undulatory appearance of flutter is due to 
the combination of the ectopic P wave and the 
 oppositely directed T wave. The more rapid 
the atrial rate the larger is the T wave. It is 
 possible that PAT associated with very fast 
atrial rates may exhibit continuous baseline 
activity as a result of atrial repolarization be-
coming electrically more prominent as sug-
gested in the tracings of case 1. At first, lead 
V1 showed an undulant baseline (fig. 1A). 
The next day, the atrial rate had slowed and 
P waves with intervening isoelectric intervals 
appeared (fig. 1B).

The esophageal lead has been recommend-
d as a diagnostic aid in differentiating 
atrial flutter from PAT with block. Aug-
mented voltage results from greater prox-
imity to the signal source and may be helpful. 
This lead, however, like all electrocardio-
graphic leads, is subject to the equivalent di-
pole limitation, which dictates that the ex-
pression of a vector quantity will be deter-
mined by the spatial relations of the electrical 
forces and the lead axis. It has been re-
ported that isoelectric intervals may be pre-
 sent at one esophageal level and an undulat-
ing baseline at others as noted in case 1 
(fig. 3).

The average, present-day electrocardiograph 
registers only the low-frequency content of 
the electrical events and provides a limited 
range of amplification. The sweep speed and 
the characteristics of the amplification system

Figure 3

Case 1 (12-17-62). Digitalis had been stopped 6 
months previously. Atrial rate, 220. Ventricular rate, 
110. The esophageal tracing 38 cm. from the nares 
shows isoelectric intervals between P waves. At 42 
 cm, an undulating pattern appeared.

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of the recording device will significantly condition the appearance of wave forms and the baseline. A discussion of these important factors is beyond the scope of this report. The reader is referred to the excellent review by Caceres. There may be clinical profit in exploring atrial dysrhythmias with high-frequency recording technics at high magnification.

The problem of inter-individual and intra-individual variation in the interpretation of electrocardiograms deserves comment. The decision concerning the presence or absence of an isoelectric interval may be a subjective judgment. Moreover, one group reported the presence of isoelectric intervals, even in leads demonstrating the characteristic undulation pattern. Prinzmetal et al. submitted tracings of atrial dysrhythmia to five electrocardiographers requiring differentiation of PAT from atrial flutter in the majority of cases. There was full agreement in only 12 of 32 records.

The diagnostic significance of a mobile baseline would thus appear to be vitiated by the interplay of many factors.

**P-P Interval**

Classic paroxysmal atrial tachycardia is characterized by a perfect regularity of the P-P cycle length. PAT with block may demonstrate a detectable variability in this interval. Barker et al. reported 10 cases showing variation of cycle length and considered alternation of the excitatory wave between two pathways as a likely explanation. Dechert et al. noted nine examples and thought the variable intervals between successive impulses may have represented vagal inhibition of the ectopic pacemaker. Rosenbaum and Lepechkin also observed this phenomenon in cases of PAT with a 2:1 AV ratio. They attributed this lack of constancy to a “negative chronotropic effect of ventricular systole” produced by the arterial pulse that triggers pressor receptors to generate inhibitory vagal impulses. P-P interval variations, as great as 0.12 second, occurred to some degree in almost half of the 83 episodes reported by Lown and Levine.

Pure atrial flutter is reported to show perfectly regular spacing of the “F-F” interval. Irregularity of this interval has been observed, especially following vagal stimuli and digitalis administration, and the term impure flutter has been applied. Wilson reported the change from pure to impure flutter following eyeball pressure, with observable variation in the interval length between homologous peaks. The marked alternation of the P-P interval following the use of digitalis, noted in the electrocardiogram of case 1 (fig. 4) resembles this finding in impure flutter.

Although this item suggests the possibility of differentiation, it may represent the fact that Lown and Levine’s episodes of PAT with block, unlike those of atrial flutter, were predominantly digitalis-induced, and digitalis is known to “sensitize” the heart to vagal stimuli. There is also reason to question whether one can truly recognize identical points on the contour of the wave form in pure atrial flutter, so as to measure cycle length, under the usual recording conditions.

**A-V Response**

Atrial flutter usually exhibits an even ratio of atrial to ventricular beats, e.g., 2:1, 4:1. Odd-numbered ratios occur less frequently in atrial flutter and a 1:1 response is seen with much greater frequency in paroxysmal atrial tachycardia. In the present cases, AV conduction was variable, and 2:1, 3:1, and 4:1 ratios were registered. The occurrence of dropped beats in rapid atrial activity is thought to represent the inability of the AV node to respond to repetitive stimuli above a certain limit. Healthy junctional tissues will
not conduct impulses faster than 250 to 300 per minute because of the normal refractory period.14 Other factors including disease, drugs, and neural stimuli will also reduce the transmission rate. It is clear that both arrhythmias may have comparable conduction ratios in the range of overlap.

Ventricular Premature Contractions

Ventricular premature contractions were absent when atrial tachysystole with block was recorded in the subjects of this report, although they were occasionally noted at times of sinus rhythm. Ventricular premature contractions may accompany both flutter and PAT with block. The relative incidence of these contractions may be useful in contrasting groups of cases; however, such a criterion is of no value in the evaluation of an individual patient. Furthermore, the differences noted in Lown and Levine’s series23 represent the weighting of the PAT group by being predominantly digitalis-induced rather than arising spontaneously.

Carotid Sinus Pressure

PAT without block may be terminated abruptly by carotid sinus pressure. By contrast, PAT with block, like atrial flutter, may show an increase in the degree of AV block but is otherwise unaffected. Differentiation is not possible with this maneuver unless the effect allows identification of P waves or flutter waves. Carotid sinus pressure had no effect in the present cases.

Onset and Offset

Lown and Levine23 observed a gradual atrial slowing before return to sinus rhythm in cases of PAT with block. PAT without block classically reverts abruptly. It seems questionable that the presence of AV block determines this difference. Indeed, Iliescu and Sebastiani16 reviewed several cases of PAT with a 1:1 response that showed gradual slowing with therapy before changing to sinus rhythm and remarked on the similarity to atrial flutter. Barker et al.26 reported abrupt onset and offset in their cases of PAT with block. The diagnostic value of this phenomenon in distinguishing PAT from flutter is thus uncertain. An abrupt transition from atrial tachysystole to sinus rhythm was recorded in case 2 but only rarely is the onset or termination of these arrhythmias graphically documented. Lead V1 shows distinct P waves at a rate of 300 per minute and the abrupt return to sinus rhythm (fig. 5).

Potassium Administration

Case 1 was admitted to the hospital on four occasions and seen several times in the clinic with atrial tachysystole with block. The first two episodes developed during digitalis administration. Digitalis was withheld and potassium chloride was given orally. Sinus rhythm returned after 2 weeks and 6 days, respectively. Two subsequent episodes occurred after digitalis had been stopped for several months. On a regimen of barbiturates and bed rest, the dysrhythmia converted to sinus rhythm in 3 and 7 days, respectively.

Case 2 demonstrated similar phenomena. Withdrawal of digitalis was followed by return to sinus rhythm on two occasions. Bed rest and barbiturates were equally effective on two subsequent attacks occurring months after digitalis had been stopped.

There is ample evidence of a potassium deficit in digitalis-induced PAT with block.3,23 The accepted therapy is to stop digitalis and to administer potassium salts. Potassium is reported not to affect atrial flutter42 or idioventricular PAT with block.23 The appearance of atrial tachysystole with block during the administration of digitalis, noted in both cases, suggested a cause-and-effect relationship. Its reversal by withholding the drug and giving potassium seemed to support this thesis. The occurrence, however, of the morphologically identical arrhythmia on subsequent occasions unrelated to digitalis therapy casts doubt on this association. The return to sinus rhythm following rest and barbiturates indicates the danger in the reliance on a therapeutic response to make an electrocardiographic diagnosis. Moreover, the efficacy of potassium in digitalis excess manifests itself after a variable period of time. Unfortunately, several days may elapse before conversion is successful;
during this period the diagnosis remains in doubt. While the electrocardiogram is a remarkably sensitive indicator of the biochemical behavior of the myocardium, its specificity is less spectacular. The registration of an arrhythmia is not pathognomonic evidence of any disease state. The dictum that therapy be determined by the clinical picture has been challenged as noted in the introduction; the findings of this report find the rule substantiated.

**Summary**

Two patients are reported who demonstrated bouts of rapid atrial activity with associated AV block at times unrelated to the administration of digitalis. The criteria of Lown and Levine for the differentiation of PAT with block from atrial flutter are examined. The application of atrial rate in the region of the arbitrary borderline is not a useful criterion. Determination of P-wave direction in leads II and III cannot be made in the presence of an undulating baseline. Identification, when possible, is not sufficient evidence for distinguishing the two arrhythmias. The appearance of the baseline may not warrant the decisive weight commonly given to it. A combination of recording instrument characteristics, the appearance of atrial repolarization at critical rates, as well as subjective factors may explain the undulatory baseline rather than denote a special electrocardiographic entity. Alternation of the P-P cycle length in PAT with block occurs inconstantly and is not an intrinsic property of the arrhythmia. Digitalis, which has a vagal effect, may contribute to the presence of this phenomenon. The occurrence of ventricular premature contractions, response to carotid sinus pressure, and the AV ratio are nonspecific findings. The mode of termination of the arrhythmia may also lack specificity. Restoration of sinus rhythm following potassium administration will be, at times, coincidental. Moreover, the successful outcome of such a therapeutic trial is evidence of digitalis intoxication not proof of a specific arrhythmia.

Experimental and clinical evidence has firmly established that digitalis is capable of producing an atrial arrhythmia attended by AV block. This report does not contest the observation. A critical review of the contrasting features of atrial flutter and PAT with block and an analysis of the data in the present cases suggest that the electrocardiogram does not provide a means for the clear-cut separation of atrial tachycardia from flutter in certain cases and questions the existence of such a division. The term atrial tachysystole with block is offered as a designation for such tracings.

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