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Atrial Activity during Exercise in Patients with Atrial Flutter or Atrial Fibrillation

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ABSTRACT

The atrial activity was studied at rest and during exercise in 6 patients with atrial flutter and in 7 patients with atrial fibrillation. In the latter, a special recording technique was used which permitted identification of the *f*-waves. No increase in the frequency of the atrial waves was found. Thus the increase of the ventricular rate during work in patients with atrial flutter or atrial fibrillation seems to be caused by a change in the atrio-ventricular conduction.

INTRODUCTION

The ventricular rate during work in patients with atrial flutter and atrial fibrillation has been studied by several investigators (1, 4, 5, 6). On the other hand, atrial activity during work has rarely been studied. The aim of this study was to compare the atrial activity during work with the atrial activity at rest in patients with atrial flutter and atrial fibrillation.

MATERIAL AND METHODS

The study was performed on 6 patients with atrial flutter and 7 patients with atrial fibrillation. The age and sex of the patients as well as the probable cause of the arrhythmia and the current medication at the time of the study are presented in Table I. Patient no. 4 had an atrial-triggered pace-maker at the time the study was performed.

In the patients with atrial flutter an ECG with 12 leads was registered at rest and during an orthostatic test. During work, the leads $CH_{2, 4, 5 \text{ and } 7}$ were registered. In the patients with atrial fibrillation a special recording technique was used (3). Three bipolar chest leads were recorded. The common electrode was placed at the angle of sternum and three different electrodes were placed at the highest point in the left mid-axillary line (S 1), at the distal end of the sternal body (S 2) and at a point over the spinal column at the level of the sternal angle (S 3). In this recording a 3-channel differential pre-amplifier with 10 times higher amplification (0.1 mV=10 mm) than in a conventional ECG-recording is used and the ECG is recorded with a Mingograph 81 (Siemens-Elema Ltd., Sweden). The paper speeds were 10 and 100 mm/s. The exercise test was performed on an electrically braked bicycle ergometer with stepwise increased 6-minute loads.

In the patients with atrial flutter the flutter-waves (F-waves) could be delimited without great difficulty, even during work, and the frequency was given to the nearest 10th per minute. In the patients with atrial fibrillation it was sometimes more difficult to delimit the atrial activity. The measurements were performed on three different parts of each registration and included 10 consecutive fibrillation waves (*f*-waves). In Table I the mean of these three measurements is given, approximated to the nearest 10th per minute. The measurements were performed on the parts of the registrations where the *f*-waves appeared most distinctively. This can give rise to an underestimation of the *f*-wave frequency, since this is often more difficult to measure when the frequency is high. To obtain an estimate of the magnitude of this risk, the registrations at rest and during work at the highest load were coded. An independent observer then estimated how much of the registrations permitted measurement of the *f*-wave frequency. At rest, the *f*-wave frequency was judged to be measurable during 70–100 (mean 84) % of the registrations. During work at the highest performed load, the *f*-wave frequency was judged to be measurable during 60–90 (mean 77) % of the registrations. The percentage of the registrations which permits measurements of the *f*-wave frequency thus seems to decrease somewhat during work, compared with at rest. One reason for this is that the increased occurrence of QRS-complexes conceals the *f*-waves.

Fig. 1 shows an example of registration with bipolar chest leads during work in a patient with atrial fibrillation. The ventricular rate was measured on tracings with a paper speed of 10 mm/s. 25 consecutive ventricular complexes were included in the measurements.

RESULTS

The results are presented in Table I.

Of the patients with flutter, 4 showed a marked increase in the ventricular rate after standing for 8 min. No definite change of the F-wave frequency or of the F-wave configuration compared with the find-

Table I

Heart diseases: AI=aortic insufficiency, AS=aortic stenosis, ASD=atrial septal defect, Coarct.=aortic coarctation. IHD=ischemic heart disease, MI=mitral insufficiency, MS=mitral stenosis, op.=operated; Medication: D=digitalis, Q=quinidine, Ve=verapamil; A=atrial wave frequency, V=ventricular rate

Pat. no.	Sex	Age	Heart disease (besides arrhythmia)	Medication	At rest before work	Orthostatic test	1st load	2nd load	3rd load	10 min after work
Flutter										
1	♀	26	ASD op.	D, Ve	A 240	250	250	250		240
					V 82	115	125	250		87
2	♂	61	IHD	–	A 330	330	320	320	320	320
					V 108	165	158	158	160	160
3	♂	51	–	–	A 300	310	310	310	310	310
					V 103	158	153	154	153	130
4	♂	40	–	D	A 300	310	310	310	300	300
					V 98	102	100	102	103	100
5	♂	19	Coarct. op.	–	A 250	260	280	280	280	260
					V 108	135	140	142	142	132
6	♂	58	MS+MI	D	A 280	290	280	280		280
					V 92	96	134	136		90
Mean (in per cent of rest value)					A 100	103	103	103	103	101
					V 100	130	138	164	133	117
Atrial fibrillation										
7	♀	55	MI+MS	D	A 460	480	460			460
					V 69	81	127			67
8	♀	54	AS+AI+MS+MI	D	A 360	370	380	400		370
					V 70	106	124	147		90
9	♂	62	MS+AI	D	A 380	400	370	360	370	380
					V 63	91	84	118	148	78
10	♂	51	MS+AI	D	A 400	400	420	330	340	380
					V 60	74	83	114	164	71
11	♂	49	IHD	Q, Ve	A 420	420	430	420	420	440
					V 79	97	99	124	157	75
12	♂	45	MS	D	A 480	480	480	480		480
					V 80	105	124	154		65
13	♂	36	–	D	A 540		520	540	500	520
					V 65		93	107	168	78
Mean (in per cent of rest value)					A 100	102	101	98	94	100
					V 100	132	151	184	241	109

ings at rest could be found. During work on the bicycle ergometer, an increase of the ventricular rate compared with the orthostatic test was found in 2 of the patients, while the other 4 did not change their ventricular rate notably. The F-wave frequency during work was almost the same as at rest.

In the patients with atrial fibrillation, the ventricular rate increased in the standing position and further during work. Six of the 7 patients did not change their *f*-wave frequency during work, while in one of the patients the *f*-wave frequency decreased from about 400/min to 330–340/min.

DISCUSSION

Atrial activity in atrial flutter and atrial fibrillation during work has not been much studied, probably due to registration difficulties because of the low amplitude in conventional registration. In atrial fibrillation, the uncertainty of what in fact is registered is a further difficulty. Prinzmetal et al. (4) studied the *f*-waves in artificially induced atrial fibrillation in dogs. A few patients were also studied during surgery. The fibrillating movements in the atria were divided into mainly two groups. One type

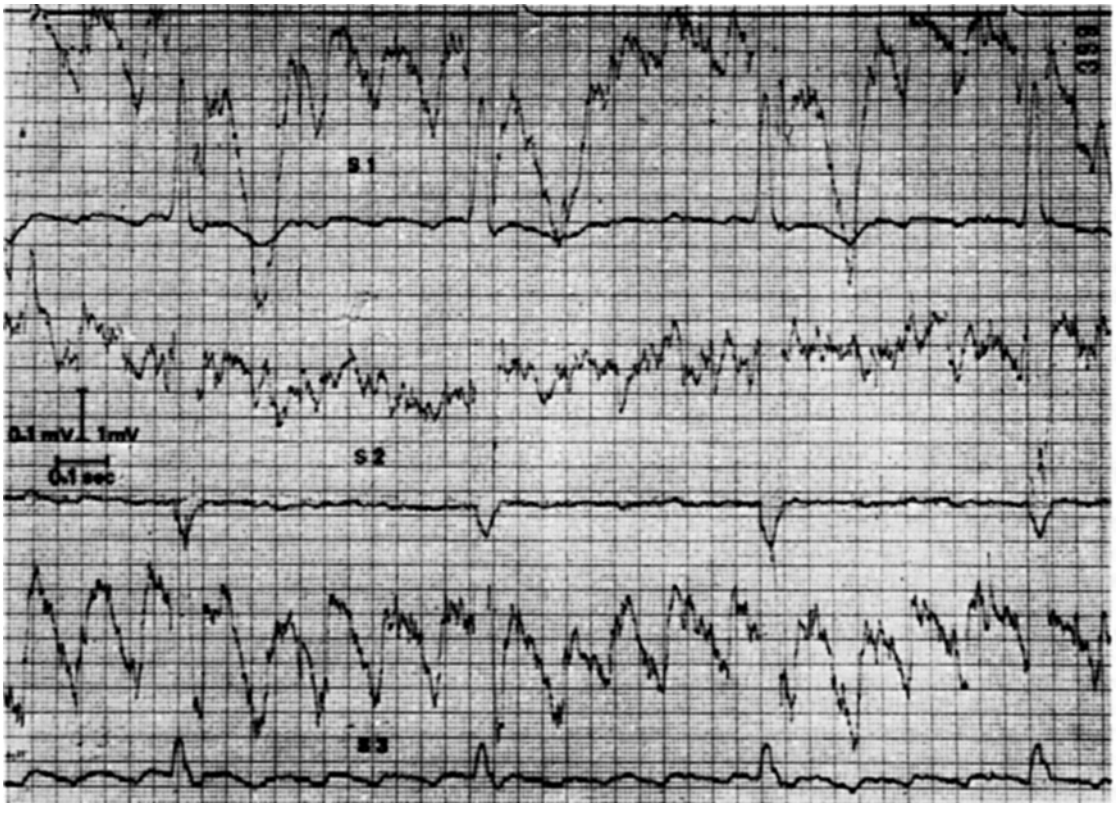

Fig. 1. Example of registration with bipolar chest leads during work in a patient with atrial fibrillation (*f*-wave frequency 480/min). The atrial activity is best seen in the 5th channel.

of movement observed had very low amplitude but high frequency (at times many thousands/min). They were called minute complexes (M-waves). Another type, probably corresponding to the *f*-waves of standard ECG, was named large waves (L-waves). Using a high-speed cinematographic technique, they found in dogs a dissociation between electrical and mechanical activity at *f*-wave frequencies over 280–300/min. Thus, the *f*-waves which are registered with conventional ECG and with higher amplitude using bipolar chest leads probably do not represent the mechanical activity in the atria, nor all of the electrical activity.

It seems reasonable to suppose that the *f*-wave frequency in atrial fibrillation is more closely related to impulse propagation in the atria than to impulse formation rate. The impulse propagation is in turn dependent on the refractory period of the different kinds of cells in the atria. During work, the vagal tone is decreased, while the sympathetic tone and the temperature increase. These factors can have different effects on the refractory period in pacemaker cells, cells of the conductive system and myocardial cells in the atria (2). Therefore, it is difficult to predict from results of studies *in vitro* of the refractory periods of different kinds of cells in the atria, how from a theoretical point of view the atrial wave frequency should be affected by physical work. The results of this study indicate that for both atrial flutter waves and atrial fibrillation waves the frequency is the same at rest as at work. One source of uncertainty is that the frequency in atrial fibrillation is periodically not measurable with the technique used. However, these periods are not much longer during work than at rest. The increase of the ventricular rate during work, which has been reported in patients with flutter and atrial fibrillation, thus seems to be caused by a change in the atrioventricular conduction and not by a change in the atrial activity.

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