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On the Reproducibility of Exercise Tests in Patients with Atrial Fibrillation

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ABSTRACT

Fifteen patients with atrial fibrillation, mostly due to advanced valvular heart disease, were examined by a graded work test and an orthostatic test on two occasions, the reason being, to study the reproducibility of the test in such patients. In 6 of the 7 patients with the highest working capacity the agreement between the two tests was good regarding heart rates at maximum work load. In the 8 patients with a low working capacity the results of the two tests differed widely. In the orthostatic test the difference in increase of the heart rate after standing was less than 5 beats/min in 3 patients in one of the tests, and in 2 patients in both tests. The exercise test in patients with atrial fibrillation must be evaluated with caution and has an acceptable reproducibility only in patients with fairly good functional capacity.

INTRODUCTION

We have previously reported on exercise tests in patients with atrial fibrillation (2, 3).

The average increase in ventricular rates at gradually increased exercise loads was often found to be close to a linear relationship. In particular, this was the case in patients with a relatively well-maintained functional capacity of the heart. However, in patients with more severely impaired heart function there was a tendency of a slightly more pronounced increase in the heart rate from resting value to especially that of the first load. In the literature different results have been presented on this problem (4, 7, 12).

In another study we have investigated the influence of different dose rates of digitalis on the heart rate and on the working capacity in patients with atrial fibrillation during exercise tests (3). By increasing the digitalis dosage the heart rate at the same load decreased.

The aim of the present study was to test the reproducibility of orthostatic and exercise tests in patients with atrial fibrillation. In such an investigation it is of critical importance that the cardiac state be stable and unchanged at, and in the interval between the two exercise tests.

MATERIAL AND METHODS

In 15 patients with atrial fibrillation exercise tests were done twice in each patient. The composition of the patient group is shown in Table I. The group is dominated by patients with valvular heart disease, often referred to this hospital for consideration for cardiac surgery. The exercise test was a part of this evaluation. Most patients had fairly advanced valvular disease. The repeated test was only performed with the patient's consent since this test was made mainly for scientific reasons.

This second exercise test was performed only in those patients fulfilling certain criteria to ensure a clinically stable condition of the patient between the time of the two tests. These criteria were:

(A) No change had occurred in clinical findings or in the patient's history of his capacity between the two tests. The patient was not in heart failure.

(B) The time interval between the two tests had not exceeded 3 months and it had frequently been much less. Seven of the cases had the tests less than 2 weeks apart.

(C) The resting ECGs were identical on both occasions. In 3 patients with more than 1 month between the tests chest X-rays were performed before the two exercise tests and were found to be identical.

(D) The patient had the same drugs in identical dosages on the two occasions. Serum potassium and other electrolytes were within normal limits at both tests.

(E) No other disease had occurred during the interval between the two tests.

The orthostatic test preceding the exercise test was performed and described in more detail by Sandberg (9). According to the recurrent nomenclature the test was considered 'negative' when the heart rate increased less than 20 beats/min and 'positive' if between 20 and 29.

The exercise test was performed according to the graded 'steady state' principle (10, 13). The exercise test was performed using a bicycle ergometer (5, 6) with the method and calculations having previously been described (2). The heart rate was determined at rest, after 8 min

Table I. *Composition of the case material*

Diagnosis	No. of patients			Age		Heart volume cc/m² BSA	
	Male	Female	Total	Mean	Range	Mean	Range
Mitral stenosis	4	3	7	42	28–57	745	510–1 060
Combined mitral disease	1	1	2	(49)	–	(650)	–
Mitral+aortic valve disease	2	3	5	48	39–62	730	590–1 010
Unknown	1		1	(36)	–	(550)	–
Total	8	7	15	44.8	28–62	714	510–1 060

standing, and after 2, 4 and 6 min at each load as the average of 25 consecutive heart intervals. The test was supervised by a physician at all times.

The results of the exercise test was expressed in different ways: as the work load at a heart rate of 110/min (W_{110}), as the highest work load which according to clinical judgment of the patient's symptoms and signs was permissible and possible to perform for 6 min (W_{max}), and as the ability to reach 'steady state' as defined below. W_{110} was calculated by slight interpolation or extrapolation, assuming a linear relationship between heart rate and work load within the small interval in question. In patients with atrial fibrillation and very low working capacity this is less precise (2). A 'steady state' was judged to be obtained when the difference between the heart rates at 2, 4 and 6 min on the same load was 10 beats/min or less.

RESULTS AND COMMENTS

The resting heart rates were fairly constant on the two occasions with few exceptions. In 13 of 15 patients the difference in resting heart rates were 10 beats/min or less and in 6 of 15 only 5 beats/min or less. The resting values (the lowest of the 2) were below 70 beats/min in 9 patients and above 90 (the highest of the 2) in 3 patients. These rates were rather high, considering that all patients except one was on maintenance dose digitalis.

With regard to the orthostatic test there was a difference between the two tests in 3 patients (from 'positive' to 'negative' or vice versa). Only in one was the difference greater. This patient had on the first occasion an increase of the heart rate of 26 beats/min after 8 min standing ('positive' reaction) and on the second test an increase of 6 beats/min ('negative' reaction). The other 2 had 18 and 16 on the first and 23 and 25 on the second test, respectively. In 5 cases the difference was 5 beats/min or less between the two tests of orthostatic reaction.

The working capacity, measured as W_{110}, was generally low, with a few exceptions (Table II). The mean W_{110} was 168 (range 18–439) and 191 (range 23–497) kpm/min at the two exercise tests. This was expected, as many patients had fairly advanced heart disease. In 8 patients with a W_{110} less than 100 kpm/min in one or both of the exercise tests there were 4 patients whose difference between the two tests did not exceed 1/3 of the lowest value. In one the difference was about 40%. In the remaining 3 in this patient group with low working capacity the difference was as much as double or more the low W_{110} in each pair. In the group with a working capacity W_{110} above 110 kpm/min, consisting of 7 patients, the agreement between the two exercise tests was slightly better. In 3 patients the results

Table II. *Results of exercise tests*

A is the first exercise test and B the second one. Definitions are given in Methods

Patients	W_{110} (kpm/min)		W_{max} (kpm/min)	
	A	B	A	B
1. A. M.	18	23	150	150
2. R. B.	50	36	150	150
3. V. R.	177	169	200	200
4. K. B.	88	116	200	200
5. A. K.	180	82	200	200
6. V. P.	23	30	250	250
7. M. S.	308	391	250	250
8. N. E.	167	86	300	300
9. G. H.	206	248	400	400
10. E. O.	75	260	400	400
11. S. K.	317	497	400[a]	600
12. E. W.	192	139	450	500
13. E. O.	37	47	500	500
14. G. S.	239	376	500	500
15. S. H.	439	367	700	700
Mean	168	191	337	353
S.D.	123	155	158	175

[a] The patient showed aberrant ventricular ECG-complexes. The first test was then interrupted. In spite of the same occurrence of aberration at the second test the exercise was allowed to continue.

Table III. *Heart rate resting, standing and during exercise*

A is the first exercise test. B−A is the difference between the second and the first test. W_1 is the first load and W_2 is the second load. Patients 1–8 have the lowest W_{max} and patients 9–15 have the highest W_{max}. Definitions in Methods

	Patients 1–8		Patients 9–15		Total	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Resting						
A	75.0	15.3	77.4	9.8	76.1	12.6
B−A	2.1	4.0	−7.3	6.7	−2.2	4.3
Standing						
A	10.4	9.9	17.3	5.6	13.6	8.7
B−A	−1.6	6.7	−0.2	3.9	−0.9	5.4
W_1						
A	104.8	19.0	107.6	23.1	105.8	19.8
B−A	4.9	10.9	−6.8	8.4	0.4	10.0
W_2						
A	125.1	25.4	134.0	26.1	128.5	25.0
B−A	5.8	12.0	−5.4	9.6	1.5	11.0
W_{max}						
A	129.4	22.1	154.2	18.1	137.5	22.4
B−A	10.3	11.6	−4.3	9.6	3.1	11.3

were almost identical, 2 had a difference of about 1/3 and the remaining 2 had about 50% increase from the lowest value in the compared pair.

W_{max} values were identical in 13 of the 15 patients. In one patient, on the second occasion, the maximal load was chosen as 500, due to a mistake, instead of as planned 450 kpm/min, while at lower loads that were the same there was a good agreement between the two tests. In another patient, there were similar heart rates at 200 and 400 kpm/min but on the first exercise test the investigator finished the test due to aberrant ventricular ECG-complexes. The second test was continued in spite of a similar aberration.

In 3 patients with a W_{max} of 500 kpm/min and more the highest attained heart rates were almost identical at the two tests, 150 and 146 in one, 171 and 171 in another and 127 and 123 in the third, respectively. In 2 patients who had a W_{max} of 400, one had heart rates of 141 and 134 but the other patient had 163 and 137. Out of the 8 patients with a low W_{max}, 2 had shown a good agreement between the heart rates at the two tests. In Table III the differences between the patients with a low and those with a higher W_{max} are seen. It is apparent from the Table that the S.D. of the differences between the two exercise tests is smaller in the group with a better W_{max}. The only exception is at rest where the S.D. was higher in the group with a higher W_{max}.

A 'steady state' was achieved on both occasions in only 2 patients. In 9 patients a 'steady state' condition at the highest load was obtained during one exercise test but not the other. Six of these patients obtained 'steady state' conditions on the second exercise test.

DISCUSSION

In many patients the case history is sufficient for a clinically appropriate judgment of the working capacity. However, it is sometimes difficult to get a reliable description from the patient and also it is often necessary to obtain a more objective and precise measurement on the functional capacity.

This is for example necessary to evaluate results after medication, surgery, or in an attempt to find an optimal time for surgical intervention etc. The need of a reliable method in this respect is obvious. Such a method is of course to a critical degree dependent upon a good reproducibility of the procedure. The ideal method should be well standardized, easy to repeat and the results should not be influenced by the training effect of repetition. The method used in the present study probably fulfils these requirements. A training effect of any significance is not probable considering the time lapse between the two tests and the fact that the test was repeated only once.

A most important factor with regard to the purpose of this study, i.e. to evaluate the repro-

ducibility of the exercise test is the stability of the patients with regard to their cardiac state. Most patients had got their atrial fibrillation in the course of a progressive heart disease and it was difficult to ascertain that the patients were stable enough for the purpose of this investigation.

In spite of a careful selection of patients, the results of the exercise tests in the patients with a low working capacity indicate either that such stable conditions were not obtained or that the arrhythmia was highly variable in itself. In the group of patients with a better heart function there was a relatively good reproducibility of the orthostatic test reaction as well as the exercise test.

The ventricular heart rate in atrial fibrillation is dependent upon the conditions of the atrioventricular junction (7, 11). It has been shown that the rate of the atrial activity is not changed during exercise in patients with atrial fibrillation (1). In spite of the irregular atrial activity the atrial rate is so rapid that there is always an impulse on hand for propagation through the atrioventricular junction. Therefore, the ventricular response in atrial fibrillation should be dependent upon the function of the atrioventricular node. Thus, we must consider influences from pharmacologic agents and the autonomous nervous system as well as from the heart disease in itself. In a previous paper we have shown that a rather high digitalis dosage is favourable for patients with atrial fibrillation (3). This has also been studied by Redfors (8).

In this study, however, there was no difference in drug therapy or electrolyte balance between the two tests. The alteration in atrioventricular function, particularly in those individuals with low working capacity, should therefore be caused either by variation in autonomic tone or by changes in the underlying heart disease.

In conclusion, the reproducibility of exercise tests was acceptable in patients with a good working capacity. On the other hand, in the group with more severely impaired heart function, the reproducibility was poor in spite of digitalization.

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