European Heart Journal (2002) **23,** 477–482
doi:10.1053/euhj.2001.2802, available online at http://www.idealibrary.com on IDEAL®

Long-lasting sport practice and lone atrial fibrillation

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Aims To analyse whether the proportion of patients with lone atrial fibrillation engaged in chronic sport practice was higher than that observed in the general population.

Methods and Results The records of 1160 patients, seen at the arrhythmia outpatient clinic, were reviewed. A total of 70 patients (6%) suffered lone atrial fibrillation and were younger than 65 years. Thirty two of them had been engaged in long-term sport practice. All patients in the sport group were men as compared to only 50% in the sedentary group ($P<0{\cdot}0001$). To avoid the confounding effect of sex distribution, women were excluded. Sportsmen started their episodes of atrial fibrillation at a younger age, they had a lower incidence of mild hypertension and their episodes of atrial fibrillation were predominantly vagal in contrast to the sedentary patients. The echocardiographic parameters were similar to those observed in the sedentary patients, but when compared with 20 healthy controls, they showed greater atrial and ventricular dimensions and a higher ventricular mass. The proportion of sportsmen among patients with lone atrial fibrillation is much higher than that reported in the general population of Catalonia: 63% vs 15% ($P<0{\cdot}05$).

Conclusion Long-term vigorous exercise may predispose to atrial fibrillation.
(Eur Heart J 2002; 23: 477–482, doi:10.1053/euhj.2001.2802)

Key Words: Lone atrial fibrillation, athlete's heart, vagal atrial fibrillation.

See page 431 doi: 10.1053/euhj.2001.3019 for the Editorial comment on this article

Introduction

Although uncommon causes of lone atrial fibrillation are occasionally identified[1–3], the aetiology of this condition often remains unknown. The observation that many patients with lone atrial fibrillation were sportsmen, prompted us to analyse whether the proportion of patients with lone atrial fibrillation engaged in long-term vigorous exercise was higher than that observed in the general population.

Revision submitted 30 May 2001, accepted 1 June 2001, and published online 19 September 2001.

Dr A. Sambola and Dr M. Vacca were supported by a Grant from the Fundació Clínic per la Recerca Biomèdica.

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Methods

Patients

The hospital records of 1160 consecutive patients seen at the Outpatient Arrhythmia Clinic between October 1997 and March 1999 were reviewed. A total of 70 patients (6%) had atrial fibrillation, were younger than 65 years-old, and did not have any identifiable structural heart disease.

Definitions

Lone atrial fibrillation

Lone atral fibrillation was defined as atrial fibrillation in the absence of structural heart disease or other identifiable cause for the arrhythmia such as hyperthyroidism or alcohol abuse. Patients with mild hypertension, controlled with only one drug, were included in the study. Individuals showing minor dilatation or mild

0195-668X/02/060477+06 $35.00/0

hypertrophy of the left ventricle or atrium were also included in the study since these changes were attributed to the athlete's heart.

Sport activity
Patients were included in the sport group if they had performed regular sport activity for at least 3 h a week for 2 years. This low cut off point was chosen because it separated, correctly, sportsmen from the rest of the patients. In fact, the majority of sportsmen had been practicing sport regularly since adolescence. None of the patients in the control group had a history of regular sport practice.

Classification of atrial fibrillation
Episodes of atrial fibrillation were classified according to the definition proposed by Gallagher and Camm[4].

Persistent atrial fibrillation
Atrial fibrillation that requires cardioversion to be terminated.

Paroxysmal atrial fibrillation
Self-terminating recurrent episodes of atrial fibrillation.

Permanent atrial fibrillation.
Patients in whom cardioversion was ineffective and remained in atrial fibrillation.

Sport practice in the general population

Data from sport practice in the general population were taken from the REGICOR study[5]. This was a cross-sectional study designed to establish the prevalence of cardiovascular risk factors in the province of Girona (Catalonia, Spain). In that study, physical activity was measured using the 'Minnesota Leisure Time Physical Activity Questionnaire'. This questionnaire was validated for use among Spanish men[6]. It measures the average daily energy expenditure in physical activity during the last year.

Data collection

Once atrial fibrillation patients had been identified through the clinical chart, they were interrogated about their sport practice and relevant clinical variables. If a recent echocardiogram was not available, a new echocardiogram was obtained. All patients gave informed consent to participate in the study. The Minnesota Leisure Time Physical Activity questionnaire was also administered to assess the physical activity performed in the last year.

Echocardiographic data

Twenty healthy controls with no regular sport activity and no other risk factors for atrial fibrillation were chosen as a control group for echocardiographic parameters. Left ventricular mass was calculated according to the Penn Convention[7].

Statistical analysis

The Fisher exact test or the chi-square test was used for categorical variables. The Student t-test or Mann–Whitney test were used for comparison of continuous variables. The one-way analysis of variance was used for the comparison of mean for more than two groups. A value of P lower than 0·05 was considered statistically significant. Statistical calculations were performed using the SPSS package[8].

Results

A total of 70 of the 1160 patients evaluated (6%) had lone atrial fibrillation. Among them, 32 (46%), who had been practising sport regularly for more than 2 years, formed the sport group. All of them were men. To avoid the confounding effect of the different sex distribution, women were excluded from the analysis.

Table 1 depicts the clinical and echocardiographic findings of the sportsmen. None of them had been engaged in professional sport, but most had participated in competitive activities at younger ages and had been on regular training after cessation of competition. Many of them practiced more than one sport, but only the main sport is depicted in the Table. Dynamic or mixed sports (soccer, cycling, swimming) predominated over static sports such as weight lifting. Mean duration of sport practice was 21 ± 12 years. Most patients (71%) had been practising sport that required vigorous exercise for more than 10 years.

Comparison with the exercise practice in the general population

According to the data obtained from the REGICOR study in Catalonia[5], 15·4% (95% CI: 12·6–18·2) of men between 25 and 65 years performed regular physical activity equivalent to 3 h of sports practice per week. The proportion of sportsmen among patients with lone atrial fibrillation was significantly higher 62·7% (95% CI: 48·1–75·9) ($P<0·01$).

Clinical characteristics

The clinical characteristics of patients with lone atrial fibrillation, according to their sports practice, are depicted in Table 2. There were no differences between sportsmen and sedentary patients in relation to the type of atrial fibrillation, the number of episodes, pharmacological treatment, complications or echocardiographic

Table 1 Clinical characteristics and echocardiographic data of sportsmen

Patients	Age (years)	HBP	Type of AF	Vagal	Age of first AF	No. of episodes	Sport type	Years of practice	EDD (mm)	ESD (mm)	IVS (mm)	PW (mm)	EF %	LA (mm)
1	50	+	Paroxysmal	0	44	30	Cycling	20	49	32	9	9	60	35
2	56	+	Paroxysmal	+	55	10	Weight l.	36	56	36	12	11	60	44
3	48	0	Persistent	+	46	3	Cycling	29	53	35	10	10	55	40
4	44	+	Paroxysmal	0	31	3	Soccer	17	62	41	10	10	57	39
5	38	0	Paroxysmal	+	38	2	Weight l.	18	56	38	11	11	58	41
6	61	0	Permanent	0	57	?	Cycling	12	51	33	11	10	59	48
7	21	0	Paroxysmal	0	18	3	Swimming	8	55	36	11	10	58	37
8	56	0	Persistent	+	54	2	Swimming	11	55	27	9	8	77	37
9	27	0	Paroxysmal	0	23	4	Soccer	10	48	28	11	11	70	31
10	48	0	Paroxysmal	+	46	2	Swimming	37	52	35	9	9	60	44
11	38	+	Paroxysmal	+	22	2	Cycling	13	58	34	12	11	67	46
12	41	0	Persistent	+	39	6	Soccer	27	59	38	13	11	59	44
13	25	0	Permanent	0	22	4	Running	7	53	32	11	9	78	38
14	62	+	Paroxysmal	0	58	3	Cycling	16	61	42	11	10	58	47
15	51	0	Paroxysmal	0	51	5	Soccer	37	54	36	8	10	65	37
16	40	0	Persistent	+	38	6	Soccer	10	56	36	9	10	61	39
17	39	0	Paroxysmal	+	36	1	Soccer	29	47	35	8	6	59	25
18	37	+	Paroxysmal	+	38	3	Soccer	16	61	37	9	9	64	43
19	15	0	Persistent	0	13	10	Swimming	5	48	29	8	8	65	28
20	60	0	Permanent	0	58	5	Cycling	37	48	36	12	11	50	48
21	55	0	Paroxysmal	+	45	10	Soccer	6	55	34	9	9	60	35
22	41	0	Paroxysmal	+	21	3	Cycling	15	54	38	10	10	51	48
23	46	0	Paroxysmal	+	43	2	Cycling	30	47	33	10	10	70	35
24	59	0	Persistent	0	57	2	Swimming	46	50	32	9	9	73	41
25	21	0	Paroxysmal	0	19	10	Soccer	11	56	39	9	8	52	38
26	64	0	Paroxysmal	+	60	6	Soccer	40	49	31	11	10	61	35
27	41	0	Paroxysmal	0	38	1	Soccer	13	48	26	10	9	72	38
28	21	0	Paroxysmal	+	21	5	Athletics	13	53	33	10	10	76	29
29	56	0	Paroxysmal	+	56	2	Swimming	30	47	26	13	12	71	37
30	33	0	Paroxysmal	+	32	15	Soccer	25	50	27	10	9	60	24
31	48	0	Persistent	+	39	6	Soccer	24	58	28	13	12	78	42
32	57	0	Paroxysmal	0	18	6	Soccer	45	57	40	10	9	66	36

AF=atrial fibrillation; EDD=end-dyastolic diameter; EF=ejection fraction; ESD=End-systolic diameter; HBP=High blood pressure; IVS=interventricular septum thickness; LA=left atrium; PW=posterior wall thickness.

parameters. However, there was a tendency for the atrial fibrillation episodes to start a younger age among the sportsmen. Furthermore, 57% of sportsmen suffered their episodes predominantly in a vagal situation (during sleep or after meals) as compared to only 18% in the non-sport patients ($P<0{\cdot}01$). On the other hand, a higher proportion of mild hypertension was observed in the non-sport group (12% vs 37% respectively $P<0{\cdot}05$).

Table 2 Clinical characteristics of male patients

	Sportsmen n=32 (63%)	Non-sportsmen n=19 (37%)	*P*
Age	44 ± 13	49 ± 11	ns
Paroxysmal	22 (69%)	12 (63%)	
Persistent	7 (22%)	7 (37%)	
Permanent	3 (9%)	0	ns
Age of first episode	39 ± 14	46 ± 10	0·08
Number of crisis	5·6 ± 6	4·3 ± 6	ns
Mild hypertension	4 (12%)	7 (37%)	<0·05
Vagal AF	17 (57%)	3 (18%)	<0·01

AF=atrial fibrillation.

Sportsmen had a higher energy expenditure than the sedentary patients according to the data obtained by the Minnesota Leisure Time Physical Activity questionnaire (274 Kcal. day^{-1} (66–1037) vs 154 Kcal . day^{-1} (14–464) $P=·03$), indicating that despite the established diagnoses of atrial fibrillation, sportsmen were still performing more exercise at the time of interrogation than their counterparts.

The statistical calculations were also done by excluding patients with mild hypertension. The results showed the same trends observed in the group as a whole.

Echocardiographic data

Table 3 depicts the results of comparing the echocardiographic parameters between sportsmen, non-sportsmen and a group of 20 healthy controls. There were no significant differences in the echocardiographic parameters between sportsmen and non-sportsmen with lone atrial fibrillation. However, there were clear cut differences in the dimensions of the left atrium, left ventricle, interventricular septum, posterior wall and left

Table 3 Echocardiographic data of sportsmen, no sportsmen and healthy controls

	Sportsmen n=32	Non-sportsmen n=19	Healthy controls n=20
Left atrium (mm)	38·4 ± 6	40·5 ± 5	34·5 ± 3*
LV end-diastolic diameter (mm)	53·3 ± 5	53·2 ± 5	50·4 ± 3#
LV end-systolic diameter (mm)	33·8 ± 4	33·2 ± 4	31·2 ± 4
Interventricular septum (mm)	9·7 ± 1	10·7 ± 1	8·6 ± 1*,#
Posterior wall (mm)	10·3 ± 1	11·3 ± 1	8·7 ± 1*,#
Shortening fraction	38 ± 7	37 ± 5	38 ± 5
Ejection fraction	63 ± 9	63 ± 8	67 ± 4
Left ventricular mass (g)	242 ± 60	275 ± 59	177 ± 42*,#

LV=left ventricular. *P<0·05 in comparison to sportsmen. #P<0·05 in comparison with non-sportsmen.

ventricular mass when compared to healthy patients not engaged in sport.

Electrophysiological study

Thirteen patients in the sports group and four in the non-sports group underwent an electrophysiological study in order to exclude potentially curable causes of atrial fibrillation. None of them showed evidence of focal atrial fibrillation and other mechanisms of tachyarrhythmia were excluded. In four patients common atrial flutter was induced during the electrophysiological study and they underwent successful radiofrequency ablation. Common flutter had been previously documented in only two of them. Two patients, both from the sports group, required ablation of the atrioventricular node with pacemaker implant due to refractory symptoms.

Therapy

A total of 48 patients (94%) received antiarrhythmic treatment. The mean number of agents was 1·5 ± 0·9 (range from 0 to 4). The therapy at the moment of analysis was: beta-blockers in 10, sotalol in eight, amiodarone in 14, propafenone in two, flecainide in 10, verapamil in three and digoxin in one. Fifty per cent of patients in each group had received beta-blockers as a therapy prior to the moment of the interrogation. However, only 27% of the sportsmen and 37% of the sedentary subjects were still receiving beta-blockers. This difference was not statistically significant.

Fourteen patients received chronic anticoagulation with acenocumarol because they had hypertension or previous cerebrovascular accident as a risk factor. Fifteen patients required cardioversion without any complication and with an effectiveness of 92%. In three sportsmen atrial fibrillation evolved to a permanent form (none among the sedentary patients). There were two episodes of transient cerebrovascular embolism. One in each group.

Discussion

Main findings

Several conditions play a role in the genesis of atrial fibrillation in patients without apparent heart disease, such as hypertension, alcohol abuse[9] or hyperthyroidism. Other causes of atrial fibrillation in structurally normal hearts have been identified such as genetic[1], focal atrial fibrillation[3] or atrial fibrillation precipitated by supraventricular tachycardias[2]. However, in many patients the cause of atrial fibrillation remains unclear. The main finding of our work is that a high proportion of men with lone atrial fibrillation (63%) had practised sport regularly for many years. This proportion is significantly higher than the proportion of males younger than 65 years who practise sport regularly in the general population (15%). These data suggest that chronic sports practice may contribute to the development of atrial fibrillation in male patients. The comparison between sportsmen and controls with lone atrial fibrillation also supports this hypothesis, since sportsmen present some differences in clinical variables: sportsmen started their episodes of atrial fibrillation at a younger age, they showed a predominant vagal pattern and they had a lower prevalence of hypertension than the control group.

The athlete's heart

It is a demonstrated fact that intense sport practice causes a variety of morphological changes in the heart[10–15]. Furthermore, prolonged training induces an enhanced vagal tone and bradycardia [16–18]. Dynamic exercise provokes an increase in the dimensions of the cavities of the heart, whereas static exercise induces

hypertrophy. Our population of sportsmen had increased heart dimensions and a higher ventricular mass than healthy controls. This may indicate that prolonged sport practice had induced these changes. On the other hand, atrial fibrillation patients who did not engage in sport practice also showed increased dimensions and left ventricular mass, suggesting that although the cause of atrial fibrillation was not apparent, they had some structural changes that contributed to the development of the arrhythmia.

Although some patients suffered mild hypertension, the results were similar when they were excluded from the analysis.

Arrhythmias in sportsmen

Sport practice is not considered to be the cause of arrhythmias by itself in the absence of an arrhythmogenic substrate [19]. Only a few studies have considered a possible relationship between sport practice and atrial fibrillation. The incidence of atrial fibrillation could be increased among competition athletes since it would be present in about 0·063% of them, as compared to 0·004% of the general population[16]. Other authors such as Coelho *et al.*[20] and Furlanello *et al.*[21] found that lone atrial fibrillation was present in about 25% of athletes seen because of palpitations or documented arrhythmia. However, the authors did not suggest any possible cause–effect relationship between sports practice and atrial fibrillation, although Furlanello *et al.* found clinical improvement of the arrhythmia upon cessation of the competitive sport. More recently, Karjalainen *et al.*[22] found an increased proportion of atrial fibrillation in a group of top ranked orienteers (5·9%) compared to controls (0·9%). Interestingly, the two patients with lone atrial fibrillation in the control group were also engaged in vigorous exercise. These previous observations are in agreement with our results.

Experimental models of atrial fibrillation

The induction of atrial fibrillation in animal models is achieved by perfusing acetylcholine and by rapid atrial pacing[23–25]. It is well known that an increase in vagal tone produces a shortening of the atrial refractory period that, combined with atrial stimulation, allows the induction of atrial fibrillation that persists as long as vagal tone is enhanced[26]. Other authors, such as Morillo *et al.*[27] have demonstrated that a certain degree of atrial dilatation is necessary to achieve chronic atrial fibrillation.

Atrial fibrillation of vagal origin

Coumel *et al.*[28] described how in some patients, an atrial fibrillation crisis appeared predominantly in a vagal context. According to the authors, vagal atrial fibrillation occurs typically at night, after heavy meals or a few hours after intense exercise. It is more frequent in young males and presents typically in paroxysms[29,30]. However, the authors did not describe a predominance of sportsmen among their patients. Although animal experiments suggest that vagal stimulation is an important factor in the triggering of an atrial fibrillation crisis, its incidence in clinical practice is considered to be low[31]. Other authors have found a very low proportion of vagal atrial fibrillation among their patients[32].

Possible mechanism of atrial fibrillation in sportsmen

In sportsmen one may identify two factors that have been clearly demonstrated to favour the occurrence of atrial fibrillation: an increased vagal tone with bradycardia, and a slight dilatation of the heart cavities[10–18]. We have observed such an enlargement of cardiac cavities and left ventricular mass in our patients when compared with healthy controls. Whether or not these changes are due to chronic sport practice cannot be established in our study. This apparent relationship between prolonged sport practice and atrial fibrillation had not been previously well established, perhaps because cardiovascular evaluation in athletes is usually performed at the time of maximal sport activity[16–21]. Our sportsmen were evaluated after many years of sport practice, when some of them had already reduced their activities to a very low level. Only after specifically asking for their past sport activity did it become apparent that these patients had been performing vigorous exercise for many years. It is well known that the incidence of atrial fibrillation increases with age. In our patients, the risk factor of sport activity may have had many years of exposure, as it occurs with other risk factors, such as hypertension, leading to the appearance of the arrhythmia.

Limitations of the study

Although these data were collected at the outpatient clinic in a series of consecutive patients with atrial fibrillation, we cannot rule out a selection bias. However, we consider this possibility very unlikely since our referring cardiologists tend to send all patients with lone atrial fibrillation to our unit for further evaluation. Furthermore, a bias in the reference would not explain the clinical differences (vagal origin or earlier age of initiation of the arrhythmia) observed in sportsmen when compared to patients not practising sport. Further case-control and longitudinal studies will establish more firmly the relationship between sport practice and atrial fibrillation.

Conclusion

There is high proportion of sportsmen among patients with lone atrial fibrillation which differ from the proportion observed in the general population.

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