

Exercise capacity after His bundle ablation and rate response ventricular pacing for drug refractory chronic atrial fibrillation

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Abstract

Objective—To evaluate exercise capacity of patients with chronic atrial fibrillation in whom His bundle ablation followed by ventricular rate response pacing (VVIR) was carried out because of drug refractoriness.

Design—Prospective study.

Patients—25 consecutive patients, all with chronic symptomatic drug refractory atrial fibrillation, underwent His bundle ablation. Before this intervention all patients were on antiarrhythmic drugs to attain acceptable heart rate control and to relief symptoms.

Main outcome measures—Exercise capacity, including measurements of $\dot{V}O_2$, was examined before and after a mean interval of seven months following His bundle ablation.

Results—Exercise capacity after His bundle ablation increased from a mean of 109 (SD 49) W to 118 (46) W ($P < 0.002$), but $\dot{V}O_2$ at peak exercise did not change significantly. Maximum exercise capacity was achieved with a significantly lower maximum driven heart rate than the spontaneous heart rate before ablation.

Conclusions—Exercise capacity of patients who underwent His bundle ablation followed by VVIR pacing remained unchanged or improved during a mean follow up of seven months. Larger patient populations with longer follow up are necessary to examine determinants of improved exercise capacity.

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Keywords: chronic atrial fibrillation; His bundle ablation; exercise capacity; VVIR pacing

Atrial fibrillation can vary from an asymptomatic disorder to one causing intolerably fast or irregular heart rates resulting in tachycardiomyopathy.¹ If symptoms cannot be treated satisfactorily with antiarrhythmic drugs, or if the side effects of antiarrhythmic drugs are not acceptable, His bundle ablation followed by chronic cardiac pacing is often done.² While this procedure has been shown to relieve symptoms and improve cardiac performance,³⁻⁶ exercise capacity has been little studied. The purpose of the present prospective study was to assess the long term effects on exercise capacity, using oxygen consumption measurements to ensure maximum effort,

after His bundle ablation and ventricular rate response pacing (VVIR) for drug refractory chronic atrial fibrillation.

Methods

PATIENTS

This prospective study was performed between August 1993 and September 1994. Patients suffering from symptomatic or incapacitating atrial fibrillation selected for His bundle ablation were included. Exclusions were patients showing (1) angina pectoris of more than New York Heart Association (NYHA) class II (IV), (2) aortic or mitral valvar stenosis or incompetence, (3) respiratory diseases interfering with normal oxygen uptake, (4) any other abnormality interfering with the capability of performing a bicycle exercise test, and (5) paroxysmal atrial fibrillation.

PROCEDURES

Exercise testing with oxygen uptake measurement was performed to ensure that patients exercised maximally. Before exercise testing both routine spirometry and measurement of haemoglobin were performed, the echocardiographic left ventricular end diastolic dimension (LVEDD) and left atrial dimension were measured using the parasternal long axis, and valve abnormalities were looked for. After His bundle ablation and pacemaker implantation a standard chest x ray was taken to determine the position of the pacing lead and to permit calculation of the cardiothoracic ratio. For each patient the Quetelet index was obtained by the formula: $\text{weight}/(\text{length})^2$ (kg/m^2).

Exercise testing with respiratory gas analysis

The study was performed using an upright bicycle ergometer. The mean heart rate during atrial fibrillation was determined by measuring the average heart rate for 15 second intervals. Following a one minute resting period on the bicycle for calibrating the gas exchange data, a continuing graded exercise test was performed, starting at 60 W. A programmable, stepwise incremental ramp of 20 W/2 min was used with on-line real time gas exchange analysis. Oxygen consumption ($\dot{V}O_2$ ml/min/kg), carbon dioxide production ($\dot{V}CO_2$ ml/min/kg), and respiratory exchange ratios (RQ) were continuously measured and analysed using an automated breath by breath system (SensorMedics Horizon System 4400TC, SensorMedics Corporation, Anaheim, California, USA). Gas variables were reported

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at 30 second intervals. Peak $\dot{V}O_2$ was defined as oxygen consumption at peak exercise calculated as the mean of the values measured during the last 30 seconds of exercise. Therefore oxygen uptake at peak exercise is referred to as peak oxygen uptake (peak $\dot{V}O_2$), not to be confused with $\dot{V}O_2$ max, defined as the maximum oxygen uptake at any time of the exercise test. Antiarrhythmic drugs used before His bundle ablation remained unchanged in advance of the exercise test. The endpoint of the exercise test was exhaustion in terms of dyspnoea or fatigue.

Pacing treatment and follow up

After achievement of complete heart block⁸ a permanent pacemaker was implanted using a bipolar lead (Encore 033–301 Telectronics, Lane Cove, Australia) connected to a VVIR pacemaker (Telectronics META III). At discharge, lower pacing rate was set at 70 pacing impulses per minute (ppm) and upper pacing rate varied from 120–150 ppm, depending on age and assumed lifestyle.⁹ A standard check of the pacemaker function was performed one and six weeks after implantation. Subsequent follow up visits were scheduled every six months and consisted of pacemaker checks, Holter monitoring, and exercise testing.

PACEMAKER CHARACTERISTICS

The Telectronics Meta III device uses changes in minute ventilation as the sensed variable for adjusting pacing rate. The minute ventilation is derived using 1 mA current pulses lasting for 15 μ s at 50 ms intervals, which are emitted between the proximal lead sensing–pacing ring and the pacemaker casing. The calculated impedance signals vary with the frequency of the respiratory rate and depth of breathing, that is, tidal volume. In the rate response mode the rate adapts to the patient's individual respiratory impedance characteristics. Changes in minute ventilation have been shown to correlate directly with changes in oxygen consumption and hence metabolic demand.^{10–12}

STATISTICAL ANALYSIS

Variables with a continuous distribution were expressed as mean values (SD). Differences were compared by means of a two tailed paired *t* test. For the linear regression a least square estimation after log transformation of the dependent variable was used.

Results

PATIENTS

Of 40 patients initially screened for participation in this study, 10 were excluded because of exclusion criteria (1) to (4) and five because of paroxysmal atrial fibrillation. Of the patients included, nine had lone atrial fibrillation (table 1). During a mean interval of 79.8 months before His bundle ablation, a mean of 3.8 different antiarrhythmic drugs was tested, either as single treatment or combined with other antiarrhythmic drugs. Further details of the patients' baseline characteristics are also given in table 1.

In all patients right sided His bundle ablation was successful at the first procedure. Measurements at pacemaker implantation showed following mean values: ventricular threshold 0.24 (0.09) V, current 0.64 (0.24) mA at pulse width 1.0 ms, and impedance 723 (92) ohms. An intracardiac electrogram could not be recorded in all patients because of lack of sufficient escape rhythm.

RESULTS OF EXERCISE TESTING

All patients were on antiarrhythmic drugs during the baseline exercise test. The second exercise test with VVIR pacing was performed at a mean interval of seven months after His bundle ablation and all patients were now free of antiarrhythmic drugs. The mean exercise capacity improved significantly from 109 W before to 118 W after the intervention ($P = 0.002$). The mean exercise duration also increased but not significantly (7.2 v 8.2 min). Peak $\dot{V}O_2$, however, defined as oxygen uptake at peak exercise, did not differ (19.0 v 18.9 ml/min/kg). The gas exchange anaerobic threshold, including the point at which carbon dioxide production increased disproportionately in relation to oxygen consumption and where there was a respiratory exchange ratio of > 1.0 , was reached in all patients. Respiratory quotient as an objective measurement of maximum exercise capacity was adequate and did not differ significantly from before to after the procedure (1.19 v 1.21). The mean maximum heart rate diminished significantly from mean of 153 beats/min to a mean of 130 ppm ($P = 0.011$).

After His bundle ablation the mean maximum heart rate was more than 90% of the programmed upper pacing limit in all patients, whereas 16 patients (64%) reached their programmed upper rate pacing limit (table 2). Pacemaker parameters were programmed depending on age and assumed lifestyle. Patients with low exercise capacity before His bundle ablation were set to a lower upper rate pacing limit (120 ppm), in contrast to those with higher exercise capacity (150 ppm). In

Table 1 Baseline clinical characteristics of 25 study patients

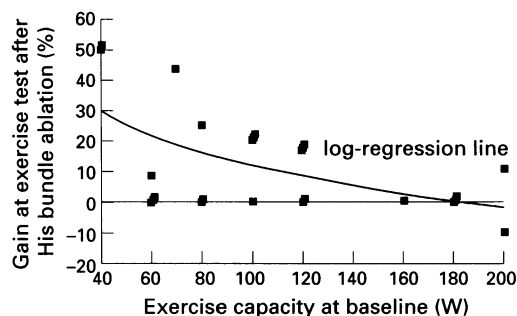
Variable	Value
Age, years	58 (11)*
Gender (male/female)	14/11
Duration of atrial fibrillation, months	79.8 (34)*
Underlying heart disease	
Ischaemic heart disease	6
Mitral valve disease	5
mitral incompetence grade I (IV)	1
mitral valve prolapse	2
mitral valve replacement	2
Congenital heart disease	1
correction ASD (type 2)	1
Systemic hypertension	4
Lone atrial fibrillation	9
Echocardiographic measurements	
Left atrial size	mm 49.2 (6.7)*
Left ventricular end diastolic diameter	mm 49.0 (5.6)*
Chest x ray, cardiothoracic ratio	% 49 (6)*
Quetelet index (ref: < 26)	kg/m ² 25.4 (3.5)*
Forced expiratory volume/s (FEV ₁)	% 73.6 (3.8)*
Blood pressure	
Systolic	mm Hg 130 (26)*
Diastolic	mm Hg 81 (5)*
Haemoglobin	mmol/l 8.1 (0.4)*

*Mean (SD).

Table 2 Programmed upper rate pacing limit and exercise capacity after His bundle ablation and VVIR pacing. Values are mean (SD)

	Upper rate 120 ppm	Upper rate 150 ppm
Number of patients	11	14
Number of patients reaching upper rate limit	5	11
Mean maximum heart rate pre-HBA (bpm)	146.4 (50.0)	159.9 (34.1)
Mean maximum heart rate post-HBA (ppm)	112.3 (18.6)	142.6 (16.7)
Mean exercise capacity pre-HBA (W)	73.6 (22.0)	137.1 (47.0)
Mean exercise capacity post-HBA (W)	81.8 (24.4)	145.7 (41.0)
Mean age (years)	65.6 (7.6)	53.4 (9.9)

Log regression line of the gain of exercise capacity (in percentage) after His bundle ablation compared to baseline (X axis). Some patients had equal exercise capacity but there was a trend for patients with low exercise capacity to have the most marked improvement. Two patients started exercise performance at a level of 40 W.



the former group, mean upper rate pacing was 112 ppm and only five patients (45%) reached their programmed upper pacing limit (table 2), whereas this was the case in the latter group in 11 of 14 patients (79%). Fine tuning of the pacemaker parameters in the individual patient can result in a better exercise performance, but it is emphasised that in this study the initial pacemaker settings were not reprogrammed during follow up.

The figure shows the individual changes in exercise capacity after His bundle ablation and VVIR pacing as compared to the baseline condition. In all but one patient the exercise capacity remained stable ($n = 12$) or improved ($n = 12$). Some patients with a low baseline exercise capacity showed a marked improvement after the intervention, whereas other patients had no change at all. A logarithmic line was fitted, which models the trend of the expected improvement of exercise capacity in relation to the baseline exercise capacity.

To identify clinical characteristics possibly related to an improvement in exercise capacity a multivariate analysis of the duration of atrial fibrillation before ablation, peak $\dot{V}O_2$, the cardiothoracic ratio, and the left ventricular end diastolic diameter was performed. This showed a favourable outcome for those patients having an LVEDD larger than 55 mm ($P < 0.002$) but this was only observed in four patients.

Discussion

In this prospective study we examined the exercise capacity before and after His bundle ablation followed by VVIR pacing for drug refractory symptomatic chronic atrial fibrillation, using oxygen consumption as an objective tool. The results of this study show that there was a significant improvement in mean exercise capacity which was most marked in patients with the lowest exercise capacity during drug treated atrial fibrillation before the His bundle ablation (figure). Although the numbers were small, it appears that patients with echocardiographic evidence of an enlarged left ventricular end diastolic diameter (mean 61.7 mm) had a greater improvement in exercise capacity.

So far several studies have reported favourable results after His bundle ablation for atrial fibrillation in terms of cardiac performance and quality of life.²⁻⁶ Four studies examined changes in the echocardiographically measured ejection fraction, showing that a normal baseline ejection fraction remained unaffected after His bundle ablation, whereas a diminished baseline ejection fraction increased.³⁻⁶ However, in three studies the patients suffered from either chronic or paroxysmal atrial fibrillation, which interferes with the outcome of such studies (table 3).^{2,4,6} Several studies have shown that after His bundle ablation the echocardiographic left ventricular end diastolic diameter did not change during follow up (table 3).^{3,5,6,13} Because improvement in quality of life and the absence of changes of the left ventricular end diastolic diameter are well established results of His bundle ablation followed by cardiac pacing, these outcomes were not investigated in the present study.

The presented results may be influenced by the behaviour of the sensor of the rate responsive pacing system, the programmed slope of the pacing rates, and the selected lower and upper pacing rates. In all patients the same pacemaker was implanted, and the initial pacemaker parameters were programmed according to age and assumed lifestyle, and were not changed during follow up. We have shown earlier, using questionnaires and exercise testing, that after the initial programming of this minute ventilation rate responsive pacemaker, requests for reprogramming during long term follow up are rare.¹² Previous studies have reported that after His bundle ablation the mean maximum achieved driven heart rate during exercise varied from 99 to 125 ppm

Table 3 Several variables at follow up after His bundle ablation

Author	Year	No of pts	AF,b	Follow up (months)	Mean max HR after HBA (ppm)	LVEDD after HBA (mm)
Kay ²	1988	12	paroxysmal + chronic	8	125	nr
Heinz ⁵	1992	10	chronic	2	nr	NS*
Twidale ⁴	1993	14	paroxysmal + chronic	1.5	99	nr
Brignole ³	1994	23	chronic	3	105	NS*
Edner ⁶	1995	29	paroxysmal + chronic	7	nr	NS*
This study		25	chronic	7	130	nr

AFib, atrial fibrillation; HBA, His bundle ablation; HR, heart rate; LVEDD, left ventricular end diastolic diameter; nr, not reported.

*Compared with LVEDD before His bundle ablation.

(table 3),²⁻⁴ whereas a mean maximum driven heart rate of 130 ppm was obtained in our study. Further studies are needed to establish the optimal pacing parameters for the individual patient after His bundle ablation for drug refractory atrial fibrillation.

Changes of left ventricular function, and the discontinuation of antiarrhythmic drug treatment, and a general improvement in wellbeing are three possible causes of improved exercise capacity. Improvement of ejection fraction has been associated with improvement of exercise capacity,^{3,5,6} but a correlation between $\dot{V}O_2$ measurement and indices of resting left ventricular function, such as ejection fraction, have not been established.¹⁴ The measured value of peak $\dot{V}O_2$, defined as oxygen uptake at maximum exercise, is generally accepted as an estimation of left ventricular function.^{15,16} In our study this value remained unchanged after His bundle ablation and VVIR pacing, and therefore it is unclear whether an improvement of left ventricular function is crucial for better exercise capacity. However, improvement in exercise capacity was associated with a significantly lower driven heart rate compared to the preablation spontaneous heart rate. This finding can be partly explained by insufficiently controlled atrioventricular conduction with antiarrhythmic drugs during atrial fibrillation. In addition, a favourable effect on left ventricular function can be expected after withdrawal of antiarrhythmic drug treatment, eliminating side effects of drugs and possible negative inotropic effects. One might speculate that a more impaired left ventricular function might benefit more from this withdrawal. Finally, one may assume that improved wellbeing can result in higher exercise capacity. Up to now the contribution of any of these—or other—causes to improved exercise capacity remains uncertain and needs further investigation.

CONCLUSION

This study showed that exercise capacity of patients with VVIR pacing remained unchanged or improved during a mean follow up of seven months. In our view, larger patient

populations with longer follow up are necessary to define the determinants of improved exercise capacity.

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