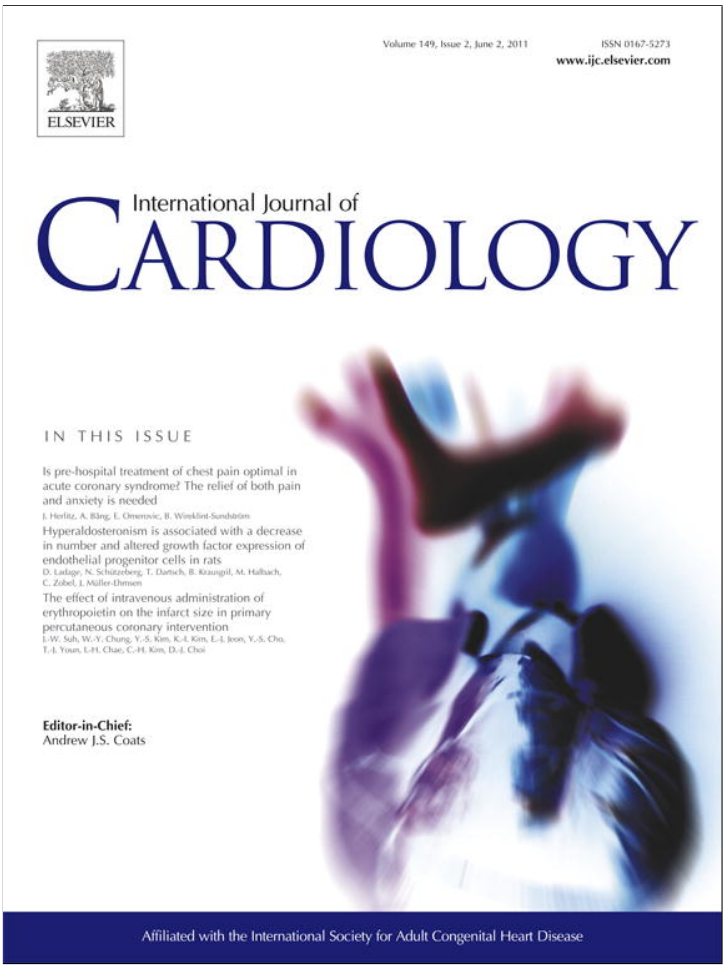

Right atrial flutter isthmus ablation is feasible and results in acute clinical improvement in patients with persistent atrial flutter and severe pulmonary arterial hypertension

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Pressure loading of the right ventricle (RV) in severe pulmonary arterial hypertension (PAH) often results in right atrial (RA) enlargement and hypertrophy. This abnormal remodelling makes patients with PAH vulnerable to atrial flutter (AFL). Indeed, AFL is the most common arrhythmia in severe PAH [1]. Patients with severe PAH already have a low cardiac output, and the loss of co-ordinated atrial contraction in AFL is not tolerated well. It is therefore crucial that sinus rhythm is restored promptly.

Radiofrequency ablation (RFA) of the RA isthmus is an established technique for the treatment of AFL. The advantages of RFA include the avoidance of negatively inotropic antiarrhythmic therapy and restoration of sinus rhythm. Moreover, a curative catheter ablation results in bidirectional isthmus conduction block preventing the occurrence of future episodes of AFL.

We hypothesised that the restoration of sinus rhythm in patients with AFL and PAH would improve exercise capacity. A retrospective study was therefore conducted in a group of patients with severe PAH to test this, and determine the feasibility and success of the ablation in this cohort.

The National Pulmonary Hypertension Unit based at Hammersmith Hospital in London, UK is a regional centre which investigates and manages patients with PAH according to published guidelines [2]. The classification of pulmonary hypertension is based on the 2003 international consensus document [3]. We included patients who presented with AFL and with PAH due to pulmonary arterial hypertension (e.g. idiopathic) and chronic pulmonary thrombo-embolism between September 2001 and 2008. Individuals that had PAH secondary to left heart (e.g. left ventricular systolic dysfunction), congenital heart and pulmonary disease were excluded. The baseline characteristics are shown in Table 1.

Patients underwent clinical and echocardiographic assessment prior and three months after flutter ablation including a six minute walk test and documentation of their WHO functional class. The latter is graded from 1 to 4; 1 having unlimited exercise capacity and 4 being breathless at rest.

Atrial flutter was confirmed to be isthmus-dependent in all cases by entrainment criteria. RFA was performed in a standard fashion. The type of AFL, the use of anti-arrhythmic drugs before and after ablation, procedure time, clinical outcome and complications of RFA was recorded.

A six minute walk test was performed according to the American Thoracic Society guidelines [4]. Echocardiography was performed immediately pre-ablation and after three months. The measurements that were analysed included RV systolic pressure (RVSP), RA volume, Tei index as first described by Tei [5], and eccentricity index in systole and diastole. Follow up was carried out three months after RFA and included an assessment of symptoms, WHO class and six minute walk test. A 12 lead resting ECG and an echocardiogram were also performed.

Results are expressed as mean with standard deviation or median with inter-quartile range for normally distributed and skewed data respectively. Pre and post ablation functional classes and six minute walk test data were analysed by Wilcoxon signed rank test and paired Students *t*-test respectively using Minitab.

Table 1
Baseline characteristics (n = 22).

Age	61 ± 16.3 years	
Male	14 (63.6%)	
Aetiology of PAH	IPAH	10
	CTEPH	11
	APAH	1
Functional capacity (mean)	WHO class	III (range II–IV)
	Six minute walk test (m)	228 (152–516)
Medication	Bosentan	16 (72.7%)
	Sildenafil	9 (40.9%)
	Treprostinil	4 (18.1%)
	Spironolactone	12 (54.5%)
	Loop diuretic	17 (77.2%)
	Amiodarone	3 (13.6%)
	Beta blocker	1 (4.5%)
	Digoxin	8 (36.3%)
Cardiac catheter data	Mean right atrial pressure (mm Hg)	12 ± 5.6
	Mean pulmonary artery pressure (mm Hg)	54.5 ± 11.1
	Cardiac index	2.13 ± 0.15
	Pulmonary vascular resistance (dyne/s/cm)	983 ± 98.75

Data as mean ± SD and median (IQR).
PAH— Pulmonary arterial hypertension, APAH— Associated pulmonary arterial hypertension, IPAH— Idiopathic pulmonary arterial hypertension, and CTEPH— Chronic thromboembolic pulmonary hypertension.

Table 2
Findings and results of radiofrequency ablation.

Type of flutter	Clockwise	6 (27.2%)
	Anticlockwise	16 (72.7%)
Flutter cycle length	290 ± 45	
Number of lesions/Ablation time	20.75 ± 2.54/353.4 ± 96 s	
Bi-directional block achieved	100%	
Complications	None	
Recurrence at follow up (3 months)	3 (13.6%)	

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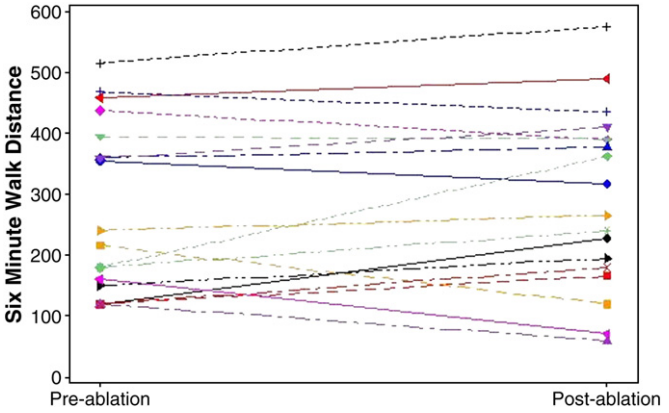

Fig. 1. Six minute walk distance before and after radiofrequency ablation (RFA) for AFL.

All patients had severe PAH, and were on at least one or more diseases modifying drug treatment. Roughly half of the patients had idiopathic PAH, whilst the other half had chronic thromboembolic PAH (Table 1).

Flutter isthmus ablation was successful and without complication in all subjects. Three patients suffered from recurrence after the three months follow up period. These underwent successful redo procedures with no further recurrence (Table 2).

Follow up data was only available on 20 patients post ablation as two died in this period from causes not directly related to the procedure (pulmonary embolism and pneumonia). Prior to ablation, eight patients were in WHO class IV, twelve in class III and two in class II. At three months after ablation, functional class improved by two in one, by one in eight and remained the same in eleven patients ($p = 0.005$). Mean six minute walk test distance pre ablation was 275 ± 141 m which increased to following ablation to 293 ± 146 m (Fig. 1) ($p = 0.301$). Data from two patients for the six minute walk test was not available as they were unable to exercise. There were no changes in echocardiographic indices of the right ventricular function post ablation (Table 3).

The advent and more widespread use of disease modifying drugs in PAH have resulted in improved prognosis and survival [6]. However, there is now an increased incidence of atrial arrhythmias as the RA is exposed to a longer duration of RV pressure overload. Cavo-tricuspid isthmus dependent flutter is the commonest arrhythmia in this group and is often difficult to diagnose as patients with PAH often have an abnormal baseline ECGs.

This is the first study in PAH to show that ablation of AFL is both feasible and improves symptoms in patients with this condition. Acute clinical improvement is the result of the restoration of sinus rhythm rather than cardiac remodelling as there were no changes in echocardiographic parameters before and after RFA. There was a statistically significant improvement in functional class status post flutter ablation.

Ventricular rate control is difficult to achieve in AFL, and often multiple anti-arrhythmic agents are required. Individuals with PAH are often not able to tolerate these because of their side effects and negative inotropic effects. Moreover, diastolic filling of the right ventricle and hence cardiac output is critically dependent on the coordinated right atrial systole. Electrical direct current cardioversion is another possibility, however this does not treat the cause and recurrence is common. In a recent study it was shown that patients are much less likely to have a recurrence of AFL after RFA compared to amiodarone and cardioversion (3% vs 30% at 13 months follow up respectively) [7]. There was also significant improvement in the quality of life in those patients treated with RFA when compared to anti-arrhythmic therapy [8].

Table 3
Echocardiographic analysis.

Value	Pre ablation 22p: mean (SD)	Post ablation 19p: Mean (SD)	P value
RA volume (ml)	184.6 (15.82)	206.7 (21.6)	$p = 0.14$
MPI index	0.67 (0.033)	0.76 (0.049)	$p = 0.15$
EIs	1.87 (0.15)	1.78 (0.16)	$p = 0.24$
EId	1.63 (0.4)	1.45 (0.082)	$p = 0.13$
RVSP	90.9 (3.54)	94.16 (6.46)	$p = 0.93$

RA— Right atrium, MPI— Myocardial performance index, EIs— Eccentricity index systole, EId— Eccentricity index diastole, and RVSP— Right ventricular systolic pressure.

This study shows that the ablation of AFL is feasible and associated with clinical improvement in patients with severe PAH on optimal medical therapy. For patients with severe PAH, RFA may be considered as an alternative to the use of anti-arrhythmic drug therapy or direct current cardioversion.

The authors of this manuscript have certified that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology [9].

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