Ablation of atrial fibrillation

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Chapter 9

Impact of thoracoscopic pulmonary vein isolation on right ventricular function

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Biomed Res Int. 2018;7392435

SUMMARY

Objective: Thoracoscopic surgical pulmonary vein isolation (sPVI) has been added to the treatment of atrial fibrillation (AF), showing excellent efficacy outcomes. However, data on right ventricular (RV) function following sPVI has never been studied. The aim of this study was to investigate RV function following sPVI and compare this to patients who underwent endocardial cryoballoon PVI.

Methods: From June 2009 to November 2011, 25 patients underwent sPVI and were pair matched retrospectively according to age, sex and AF type with 21 patients who underwent cryoballoon PVI. RV function was measured using both tricuspid annular plane systolic excursion (TAPSE) and RV strain with 2D speckle tracking. Echocardiography was performed at baseline and at a median of 6 months (range 3-12) follow-up.

Results: Mean age was 54±9 years and 84% were male, AF was paroxysmal in 92%. In the sPVI group, TAPSE was reduced with 31% at follow-up echocardiography ($p<0.001$) and RV strain showed a 25% reduction compared to baseline echocardiography ($p=0.018$). In the control group, the TAPSE and RV strain did not change significantly (-3% and +13%, $p=0.410$ and $p=0.148$ respectively). The change in TAPSE and RV strain was significantly different between groups ($p=<0.001$ and $p=0.005$ respectively).

Conclusions: This study shows that RV function is significantly decreased following sPVI during the first year. This effect was not observed in our control group, a similar patient population who underwent cryoballoon PVI.

INTRODUCTION

In recent years, thoracoscopic surgical pulmonary vein isolation (sPVI) has been added to the treatment of atrial fibrillation (AF). This technique has shown to be safe and numerous studies have shown excellent efficacy outcome in paroxysmal and short-standing persistent AF, due to high transmurality yielded epicardially by bipolar radiofrequency devices (1,2). However, right ventricular (RV) function following sPVI has not been investigated. The occurrence of RV dysfunction is not easily predictable and is often unexpected. However, RV function is a major determinant of clinical outcomes following cardiac surgery (3). With the development of speckle tracking echocardiography, assessment of the RV has become more accessible and reliable for routine clinical practice (4). The aim of this study was to investigate the right ventricular (RV) function in patients who underwent sPVI and compare this to cryoballoon PVI outcomes.

METHODS

We studied a series of patients who underwent sPVI as a first PVI procedure during the period 2009-2011 in our university medical center. Inclusion criteria were highly symptomatic paroxysmal or early-persistent AF, without concomitant cardiac structural disease, refractory to class I and/or III antiarrhythmic drugs (2). Exclusion criteria for surgical PVI were left atrial size >55mm (parasternal view), prior transcatheter PVI, prior heart or lung surgery, significant coronary disease or previous myocardial infarction, left ventricle hypertrophy >12mm, previous hospitalization for heart failure, left ventricular dysfunction (ejection fraction <50%), moderate or severe mitral- or aortic valve disease, or lung disease (prior tuberculosis or chronic obstructive pulmonary disease Gold class III-IV). The control group consisted of patients with the same indication who underwent cryoballoon PVI in the same period, also as first invasive procedure. Patients who underwent sPVI were pair matched retrospectively according to age, sex and AF type with patients who underwent cryoballoon PVI. All sPVI patients were treated using the video assisted bilateral thoracoscopy. To isolate the pulmonary veins, a bipolar radiofrequency clamp (Isolator, AtriCure, Cincinnati, Ohio, USA) was used to create linear, thermal lesions. Following the ablation, exit block was confirmed, no additional linear ablation lines were applied and the left atrial appendage was not excluded (1,2). The lateral incision of the pericardium was not routinely closed after completion of the lesion set. The control group consisted of patients who underwent endocardial PVI using the second-generation cryoballoon (Arctic Front Advance™, Medtronic Cryocath LP, Pointe-Claire, Canada). Following ablation, anti arrhythmic drugs were continued during the first three months. Patients underwent a standardized transthoracic echocardiogram preoperatively and at 6 (range 3-12) months follow-up. Off-line analyses were performed

by an expert sonographer (YMH) who was blinded for treatment type. All measurements were performed using EchoPac BT12, following the 2015 recommendations of the American Society of Echocardiography [5]. RV function was measured using tricuspid annular plane systolic excursion (TAPSE-M-mode) and RV longitudinal deformation (strain) with 2D speckle tracking; in an apical four chamber view the edge of the RV endocardium was manually traced, after which the software automatically generated tracings. The basal, middle and apical segments of the RV were traced. In the analysis a mean strain of these three segments was calculated. To reliably measure RV function, patients with AF or atrial flutter during echocardiography were excluded from the analysis. Differences between groups were evaluated by the Student *t*-test, differences within groups were evaluated using the paired *t* test. Chi-square was used for comparison of categorical variables.

Statistics

Baseline descriptive statistics are presented as mean ± standard deviation or median (range) for continuous variables, as appropriate, and counts with percentages for categorical variables. Differences between groups, in terms of patient characteristics at baseline, different follow-up moments, were evaluated by the Student t test or the Mann-Whitney U test, depending on normality of the data. Differences within subgroups were evaluated using the Paired t test. Chi-square or Fisher's exact test were used for comparison of categorical variables. The statistical software package IBM SPSS Statistics v.22 was used.

RESULTS

The sPVI group consisted of 25 patients, mean age was 54±9 years and 84% were male. AF was paroxysmal in 92% and short term persistent in 8%. The control group consisted of 21 patients with similar characteristics who underwent cryoballoon PVI in the same center and period. Baseline patient characteristics did not differ significantly between groups (**Table 1**). There was no concomitant structural coronary, heart or valve disease present at baseline. At baseline, echocardiography parameters were comparable between groups except for RA length, which was larger in the sPVI group (57.8±6.2 vs 52.8±5.1, p=0.005), but RA width did not differ between groups (43,7±5,9 vs 41,6±5,1, p=0.212). At baseline echocardiography, TAPSE was higher in the sPVI group compared to the cryoballoon-group (26,6±4,0 vs 23,9±3,7, p=0.025; **Table 2**). In the sPVI group, RV function measured by TAPSE was significantly reduced with a mean of -8.3mm (-31%) at median 6 months follow-up echocardiography (p<0.001) (**Figure 1A**). Furthermore, the average RV strain showed a mean change of -5.6 percentage points (-25%) compared to baseline echocardiography (p=0.018) (**Figure 1B**). In the control group, the TAPSE was reduced with a mean of -0.8mm (-3%) and RV strain increased with 2.7 percent points (+13%), this was not significant

(p=0.410 and p=0.148 respectively). When the change from baseline to follow-up (delta) measurement in TAPSE and RV strain was compared between the two groups, this showed a significant difference (mean TAPSE -8.3mm vs -0.8mm, p=<0.001 and mean RV strain -5.6 percentage points vs +2.7 percentage points, p=0.005).

Table 1. Baseline characteristics and echocardiography outcomes

Baseline patient characteristics			
Parameter	**SPVI (n=25)**	**CRYO (n=21)**	P-value
Age (years)	54±9	58±7	0.089
Male (n, %)	21 (84%)	15 (71%)	0.303
AF history, years [range]	3 [1-14]	4 [1-15]	0.178
Paroxysmal AF n,(%)	23 (92%)	17 (81%)	0.268
Short-standing persistent AF n, (%)	2 (8%)	4 (19%)	
BMI (kg/m²)	27.1±2.9	28.2±3.3	0.251
BP systolic (mmHg)	132±17	137±16	0.383
BP diastolic (mmHg)	79±9	83±10	0.234

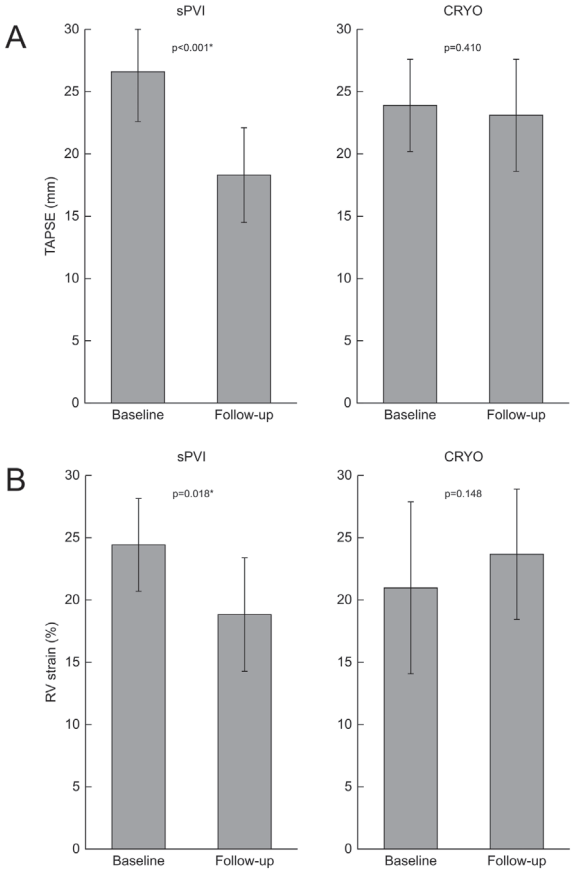
AF= atrial fibrillation, BMI= body mass index, BP= blood pressure, sPVI= surgical pulmonary vein isolation, TAPSE= tricuspid annular plane systolic excursion.

Table 2. Echocardiography outcomes

	sPVI group echocardiography			**Cryo group echocardiography**		
Parameter	**Baseline**	**Follow-up**	P-value	**Baseline**	**Follow-up**	P-value
LV Ejection Fraction (%)	60±5	57±5	0.062	60±6	58±7	0.198
LA Volume (mm³)	75±19	78,3±23.6	0.674	79±26	71.0±26.0	0.209
LA volume indexed	33,7±6	35,8±10.2	0.430	36.3±11	34.0±12.5	0.414
RA length (mm)	57,8±6.2*	57,4±5.3	0.647	52.8±5.1*	50.1±5.5	0.048
RA width (mm)	43,7±5.9	43,7±5.1	0.835	41.6±5.1	37.6±5.8	0.035
RVEDD (%)	38,8±5.5	39,0±5.3	0.771	39.6±7.9	37.4±4.5	0.332
TAPSE (mm)	26,6±4.0*	18,3±3.8	<0.001	23.9±3.7*	23.1±4.5	0.410
RV strain (%)	24.4±3.7	18.8±4.6	0.018	21.0±6.9	23.7±5.2	0.148

LA= left atrial, LV= left ventricular, RA= right atrial, RVEDD=right ventricle end diastolic diameter, sPVI= surgical pulmonary vein isolation, TAPSE= tricuspid annular plane systolic excursion. *significant difference (p<0.05) between groups at baseline

Figure 1. A. Tricuspid annular plane systolic excursion B. Right ventricular strain



sPVI = surgical pulmonary vein isolation CRYO = cryo balloon PVI

DISCUSSION

This study shows that RV function is significantly decreased following sPVI during the first year. This effect was not observed in our control group, a similar patient population who underwent cryoballoon PVI. Both study groups underwent echocardiographic analysis pre-operative and at 6 months follow-up, there was no significant valve disease and atria were moderately dilated in both groups without significant differences at baseline, except for RA length, which was larger in the sPVI but RA width did not differ between groups. In both groups, the left atrium was moderately dilated in concordance with the disease. At baseline, mean TAPSE was significantly higher in the sPVI group compared to the CRYO group. However, at follow-up, this was significantly lower. This effect was objectified by means of RV strain.

Decreased RV function following sPVI has not been described previously. On the other hand, in patients who underwent open-chest CABG (both on- and off pump), a reduced RV function has been already documented (6). Remarkably, a study comparing conventional surgical aortic valve replacement (AVR) to transcatheter AVR demonstrated a similar reduction of RV strain at follow-up in patients who underwent surgery (7). Although the present analysis does not allow definite conclusions regarding the exact underlying mechanism, the reduction of RV function might be attributable to two factors; First, due to the lateral opening of the pericardium the mechanical support (restraint) is reduced. The right atrium and right ventricle have relatively limited intrinsic stiffness, compared to the left heart side, and are therefore more dependent on pericardial support (8). Second, the opening of the pericardium causes an inflammatory reaction, which leads to the formation of adhesions between the pericardium and the epicardium. These adhesions can reduce compliance, especially of thin-walled chambers (RA and RV) and thereby impair ventricular filling. Off course, also a combination of both factors could contribure to a reduced RV function following sPVI. Whether decrease in RV function is permanent, is associated with symptoms or even heart failure needs to be determined in future studies. An appropriate understanding of pericardial constraint is required. The observational nature of our study and limited number of patients does not allow definitive conclusions.

In conclusion, this study shows that RV function is significantly decreased following sPVI during the first year. This effect was not observed a similar patient population who underwent cryoballoon PVI. In accordance with the findings of this study, our operative protocol has changed. The right lateral pericardial incision is now routinely closed with a single approximating endosuture of the pericardium.

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