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Short Communication

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Outcomes After Supraventricular Tachycardia Ablation in Patients With Group 1 Pulmonary Hypertension

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Abstract

Background: Pulmonary hypertension (PH) is associated with right ventricular pressure overload and atrial remodeling, which may result in supraventricular tachycardias (SVTs). The outcomes of catheter SVT ablation in patients with World Health Organization (WHO) group 1 PH are incompletely characterized.

Methods: We conducted a retrospective cohort study of all patients with WHO group 1 PH undergoing catheter SVT ablation during a 10-year period at a major academic tertiary care hospital. Baseline patient characteristics and procedural outcomes at 3 months and 1 year were extracted from the electronic medical record.

Results: Ablation of 60 SVTs was attempted in 38 patients with group 1 PH. The initial procedural success rates were 80% for atrial fibrillation (AF, n = 5), 89.7% for typical atrial flutter (AFL, n = 29), 57.1% for atypical AFL (n = 7), 60% for atrial tachycardia (AT, n = 15), and 75% for atrioventricular nodal reentrant tachycardia (AVNRT, n = 4). The 1-year post-procedural recurrence rates were 100% for AF (n = 4), 25% for typical AFL (n = 20), 50% for atypical AFL (n = 2), and 28.6% for AT (n = 7). No patients had recurrent AVNRT (n = 2). There were seven (18.4%) peri-procedural decompensations requiring pressor initiation and transfer to intensive care and one (2.6%) peri-procedural death.

Conclusions: The study demonstrates that SVT ablation in group 1 PH can be performed relatively safely and effectively, albeit with lower initial success rates and higher risk of clinical decompensation than in the general population. Recurrence rates at 1 year were higher in AF and atypical AFL ablations and similar for typical AFL and AT ablations when compared to the general population.

Keywords: Supraventricular tachycardia; Pulmonary hypertension; Outcomes; Ablation; WHO; Group 1

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Introduction

Pulmonary hypertension (PH) is associated with right ventricular pressure overload [1]. This can lead to atrial remodeling, increasing the risk of supraventricular tachycardias (SVTs) [2, 3]. Catheter ablation safely and effectively treats SVT in the general population [4]. Patients with group 1 PH have structural abnormalities that may make SVT ablation more technically challenging and increase the risk of arrhythmia recurrence. Prior studies of SVT ablation outcomes in PH patients have either included all World Health Organization (WHO) PH classes or excluded some SVT types [5-7]. This study aimed to address incompletely characterized SVT ablation outcomes specifically in patients with group 1 PH.

Materials and Methods

Following institutional review board approval, we performed a retrospective study of patients with group 1 PH who underwent SVT ablation between January 1, 2012 and December 31, 2022 at University of Texas Southwestern Medical Center. Relevant cases were identified by searching for patients with a diagnosis code for PH and a prescription for group 1 PH-specific therapies (epoprostenol, treprostinil, selexipag, ambrisentan, bosentan, macitentan, riociguat, sildenafil, and tadalafil) who underwent cardiac ablation for atrial fibrillation (AF), atrial flutter (AFL), atrial tachycardia (AT), or atrioventricular nodal reentrant tachycardia (AVNRT). Chart review was performed to confirm eligibility and abstract baseline data (medications, exercise tolerance and WHO functional status, transthoracic echocardiogram (TTE)/cardiac magnetic resonance imaging (cMRI)/right heart catheterization (RHC) results). Only the most recent data within 1 year of the index procedure were recorded. Diagnosis date was defined as the date of the first RHC demonstrating PH (mean pulmonary artery pressure > 20 mm Hg) or via an explicitly stated date in clinic notes, whichever was earlier. Cardiac indices were measured via thermodilution when possible and via the Fick method otherwise. Clinic and procedure notes were searched to determine the course of the index procedure and recurrences at 3 months and 1 year. Recurrence was determined by any mention of recurrent tachycardia symptoms and a cardiologist-confirmed electrocardiogram demonstrating an arrhythmia pattern ablated in the index procedure. If multiple arrhythmias of one type were initially ablated (e.g., multiple AFL foci) and no repeat ablation was performed to identify the

recurrent focus, all foci were assumed to have recurred. If a repeat ablation occurred, only the demonstrated arrhythmias were documented as recurrent. Mann-Whitney U-tests and Fisher's exact tests with an alpha of < 0.05 were performed as appropriate to investigate differences between patients with and without recurrence. Logistic regression was performed to investigate whether attempting to ablate any specific SVT was associated with post-procedural decompensation, defined as the need for pressor support to maintain mean arterial pressures > 65 mm Hg and transfer to intensive care unit (ICU).

Ethics approval and informed consent waiver were obtained from institutional IRB.

Results

Thirty-eight patients (male: 17 (44.7%); female: 21 (55.3%)) of age 53.7 ± 13.7 years with group 1 PH were included. Baseline characteristics are presented in Table 1; while all patients were classified as group 1 PH, significant pulmonary or cardiovascular comorbidities were present in nine (23.7%) patients, including three patients with a wedge pressure > 15 mm Hg. Index ablations were attempted for 60 arrhythmias (5 AF; 8.3%, 36 AFL; 60%, 15 AT; 25%, 4 AVNRT; 6.7%). A summary of initial success rates and outcomes stratified by ablation location is provided in Table 2. All AT ablation targets with recorded locations were in the right atrium. Of five atypical AFL ablation targets, one was in the right atrium and four were in the left atrium; all noted AFL recurrences were of left atrial targets. Of 14 failed initial ablations, nine (64.3%) failed due to an inability to sustain the arrhythmia for sufficient time to map and ablate, two (14.3%) failed due to hemodynamic instability forcing procedure termination, two (14.3%) failed due to patient intolerance of the procedure length, and one (7.1%) failed due to unknown reasons. One recurrent typical flutter was successfully re-ablated at 3 months; this flutter recurred again at 1 year and no re-ablation was attempted. Two recurrent typical flutters were successfully re-ablated at 1 year. No repeat AF or AT ablations were attempted.

No baseline patient characteristics were significantly associated with recurrence. There was a trend towards lower left ventricular ejection fractions and higher pulmonary capillary wedge pressures in patients experiencing recurrent arrhythmias which did not reach statistical significance. Fifteen (39.5%) procedures were performed using general anesthesia; 23 (60.5%) were performed using anesthesia-monitored moderate sedation. There was one (2.6%) peri-procedural death secondary to acute mixed respiratory failure triggered by procedural moderate sedation for ablation of AF. There were seven (18.4%) post-procedural decompensations requiring initiation of pressors and transfer to the medical ICU, including three (42.9%) patients receiving moderate sedation and four (57.1%) patients receiving GA (P = 0.40). In all but one patient, pressors were weaned off in less than 48 h. Post-procedural decompensations were noted in five (18.5%) index procedures involving typical AFL ablation, two (22.2%) index procedures involving AT ablation, and two (50%) index procedures involving AVNRT ablation. No index procedure involving AF or atypical AFL ablation resulted in post-procedural decompensation. None of the included SVT ablation types were significantly associated with post-procedural decompensation in a logistic regression model.

Discussion

Retrospective studies in patients with group 1 PH have associated untreated SVTs with right ventricular failure, declines in exercise capacity, diuretic-resistant volume overload, and excess mortality [8]. These studies also suggest that restoration of sinus rhythm can reverse SVT-associated clinical declines.

Despite the known benefits of rhythm control in PH, pharmacologic rhythm control was infrequently used in our population, reflecting the particularly challenging nature of anti-arrhythmic drug use in these patients with severe structural heart disease and precarious hemodynamics [8]. Current European Society of Cardiology (ESC) guidelines on the management of SVTs specifically recommend against the use of flecainide and propafenone in patients with structural heart disease, note numerous cardiac and extracardiac side effects of amiodarone (some of which strongly affect patients with PH, e.g., negative inotropic side effects, drug-drug interactions, and long-term toxicity), and urge caution regarding excess mortality produced by the pro-arrhythmic effects of several anti-arrhythmic drugs (e.g., class 1A agents, sotalol) [9, 10]. With pharmacologic therapy limited by toxicity, definitive rhythm control via catheter ablation is an attractive option.

Registry studies of SVT ablations in the general population have demonstrated procedural death and complication rates of < 1% [11, 12]. By contrast, in this high-risk population, procedural mortality was 2.6%, and 18.4% of patients required pressor support and intensive care peri-procedurally. This is unsurprising given the severity of PH in our population as demonstrated by markedly elevated pulmonary pressures and evidence of right heart failure on cardiac imaging in a majority of patients. Additionally, these outcomes are in line with anesthesia outcomes in PH in general [13]. The relatively high post-procedural ICU admission rate, while a concern, is in part intentional, as our institutional protocols recommend a very low threshold for the initiation of pressors or pressor-inotropes during anesthesia in PH so as to reduce risk of more severe decompensation. Despite these measures, one periprocedural death occurred, highlighting the careful risk/benefit considerations required in this population [14]. The ablation success rates and outcomes reported in this study will help inform future clinical decision making and studies in this unique group.

Prior large studies of SVT ablations in the general population have reported high initial success rates of 93.1-96.4% for AF, 96.0-98.3% for typical AFL, 79-90% for atypical AFL, 98.9-99.8% for AVNRT, and 84.3-93.6% for AT [11, 12, 15-18]. Lower initial success rates for all arrhythmia types were observed in this study; atypical AFL and AT were particularly difficult to ablate successfully. A combined 28.6% of procedures failed due to either hemodynamic instability forcing termination or patient intolerance of extended procedure length, reflecting the underlying clinical fragility of patients with PH.

Table 1. Baseline Patient Characteristics Stratified by Presence of Any Recurrence of an Initially Ablated Arrhythmia During Maximum Available Follow-Up Time

	Overall (n = 38)	No recurrence (n = 28)	Recurrence (n = 10)	P-value
Male sex (%)	17 (44.7)	12 (42.9)	5 (50.0)	0.73
Mean age (years) (SD)	53.7 (13.7)	52.4 (13.8)	57.6 (13.5)	0.35
Mean BMI (SD)	28.8 (7.2)	28.0 (7.2)	31.1 (7.2)	0.23
Medications (%)				
Beta-blocker	11 (28.9)	9 (32.1)	2 (20.0)	0.69
Calcium channel blocker	5 (13.2)	3 (10.7)	2 (20.0)	0.59
Digoxin	9 (23.7)	8 (28.6)	1 (10.0)	0.40
Flecainide	2 (5.3)	1 (3.6)	1 (10.0)	0.46
Sotalol	1 (2.6)	0 (0.0)	1 (10.0)	0.26
Dofetilide	1 (2.6)	0 (0.0)	1 (10.0)	0.26
Amiodarone	2 (5.3)	0 (0.0)	2 (20.0)	0.06
One non-parenteral PH therapy[a]	12 (31.6)	7 (25.0)	5 (50.0)	0.23
Two non-parenteral PH therapies	3 (7.9)	3 (10.7)	0 (0.0)	0.55
Three or more non-parenteral PH therapies	9 (23.7)	8 (28.6)	1 (10.0)	0.40
Parenteral[b] +/- non-parenteral PH therapy	11 (28.9)	8 (28.6)	3 (30.0)	1.00
Median 6MWT distance (m) (SD)	302.3 (144.3)	294.8 (146.0)	323.9 (148.6)	0.66
WHO functional class (%)				0.38
II	7 (25.9)	7 (31.8)	0 (0.0)	
III	18 (66.7)	13 (59.1)	5 (100.0)	
IV	2 (7.4)	2 (9.1)	0 (0.0)	
Comorbidities (%)				
Left-heart disease	7 (18.4)	4 (14.3)	3 (30.0)	0.35
Lung disease	5 (13.2)	5 (17.9)	0 (0.0)	0.30
Median time from PH diagnosis (days) (IQR)	2,420 (593 - 3,647)	2,289 (313 - 3,909)	2,550 (1,014 - 2,769)	0.90
Echocardiography				
Mean LV ejection fraction (%) (SD)	58.9 (12.5)	60.0 (13.1)	55.8 (10.4)	0.08
RV systolic function, qualitative (%)				0.53
Normal	8 (24.2)	5 (20.8)	3 (33.3)	
Mild depression	9 (27.3)	6 (25.0)	3 (33.3)	
Moderate depression	11 (33.3)	8 (33.3)	3 (33.3)	
Severe depression	5 (15.2)	5 (20.8)	0 (0.0)	
Mean RV systolic pressure (mm Hg) (SD)	59.8 (21.7)	61.6 (22.0)	54.0 (20.8)	0.53
Mean RV systolic velocity (cm/s) (SD)	11.0 (3.7)	11.0 (0.4)	11.1 (0.5)	0.67
RV TAPSE (cm) (SD)	1.8 (0.5)	1.8 (0.4)	1.7 (0.5)	0.78
RV tricuspid regurgitation, qualitative (%)				0.51
Trace	6 (17.6)	6 (23.1)	0 (0.0)	
Mild	11 (32.4)	7 (26.9)	4 (50.0)	
Moderate	9 (26.5)	7 (26.9)	2 (25.0)	
Severe	8 (23.5)	6 (23.1)	2 (25.0)	
Right heart catheterization				
Mean RA pressure (mm Hg) (SD)	11.0 (8.5)	10.5 (7.9)	13.0 (10.8)	0.76
Mean PA pressure (mm Hg) (SD)	46.1 (10.4)	43.9 (8.8)	53.5 (12.9)	0.13

Table 1. Baseline Patient Characteristics Stratified by Presence of Any Recurrence of an Initially Ablated Arrhythmia During Maximum Available Follow-Up Time - *(continued)*

	Overall (n = 38)	No recurrence (n = 28)	Recurrence (n = 10)	P-value
Mean PVR (Wood units) (SD)	6.9 (2.7)	7.2 (2.8)	6.0 (2.2)	0.45
Mean pulmonary capillary wedge pressure (mm Hg) (SD)	10.4 (7.6)	9.1 (7.2)	15.4 (7.7)	0.05
Mean cardiac index (SD)	2.9 (0.8)	2.9 (0.9)	3.0 (0.5)	0.63
Cardiac magnetic resonance imaging				
RA volume, qualitative (%)				1.0
Normal	3 (18.8)	2 (16.7)	1 (25.0)	
Mild dilation	3 (18.8)	2 (16.7)	1 (25.0)	
Moderate/severe dilation	10 (62.5)	8 (66.7)	2 (50.0)	
RV systolic function, qualitative (%)				1.0
Normal	5 (33.3)	3 (27.3)	2 (50.0)	
Mild depression	2 (13.3)	2 (18.2)	0 (0.0)	
Moderate depression	3 (20.0)	2 (18.2)	1 (25.0)	
Severe depression	5 (33.3)	4 (36.4)	1 (25.0)	
Mean RV ejection fraction (%) (SD)	39.1 (14.2)	39.2 (15.8)	38.8 (9.4)	0.86

Most recent values available within 1 year of index procedure are shown. Not all values were available for all included patients; values shown are calculated from available values. [a]Non-parenteral PH therapies included: selexipag, ambrisentan, bosentan, macitentan, riociguat, sildenafil, tadalafil, inhaled treprostinil. [b]Parenteral PH therapies included: IV epoprostenol, IV/subcutaneous treprostinil. BMI: body mass index; 6MWT: six-minute walk test; LV: left ventricle; RV: right ventricle; TAPSE: tricuspid annular systolic plane excursion; RA: right atrium; PA: pulmonary artery; PVR: pulmonary vascular resistance; IQR: interquartile range; SD: standard deviation.

Studies of SVT ablations in the general population have shown long-term (i.e., average follow-up of 12 months or greater) recurrence rates of 29.8-45.6% for AF, 10.9-30% for typical AFL, 23-27% for atypical AFL, 22-32.3% for AT, and 3.9-4.5% for AVNRT [15, 18-23]. This study demonstrated qualitatively comparable recurrence rates for typical AFL and AT and higher rates for atypical AFL and AF. AF ablation in particular exhibited a 100% recurrence rate at 1 year, indicating that the long-term utility of AF ablation must be very carefully considered in this population. Given the small sample size (n = 4 with AF), further study is also needed to better assess recurrence rates. There was a trend towards higher pulmonary capillary wedge pressures and lower left ventricular ejection fractions being associated with recurrence, possibly indicating that patients with concomitant group 1 PH and left-sided heart failure are at especially high risk of recurrence. However, these results should be interpreted with caution as our analysis was not adjusted for multiple comparisons. Despite high recurrence rates overall, few repeat ablations were performed, possibly due to concerns about safety of additional ablations, concerns for recurrence despite repeat ablation, and concerns for competing risks limiting the benefit of repeat ablation.

Limitations of the study include its small sample size, clinical heterogeneity (reflecting the rarity of group 1 PH patients), and long duration of inclusion. Risk/benefit and overall outcomes may differ based on both patient and institutional

Table 2. Initial Success Rates and Outcomes of Attempted Ablations Stratified by Arrhythmia Type

Arrhythmia	Total attempted	Initially successful ablations	Recurrence rate at 3 months (n available)	Recurrence rate at 1 year (n available)	Initial success rates previously observed in general population	Long-term (≥ 1 year) recurrence rates previously observed in general population
AF	5	4 (80%)	100% (4)	100% (4)	93.1-96.4%	29.8-45.6%
CTI-dependent typical AFL	29	26 (89.7%)	4.2% (24)	25% (20)	96.0-98.3%	10.9-30%
Atypical AFL	7	4 (57.1%)	25% (4)	50% (2)	79-90%	23-27%
AT	15	9 (60%)	22.2% (9)	28.6% (7)	84.3-93.6%	22-32.3%
AVNRT	4	3 (75%)	0% (3)	0% (2)	98.9-99.8%	3.9-4.5%

Sample sizes shown indicate number of patients available for follow-up at each time point. Initially unsuccessful ablations were not included in recurrence calculations. For comparison, initial success rates and long-term (i.e., average follow-up of 12 months or greater) recurrence rates of AF, typical and atypical AFL, AT, and AVNRT from prior studies in the general population [11, 12, 15-23] are reproduced in this table. AF: atrial fibrillation; AFL: atrial flutter; AT: atrial tachycardia; AVNRT: atrioventricular nodal reentrant tachycardia; CTI: cavotricuspid isthmus.

factors, and we would recommend caution in the management of these high-risk patients.

Conclusions

Overall, this study demonstrates that SVT ablation in group 1 PH can be performed with moderate risk of peri-procedural morbidity and mortality. Compared to the general population, initial success rates are lower across all SVTs and 1-year recurrence rates are higher for some SVTs. Clearer determination of what risk factors (e.g., higher pulmonary artery/right atrial pressures, more severe right ventricular failure, or larger right atrial sizes) produce higher individual risk of recurrence will require larger multicenter studies.

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None to declare.

Financial Disclosure

None to declare.

Conflict of Interest

None to declare.

Informed Consent

Informed consent waiver was obtained from institutional IRB.

Author Contributions

Study design: TS, KC, NP; data collection: TS; data analysis: TS; manuscript preparation and review: TS, KC, NP.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Abbreviations

SVT: supraventricular tachycardia; PH: pulmonary hypertension; WHO: World Health Organization; AF: atrial fibrillation; AFL: atrial flutter; AT: atrial tachycardia; AVNRT: atrioventricular nodal reentrant tachycardia; TTE: transthoracic echocardiogram; cMRI: cardiac magnetic resonance imaging; RHC: right heart catheterization

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