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Strategies for Phrenic Nerve Preservation During Ablation of Inappropriate Sinus Tachycardia

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Abstract

Background—Radiofrequency (RF) ablation can alleviate drug-refractory inappropriate sinus tachycardia (IST). However, phrenic nerve (PN) injury and other complications limit its use.

Objective—We sought to characterize the maneuvers utilized to avoid PN injury and the long-term clinical outcomes.

Methods—Retrospective analysis of consecutive patients who underwent ablation for IST.

Results—RF ablation was carried out on 13 consecutive female patients with drug-refractory IST. Eleven patients exhibited PN capture at desired ablation sites. In one patient, PN capture was not continuous throughout the respiratory cycle and ventilation holding sufficed to avoid PN injury. In 10 patients, pericardial access (PA) and balloon (PB) insertion was required. Initially (n=4) a posterior PA was utilized, which was replaced by an anterior PA in the subsequent 6 cases. PA to optimal balloon positioning time was significantly lower in anterior vs. posterior PA (16.3±6 min vs. 58±21.3 min p=0.01), as was fluoroscopy time (15.66±16.72 min vs. 35.9±1.8 min, p=0.03). RF ablation successfully reduced sinus rate to less than 90 bpm in 13/13 patients. Procedure times and total radiofrequency times were not significantly different in anterior vs posterior PA. Major complications occurred in 2 patients, including unremitting pericardial bleeding requiring open-chested repair in one patient and sinus pauses mandating pacemaker implantation in another. Long-term symptom control after a follow-up of 811±42 days was successful in 84.6%.

Conclusion—Ventilation holding and/or pericardial balloon insertion are frequently warranted in IST ablation. Anterior PA appears to facilitate the procedure over posterior PA.

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Keywords

Catheter Ablation; Inappropriate Sinus Tachycardia; Phrenic nerve injury

INTRODUCTION

Inappropriate Sinus Tachycardia (IST) syndrome is a tachyarrhythmia characterized by unexpectedly increased and symptomatic heart rates (HR) during sinus rhythm, at rest or in response to minimal physical activity and psychological stress.¹⁻³ It has been shown to be more prevalent in middle-aged women,⁴ and is associated with significant loss of quality of life.^{1, 5} Pharmacological treatment aims to reduce HR and ameliorating clinical symptoms. Empirical first-line therapy with β -adrenergic, calcium channel blockers or ivabradine has yielded low to moderate success.^{2, 6} Endocardial ablation/modification of the sino-atrial node (SAN) is a viable alternative in refractory cases of IST.^{4, 7} Limitations of this procedure stem from the predominantly epicardial location of the SAN,⁸ in close proximity to the right phrenic nerve (PN), which could be damaged during radiofrequency (RF) delivery.^{1, 9, 10} Information regarding the best approach to avoid PN injury remains scarce. Furthermore, gaps of knowledge persist regarding long-term symptom recurrence following IST ablative procedures.¹¹

We sought to characterize the maneuvers utilized to avoid PN injury and the long-term clinical outcomes in a series of consecutive patients referred for IST ablation/modification.

METHODS**Patient Selection**

This retrospective analysis includes consecutive patients (n=13) who underwent ablation for IST between September 2008 and August 2015 in a single tertiary center. IST was defined by a HR >100 bpm at rest or with mild physical activity/psychological stimuli with associated symptoms.⁷ Primary causes of sinus tachycardia were ruled out, as were other mechanisms of supraventricular tachycardia. Every patient underwent 12-lead electrocardiogram to confirm normal P-wave morphology. Additional evaluations included: baseline blood testing (complete metabolic panel, thyroid function, blood count, renal function, electrolytes, drug testing and serum and urine catecholamines),^{3, 12-14} and autonomic testing (tilt table testing, in order to rule out postural orthostatic tachycardia syndrome [POTS]). Patients who proved refractory to, or intolerant of, pharmacologic therapy were offered ablative treatment. Risks, benefits and alternatives were explained at length and patients provided written informed consent prior to the procedure. Data were reviewed under an IRB-approved registry.

Activation time and PN mapping

Patients were studied in the fasting state under general anesthesia without the use of paralytic agents. Antiarrhythmic drugs and beta-blockers were withheld at least five half-lives prior to the procedure. Under local anesthesia, a multipolar catheter was advanced through the left femoral vein into the right atrium (RA) and positioned with its distal ten

poles in the coronary sinus (CS) and the proximal poles within the tricuspid annulus. A tetrapolar catheter was placed in the His bundle region. Mapping and ablation were performed using an open-irrigated 3.5-mm tip catheter. A 3-dimensional (3D) activation map was created using the CARTO (Biosense-Webster, Diamond Bar, CA) (n=9), NavX system (St. Jude Medical, St Paul, MN) (n=3), and Rhythmia Mapping System (Rhythmia Medical/Boston Scientific, Marlborough, MA, (n=1). A baseline electrophysiology study was performed to exclude other mechanisms of supraventricular tachycardia (SVT). A PN capture map was created along with activation mapping by unipolar pacing from the distal pole of the ablation catheter at a maximum output of 25 mA with a pulse width of 2 msec. Diaphragmatic contraction was confirmed by fluoroscopic visualization. Bipolar activation mapping was undertaken to identify the earliest site referenced to both an endocardial fiducial point (e.g., coronary sinus electrogram [EGM]) and the surface P wave. After identification of the earliest endocardial activation, prior to RF delivery, high-output pacing was performed to confirm the absence of PN stimulation. The sites of PN capture were marked on the activation map. Figure 1 shows examples.

Pericardial access

If PN stimulation could not successfully be eliminated by minor adjustments in the orientation of the catheter tip and/or ventilation holding, pericardial access (PA) was then obtained. Percutaneous subxyphoid access to the pericardium was performed with a Tuohy needle as described by Sosa et al.¹⁵ In the first 4 cases, a posterior approach was used, whereby the needle was advanced from the subxyphoid access point at a ~30-45-degree angle, aiming to the diaphragmatic wall of the heart silhouette. In the 6 subsequent procedures, an anterior approach was chosen, in which the needle was advanced at a shallow angle into the substernal space, as guided by a lateral fluoroscopy projection. Figure 2 shows examples. Once the needle tip reached the anterior mediastinal space, a steeper angle was adopted to enter the pericardium anterior to the right ventricle (RV). Upon entry into the pericardium, a long wire was advanced so that it wrapped around the entire cardiac silhouette, ensuring no entrance into the RV or the pleural space. A deflectable sheath (Agilis NxT, St. Jude Medical, Minnetonka, MN, USA) was advanced over the wire into the pericardium. Its tip was deflected to direct the wire towards the superior vena cava-right atrial junction. Subsequently, an 18-mm × 4-cm balloon dilation catheter (ATB Advance PTA; Cook Medical, Bloomington, IN, USA) or in 1 case a 14-mm × 4-cm balloon dilatation catheter (Bard Atlas, Murray Hill, NY) was placed through the deflectable sheath on the lateral wall of the RA, aiming for a position between the ablation site and the PN. PN capture at the ablation site was verified after balloon positioning. If still present, further balloon manipulations were performed until PN capture at the desired ablation site was no longer present. Figure 2 shows examples of posterior vs. anterior PA and pericardial balloon (PB) positioning respectively.

Ablation

After confirming stable positioning of the catheter at the site of earliest activation, RF energy was delivered for 60 seconds per lesion, with up to 35 W, 30 cc/min irrigation flow, whilst maintaining a temperature <43°C using a Thermocool catheter (Biosense-Webster, Diamond Bar, CA). Ablation was performed in the baseline state without isoproterenol in

order to maximize catheter stability. With each change in HR or P-wave morphology, the site of earliest activation was again reassessed. Subsequently, the new site of earliest activation was targeted with RF energy in an effort to shift the sinus rhythm more caudally as determined by a change in P-wave morphology or achievement of a junctional rhythm. The endpoint was achieved when there was a decrease in HR of $\geq 20\%$ from baseline off isoproterenol and an associated change in the P-wave morphology in lead III and aVF from a positive to a flat or negative deflection.^{1, 8, 11} Isoproterenol infusion was reinitiated post ablation to demonstrate the persistent change in P-wave morphology and to show a lower site of early activation as compared to the pre-ablation state at the same dose of isoproterenol.

Clinical Follow-Up

Patients underwent electrocardiographic monitoring for 24 hours post-ablation. They were seen in the office 4–6 weeks post procedure and then at 6-month intervals. A 12-lead electrocardiogram (ECG) was performed at each visit and repeat 24-hour Holter was performed at 6 months or at the onset of symptom recurrence if any.

Statistical Analysis

Continuous data were reported as mean $\pm$ standard deviation (SD), whereas qualitative findings were described as numbers and percentages. Pre and Post-ablation categorical variables were compared. Univariate analyses were performed using the paired and unpaired t-tests. The chi-square test was utilized to compare categorical variables. Statistical significance was attributed to outcomes with a p value < 0.05 .

RESULTS

Baseline Characteristics

A total of thirteen consecutive female patients were enrolled, with a mean age of 34.2 years (Range: 20–49 years old). Symptoms of IST included baseline sinus tachycardia, palpitations, syncope, pre-syncope, and unresponsiveness to medical therapy. All patients had failed maximum tolerated doses of β -blockers, calcium channel blockers, sotalol or ivabradine, either as the sole therapy or in combination (Table 1). Twelve out of thirteen patients were also on anxiolytic medication. A 2D echocardiogram confirmed the absence of structural heart disease in all patients and all secondary and reversible causes of sinus tachycardia were systematically excluded as well.

Acute Procedural Results

In the electrophysiology laboratory, the mean baseline sinus rate was 104 ± 18.1 bpm. The ablation procedure was successful in reducing the baseline sinus rate to less than 90 bpm in all 13 patients. Sinus rate during isoproterenol infusion after ablation dropped by at least 20% from pre-ablation values in 13 of 13 patients (Tables 1 and 2). The mean number of radiofrequency applications was 14.90 ± 7.8 . The mean duration of fluoroscopic exposure was 22.56 ± 15.60 min. After SAN modification at the time of the electrophysiological study, the baseline sinus rate slowed significantly to 71.9 ± 10.8 bpm ($p < 0.001$), a more than 20% increase from baseline.

The earliest local atrial electrogram in each patient at sites of RF energy application preceded the P wave by a mean of 26 ± 14 ms. For all patients, consecutive applications of RF energy at the site of earliest endocardial activation resulted in a cranial-to-caudal migratory pattern of earliest endocardial activation, starting in the high lateral RA and descending to the mid-lateral RA (Figure 1). All patients exhibited either flattening of the P-wave amplitude or the development of negative P waves in leads III and aVF post RF application, along with a heart rate drop of $\sim 20\%$ from baseline. Post ablation, a caudal shift of the site of earliest activation was observed in all patients. In these patients, junctional rhythm was also achieved. In all patients, a low-right atrial rhythm arose within 24 hours of ablation. One patient, however, developed symptomatic sinus pauses (3-4 seconds) and underwent pacemaker implantation.

PN protection strategies

All patients but two had PN capture at one or more of the desired ablation sites. In one patient, capture was only present during inspiration and ventilation holding was sufficient to avoid PN injury. Figure 1 shows an example: Several consecutive sites were targeted for ablation and PN damage was avoided by ventilation holding. PN injury was monitored during ablation by high-output pacing in the SVC. Ten patients (76.9%) exhibited continuous PN capture throughout the respiratory cycle at the desired ablation sites and underwent PB insertion.

Pericardial access

Either posterior (n=4) or anterior (n=6) PA were used (Figure 2). Posterior PA required more laborious sheath manipulation to achieve a desired balloon positioning lateral to the RA that would avoid PN capture. After balloon positioning, repeat activation maps were performed that showed an obvious distortion of the right atrial geometry. In the cases of anterior PA, the balloon created an indentation at the junction between the superior vena cava and the right atrium (Figure 3). Using high-density detailed activation mapping (Rhythmia®) illustrates the anatomical compression of the right atrium with additional detail (Figure 4).

Time from PA to optimal balloon positioning (elimination of PN capture at ablation sites) was significantly lower in anterior pericardial access (PA) vs. posterior PA (16.3 ± 6 min vs. 58 ± 21.3 min $p=0.01$) as was fluoroscopy time (15.66 ± 16.72 min vs. 35.9 ± 1.8 min, $p<0.03$). Procedure times and total radiofrequency were not significantly different. In two posterior PA cases, radiofrequency had to be delivered whilst holding inspiration due to intermittent PN capture during expiration.

Procedure outcomes

There were no cases of PN injury. All patients had intact PN function after the procedure as evidenced by diaphragmatic contractions during SVC pacing after ablation. However, major complications were unavoidable. One patient developed unremitting pericardial bleeding due to a right ventricular perforation during pericardial access. She thus underwent urgent sternotomy and open repair, followed by surgical ablation. In this case, posterior PA had been chosen. Another patient, as previously mentioned, developed symptomatic sinus pauses during anterior PA and underwent pacemaker implantation.

Upon discharge, patients were prescribed colchicine 0.6 mg twice per day for two weeks, and at no point exhibited any signs of pericarditis.

Long-Term Outcomes

After a mean follow-up of 811 ± 42 days (range: 40- 2372 days), 11 of the 13 patients (84.6%) remained free of IST symptom recurrence. Eleven of them have required no drug therapy post-ablation. However, two patients reported mild symptoms not bothersome enough to necessitate repeat ablation, but significant enough to mandate pharmacologic therapy (beta-blocker and calcium channel-blocker, patients number 7 and 9 table 2). These two patients had not undergone PB insertion.

Overall, at the time of the most recent outpatient evaluation, mean heart rate at rest measured 73 ± 54 bpm (SD 13,87). This value was significantly lower than that documented before RFA (baseline HR: 104 ± 18.1 bpm; $p < 0.001$).

DISCUSSION

Our study provides novel insights into the merits of different strategies to prevent PN injury, a known common complication of IST ablation: 1) Ventilation holding can be sufficient, in a minority of patients, to avoid PN damage when phasic variations of PN capture are present; 2) PA and balloon insertion are necessary in a majority of patients (81%) and achieves 100% success at avoiding PN injury; 3) The anterior PA approach allows for a straightforward balloon positioning at the SVC-RA junction, with successful separation between the PN and the targeted sites being achieved faster and with reduced fluoroscopic exposure; 4) We report on the acute and chronic effectiveness of IST ablation, in terms of both subjective and objective symptom relief, showing an optimal acute success rate but with 15.4% recurrence after a single procedure.

IST ablation has a broad range of possible complications. Besides PN injury¹⁶, some of the most common include narrowing of the superior vena cava,¹⁷ pericardial effusion,¹⁸ and bradycardia requiring a pacemaker.⁷ Major complications including pacemaker implantation and bleeding requiring sternotomy were unavoidable in our series.

PN protection strategies: Posterior vs. Anterior Pericardial Access

Different strategies have been proposed to avoid PN injury. Our first approach, used when PN capture disappeared during phases of the respiratory cycle, was simple ventilation holding. However, the vast majority of patients (11/13) had continuous PN capture throughout the respiratory cycle and PA and balloon insertion was required. Jacobson et al reported their experience on combined epicardial/endocardial SAN ablation in 5 patients.⁴ A pericardial balloon delivered via posterior PA was used in 3 patients. Two of their patients required injection of saline and air to further protect the PN. In our series, end-inspiration PN capture persisted even after pericardial balloon insertion in 2 patients using posterior PA. Simple ventilation holding was sufficient without the need for further saline or air injection.

Posterior PA as described by Sosa et al, was reported as a tool to facilitate ablation of ventricular tachycardia.¹⁵ The point of entry is most commonly at the diaphragmatic wall of

the RV, and catheter reach of the LV's infero-posterior wall is straightforward. However, turning towards the right side of the pericardial sac to reach the SVC-RA junction was not as facile in our experience and required extensive catheter manipulation, use of a deflectable sheath and prolonged fluoroscopy time. Additionally, balloon inflation –after positioning a wire from inferior-to-superior- failed to continuously protect the PN with this approach and required ventilation holding in 2 cases.

Using the anterior approach proved more useful. In this approach, as described by Jais et al,¹⁹ the point of pericardial entry is substernal, anterior to the RV. Directing the wire and balloon towards the SVC-RA junction with a deflectable sheath allowed deployment of the balloon from high-to-low, created an indentation in the RA geometry precisely at the location of the SAN (Figure 3), and achieved PN protection consistently.

Jacobson et al described one RV puncture during percutaneous subxyphoid access without sequelae.⁴ Additionally, 3 of their patients required steroids and/or colchicine for postprocedure pericarditis. In our series, RV puncture occurred in one patient for whom the posterior approach was chosen.

Effectiveness of SAN ablation

Our results are comparable to pre-existing literature. We achieved successful long-term rate reduction and symptomatic relief in 84.6% of patients. Prior studies have included limited numbers of patients ranging from 5⁴ or 39¹¹ individuals. In one of the earliest reports, Lee et al performed SAN ablation/modification in 16 drug-refractory, highly symptomatic patients with IST.⁷ Holter monitoring demonstrated a decrease in maximal and mean heart rates (167.2 ± 2.6 beats/min vs. 96.7 ± 5.0 beats/min, $p < 0.001$, and 125.6 ± 5.0 beats/min vs. 54.1 ± 5.3 beats/min, $p < 0.001$, respectively) along with long-term benefits. Man et al reported on 29 IST patients undergoing ablation, of whom 22 (76%) exhibited acute reduction of sinus rates to less than 90 beats/min.²⁰ Importantly, symptoms recurred 4.4 ± 3 months after the procedure in 6 of the 22 patients (27%). Repeat ablation lead to successful symptom elimination in 3 of them. In a more recent report, long-term results of 3-dimensional map-guided ablation of IST were reported in 39 patients.¹¹ After ablation, the mean sinus rate normalized (72 ± 8 beats/min), but 21% of patients experienced recurrent IST and underwent repeat ablation. It is conceivable that the use of PN protection in our series allowed a more liberal and extensive ablation that may have augmented long-term success rates as compared to those previously reported.

The suboptimal long-term success rates observed in IST ablation may be multifactorial. The origin of IST is unclear, and it frequently overlaps with other entities, including but not limited to sympathotonic orthostatic hypotension, idiopathic hypovolemia, chronic fatigue syndrome, mitral valve prolapse syndrome, and POTS,² all of which can be associated with symptoms independent of an elevated HR. Another contributor to procedural failure lies in the potential for tachycardia to recur from other sinus nodal sites or even from the atrioventricular junction following complete SAN ablation.² Furthermore, symptoms can persist despite SAN slowing, and observed benefits may only be short term.²¹ As a matter of fact, two of our patients who recounted failure of clinical improvement objectively

demonstrated successful SAN modification (lower HR) not only acutely but also in the long-term.

All in all, RF ablation remains a somewhat suboptimal intervention of last resort in drug refractory IST. Its proven effectiveness in this population is not universal, and a spectrum of complications has restricted its widespread adoption. Even with experienced operators, major complication rates remain unavoidably significant. Chief amongst them is PN damage. Ventilation holding and anterior balloon insertion appears to be promising interventions that may significantly reduce the incidence of PN injury, which may favor a more frequent implementation of the procedure.

Limitations

Our study had multiple limitations. The major deficiency of this series is its small population size that may have been suboptimal in establishing statistical power in multiple comparisons made. Our series size is, however small, comparable to that of others reported in the literature.^{4, 7, 8, 11} We compare consecutive patients undergoing posterior vs. anterior PA in a retrospective data registry. While a prospective randomized trial would have been optimal, given the relative small numbers of patients available in all IST series, the data presented offers valuable insights as to how to best approach these patients.

CONCLUSION

IST modification carries significant risks of PN injury. Maneuvers designed to avoid this sequelae, including ventilation holding and/or pericardial balloon insertion are frequently warranted. An anterior epicardial approach appears to be more effective in complication prevention, prompt optimal balloon positioning and fluoroscopy time reduction as compared to the posterior approach.

ABBREVIATIONS

HR	Heart rate
IST	Inappropriate sinus tachycardia
PA	Pericardial access
PB	Pericardial balloon
POTS	Postural orthostatic tachycardia syndrome
PN	Phrenic nerve
RA	Right atrium
RF	Radiofrequency
RV	Right ventricle
SAN	Sino-atrial node

SVC Superior vena cava

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Clinical Perspectives

Radiofrequency (RF) ablation is utilized as a last resort in the treatment of drug-refractory inappropriate sinus tachycardia (IST). Our series confirms high acute and chronic success rates consequent to the intervention. However, its use remains limited by major complications including phrenic nerve (PN) injury. We demonstrate that ventilation holding and pericardial balloon insertion are effective in avoiding PN injury. Anterior pericardial access appears superior to the posterior approach in balloon positioning time and fluoroscopic exposure time. Detailed instruction in carrying out this approach is provided for application in drug-refractory IST. Other major complications remain unavoidable however, and must be considered prior to advocating this intervention.

Figure 1.

Right posterior view of activation maps (red color indicates the earliest activation time and purple the latest one) and phrenic nerve (PN) capture map (black dots). PN injury was avoided by ventilation holding. A, Earliest local activation time at the initial map. After radiofrequency delivery, the activation pattern changed and earliest sites were subsequently mapped at progressively more caudal locations (B, C and D). Despite the apparent close overlap of earliest sites with PN capture sites, PN capture was not continuous during the respiratory cycle at the targeted sites. Ablation was delivered during ventilation holding, successfully avoiding PN injury. Abbreviations: CS: coronary sinus. IVC: inferior vena cava. RA: right atrium. SVC: superior vena cava.

Figure 2.

Posterior vs anterior pericardial puncture for epicardial balloon placement. A-D, Posterior pericardial access. After tenting the pericardial sac (A), the pericardium is punctured and a wire is advanced (B). A deflectable sheath is then used to direct the wire and angioplasty balloon under the diaphragmatic wall of the heart, posteriorly (C) and rightward (D). The balloon is positioned from low-to-high, aiming to occupy a space anterior to the superior vena cava and lateral to the targeted ablation site (white arrows). E-F, Anterior pericardial access. In the right lateral projection (RL), the pericardium is tented at a substernal location (E) and punctured, directing a wire over the anterior heart silhouette (F). The deflectable sheath directs wire and balloon posteriorly (G) and towards the right side (H), positioning the balloon at targeted sites from high-to-low, opposite to the ablation sites (white arrows). Fluoroscopic projections: LAO, left anterior oblique; RAO, right anterior oblique; RL, right lateral.

Figure 3.

Successful balloon PN displacement by anterior pericardial access. A, Right anterior oblique (RAO) projection showing the location of the balloon and the ablation catheter (white arrow). B, Consecutive activation maps and PN capture map (black dots) before (left) and after (right) pericardial balloon insertion. Pre-balloon map show overlap between PN capture and earliest sites. Ablation slightly anterior to earliest site (red dots) failed. Post balloon map showed an obvious indentation in the atrial geometry (arrow), but no PN capture, and ablation of targeted sites was successful. Abbreviations: CS: coronary sinus. IVC: inferior vena cava. RA: right atrium. SVC: superior vena cava.

Figure 4.

High-density activation maps. Consecutive right atrial geometry and maps were obtained, before (A) and after (B-D) PB insertion using an anterior approach. Note the obvious indentation of the chamber geometry after balloon positioning, which is most marked at the SVC-RA junction (asterisks), where earliest activations arise. PB eliminated PN capture. After the initial ablation (earliest site in B), subsequent maps showed a caudal migration of the earliest site, all successfully ablated. Abbreviations: IVC: inferior vena cava. RA: right atrium. SVC: superior vena cava.

Table 1

Patient Characteristics.

	Patients (n=13)
Age (years, range)	34.2 (20-49)
Male/Female (n)	0/11
Creatinine mg/dl (SD)	1.09 (0.35)
BMI (SD)	23.8 (6.1)
SPB (SD)	121.46 (86-166)
DBP (SD)	77.45 (43-106)
Heart rate (SD)	104 (18.1)
LVEF (% , SD)	63.9 (3.8)
Beta-blockers	12 (92.3%)
Calcium channel blockers	5 (38.4%)
Ivabradine	2 (15.4%)
Sotalol	2 (15.4%)

AF= Atrial fibrillation; *BMI*= Body mass index; *CKD*= Chronic kidney disease (MDRD-4<60 ml/min/1.73 m²); *DBP*= Diastolic blood pressure; *LVEF*= Left ventricular ejection fraction; *SBP*= Systolic blood pressure; *SD*= Standard deviation.

Table 2

Patient characteristics, electrophysiological and ablation data

Patient No./Sex	Age	Sx	No. Drugs Failed	β - B	CCB	So	Ib	Pre-abl Resting HR	PNI Prevention Maneuver	JR	Abrupt HR Response	HR 24 hr Post-abl.	HR Last F/U	Sx Impr.	Drugs Needed Last F/U	Days to Last F/U
1/F	39	Palpitations	3	Y	Y	Y	Y	120	PB (anterior)	Y	65	60	85	Y	N	40
2/F	49	Palpitations, SOB	1	Y	N	Y	N	117	PB (anterior)		70	84	58	Y	N	773
3/F	20	Palpitations, SOB	1	Y	N	N	N	90	PB (posterior)	Y	90	69	62	Y	N	276
4/F	35	Palpitations	3	Y	Y	N	N	110	PB (anterior)	Y	70	66	65	Y	N	225
5/F	23	Palpitations, Dizziness	1	Y	N	N	N	93	PB (posterior)		70	98	60	Y	N	1251
6/F	38	Palpitations	2	Y	Y	N	N	108	PB (posterior)	N/A	N/A	N/A	92	Y	N	925
7/F	38	Palpitations	1	N	Y	N	N	113	PB (posterior)	Y	90	66	76	Y	CCB	201
8/F	32	Palpitations, Chest pain	2	Y	N	N	N	93	PB (anterior)	Y	60	82	88	N	N	1853
9/F	35	Palpitations, Fatigue, DEO, Dizziness, Chest tightness	1	Y	N	N	N	120	PB (anterior)	Y	80	77	56	Y	β-B	923
10/F	38	Palpitations, Fatigue, SOB, Headache	2	Y	Y	N	N	85	Not needed	Y	60	51	78	N	N	65
11/F	37	Palpitations, Chest pain, SOB, Lightheaded, Dizziness	1	Y	N	N	N	94	Not needed	Y	80	80	75	N	N	2496
12/F	25	Palpitations	1	Y	N	N	N	110	Holding ventilation	Y	70	80	87	Y	N	334
13/F	36	Palpitations, Chest pain, SOB, Dizziness, Anxiety, Migraine	2	Y	N	N	Y	94	PB (anterior)	Y	65	62	61	Y	N	19

β-B= Beta-Blockers; **CCB**= Calcium Channel Blockers; **DOE**= Dyspnea on exertion; **F**= Female; **F/U**= Follow-Up; **HR**= Heart Rate; **hr**= Hours; **Ib**= Ivabradine; **JR**= Junctional Rhythm; **N**= No; **No.**= Number; **PB**= Pericardial Balloon; **PNI**= Phrenic Nerve Injury; **Pre-abl**= Pre-ablation; **Post-Abl**= Post-ablation; **SOB**= Shortness of Breath; **So**= Sotalol; **Sx**= Symptoms; **Sx Impr**= Symptoms Improvement; **Y**= Yes.