Effect of Radiofrequency Current Application during Catheter Ablation on Heart Rate Variability in Patients with Supraventricular Tachycardia

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ABSTRACT
Background: To a large extent, the heart's functions are influenced by the autonomic nervous system involving hemodynamics, properties of cardiac conduction, heart rate (HR), as well as cardiac myocytes cell functions, and cardiac arrhythmogenesis. In the present study, heart rate variability (HRV) was evaluated in patients receiving radiofrequency catheter ablation for supraventricular tachycardias to determine if there was a correlation between the amount of radiofrequency current used and the HRV change.
Patient and Methods: For this one-arm clinical trial, 60 patients with drug-resistant supraventricular tachycardias were recruited; they underwent radiofrequency ablation and were followed up for 6 months after the procedure.
Results: Compared with pre-ablation data, at the follow-up evaluation after radiofrequency ablation, HRV were found to be shorter. Results from a 24-hour Holter monitor showed an increase in mean HR, whereas HRV parameters such as time domain indices (SDNN, rMSSD) and frequency domain index, which reflect the attenuation of parasympathetic tone, were reduced in the follow-up at 1 month and 6 months post-ablation. 30 patients, or 50%, had a high sinus rate 6 months after ablation. Compared to patients without AV nodal modification or postero-septal accessory pathway ablation, HRV changes were more pronounced in those with these procedures.
Conclusion: Six months following radiofrequency ablation, cardiac autonomic dysfunction was still evident when measured by alterations in time domain and frequency domain HR variability measures. Perhaps one cause of parasympathetic denervation is its role in post-ablation sinus rate.
Keywords: Radiofrequency ablation, Catheter Ablation, Heart Rate Variability, Supraventricular Tachycardia, Post ablation high sinus rate.

INTRODUCTION

To a large extent, the heart's functions are influenced by the autonomic nervous system involving hemodynamics, properties of cardiac conduction, heart rate (HR), as well as cardiac myocytes cell functions, and cardiac arrhythmogenesis [(1)]. Analyzing heart rate variability (HRV) is one of the noninvasive procedures used to evaluate your heart's autonomic function [(2)]. The utility of HRV measures for prediction of outcome or detection of changes in the clinical status depends on their stability over time. HRV is influenced significantly by sex, age, race, clinical conditions, physical fitness, and drug treatment.

HRV testing is a low-cost, widely available, non-invasive method for assessing cardiac autonomic function. Although measurements are based on the RR interval (cardiac inter-beat interval obtained from a continuous electrocardiogram (ECG) recording and usually from the normal sinus to normal sinus [NN] intervals), Analysis of HRV patterns from continuous electrocardiograms (ECGs) permits the identification and measurement of underlying physiologic rhythms. The strength of these rhythms is expressed by the magnitude of different frequency-domain HRV indices. Recordings Holter ECG at least 24 hours reveal that the circadian rhythm is the physiologically dominant rhythm responsible for the vast majority of HRV, with higher sympathetic activity correlating to higher heart rates during the day and higher vagal activity correlating to lower heart rates during the night [(3)].

During normal sleep, there are prominent physiologic rhythms associated with each 90-minute sleep cycle, and there is evidence that these rhythms persist during awake time, possibly in association with neuroendocrine rhythms, but ultradian HRV measures have not found clinical applications at this point. As the autonomic nervous system has far-reaching effects on the heart, it stands to reason that its influence would extend to accessory pathway characteristics in ventricular preexcitation. One possible symptom of ventricular preexcitation syndromes is sudden cardiac death [(4, 5)]. Holter monitoring, and invasive electrophysiological study are being used for this purpose [(6,7)]. Catheter ablation of a cardiac arrhythmia is typically recommended when medical therapy has failed to control a patient's symptoms from a recurrent or chronic symptomatic arrhythmia, or when medical therapy is not favored or tolerated. Ablation of supraventricular tachycardia with a radiofrequency catheter has been shown in multiple trials to enhance HR and decrease HRV [(8)].

We aimed to assess the relationship between radiofrequency (RF) current application during catheter ablation and its effect on HRV among patients undergoing RF catheter ablation for supraventricular tachycardias.

PATIENT AND METHODS

For this one-arm clinical trial, 60 patients underwent RF ablation of supraventricular tachycardias, and were followed up at 1 and 6 months after the procedure.

These patients were included in the study: Patients with supraventricular tachycardia documented by standard surface ECG or 24 hours Holter recording who were candidates for ablation using RF techniques, age

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ranging from 18 to 60 years old, patients with structurally normal heart, normal thyroid function and ablation was done successfully terminating the tachycardia. We excluded patients with structural heart disease, patients receiving drugs affecting the autonomic nervous system, patients with previous ablation, patients with history of prior cardiac surgery and patients suffering from acute systemic infections from the study.

The selected patients were subjected to the following: (1) Thorough history taking with particular stress on: tachycardia (frequency, rate, duration of attack), syncopal attacks, anti-arrhythmic drug history prior history of direct current (DC) cardioversion, underlying heart disease (e.g.: ischemic heart disease, rheumatic heart disease, dilated cardiomyopathy and congenital heart disease), history of previous cardiac procedures e.g. electrophysiologic procedure, coronary intervention and history of cardiac surgery. (2) Complete physical examination with special emphasis on orthostatic hypotension. (3) Routine blood tests: Complete blood count, renal function tests, liver function tests, coagulation profile and thyroid function test were verified within one month before the procedure. (4) Prior to and following the procedure, a 12-lead ECG is taken to evaluate HR, rhythm, baseline intervals, and the presence of any conduction abnormalities.(5) Echocardiogram: A standard study in the left lateral position was performed using ultrasound scanner (Vivid S5, General Electric, Chicago, Illinois), utilizing two dimensional and M-mode modalities to look for any structural abnormality and measure left ventricular and right ventricular dimensions, systolic and diastolic functions and valvular functions. In the parasternal long axis image, the left atrium's antero-posterior diameter was calculated. (6) Using Holter monitor recordings obtained before and after procedure (1 and 6 months later), heart rate variability was evaluated. (7) Electrophysiologic study and ablation procedure. The success rate and parameters for any cardiac autonomic dysfunction were assessed through post-ablation treatment and follow-up one and six months following the procedure. It was determined what follows: (1) Collecting a patient's symptomatic history, (2) Full-body examination, (3) In the first month and the sixth month after the operation, surface ECG was performed, (4) Holter monitoring in all patients one month and six months after the procedure was done to evaluate basic sinus rate and HRV data and compare it with Holter data obtained before the procedure. When experiencing symptoms, patients were instructed to record a 12-lead ECG. Patients were excluded from the study if they experienced a clinical recurrence, as verified by ECG or Holter monitoring, of atrial tachyarrhythmia lasting more than 30 seconds.

In order to examine the parameters of HRV, a 24 hour Holter monitor was used before ablation and one month and six months after ablative procedures. High-quality recordings were the only ones used for analysis by two experts, who were blinded to the study. Some metrics of HRV were utilized to measure autonomic activity: Standard deviation of RR interval (SDRR), mean RR interval (mean NN interval), low frequency/high frequency ratio (LF/HF), and root mean square of variations (rMSSD) in RR intervals, a triangular index (obtained by plotting the length of RR intervals on the horizontal axis and their occurrence frequencies on the vertical axis in a density histogram of normal RR intervals). Each histogram column's points join to form a triangle, the width of whose base stands for the range of RR intervals. Resting sinus tachycardia > 92 bpm or an increase of > 20 bpm after catheter ablation were considered to be examples of post ablation high sinus rate (PA-HSR)[9]. Comparison between mean sinus rate pre and post ablation was done. HRV changes (as an indicator of autonomic changes post ablation) were obtained.

Ethical consent:

An approval of the study was obtained from Ain Shams University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

In order to analyze the data acquired, Statistical Package for Social Science (SPSS) version 20 was used to execute it on a personal computer. In order to convey the findings, tables and graphs were employed. The quantitative data was presented in the form of the mean, median, standard deviation, and confidence intervals. The information was presented using qualitative statistics such as numbers and percentages. The student's t test (T) is used to assess the data while dealing with quantitative independent variables. Pearson chi-Square (X^2) and chi-Square for linear trend were used to assess qualitatively independent data. The significance was set at p value equals or less than 0.05. Through the use of repeated measures, we were able to compare more than two paired groups with quantitative data and parametric distribution. With parametric distributions, we used ANOVA and Bonferoni correction for post hoc analysis, and with nonparametric distributions, we used the Freidman test and the Wilcoxon rank test for post hoc analysis. One-way analysis of variance (ANOVA) was used to compare three or more groups when the quantitative data followed a normal distribution; Kruskall-test Wallis's was used when the data did not follow a normal distribution. Margin of error was set at 5% and the confidence interval was set at 95%.

RESULTS

The mean age was 27.70 (SD 8.08) years, and 64% were females. Demographic data and SVT clinical characteristics are shown in table 1.

Table (1): Demographic data and SVT clinical characteristics of the participants.

Variable		Total no. = 60
Age	Mean ± SD Range	27.70 ± 8.08 19 – 44
Gender	Males Females	21 (35%) 39 (65%)
Longest SVT episode duration (hours)	Mean ± SD Range	1.68 ± 0.80 0.5 – 3
SVT frequency/month	Median (IQR) Range	3 (2 – 4.5) 1 – 12
Syncope	No Yes	48 (80%) 12 (20%)
History of DC shock	No Yes	51 (85%) 9 (15%)

DC: direct current, IQR: interquartile range, no: number SD: standard deviation, SVT: supraventricular tachycardia.

The data were shown as baseline values and the delta change from baseline to follow up values. We found the delta by subtracting the baseline from the subsequent measurement. Among the 60 patients who underwent RF ablation, the post-ablation mean HR was significantly higher, with significant reduction in SDNN, rMSSD, HRV triangular index, and frequency domain indices (VLF, LF and HF) as shown in Table 2. Thirty patients (50%) experienced post ablation high sinus rate after 1 month follow up (89.00 ± 2.68) and after 6 months follow up (92.05 ± 4.03).

Table (2): Change in heart rate variability of the participants.

Variable		Pre-Ablation	1st follow-up (1 month)	2nd follow-up (6 month)	P-value	Sig.
HR	Mean ± SD	82.40 ± 4.79	89.00 ± 2.68	92.05 ± 4.03	0.000	HS
SDNN	Mean ± SD	159.50 ± 41.71	111.70 ± 20.80	95.85 ± 18.07	0.000	HS
rMSSD	Mean ± SD	64.70 ± 15.87	36.75 ± 8.11	28.95 ± 6.21	0.000	HS
HRV triangular index	Mean ± SD	42.60 ± 11.12	32.60 ± 8.42	26.20 ± 4.02	0.000	HS
VLF	Mean ± SD	2750.70 ± 613.69	1427.80 ± 321.84	1035.25 ± 252.25	0.000	HS
LF	Mean ± SD	1940.10 ± 445.30	967.05 ± 492.57	642.20 ± 353.08	0.000	HS
HF	Mean ± SD	1547 ±350.12	575.5 ± 133.21	428.5 ± 98.21	0.000	HS

Post hoc analysis (P value)			
Variable	Baseline Vs 1st follow up	Baseline Vs 2nd follow up	1st follow up Vs 2nd follow up
HR	0.000	0.000	0.032
SDNN	0.000	0.000	0.004
rMSSD	0.000	0.000	0.001
HRV triangular index	0.000	0.000	0.004
VLF	0.000	0.000	0.001
LF	0.001	0.000	0.005
HF	0.000	0.000	0.000

HF: high frequency, HR: Heart rate, HRV: heart rate variability, HS: highly significant, LF low frequency, RMSSD root mean square of differences between successive NN intervals, SD: standard deviation, SDNN standard deviation of NN interval, VLF very-low-frequency band

P-value > 0.05: Nonsignificant; P-value ≤ 0.05: Significant; P-value < 0.01: Highly significant.

Among the study population 45 patients were the diagnosed with the AVNRT (atrioventricular nodal re-entry tachycardia) in which modification of the slow pathway was done during the ablation procedure, the post-ablation mean HR was significantly higher, accompanied by a significant reduction in SDNN, rMSSD, HRV triangular index and frequency domain indices (VLF, LF and HF) as shown in table 3.

However, when comparing time and frequency domain indices of HRV characteristics between pre-ablation and post-ablation in 9 patients who received left lateral accessory pathway ablation, there were no statistically significant alterations as shown in table 4.

Table (3): Post RF modification of slow pathway in cases diagnosed with AVNRT.

Variable		**AVNRT**			**P-value**	**Sig**
		Baseline	**1st follow up**	**2nd follow up**		
HR	Mean ± SD	83.53 ± 4.1	89 ± 2.65	91.87 ± 4.53	0.000	HS
SDNN	Mean ± SD	153.4 ± 36.03	108.73 ± 18.63	95.93 ± 19.2	0.000	HS
rMSSD	Mean ± SD	64.27 ± 14.97	35.4 ± 8.19	28.4 ± 6.79	0.000	HS
HRV triangular index	Mean ± SD	39.6 ± 8.71	31.6 ± 7.85	26.13 ± 6.09	0.000	HS
VLF	Mean ± SD	2715.87 ± 624.32	1392.27 ± 332.41	1056.07 ± 291.12	0.000	HS
LF	Mean ± SD	2076.8 ± 448.85	1040.73 ± 254.98	683.13 ± 168.19	0.000	HS
HF	Mean ± SD	1547 ±263.85	588 ± 120.36	463 ± 109.81	0.000	HS

Post hoc analysis (P value)			
Variable	**Baseline Vs 1st follow up**	**Baseline Vs 2nd follow up**	**1st follow up Vs 2nd follow up**
HR	0.000	0.001	0.190
SDNN	0.002	0.001	0.085
rMSSD	0.001	0.000	0.017
HRV triangular index	0.003	0.001	0.073
VLF	0.000	0.001	0.033
LF	0.008	0.001	0.008
HF	0.001	0.001	0.002

HF: high frequency, HR: Heart rate, HRV: heart rate variability, HS highly significant, LF low frequency, RMSSD root mean square of differences between successive NN intervals, SD: standard deviation, SDNN standard deviation of NN interval, VLF very-low-frequency band

P-value > 0.05: Nonsignificant; P-value ≤ 0.05: Significant; P-value < 0.01: Highly significant.

Table (4): Post RF ablation of left lateral accessory pathway in the participants.

Variable		Left lateral accessory pathway			P-value	Sig
		Baseline	1st follow up	follow up		
HR	Mean ± SD	79.67 ± 6.66	88.67 ± 2.52	93 ± 0	0.093	NS
SDNN	Mean ± SD	184.67 ± 24.03	128.33 ± 20.21	100.33 ± 16.77	0.054	NS
rMSSD	Mean ± SD	65.33 ± 14.62	43.33 ± 9.34	33 ± 4	0.051	NS
HRV triangular index	Mean ± SD	52 ± 7.21	35.67 ± 8.32	25.33 ± 5.51	0.083	NS
VLF	Mean ± SD	3034 ± 509.32	1662.67 ± 342.61	930 ± 191.58	0.090	NS
LF	Mean ± SD	1817.67 ± 427.35	805 ± 197.41	627.67 ± 25.4	0.109	NS
HF	Mean ± SD	1705 ± 403.31	534 ± 113.81	390 ± 89.32	0.050	NS

HF: high frequency, HR: Heart rate, HRV: heart rate variability, LF low frequency, RMSSD root mean square of differences between successive NN intervals, SD: standard deviation, SDNN standard deviation of NN interval, VLF very-low-frequency band

P-value > 0.05: Nonsignificant; P-value ≤ 0.05: Significant; P-value < 0.01: Highly significant

When comparing HRV measurements between the baseline and the follow-up, the electrophysiologic investigation found no statistically significant correlation between the various tachycardia generation methods as shown in Tables 5 and 6.

Table (5): Method of induction of narrow complex tachycardia at 1st follow up of the participants.

1st Follow-up		Induction method				P-value	Sig
		Extra stimulus	Spontaneous	Burst	Mechanical		
		No. = 30	No. = 15	No. = 9	No. = 6		
HR	Mean ± SD	88.7 ± 2.31	90.2 ± 2.28	89.67 ± 4.73	86.5 ± 0.71	0.408	NS
SDNN	Mean ± SD	118 ± 17.49	110.6 ± 21.98	106 ± 23.28	91.5 ± 14.85	0.411	NS
rMSSD	Mean ± SD	40.2 ± 9.82	35.8 ± 6.06	29.67 ± 5.32	32.5 ± 7.63	0.505	NS
HRV triangular index	Mean ± SD	35.1 ± 8.2	31.2 ± 6.02	34.33 ± 8.69	21 ± 4.24	0.174	NS
VLF	Mean ± SD	1562 ± 371.73	1300.2 ± 312.32	1347 ± 318.31	1197 ± 285.22	0.733	NS
LF	Mean ± SD	886.3 ± 181.52	1039 ± 287.88	1290.67 ± 318.11	705.5 ± 165.17	0.560	NS
HF	Mean ± SD	651.5 ± 148.32	534 ± 112.81	643 ± 118.62	725.5± 155.91	0.875	NS

HF: high frequency, HR: Heart rate, HRV: heart rate variability, LF low frequency, NS: non-significant, RMSSD root mean square of differences between successive NN intervals, SD: standard deviation, SDNN standard deviation of NN interval, VLF very-low-frequency band

P-value > 0.05: Nonsignificant; P-value ≤ 0.05: Significant; P-value < 0.01: Highly significant

Table (6): Method of induction of narrow complex tachycardia at 2nd follow up

2nd Follow-up		Induction method				P-value	Significance.
		Extra stimulus	Spontaneous	Burst	Mechanical		
		No. = 30	No. = 10	No. = 9	No. = 4		
HR	Mean ± SD	92.1 ± 4.63	91 ± 2.92	93.67 ± 5.03	92 ± 4.24	0.866	NS
SDNN	Mean ± SD	100.5 ± 19.27	95.6 ± 14.22	79 ± 8.19	98.5 ± 21.81	0.368	NS
rMSSD	Mean ± SD	30.9 ± 7.19	28.2 ± 6.31	25.67 ± 4.84	26 ± 6.81	0.751	NS
HRV triangular index	Mean ± SD	28.1 ± 6.65	24 ± 3.24	24.33 ± 5.03	25 ± 5.43	0.717	NS
VLF	Mean ± SD	1159.9 ± 171.43	1045.2 ± 281.21	741 ± 154.33	828.5 ± 198.21	0.323	NS
LF	Mean ± SD	641.3 ± 153.81	669.8 ± 112.63	733 ± 117.81	441.5 ± 99.81	0.855	NS
HF	Mean ± SD	477.5 ± 105.32	390 ± 88.61	394 ± 83.91	417.5 ± 90.15	0.899	NS

HF: high frequency, HR: Heart rate, HRV: heart rate variability, LF low frequency, NS: non-significant, RMSSD root mean square of differences between successive NN intervals, SD: standard deviation, SDNN standard deviation of NN interval, VLF very-low-frequency band
P-value > 0.05: Nonsignificant; P-value ≤ 0.05: Significant; P-value < 0.01: Highly significant

There was no statistically significant relationship between the time of current application during RF ablation and the HRV parameters at baseline and at time of follow up as shown in tables 7 and 8.

Table (7): Effect of duration of RF current application at 1st follow up after 1 month.

1st Follow up		RF current application duration			P-value	Sig
		1 min	2 min	3 min		
		No. = 24	No. = 21	No. = 15		
HR	Mean ± SD	89.5 ± 2.67	88.43 ± 2.7	89 ± 3.08	0.762	NS
SDNN	Mean ± SD	110.25 ± 17.1	107 ± 21.5	120.6 ± 26.61	0.544	NS
rMSSD	Mean ± SD	34.63 ± 7.65	36.29 ± 8.38	40.8 ± 9.86	0.641	NS
HRV triangular index	Mean ± SD	32.75 ± 5.28	30.29 ± 6.62	35.6 ± 7.38	0.584	NS
VLF	Mean ± SD	1444.75 ± 340.51	1332.29 ± 305.21	1534.4 ± 295.32	0.815	NS
LF	Mean ± SD	1080.5 ± 252.25	995.29 ± 283.17	746 ± 150.71	0.508	NS
HF	Mean ± SD	603 ± 132.91	588 ± 118.71	534 ± 126.32	0.985	NS

HF: high frequency, HR: Heart rate, HRV: heart rate variability, LF low frequency, NS: non-significant, RMSSD root mean square of differences between successive NN intervals, SD: standard deviation, SDNN standard deviation of NN interval, VLF very-low-frequency band
P-value > 0.05: Nonsignificant; P-value ≤ 0.05: Significant; P-value < 0.01: Highly significant

Table (8): Effect of Duration of RF current application at 2nd follow up after 6 months

2nd Follow up		RF current duration			P-value	Sig
		1 min	2 min	3 min		
		No. = 24	No. = 21	No. = 15		
HR	Mean ± SD	94.13 ± 4.19	89.29 ± 3.59	92.6 ± 2.19	0.055	NS
SDNN	Mean ± SD	97.38 ± 23.63	94.29 ± 14.24	95.6 ± 16.15	0.952	NS
rMSSD	Mean ± SD	26.63 ± 5.83	30.43 ± 7.68	30.6 ± 7.63	0.611	NS
HRV triangular index	Mean ± SD	28.5 ± 6.55	23.43 ± 5.61	26.4 ± 6.21	0.397	NS
VLF	Mean ± SD	1041.13 ± 248.68	1073.14 ± 231.06	972.8 ± 210.83	0.908	NS
LF	Mean ± SD	716.38 ± 156.21	645.14 ± 145.38	519.4 ± 119.84	0.644	NS
HF	Mean ± SD	431.5 ±99.81	463 ± 86.81	390 ±82.93	0.956	NS

HF: high frequency, HR: Heart rate, HRV: heart rate variability, LF low frequency, NS: non-significant, RMSSD root mean square of differences between successive NN intervals, SD: standard deviation, SDNN standard deviation of NN interval, VLF very-low-frequency band

P-value > 0.05: Non-significant; P-value ≤ 0.05: Significant; P-value < 0.01: Highly significant

DISCUSSION

This study investigated the incidence of post SVT ablation cardiac autonomic dysfunction using RF catheter ablation. During the follow up of HRV parameters after 1 month and 6 months changes in time domain and frequency domain parameters persisted for 6 months after ablation.

Sixty patients were studied; with a mean age of 27.70 (SD 8.08) years and females representing 65.0% of the study population. All patients were referred for ablation of paroxysmal SVT and underwent RF ablation procedure. The 24-hour Holter monitoring showed that after 1 month and 6 months of follow-up, the mean HR was significantly higher than at baseline., Parasympathetic tone was dampened post-ablation, as measured by a drop in time domain indices (SDNN, rMSSD) and frequency domain indices (VLF, LF, and HF domains). Post ablation high sinus rate (PA-HSR) was defined as an increase in resting sinus rate ≥ 20 bpm or a resting sinus rate ≥ 92 bpm without physiological or hemodynamic causes. In this study 30 patients (50%) complained of palpitations due to early post ablation high sinus rate. These results demonstrated a significant increase in mean HR after 1 month follow up (89.00 ± 2.68) and after 6 months follow up (92.05 ± 4.03). This increase in HR may be due to abolishing vagal reflexes owing to denervation of vagal nerve endings related to preganglionic or postganglionic parasympathetic fibers that are located in the ablation area.

There is relation between the target site of RF ablation and the change in the HRV parameters. Modification of the AV node or ablation of the postero-septal accessory pathway, frequency domain analysis indicative of parasympathetic denervation, showed a significant dampening of high frequency components (0.15 to 0.40 Hz). After ablation of the left lateral accessory pathway, these alterations were not present. Disruption of parasympathetic fibres along the AV node's slow pathway and the postero-septal accessory pathway may be to cause. Reduced HRV in subjects who underwent AV node modification or ablation of the postero-septal accessory pathway, but no significant changes in HRV after ablation of the left free-wall accessory pathway, were reported by **Kocovic *et al.*** [10] they hypothesised that this was due to the parasympathetic withdrawal that occurred after the procedure. Moreover, when **Psychari *et al.*** [11] investigated the effects of RF ablation on the atrioventricular nodal slow pathways, postero-septal, and left lateral accessory pathways, they found that RF ablation in the anterior, mid, and posterior regions of the low intra-atrial septum could disrupt sympathetic fibers located in these regions, resulting in cardiac sympathetic denervation. Reduced fiber density can be seen along the left atrioventricular groove.

Additionally, **Soejima *et al.*** [8] investigated HRV before and after RF catheter ablation in 17 patients with AVNRT and 38 patients with accessory pathways. Free wall of the right or left ventricle, or the posterior interventricular septum, accessory pathways were examined. Our findings are consistent with those of others who have found that RF ablation increases sinus rate in patients with AVNRT or with the accessory pathway at the posterior septum. This indicates that radiofrequency-induced lesions may activate or inhibit reflex circuits in addition to directly interrupting anatomically different nerve fibers.

AVNRT and/or accessory pathway ablation has been shown to cause significant changes in HRV in certain studies, whereas in others, no such alterations have been detected, which runs counter to what we found. Using serial 24-hour Holter recordings, **Purerfellner *et al.*** [12] demonstrated that RF ablation of the slow pathway in AVNRT does not significantly alter parameters of HR and HRV. After AVNRT ablation, **Kowallik *et al.*** [13] found that autonomic regulation of the sinus and AV nodes was still present. These findings suggest that alterations in autonomic input to the AV node are not always responsible for the effects of applying RF current to the posteroseptum. Differences between their findings and ours can be attributed to the fact that they analyzed ECG data from nighttime recordings rather than daytime ones, they estimated the variations in the automatic modulation of the sinus and AV nodes, as well as the power spectra of beat-to-beat PP and PR intervals.

Yu *et al.* [14] studied the post ablation high sinus rate (PA-HSR) among 991 patients post RF atrial fibrillation ablation. They defined PA-HSR as average HR in 24-hour Holter ≥ 92 bpm. They demonstrated that only 28 patients (2.8%) developed PA-HSR by month-3 follow up. Also, **Kang *et al.*** [15] demonstrated an increase of (8 ±14 bpm) from the baseline mean HR (65±9 bpm) by 3 months follow up. The increase in HR may be so early to be evident during the ablation procedure after abolishing vagal reflexes owing to denervation of vagal nerve endings related to pulmonary veins and this response is associated with good prognosis regarding clinical recurrence and effective ablation. However, those patients are frequently symptomatic and require medication to control high sinus rate.

CONCLUSION

Six months following RF ablation, cardiac autonomic dysfunction was still evident when HRV measures measured by alterations in time domain and frequency domain. Perhaps one cause of parasympathetic denervation and its role in Post-ablation sinus rate.

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