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Measuring the refractory period threshold of AV-node after Radiofrequency ablation

Sima Sayah[1*], Hossein Arayeshkhah[2]

MD, Cardiologist, Electrophysiologist, Faculty of Medicine, Booali Hospital, Qazvin University of Medical Sciences, Qazvin, Iran

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ABSTRACT

Introduction: Reentrant tachycardia of atrioventricular node (AVNRT) is one of the most common type of supraventricular tachycardia (SVT) which is caused by dualAV node physiology. Radiofrequency ablation is an effective therapeutic procedure for this arrhythmia with 95% of success rate and about 5% of recurrence chance.
Objective: The purpose of current study was determining a threshold of the AV node refractory period after radiofrequency ablation, in which, obtaining that threshold would correspond with lowest possible recurrence rate.
Material and Methods: Patients admitted with primary diagnosis of supraventricular tachycardia (SVT) based on the ECG results and possible diagnosis of AVNRT were undergone electrophysiological study (EPS). After confirmation of the AVNRT diagnosis, they have undergone radiofrequency ablation, then after one year, they have followed up for arrhythmia recurrence based on the symptoms and ECG results. The communication with participants were done through telephone call.
Results: In one-year follow-up period, 1.6% of patients (n=3) were experienced arrhythmia based on ECG results and all of them was female participants. There weren't any significant differences between changes in refractory period of AV node of patients with recurrence and without recurrence, based on the anterograde Wenckebach cycle results. The changes in AV Wenchebach cycle were -34.66 ms in patients with recurrence and +4.17 ms in patients without recurrence.
Conclusion: The study findings shown an increasing trend in anterograde Wenchebach cycle of the AV node of patients with recurrent and decreasing trend in patients without recurrence. Although the recurrent rate was 1.6%, but there wasn't any possibility for determining an absolute threshold for refractory period of the AV node based on the anterograde Wenchebach cycle of the AV node with lowest recurrent rate.
KEYWORDS: Reentrant tachycardia of atrioventricular node, radiofrequency ablation, dual physiology of the atrioventricular node

INTRODUCTION

Previous studies have shown that various type of paroxysmal supraventricular tachycardia (PSVT) is the result of re-entry circuits formation in the atrioventricular node (Fig. 1).

Atrioventricular node re-entry tachycardia (AVNRT) follows the formation of this re-entry circuits in slow pathway (retrograde conduction) and fast pathway (retrograde conduction) in the atrioventricular node (Fig. 2).

This is happening due to the presence of both of the slow and fast conduction pathways in the atrioventricular node (1). These dual pathway (dual AV node physiology) led to the presence of two QRS complexes per P wave or two P wave for every QRS complex in the electrophysiology studies tracing (Fig. 3). In order to show the presence of this dual pathway during EPS, following 10 ms reduction in applied stimuli intervals through high right atrium, the retrograde conduction of the fast pathway was blocked and retrograde conduction in slow pathway was continued and reached the ventricles (1). This wave can conduct back to atrium through fast pathway and then again, moved forward through slow pathway and form a reentry circuit (Fig. 4). This reentry circuit lead to an increase in the AH interval which is over 50 ms and called jump (Figs. 5, 6). Sometimes we witnessed two ventricular responses with different AH intervals after stimulation of HRA (*8) (Fig. 6). This phenomenon appears as changes in PR interval in the sinus rhythm, although uncommon. About 90-95 percent of the AVNRT cases are like this and called typical. Some patients with AVNRT do not shows discontinuous refractory period curves of AV node, unlike many peoples without AVNRT who shows discontinuous refractory period curves (Fig. 7). The site for radiofrequency ablation is slow pathway which is located in the Koch triangle between coronary sinus (CS) and tricuspid valve (2). The endpoint of ablation is complete ablation of the slow pathway and eradication of the dual physiology (dual pathway) without affecting fast pathway which is determined through changes in relative refractory period of AV nod based on the changes in wenkbach cycle of the AV node (AVWB). Complete ablation of retrograde conduction through slow pathway is not necessary clinically, because this can increase the chance of fast pathway blockage that called modification conversion.

The dual physiology will remain in 40-50% of the radical ablation of the slow pathway, and there are AV node echo wave in 75% of the cases. However, AVNRT couldn't induce in this condition, although there are echo wave, and

***Corresponding Author:** Sima Sayah, MD, Cardiologist, Electrophysiologist, Faculty of Medicine, Booali Hospital, Qazvin University of Medical Sciences, Qazvin, Iran

that's why they called it modification (2). This method isn't contributing with increasing the risk of AVNRT recurrences. Therefore, lack of AVNRT induction with or without isoproterenol and presence of a dual pathway with echo wave of less than 30 milliseconds are acceptable. The success rate of RF ablation is 95% and recurrence rate is 5%. The restoration of conduction pathway was seen in 40% of the patients with recurrence of the arrhythmia. The AV node complete blockage rate is 2% and seen in the first 24 hours after procedure. The induction of fast junction rhythm during ablation indicate that ablation catheter is approaching fast pathway, which is correspond with higher possibility of damaging fast pathway and complete heart block.

There is 10% chance of complete and permanent blockage of the AV node in ablation of the fast pathway. According to above, we suppose in this study that changes in the refractory period cycle of the AV node could contribute with the recurrence of the AVNRT after ablation therapy. This hypothesis was investigated the possibility of presence of a relative refractory period threshold that have had the lowest recurrence rate of AVNRT. We've studied various parameters among patients with AVNRT in current study. There are many articles about radiofrequency treatment and physiology of AVNRT in previous literature, but there wasn't any study that investigated these parameters along with changes in refractory period before and after ablation therapy and its effects on the AVNRT relapse. The purpose of current study was determining a refractory period threshold of Arnode which was produced through radiofrequency ablation and correspond with lowest recurrent rate of the arrhythmia.

MATERIAL AND METHODS

This was a descriptive-analytic study performed on patients experiencing paroxysmal supraventricular tachycardia with differential diagnosis of AVNRT which was undergone electrophysiology study (EPS) and after confirmation of their disease, treated by radiofrequency ablation method. The research setting was Qazvin Ibn-e-Sina hospital and Shahid Rajaei Heart Center, Tehran that lasted about 2 years from 2011-2013. The electrophysiology interventions fellowships were performed the arrhythmia study and diagnosis and radiofrequency ablation method. A standard electrophysiology study machine (Bard) and radiofrequency ablation apparatus were used for all the study's participants in both health centers. According to standard protocols for indications of radiofrequency ablation participants were selected and final confirmation were applied based on the electrophysiology study results. Data were analyzed using IBM SPSS V.20 software package. P values less than 0.05 was considered statistically meaningful.

RESULTS AND FINDINGS

A total of 185 patients were included in the study, in which, one patient was passed away 4 months after vascular bypass due to heart failure and another patient was died due to complications of the vascular bypass surgery at hospital, thereby, 2 patients were excluded from study and remaining 183 patients were followed-up for a year after treatment.

The sample consisted of 117 females and 66 males. The patient's baseline parameters regarding AVNRT was studied and compared according to their age in subgroups of 10-year and their sex; and then again, these parameters were compared between patients with and without recurrence. The frequency distribution of AVNRT was 65% and 35% for male and female participants, respectively.

After dividing patients in 10-year interval subgroups ascendingly, the highest frequency distribution observed in the subgroup of 45-54 year which was 28% in female participants, although 65 year or over have the highest frequency in the male participants.

Table 1. Age and Sex of the participants

Variable	Subgroups n(%)	Sex n (%)		Total (%)
		Female n (%)	Male n (%)	
Age (yr)	12-24	10 (8.4)	5 (7.9)	15 (8.2)
	25-34	11 (9.3)	9 (14.3)	20 (11.0)
	35-44	25 (21.0)	10 (15.9)	35 (19.2)
	45-54	39 (32.8)	12 (19.0)	51 (28.0)
	55-64	23 (19.3)	10 (15.9)	33 (18.1)
	≥65	11 (9.2)	17 (27.0)	28 (15.4)
	Total	119 (65.4)	63 (34.6)	

Seventeen different baseline parameters and some pre-post intervention parameters were explored and mean differences were recorded. The mean of AVWB (*3) were 325.29 ± 56.59 ms and 328.80 ± 63.78 mspre and post intervention, respectively. It shown the increase in anterograde refractory period of the AV node.

The VAWB of pre and post intervention was 332 ± 72.67 ms that reduced to 310 ± 64.01 ms, and shown a reduction in retrograde refractory period of the slow pathway after its ablation (Table 2).

Table 2. Demographic characteristics of the sample

	Mean ± SD	min	Max
Age	48/34±15/53	12	91
CL	729/97±139/81	38	1200
QRS	91/53±18/69	46	185
PR	140/98±25/14	46	240
QT	387/22±37/10	300	520
AV WB1	325/29±56/59	210	580
AV WB2	328/80±63/78	220	550
AERP-AVN	268/71±55/65	179	550
AH1	84/01±19/58	42	180
AH2	83/34±18/44	38	158
HV1	46/47±8/45	26	54
Hv2	48/08±9/00	30	58
VA WB1	332/± 72/67	199	650
VA WB2	310/09±64/01	189	580
RERP – AVN	264/94±69/73	189	500
NRF	10/77±10/65	1	68
(SEC)Time	348/60±434/22	18	3360

The patient-related parameters were compared in 10-year subgroups and there were significant differences between age groups regarding to PR, QT, AH (*1) after treatment, VAWB (*4) pre and post intervention and also RERP-AVN (*6) before treatment (Table 3).

Table 3: Comparison of mean variable of 10-year subgroups

	Pvalue
CL	0.433
QRS	0.210
PR	<0.001
QT	0.011
AV WB1	0.108
AV WB2	0.078
AERP-AVN	0.571
AH1	0.230
AH2	0.001
HV1	0.926
Hv2	0.943
VA WB1	0.008
VA WB2	0.010
RERP – AVN	<0.001
NRF	0.852
Time	0.808

The same parameters were explored based on the sex of participants and results shown a significant statistical difference between the sexes regarding to baseline cycle length, PR, AVWB (*3) and HV (*2) of pretreatment (Table 4).

Table 4. Variable's mean based on the sex

Variable	Male (Mean ± SD)	Female (Mean ± SD)	t	P value
Age	50.71 ± 18.16	46.93 ± 13.81	1.446	0.151
CL	760.07 ± 179.07	708.97 ± 123.89	2.025	0.046
QRS	103.96 ± 88.93	91.11 ± 17.84	1.135	0.261
PR	147.34 ± 27.16	137.96 ± 23.66	2.420	0.017
QT	390.47 ± 38.16	385.64 ± 36.84	0.831	0.407
AV WB1	338.03 ± 60.72	52.319 ± 88.94	2.055	0.014
AV WB2	330.04 ± 73.93	327.57 ± 58.28	0.242	0.809
AERP-AVN	64.53 272 ± 0.04	266.90 ± 49.87	0.569	0.570
AH1	21.12 88 ± 0.19	85.89 ± 29.47	-0.116	0.908
AH2	19.45 86 ± 0.49	82.07 ± 17.87	1.437	0.153
HV1	9.42 48 ± 0.62	45.26 ± 7.69	2.418	0.017
HV2	8.43 49 ± 0.32	9.47 ± 39.48	1.221	0.224

VA WB1	79.67 338 ± 0.13	69.330 ± 27.11	0.686	0.494
VA WB2	70.33 319 ± 0.07	304.88 ± 60.74	1.192	0.198
REEP-AVN	260.44 ± 74.31	268.10 ± 68.16	-0.660	0.510
NRF	10.78 10 ± 0.50	10.57 ± 10.40	-0.231	0.817
Time (sec)	551.72 408 ± 0.22	311.34 ± 357.55	-1.149	0.250

We compared these parameters between groups with and without arrhythmia's relapse. There was significant difference between two group regarding to baseline retrograde refractory period (RERP-AVN) (Table 5).

Table 5. Comparison of patients with and without recurrence of the arrhythmia

	Recurrent	**Non-recurrent**	**Diff**	**P value**
Age (yr)	42.66 ± 13.65	48.44 ± 15.58	-0.638	0.524
CI (ms)	713.0 ± 38.43	48.44 ± 15.58	-0.146	0.884
QRS (ms)	84.66 ± 14.74	95.48 ± 54.21	-0.345	0.731
PR (ms)	129.33 ± 6.11	141.17 ± 25.29	-0.808	0.420
QT (ms)	382.66 ± 31.64	387.30 ± 37.25	-0.124	0.831
AVWP1	314.66 ± 13.79	325.47 ± 57.04	-0.327	0.744
AVWP2	28.0 ± 45.82	329.64 ± 63.81	1.340	0.189
AERF-AVN (ms)	269.66 ± 9.50	268.70 ± 65.15	0.030	0.976
AH1 (ms)	80.0 ± 6.92	89.0 ± 70.16	-0.222	0.825
AH2 (ms)	83.0 ± 15.55	83.35 ± 18.52	-0.027	0.979
HV1 (ms)	44.66 ± 3.05	46.50 ± 8.51	-0.373	0.709
HV2 (ms)	47.0 ± 1.41	48.09 ± 9.06	-0.170	0.865
VAWP1 (ms)	355.0 ± 57.66	331.59 ± 72.97	0.552	0.582
VAWP2 (ms)	286.33 ± 60.74	310.56 ± 64.18	-0.648	0.518
RERP-AVN (ms)	212.66 ± 11.84	265.66 ± 69.99	-6.074	0.001
NRF (ms)	8.33 ± 2.51	10.81 ± 10.73	-0.065	0.948
TIME (S)	233.33 ± 89.53	350.50 ± 437.45	-0.038	0.970

There wasn't any significant difference between two group of participants who experienced recurrent of arrhythmia and those who wasn't, maybe due to lower number of patients with relapse that monitored in current study. All the recurrent episodes were happened in women and no relapse was observed in men (Table 6).

Table 6. The relationships between number and sex (Fisher exact test)

		N (%)	**Recurrent**		
		-	**+**	**Chi-square**	**p-value**
Sex	Male	63 (35)	0 (0)	1.601	0.552
	Female	117 (65)	3 (100)		
	Total	180 (98.4)	3 (1.6)		

There was an increase in mean variations of the AVWB (*3) before and after ablation, which is suggesting an increase in refractory period of the AV node after treatment (chart 1). There was an apparent numerical differences between patients with and without arrhythmia recurrence regarding to AVWB (*3) of before and after ablation. So that, AVWB (*3) measures have had decreasing trend after treatment in patients with relapse comparing with patients who haven't experience any recurrence of the arrhythmia; while, it had increasing trend in patients who experienced recurrent of the arrhythmia. Although the mean of difference of two groups wasn't significant statistically, this may be due to the smaller number of cases with recurrent, resulting in increasing the chance of random results (the null hypothesis); that's the explanation for P values higher than 0.05 (chart 2).

DISCUSSION AND CONCLUSION

According to the Companion to Braunwald's Heart Disease (2015), this arrhythmia recurrent rate is about 5%. New England medical center (2010) have explored the effects of slow pathway ablation through radiofrequency approach on arrhythmia recurrent rate and reported a 13% recurrence rate for this arrhythmia (*3). In a study conducted in South Korea (2011) on a sample of 1391 patients, 63% were female, mean age of patients was 45 years, and average time of the treatment (Burn) was 28 ± 63 minutes; they've reported a recurrence rate of 1.8% and the need for permanent pacemaker implantation (ppm) in 0.2% of patients; the VA (*2) was 30 ± 1.35 ms, while we found a recurrent rate of 1.6% and number of female participants were 65.4%.

Another study that published in US in 2015, they have treated 835 RERP-AVN patients affected by arrhythmia (AVNRT), in which, 136 patients were experienced recurrent of the arrhythmia and during a 2-year follow-up, most of the participants have experienced sinus tachycardia and only 5.2% of participants have had AVNRT relapse (5), while in our study, the recurrent rate was 1.6%.

Many research studies have explored the variation rate of AVWB (*3) of patients before and after ablation therapy. An extensive literature review shown that variation of AVWB have not been studied before and after RF ablation; and based on our findings, it could be argued that variation of this parameter before and after RF ablation and

also increasing trend of AVWB could been considered as a criterion for reducing recurrent rate. However, determining the endpoint number require more extensive studies with higher number of participants.

Recommendations

Although we observed a decreasing trend in AVWB of patients with recurrent and decreasing trend in patients without recurrent; but due to small number of recurrent cases, we couldn't determine a specific limit of increase in AVWB as the optimal limit for reducing the possibility of arrhythmia recurrence. Therefore, determination of this limit in a study with larger sample size is recommended.

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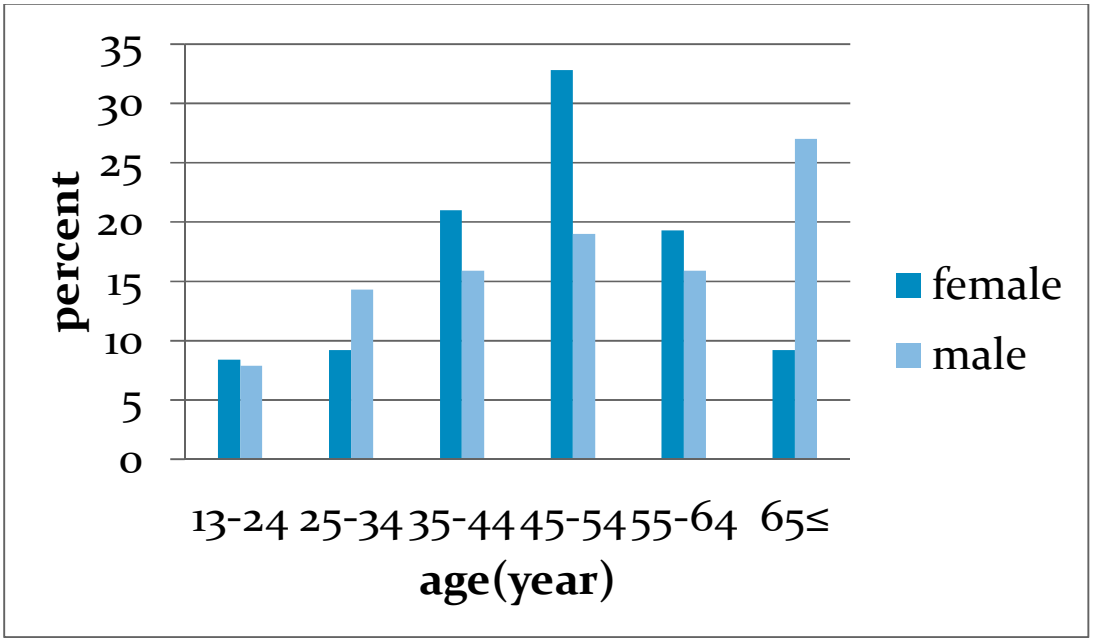

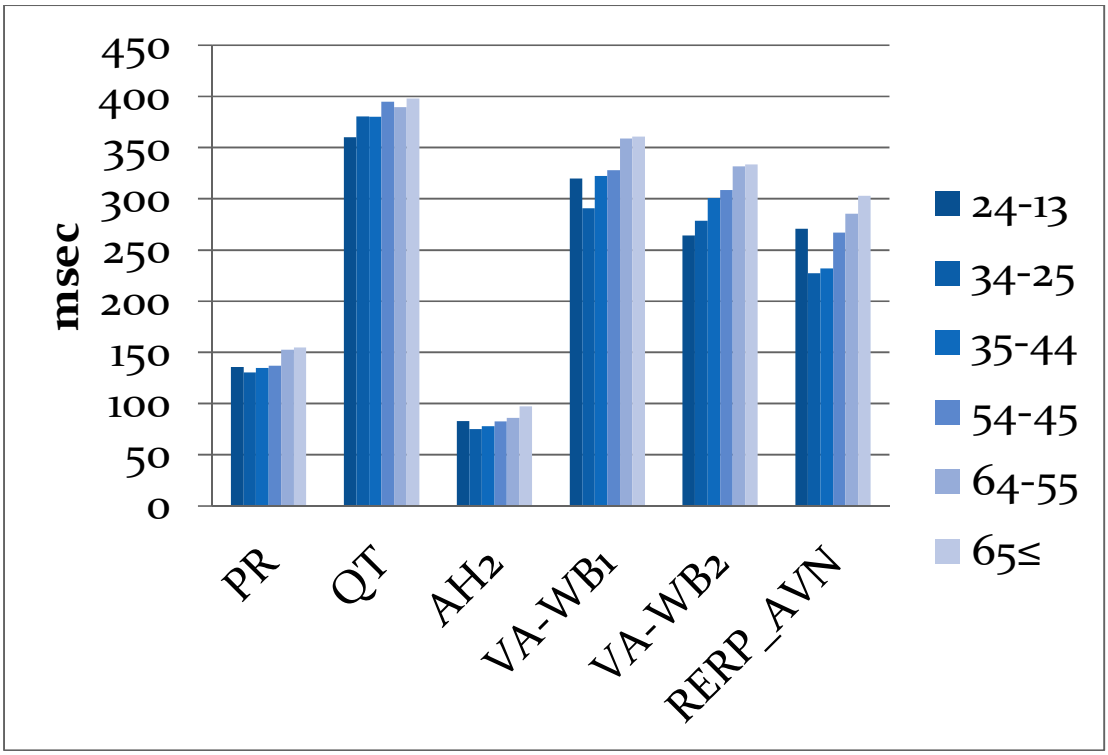
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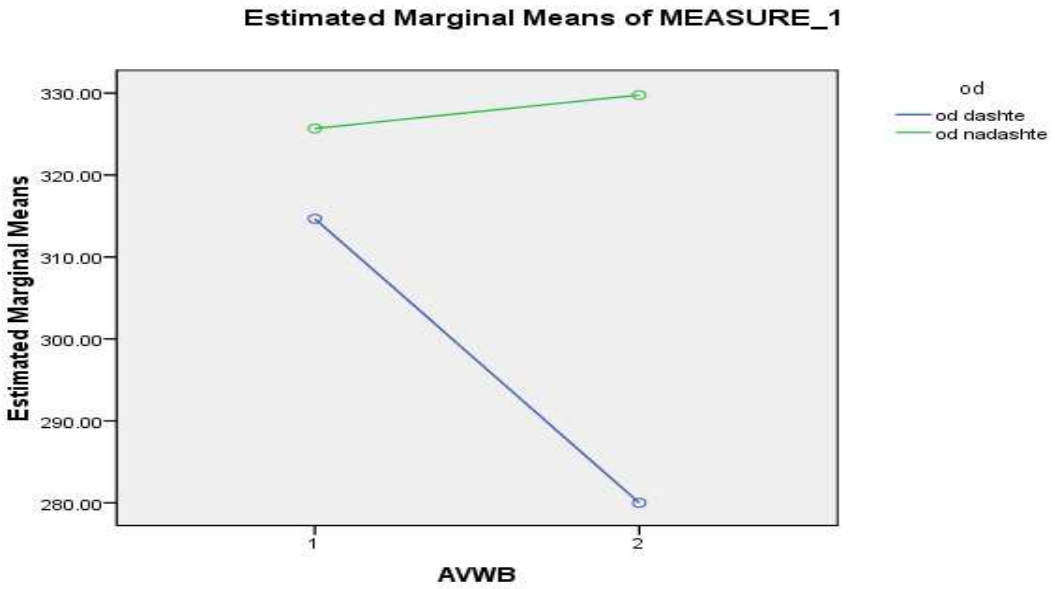
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