Feasibility of Completing Radiofrequency Catheter Ablation of Typical Atrioventricular Nodal Reentrant Tachycardia Using the Ablation Catheter Only

Hatem Abdlateif Kholieif[1], Tarek Basiouny[1], Mohamed Karim[1], Mansour Mostafa[1] and Mohammed Abdo Ali[2]

[1] Cardiology department, Al-Azhar University, Cairo, Egypt
[2] Health insurance Hospital, Cairo, Egypt

Abstract: Background: Atrioventricular nodal reentrant tachycardia (AVNRT) is the most common form of regular SVT. Typical slow fast form of AVNRT comprises 85% of all AVNRT. The diagnosis of this form of AVNRT requires exclusion of alternative mechanisms; these include atypical form of AVNRT, AV re-entry using a retrograde accessory pathway and atrial tachycardia. Many electrophysiological characteristics can differentiate typical form of AVNRT from these types of tachycardias, this includes an intracardiac VA interval during the tachycardia ≤ 65msec (an interval measured from the surface QRS to A wave of HRA). Diagnosis and ablation of this form of AVNRT requires use of multiple catheters. The aim of this study was to use the previous electrophysiological characteristics to try to demonstrate the ability of ablating typical AVNRT using only the ablation catheter. **Patients and methods:** Our study comprised patients with documented narrow QRS complexes SVT referred for electrophysiological study and RFA in our institute. Inclusion criteria were: absence of manifested WPW syndrome in surface ECG, atrial flutter or fibrillation and presence of an intracardiac RA interval during the tachycardia ≤ 65msec. **Results:** 15 patients fulfilled the criteria for typical AVNRT. The slow AVN pathway was successfully ablated in 14 out of 15 patients (93%) without complication. Only one patient required the use of multiple catheter technique. **Conclusion:** It is possible to diagnose and ablate typical form of AVNRT using the ablation catheter only with high success rate and low risk of complications.
[Hatem Abdlateif Kholieif, Tarek Basiouny, Mohamed Karim, Mansour Mostafa and Mohammed Abdo Ali. **Feasibility of Completing Radiofrequency Catheter Ablation of Typical Atrioventricular Nodal Reentrant Tachycardia Using the Ablation Catheter Only.** *J Am Sci* 2014;10(8):202-208]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 28

Key words: Radiofrequency catheter ablation, typical atrio-ventricular nodal reentrant tachycardia, single catheter.

1. Introduction:

Supraventriculat tachycardias (SVT) are common clinical disorders that tend to attack relatively healthy adult population and they are of different electrophysiological mechanisms. Atrioventricular nodal reentrant tachycardia (AVNRT) is the most common form of regular SVT **(Wu *et al.,* 1987**). Typical slow fast form of AVNRT comprises 85% of all AVNRT **(Gonzalez *et al.,* 2011).** The diagnosis of typical form of AVNRT requires exclusion of alternative mechanisms. These include atypical form of AVNRT, AV re-entry using a retrograde accessory pathway (ORT) and atrial tachycardia. Different criteria have been proposed that favour the diagnosis of atrial tachycardia and can be used to differentiate it from AVNRT or ORT, among these criteria: the changes in A-A precede changes in V-V interval, variable ventriculo-atrial interval (VA) during sustained tachycardia and spontaneous termination of tachycardia with an atrial activation not followed by ventricular activation **(Badhwar *et al.,* 2011).** Typically, if the intracardiac VA interval during the tachycardia ≤ 65msec (an interval that can be measured from the surface QRS to A wave of HRA) (RA interval) ORT is highly unlikely with a positive predictive value of 95% for typical AVNRT **(Josephson, 2008).** The V-V post pacing <115 msec longer than V-V of SVT [difference between post-pacing interval (PPI) and tachycardia cycle length (TCL) without correction of AV node delay] favours the diagnosis of ORT using a septal accessory pathway **(Josephson 2008).**

Electrophysiological study (EPS) and Radiofrequency ablation (RF) of SVT routinely requires introduction of at least three catheters positioned in His bundle, coronary sinus and right ventricular apex or high right atrium (HRA) as well as the ablation catheter **(Jackman *et al.,* 1992).**

RF ablation of overt left-sided free-wall accessory pathways is feasible and effective using just the ablation catheter **(Kuck *et al.,* 1991).**

The aim of this study was to use the previous electrophysiological characteristics to try to demonstrate the ability of ablating typical AVNRT using only the ablation catheter.

2.Patients and methods:

Study populations

Patients with narrow complex SVT referred for EPS in our institute in the period from March 2011 till September 2013 were enrolled. Inclusion criteria were: absence of manifested WPW syndrome in surface

ECG, atrial flutter or fibrillation and presence of an intracardiac RA interval during the tachycardia ≤ 65msec.

Antiarrhythmic drugs were ceased for at least five half-lives before the procedure.

Electrophysiological study and catheter ablation

The EPS and RF ablation was explained to each patient and all patients provided medical written consent. The EPS and RF ablation was performed in the fasting state at least three hours before the procedure. Right inguinal region was cleaned by povidine iodine. Puncture of right femoral vein was done under local anesthesia using 6F introducer set & Seldingers technique. A 6F quadripolar ablation catheter (4mm tip) was positioned in HRA. Pacing was performed through the distal electrodes of the ablation catheter while recording of the atrial activity was obtained from the proximal electrodes. Incremental atrial pacing was done till the Wenckbach point or initiation of the tachycardia achieved. Programmed atrial pacing was performed at two different cycles to initiate the tachycardia. Once the SVT was initiated, the R wave from surface ECG to A wave of high right atrium was measured. An interval ≤65msec suggests typical AVNRT **(Josephson, 2008),** (Fig. 1). Patients with longer interval were excluded from the study and were scheduled for routine multiple catheters EP study.

If RA interval was equal 65 msec and septal concealed accessory pathway was suspected entrainment was performed by pacing the right ventricle at a cycle length 10 to 40 msec shorter than the tachycardia cycle length (TCL), a PPI-TCL >115 msec. excludes ORT using an accessory pathway **(Josephson 2008)** (Fig. 2), entrainment was confirmed by advancement of the P wave over the surface ECG.

After diagnosis of the typical AVNRT the tachycardia was then terminated, the ablation catheter was positioned on His bundle to record the AH & HV intervals. The position of the ablation catheter (at site of His) in RAO 30° (or AP view) was marked on the screen by non-permanent white board marker to be as a landmark, the coronary sinus ostium was similarly marked on the screen. (fig. 3), then the ablation catheter was manipulated inferiorly in Koch's triangle (anatomic approach) to record a bigger V than multicomponent A (site of trial of ablation with A/V ratio range from 1:10 to 1:3) **(Gonzalez *et al.,* 2011)** (fig. 4). RF ablation was applied for 10 seconds. If JR occurred during the first 10 second the ablation was continued for 45 sec. RF ablation was stopped immediately if VA dissociation occurred during the junctional rhythm (JR) or any degree of AV block occurred during the ablation. Visualization of the atrial signals from proximal electrodes of ablation catheter was a must during RF application (Fig.5) and if any noise encountered during ablation diminution of signal of the distal pole of ablation catheter was applied

The inducibility of AVNRT was tried by incremental atrial pacing as well as atrial extra-stimuli immediately and 30 minutes following successful ablation. The Wenckebach point & the effective refractory period (ERP) of the atrium (if possible) were recorded before and after ablation. If any difficulties encountered during the procedure, further diagnostic catheters were introduced.

Data description:

All variables were recorded and continuous data were expressed as mean ± standard deviation (SD).

3. Results:

Diagnosis of AVNRT

During EPS of our patients several electrophysiological diagnostic criteria of AVNRT (beside VA interval ≤ 65 msec. for typical form) that can be helpful upon using single catheter positioned in the HRA were used, these includes a jump in AR interval (measured from last extrastimulus A wave from HRA to surface QRS) which is commonly due to the increase in AH interval (fig. 6), the echo beat (Fig. 7), captured of atrium by an atrial premature beat without affecting tachycardia cycle length (Fig. 8) or the upper and lower common AVN pathway effect (Fig. 9) that might occur occasionally during the tachycardia.

Out of 34 patients referred with narrow QRS complex tachycardia fifteen patients fulfilled the criteria for typical AVNRT. Excluded cases because of long VA interval (>65 msec) were subsequently studied by introduction of other catheters in His, Cs and RV and were found to have a concealed AP (3 patients), atypical AVNRT (2 patients) or atrial tachycardia (one patient). The rest were excluded (13 patients) because of having WPW manifestation on the surface ECG or atrail fibrillation.

Twelve out of the 15 patients were females (80%). Age of patients ranged from 26 to 62 years with a mean of 46.6 ± 11.03 years.

Result of RF ablation on AVN pathway

After ablation using a single catheter the AVNRT was not inducible in 14 out of 15 patients (93%). During EP study, the SVT was induced before reaching the effective refractory period (ERP) in six cases. Table 1 represents means and SD of results of electrophysiological study (AH, HV, AV block CL and the ERP) before and after RF ablation.

The effect of RF ablation was determined according to these measurements as follows: **Complete slow pathway ablation** (increase AV block CL & ERP of AVN without effecting AH interval and no AV jump or echo): observed in 7 cases (47%), **Slow pathway modification** (No increase in AV block CL or ERP of

AVN, presence of jump &/or echo): was observed in two cases (13%), **Fast pathway ablation** (abnormal increase in AH interval, no jump & no echo): was not seen in any of our cases while suggested, **Fast pathway modification** (decrease ERP of AVN ± AV block CL = increase in AH interval but still within the normal range): was observed in 3 cases (20%).

The AV block CL and ERP cannot be determined before ablation in 3 cases (20%) as the SVT was inducible before Wenckebach or ERP was reached.

The patient which was disqualified from ablation using a single catheter had a VA interval of 43 msec (with occasional upper common pathway block represented in fig. 9) diagnostic for AVNRT; the procedure for single catheter ablation was aborted because of appearance of atrial tachycardia during mapping (Fig. 10) demanding multiple catheters mapping. Another setting of EP study was done to the patient after few weeks with the use of multiple catheters for mapping and ablation of the atrial tachycardia and the AVNRT, however, AVNRT was the only type of tachycardia initiated in multicatheters mapping setting which was successfully ablated by the first RF application.

Table 1: Results of Electrophysiological study in mean and standard deviation:

	AH interval		HV interval		SCL		AV block		ERP		SVT CL	VA interval
	Before	After	Before	After	Before	After	Before	After	Before	After		
Mean ± SD	69.47 ± 18.41	73.27 ± 16.12	39.8 ± 5.78	43.13 ± 8.03	618.5 ± 75.9	712.53 ± 127.1	333.33 ± 68.40	342 ± 48.43	214.9 ± 51.59	258 ± 47.9	323 ± 34.9	39.2 ± 15.94

SCL sinus cycle length, ERP effective refractory period, SVT CL Supraventricular tachycardia cycle length.

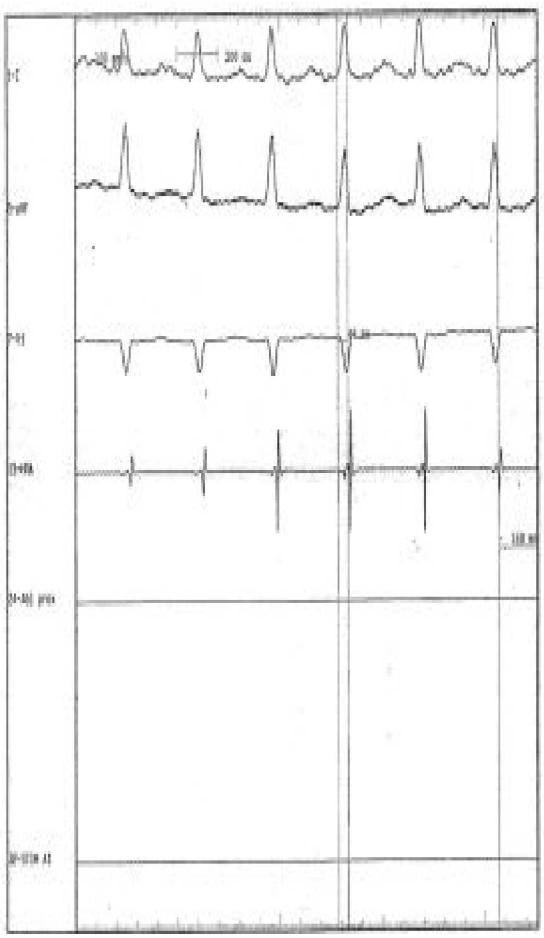

Figure 1. ECG leads I**,** aVF, VI, and intracardiac recording from HRA by the distal electrodes of the ablation catheter with VA interval of 47 msec during the tachycardia diagnostic for typical AVNRT.

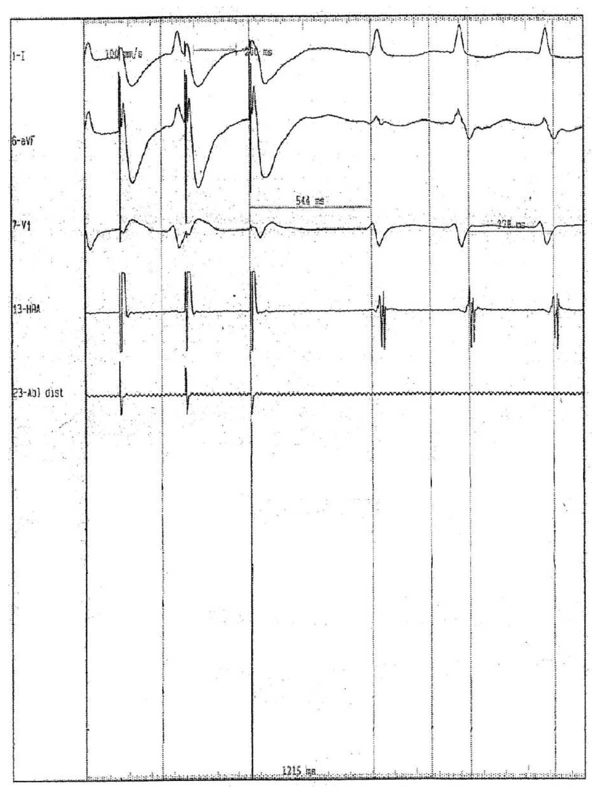

Figure 2. ECG leads I, aVF, VI, and intracardiac recording of HRA from the proximal electrodes of the ablation catheter with pacing from the distal electrode at 350 msec to entrain the tachycardia. The post-pacing interval is 544 and the tachycardia CL is 378 msec. The difference between the post-pacing interval and the tachycardia CL >115 msec. excludes ORT using a posteroseptal accessory pathway.

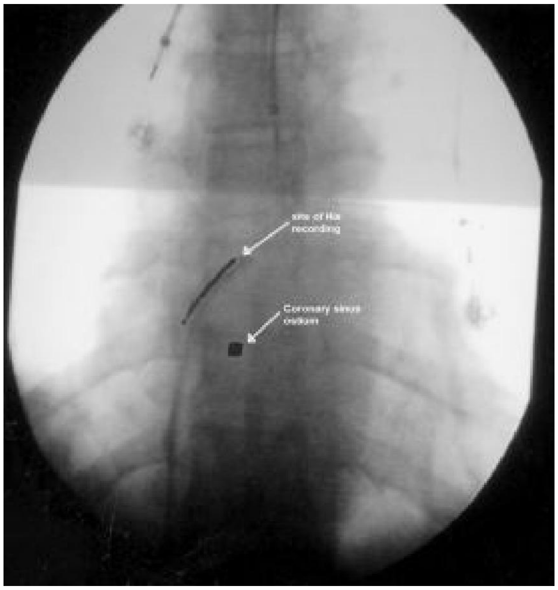

Figure 3. Fluoroscopic image of the heart in AP view. The RF ablation catheter was positioned in the site recording His. The RF catheter was marked on the screen by a white board marker to be as a landmark before moving it in the posterior area of Koch's triangle, the coronary sinus ostium was also marked on the screen

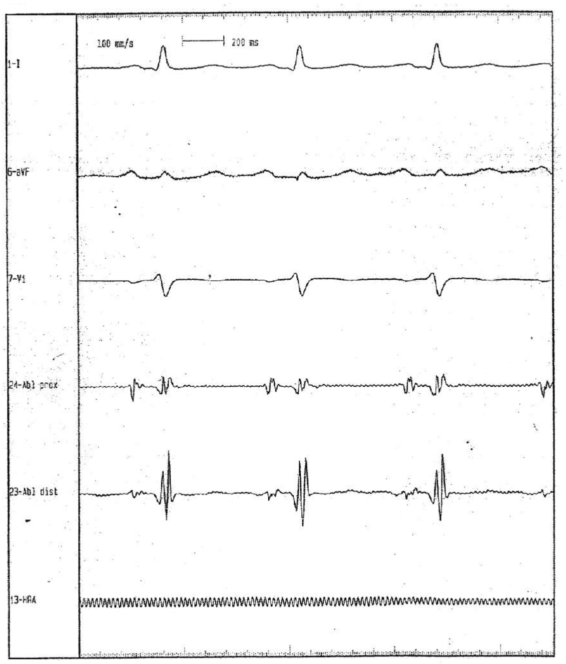

Figure 4. Site of successful ablation. ECG leads I, aVF, V1 and intracardiac recording from ablation catheter at site of successful ablation. Note the bigger V than the multicomponent A deflection at the distal electrodes.

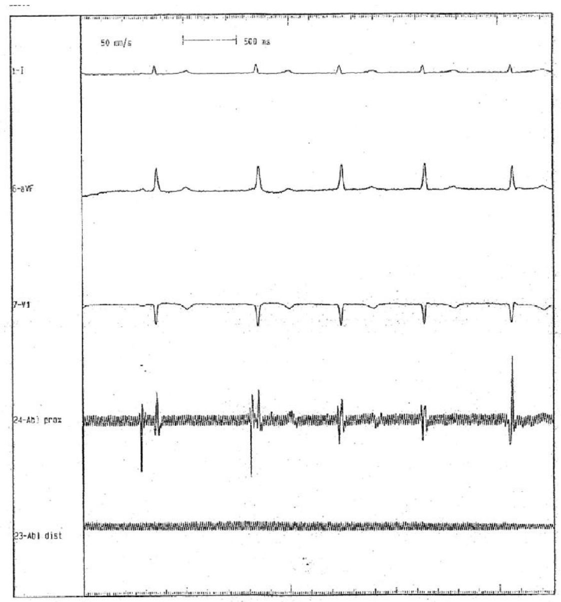

Figure 5. Represents junctional rhythm obtained during RF ablation of the slow AVN pathway through the distal electrodes of the ablation catheter. ECG leads I, aVF, VI, and intracardiac recording from the proximal electrodes of the ablation catheter. Notice that noise was not affecting the judgement over the signals in the proximal electrodes.

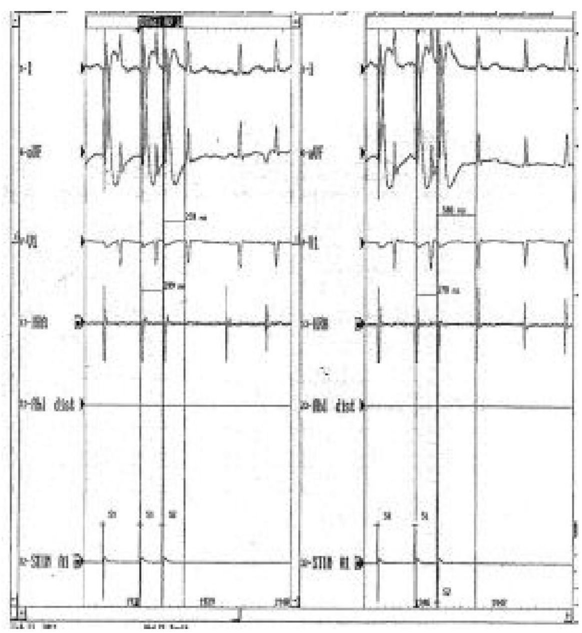

Figure 6. Marked AV prolongation of 218 msec with 20 msec decrement in atrial extrastimulus commonly due to AH jump. Left panel: AV = 290 with S1S2=299 msec. Right panel (AV jump): AV= 508 with SIS2=280 msec. ECG leads I, aVF, VI, and intracardiac recording of HRA from the proximal electrodes of ablation catheter.

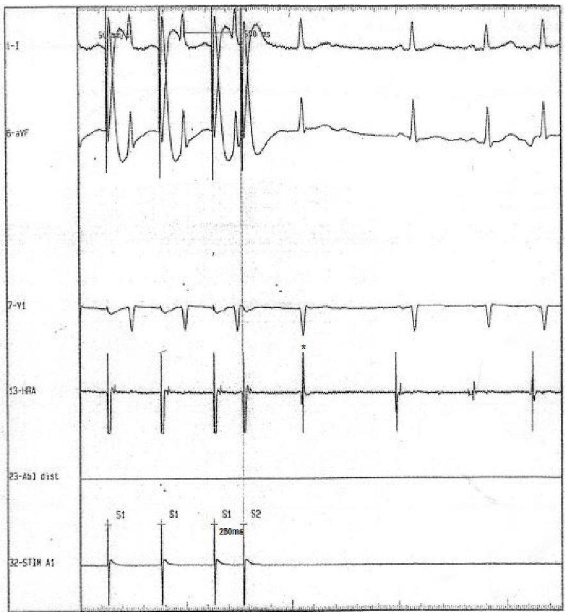

Figure 7. Echo beat (asterisk) after atrial extrastimulatiom (4th. beat) suggests AVNRT. ECG leads I, aVF, VI, and intracardiac recording of HRA from the proximal electrodes of ablation catheter in S1S2=280. A single echo beat with nearly simultaneous A and V occurred after the extrastimulus.

Figure 8. ECG leads I, aVF, VI, and intracardiac recording from HRA by the proximal electrodes of the ablation catheter. Atrial premature beat (4th. beat) captured the atrium during the tachycardia without affecting tachycardia circuit. This excludes AVRT.

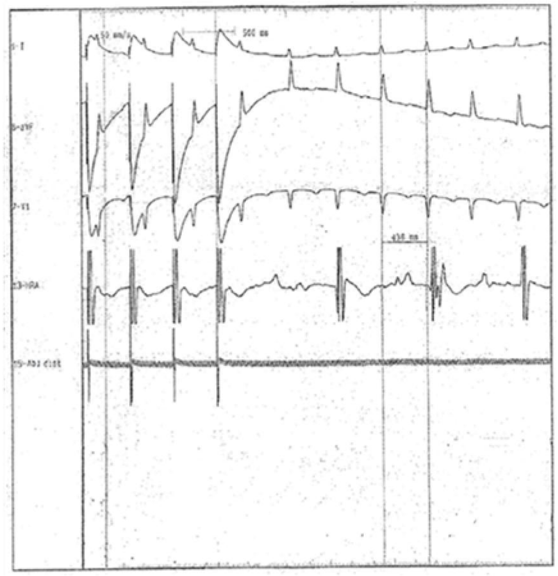

Figure 9. ECG leads I, aVF, VI, and intracardiac recording from HRA by the proximal electrodes of the ablation catheter. Note SVT with ventricular rate faster than the atrial rate due to upper common pathway block.

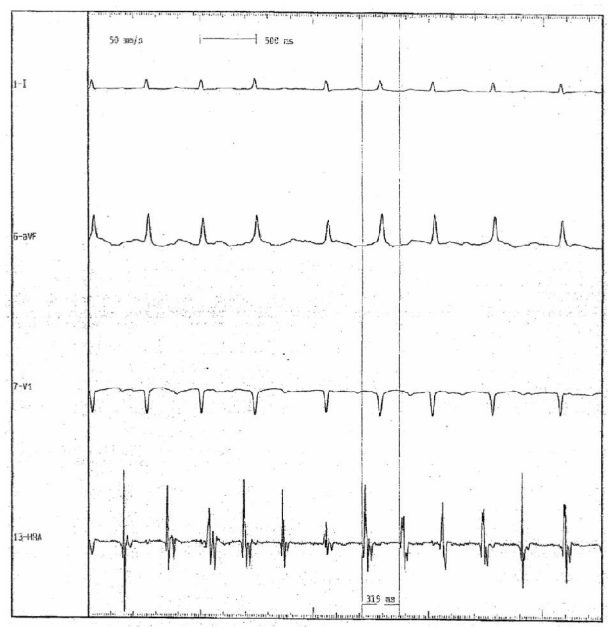

Figure 10. ECG leads I, aVF, VI, and intracardiac recording of HRA from the proximal electrodes of the ablation catheter showing SVT with atrial rate faster than ventricular rate with variable VV intervals and no relation of V to A deflections (mostly an atrial tachycardia with variable AV block) recorded frequently during the study of the patient that was subsequently disqualified from ablation using the ablation catheter only

4.Discussion:

The current study tried to use the ablation catheter only for diagnosis and ablation of typical AVNRT by using criteria previously described by literatures **(Josephson, 2008).** Fifteen patients fulfilled these criteria at the period of this study.

The acute success rate for slow pathway ablation for AVNRT using multiple catheters is 97% to 100%. **(Gonzalez *et al.,* 2011).** In our study the success rate of AVNRT ablation using only the ablation catheter reached 93% (14 out of 15 patients). The remaining patient required restudy with introduction of diagnostic catheters in RV, His and Cs in addition to the ablation catheter due to the appearance of an atrial tachycardia. The diagnosis of AVNRT which was reached by the use of the ablation catheter only was assured by using multiple catheters in the second session for this patient. According to a previously published study 7% of patients presented with atrial tachycardia can easily have inducible AVNRT in EP laboratory **(Gonzalez *et al.,* 2004)** relying on that base another study was done for mapping the atrial tachycardia using multiple catheters. In the restudy session with multiple catheters, atrial tachycardia was not inducible at all and the only confirmed inducible SVT was an AVNRT. The reason for failure of the atrial tachycardia to appear in the second session was not exactly known.

The most commonly accepted end point for RF ablation of AVNRT is non inducibility of tachycardia after the ablation and an increase in AVN effective refractory period (ERP) without change in AH intervals. or in the retrograde conduction properties of AV node (**Jazayeri *et al.,* 1992**), this effect was observed in 7 patients of our cases (47%).

Patients in whom there is evidence of residual slow pathway function after successful ablation of sustained AVNRT may have no change in the AV block cycle length or AV nodal effective refractory period **(Lindsay *et al.,* 1993, Hummel *et al.,* 1995, Manolis *et al.,* 1994, Estner *et al.,* 2005),** this can reach to approximately 40% of all ablated cases of AVNRT **(Jazayeri *et al.,* 1992).** In our study two Patients (13%) showed this effect.

None of our patients had an abnormal increase in AH interval after ablation which would be an evidence of fast pathway ablation. However, 3 patients out of 14 (20%) had a shorter ERP of the AV node and/or a shorter AV block cycle length following ablation suggesting fast pathway modification. It has been published that ERP of the fast pathway may decrease in some patients after slow pathway ablation, possibly because of electronic interaction between the two pathways **(Miller *et al.,* 2012).**

In our study, using a single catheter, we depended mainly on the anatomic approach in the suggested inferoposterior area of Koch's triangle. Randomized studies have shown equivalent outcomes using the anatomic and electrocardiogram-guided approaches, **(Kalbfleisch *et al.,* 1994, Efremidis *et al.,* 2009),** although the electrogram-guided approach may have a lower incidence of residual slow pathway function **(Efremidis *et al.,* 2009).**

Gonzalez-Torrecilla and associates demonstrated that after entrainment of SVT by ventricular pacing the corrected PPI-TCL more than 110 msec is among the diagnostic criteria of AVNRT **(Gonzalez-Torrecilla *et al.,* 2006).** This measurement would not be applicable using a single catheter as measuring the increment in AV nodal conduction time in the first PPI require the use of two catheter, one for pacing the RV for entrainment and another catheter at the His to measure the increase in the AV nodal conduction time.

Generally, atrial tachycardia is one of possible mechanisms for narrow complex SVT, however, it accounts for only 5 to 15% of adults undergoing electrophysiological studies **(Roberts-Thomson *et al.,* 2005),** and is typically a long RA interval SVT (VA interval is longer than AV interval). It is rarely represented with a short VA interval except in cases where the AV nodal conduction is prolonged **(Badhwar *et al.,* 2011).** The one of the cases excluded from our study which was found to have atrial tachycardia with multiple catheters mapping had RA interval >65 msec during single catheter mapping.

The major complication of RF ablation to cure AVNRT is the development of heart block. The risk of heart block during attempts of ablating the slow AVN pathway with using multiple catheters is less than 1% (**Jackman *et al.,* 1992, Jazayeri *et al.,* 1992)** does not seems to be able to be improved upon no matter how careful the investigator **(Josephson, 2008).** In our study none of the 14 cases in whom ablation was successful by using only the ablation catheter developed heart block.

The overall success rate of modification of the AV node to cure typical AVNRT was achieved by using the ablation catheter only in 93% of patients in our study.

Limitations:

Small number of patients was a limitation in this study as larger number of patients would yield more information regarding success rate and ratio of complications. Parahisian pacing can identify retrograde conduction over the AV node or anteroseptal and mid-septal AP **(Hirao *et al.,* 1996).** It was difficult in our study to measure the VA intervals of captured and non-captured beats during parahisian stimulation because of small A wave or in-apparent A wave recorded in the parahisian site. It was reported that a minimum of two catheters are needed to perform this maneuver, one at the His position and a second catheter in the right atrium **(Chugh *et al.,* 2008).** In our study population none of the patients had dual AV nodal pathway associated with a concealed AP, however, if data obtained diagnose the presence of concealed AP the patient would be excluded from the study and multiple catheters would be used.

The physicians should be aware that, in few cases with slowly conducting AV pathways the atrial activation during the tachycardia follows not the preceding V but the previous one and the VA interval could be <65 msec mimicking an AVNRT **(Gonzalez *et al.*, 2011).**

Conclusion:

Ablation of typical form of AVNRT can be successfully achieved with a single catheter with a high rate of success without increasing the risk of heart block.

References:

1. Wu D., Denes P., Amat-Y-Leon F., *et al.* Clinical electrocardiographic and electrophysiologic observations in patients with paroxysmal supraventricular tachycardia. *American Journal of Cardiology* 1987;41: 1045-1051.
2. Gonzalez MD, Banchs JE, Rivera J. Ablation of atrioventricular nodal reentrant tachycardia and variants In: Huang SK, wood MA (2nd ed) Catheter ablation of cardiac arrhythmia. Saunders, Elsevier 2011; 318-350.
3. Badhwar N, Lee BK, Olgin JE; Ablation of focal atrial tachycardias In: Huang SK, wood MA (2nd ed) Catheter ablation of cardiac arrhythmia. Saunders, Elsevier 2011; 164-175.
4. Josephson M.E. *Clinical Cardiac Electrophysiology: techniques and Interpretation*. Philadelphia, P A: Lippincott Williams & Wilkins, 4th ed. 2008; Ch. 8, 242.
5. Jackman WM, Beckman KJ, McClelland JH, *et al.* Treatment of suraventricular tachycardia due to atrioventricular nodal reentry by radiofrequency catheter ablation of slow - pathway conduction. *New England Journal of Medicine*. 1992; 327: 313-318.
6. Kuck KH, Schlüter M. Single-catheter approach to radiofrequency current ablation of left-sided accessory pathways in patients with Wolff-Parkinson-White syndrome. Circulation. 1991 Dec;84(6):2366-75.
7. Gonzalez M.D., Contreras L.J., Jongbloed M.R.M., *et al.* Left atrial tachycardia originating from the mitral annulus- aorta junction. *Circulation* 2004; 110:3187-3192.
8. Jazayeri M.R., Hempe S.L., Sra J.S., et al. Selective trans catheter ablation of the fast and slow pathways using radiofrequency energy in patients with atrioventricular nodal reentrant tachycardia. *Circulation* 1992; 85:1318-1328.
9. Lindsay BD, Chung MK, Gamache MC, *et al.* Therapeutic end point for the treatment of atrioventricular node reentrant tachycardia by catheter-guided radiofrequency current. J Am Coll Cardiol. 1993; 22:733-740.
10. Hummel JD, Strickberger SA, Williamson BD, *et al.* Effect of residual pathway function on the time course of recurrence of atrioventricular nodal reentrant tachycardia after radiofrequency ablation of the slow pathway. Am J Cardiol.1995; 75:628-630.
11. Manolis AS, Wang PJ, Estes NA 3rd. Radiofrequency ablation of slow pathway in patients with atrioventricular nodal reentrant tachycardia: do arrhythmia reccurence correlate with persistent slow pathway conduction or site of successful ablation? Circulation. 1994; 90:2815-2819.
12. Estner HL, NDrepepa G, Dong J. Acute and long-term results of slow pathway ablation in patients with atrioventricular nodal reentrant tachycardia: an analysis of the predictive factors for arrhythmia recurrence. Pacing Clin Electrophysiol. 2005: 28;102-110.
13. Miller M.J., Zipes D.P. Therapy for cardiac arrhythmias. In *BRAUNWALD'S HEART DISEASE* A Textbook of Cardiovascular Medicine. Ed: Bonow, Zipes & Lippy. Elsevier Saunders, 9th ed., 2012; 734.
14. Kalbfleisch S.J., Strickberger S.A., Williamson B., Vorperian V.R., Do C.M., Hummel J.D. Randomized comparison of anatomic and electrogram mapping approaches to ablation of the slow pathway of atrioventricular node reentrant tachycardia. *Journal of American College of Cardiology* 1994; 23: 716-723.
15. Efremidis M, Sideris A, Letsas KP, *et al.* Potential-guided versus anatomical guided approach for slow pathway ablation of the common type of atrioventricular nodal reentry tachycardia:a randomized study. Acta Cadiol.2009; 64:477-483.
16. Gonzalez- Torrecilla E., Arenal A., Atienza F., *et al.* First postpacing interval after tachycardia entrainment with correction for atrioventricular node delay: A simple maneuver for differential diagnosis of atrioventricular nodal reentrant tachycardias versus orthodromic reciprocating tachycardias. *Heart Rhythm* 2006;3: 674-679.
17. Roberts-Thomson KC, Kistler PM, Kalman JM. Atrial tachycardia: mechanisms, diagnosis, and management. Curr Probl Cardiol. 2005 Oct;30(10):529-73.
18. Hirao K., Otomo K.,Wang X., et al. Para-Hisian pacing: a new method for differentiating retrograde conduction over an accessory AV pathway from conduction over the AV node. *Circulation* 1996; 94: 1027-1035.
19. Chugh A., Bogun F., Morady F. Catheter ablation of accessory pathways. In Wilber DJ, Packer DL, Stevenson WG (ED): *Catheter Ablation of Cardiac Arrhythmia Basic Concepts and Clinical Application*, Blackwell. Future, 3rd.ed., 2008;153.

8/3/2014