

Original Research Article

**Radiofrequency Ablation of Typical Atrioventricular Nodal Reentry  
Tachycardia in Dual and Multiple AV Nodal Pathways**

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**Abstract**

Typical atrioventricular nodal reentrant tachycardia (AVNRT) is the most common paroxysmal supraventricular tachycardia among adults. The concept of dual pathway physiology remains widely accepted. Slow pathway (SP) ablation is the first-line treatment approach with a high acute success rate and a low risk of inadvertent complete atrioventricular (AV) block and noninducibility consider the primary end point of ablation. Aims of study to determine the percentage of multiple AV nodal pathways in patients with only typical AVNRTs and to compare its electrophysiological data with usual dual AV nodal pathways.

The study included 40 patients with only typical AVNRT (mean age  $51 \pm 6.8$  years, 28 (70%) women) who underwent SP ablation using an electrophysiological and anatomical approach. Electrophysiological analysis was performed for; differentiate dual from multiple pathways and potential predictors of acute success ablation. The patients were divided into two groups according to the number AH-jump as increase by 50 ms or more which was analysed after applied atrial programmed electrical stimulation. Group I 25 (62.5%) with dual AV nodal pathway and Group II 15 (37.5%) with multiple AV nodal pathways. The tachycardia cycle length seems to be faster in Group I ( $345 \pm 65$  versus  $410 \pm 70$ ). Acute successful ablation was achieved in all patients 100%. More radiofrequency energy applications were required in group II ( $14 \pm 5.6$  versus  $7.8 \pm 4.6$ ) in Group (I). In patients with more than two AV-nodal pathways Group II, the catheter intervention resulted more frequently in a modulation of slow pathway conduction than in an ablation of the slow pathway 10 (25%) was modulated versus only 5 (12.5%) were ablated. While 19 (47.5%) was ablated versus 6 (15%) were modulated in Group (I). One patient (2.5%) had developed persistent first-degree (PR 250ms) and transient second-degree AV block after ablation.

There is unexpectedly high percentage of typical AVNRTs (37.5%) with more than two AV nodal pathways and these require good electrophysiological evaluation for successful ablation. The slow pathway SP ablation of typical AVNRTs using radiofrequency energy is a highly effective procedure with an extremely low risk of development AV block.

**Key words:** Typical AVNRT, AV node pathway and Ablation.

**الخلاصة**

يعتبر التسارع الاذيني الانتيابي النموذجي حول العقدة الاذينية الحبيبية من الامراض الشائعة وخاصة لدى النساء. ان فكرة فزيولوجية ثنائي الذراع للعقدة الحبيبية هي الاكثر قبولا لتكوين التسارع الانتيابي. وان عملية كوي احدى الذراعين خصوصا (الذراع البطيء) يعتبر العلاج الرئيسي لهؤلاء المرضى. تهدف هذه الدراسة لمعرفة وجود اكثر من ذراعين للعقدة الحبيبية ولمقارنة الخصائص الكهرو فزيولوجية بين الاثنين بعد تقسيم المرضى الى مجموعتين. الاولى تتضمن 25 مريض ثنائي العقدة الحبيبية والثانية 15 مريض ثلاثي العقدة الحبيبية. ولوحظ من خلال الدراسة ان مرضى ثنائية الذراع هم الاكثر في الغالب , والاكثر استفادة من كوي الذراع البطيء بشكل كامل وان عملية الكوي مصحوبة بعامل خطورة قليل جدا او معدوم في ما يتعلق بتوقف العقدة الحبيبية اثناء الكوي.

## **Introduction**

**T**ypical atrioventricular nodal reentrant tachycardia (AVNRT) is the most common paroxysmal supraventricular tachycardia among adults. The concept of dual pathway physiology remains widely accepted [1]. It is most effectively treated by radiofrequency ablation (RF) of the slow pathway with high immediate success rate. AVNRT is categorized among the paroxysmal SVTs (PSVTs). It is the most common form of the PSVTs, accounting for nearly two-thirds of cases [2].

The physiologic substrate for AVNRT involves dual electrical pathways in or near the AV node. Structural heart disease is not necessary for the development of AVNRT. The arrhythmia usually develops in hearts that are otherwise normal, although it can also occur in the presence of organic heart disease. There is often no apparent precipitating cause for episodes of AVNRT. However, in some patients, nicotine, alcohol, stimulants, exercise, or surges in vagal tone can initiate episodes. Familial AVNRT has been reported [3].

The symptoms associated with arrhythmia episodes are nonspecific. The nature and severity of symptoms are often influenced by the rate of the tachycardia. Because of the paroxysmal nature of the arrhythmia, the onset and termination of the symptoms are usually sudden. Patients most commonly complain of palpitations, an odd feeling in the chest, and, on occasion, lightheadedness. Those with significant heart disease may have additional symptoms such as dyspnea and chest pain. Some patients with AVNRT have a feeling of polyuria and experience a diuresis during or after AVNRT; the mechanism probably is related to an elevated mean right atrial pressure and plasma level of atrial natriuretic peptide which are present during the arrhythmia [4].

In the typical slow-fast form of AVNRT, the onset of atrial activation appears before, at the onset, or just after the QRS complex, thus maintaining an atrial-His/His-atrial ratio (AH/HA) more than

one. Although typically, the earliest retrograde atrial activation is recorded at the His bundle electrogram, careful mapping studies have demonstrated that posterior or even left septal fast pathways may occur in up to 7.6% of patients with typical AVNRT [5].

This study shows the ablation strategy in typical form of AVNRT using RF energy after electro-anatomical localization, which provides a high success rate for typical AVNRT treatment whether it's dual or multiple AV nodal pathways. And is associated with a very low rate of CHB.

The simplest concept of AV nodal physiology that allows for reentry involves separate electrical pathways within or proximal to the AV node. This model is supported by clinical observations as well as animal and human mapping studies. These pathways may be distinct anatomic structures, or may be functionally separate. Whether the dual pathways are anatomic or functional, in order for reentry to occur, they must have different conduction velocities and refractory periods [6]:

1. One pathway conducts rapidly and has a relatively long refractory period. This is called the fast or beta pathway.

2. The second pathway conducts relatively slowly and has a shorter refractory period. This is called the slow or alpha pathway.

The origins of the fast and slow pathways are probably in perinodal atrial tissue. These pathways join and enter a final common pathway in the AV node. While atrial tissue above the AV node appears to be part of the reentrant circuit, the bundle of His below the node is probably not a necessary part of the circuit. This can be illustrated by the following observations:

1. AVNRT is associated with 2:1 AV block in approximately 10 percent of patients. With this form of block, the completion of two complete circuits is evidenced by two retrograde P waves while only one of the impulses traverses the His bundle on the way to the ventricles. Thus, the bundle of His is not a required component of the circuit. The AV block in

this setting is probably a functional infranodal block within the bundle of His [7].

2 His bundle electrograms indicate that reentry is proximal to the recording site [8].

Dual pathways during normal sinus, AV conduction occurs as follows:

1. The normal sinus beat enters the AV node and the impulse travels down both the fast and slow pathways.
2. The impulse traveling down the fast pathway reaches the His bundle first creating a refractory wake.
3. The impulse traveling down the slow pathway is extinguished when, in the area of the final common pathway, it runs into the refractory wake of the impulse that had traveled down the fast pathway.

Multiple AVN pathways in response to AES can be observed in up to 14% of patients. These are characterized by multiple AH interval jumps of 50 milliseconds or more in response to an increasingly premature AES. In these patients, a single AES may initiate multiple jumps in only 68%, whereas double AESs or atrial pacing is required in 32%. Such patients can have AVNRT with longer tachycardia CLs and longer ERP and FRP of the AVN. It is uncommon for multiple AVNRTs with different tachycardia CLs and P-QRS relationship to be present in the same patient [9].

## **Materials and Methods**

### **Study Population**

From all patients that refers for catheter ablation with paroxysmal supraventricular tachycardia corresponding to the AVNRT, only forty (40) patients with typical (common type) AVNRT were include in this study. Electrophysiological study and catheter ablation was undergone in all patients with typical AVNRT, all AVNRT in those patients induced by programmed electrical stimulation. Patients were dividing into two groups, group (I) if dual AV nodal physiology was found which is the usual that indicated by single AH jump. And group (II) if multiple AV nodal

physiology was found which is unusual that indicated by multiple AH jumps.

### **Electrophysiological Study**

On the day before the investigation, all patients gave written, informed consent to undergo the electrophysiological study and catheter ablation when needed. All anti-arrhythmic drugs had been withdrawn at least 48 hours before the study. All patients underwent basic electrophysiological study in the unsedated state, if necessary, diazepam iv (5–10 mg). Continuous monitoring of the heart rhythm was considered since the patient might develop dangerous arrhythmia at any time during the study. Surface ECG was recording simultaneously with intracardiac electrocardiogram by surface electrodes. Which were connected to a multichannel monitor of the EP.

Multipolar electrode catheters are positioned in the heart. The progression of the catheters was followed under fluoroscopy. Quadripolar electrode catheter 5-French with a 5 mm inter electrode space positing the right atrial appendage and a 4-French bipolar into the right ventricular apex (RVA); another catheter was also positioned across the tricuspid annulus to record a potential from the bundle of His (His).

Intracardiac electrograms (EGMs) and the surface leads I, II, V1 and V6 were displayed on a multichannel screen (GE.64, Lab Systems ) at a maximum paper speed of 100 mm/s, for continuous monitoring and all EGMs acquired (12 surface and up to 32 intracardiac channels) were stored on an optical disc drive. Programmed pacing at a pulse duration of 2.0 ms was performed using a programmable stimulator (UHS 3000, Biotronik, Germany).

After baseline measurements were recorded, programmed electrical stimulation (PES) is administered and repeated in different sites according to the electrodes catheters. The technique of PES was used to assess the AV conducting system if there were any changes in the baseline recording.

The standardized stimulation protocol included to induce SVTs and study was done only on typical AVNRT by determination of atrial and antegrade atrioventricular refractory periods using single atrialextrastimuli with decrement shortening of coupling interval in 10-ms steps during sinus rhythm and at 500, 400 and 360ms basic drive cycle lengths and Incremental atrial and ventricular pacing for determination of antegrade and retrograde AV nodal conduction characteristics.

AH interval always checked in base line, during stimulation and after induction of AVNRTs and then we assess AH interval for AH jump by shortening coupling interval in 10 ms step during the sinus rhythm, and to follow if there is Echo beat or not during that.

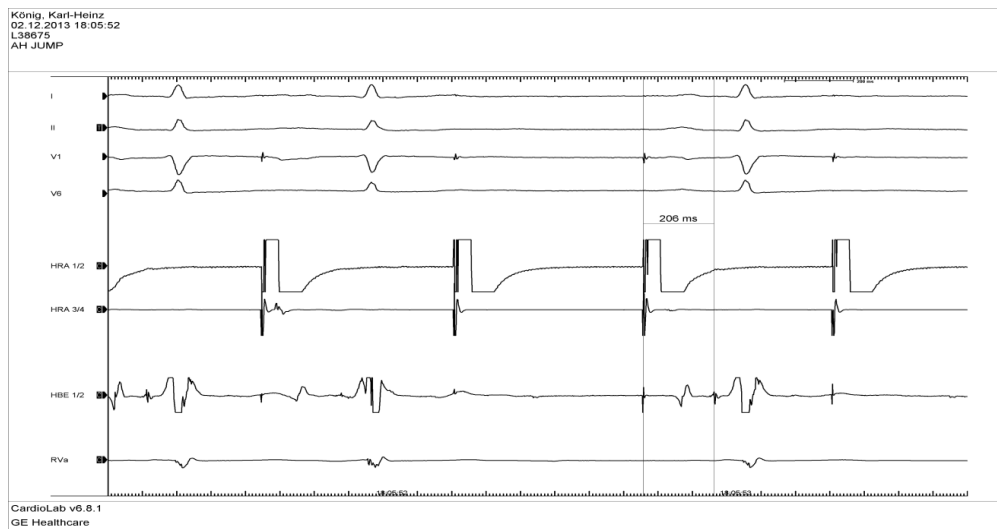
In some cases when dual AV nodal conduction behavior could not be Occur , or if an AVNRT was not induced by using this aggressive stimulation protocol, single atrial stimuli, double stimuli were applied likewise in 10-ms decrements.

Furthermore, orciprenaline 0.25–0.5 mg was used at dosages which are able to increase spontaneous heart rate by 50% of basic rate, and the stimulation protocol was repeated to induced SVTs.

### AH Jump

Dual atrioventricular conduction was defined by a sudden increase in A2–H2 interval (>50 ms, AH jump) at a critical coupling interval A1–A2 applying atrial extrastimuli shortened in 10-ms decrements (figure 1 and b), leading to a discontinuity in the atrioventricular conduction curve A1–A2 vs A2–H2 .The longest A1–A2 interval after the AH jump characterized the effective refractory period of the fast pathway.

The occurrence of multiple atrioventricular conduction pathways was defined as being present, if more than one sudden increases in A2–H2 interval during atrial extrastimulus testing was detected, resulting in two or three discontinuities in the atrioventricular conduction.



**Figure 1a:** AH jump



**Figure 1b:** second AH jump with decremental stimulation.  
Mapping and Radiofrequency ablation

After all measurement and when the diagnosis of typical type AVNRT was established, ablation catheter quadripolar with 4 mm tip size was inserted to assumed slow pathway area. Initially, the electrode was placed in a posterior position, achieving a ratio of atrial to ventricular potential of 1–3. We looked for a local late high frequency signal representing the potential of the slow pathway.

Radiofrequency current was generated from an EP-Shuttle system. Ablation was performed in temperature-guided mode (preselected maximum temperature at 60°C). Energy was limited at 30 to 35 W with a maximum time period of 60 s each time.

Application was stop if the accelerated junctional rhythms not delivered within 20 seconds and if it is appear that indicator of good ablation site, ablation consider successful if AVNRT could not be induced even after using the same programmed stimulation that used in the beginning with administration of Orciprenaline (0.5–1 mg) to prove noninducibility of AVNRT, presence of anterograde slow pathway with or without AV node echo beat after ablation was not consider as failure. So Noninducibility of the arrhythmia is the widely accepted endpoint of successful ablation of

atrioventricular nodal reentrant tachycardia (AVNRT) [10].

#### Statistical Analysis

Data was expressed as means  $\pm$  SD. Statistical analysis was performed using Student's t-test for unpaired variables including F-test for analysis of variance to compare two sets of data; multiple analyses of variance was used to compare continuous variable between two groups. A *P*-value of  $<0.05$  was considered to be significant.

#### Results

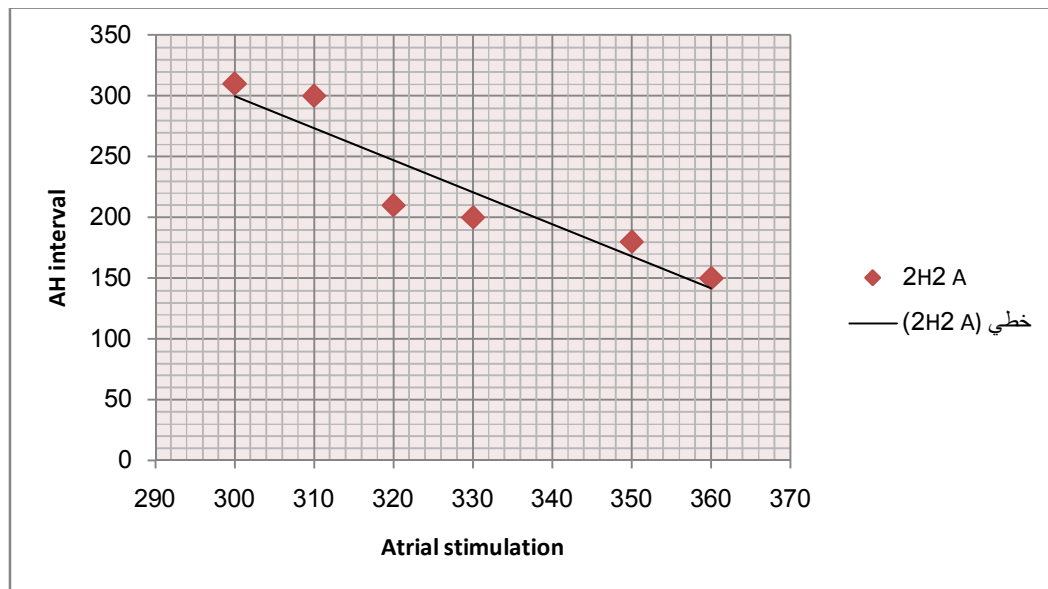
Forty (40) patients with typical type AVNRT were included in this study there were 28 female (70%) and 12 male (30%). with age ranging from 20–70 years. According to the result of the electrophysiological study, we measured the AH interval in base line and after the tachycardia induction. We categorized the induced tachycardia in to two groups, Group (I) Twenty five patients (62.5%) showed single AH jump (dual AV nodal physiology), Group (II) Fifteen patients (37.5%) showed multiple AH jumps (multiple physiology).

The mean value of AH interval was change from the base line by sudden increase (AH Jump) A2H2 after applying atrial extrastimuli (A1 A2) 10 ms

decrements leading to discontinuity in the AV conduction curve.

In patients with double AV nodal pathways (figure 2) the AH jump occur for

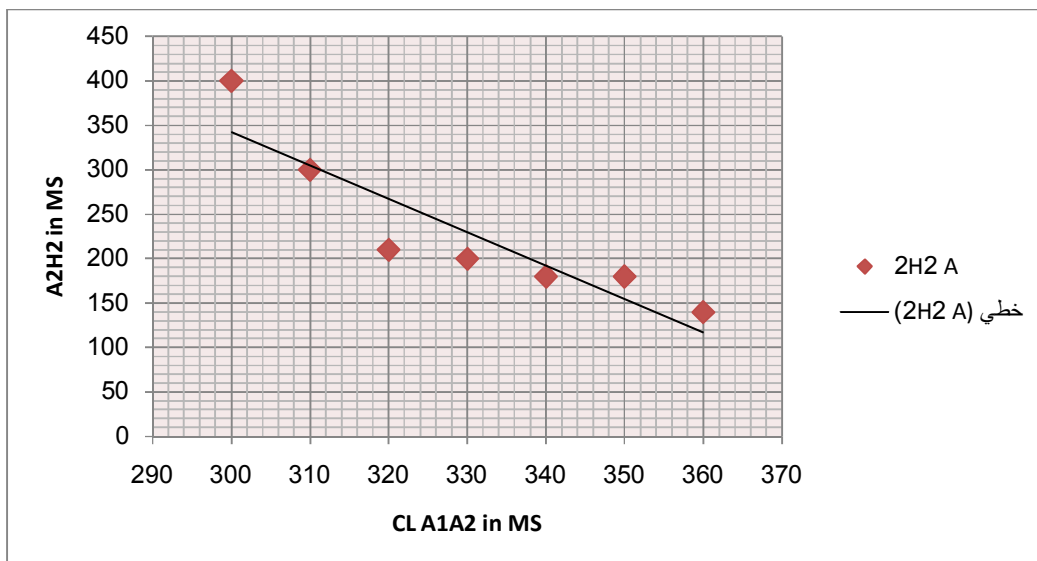
one time from A2H2 (210ms to 320 ms) at 320 ms extrastimulus, which consider the effective refractory period.



**Figure 2:** AV conduction curve in patients with double AV nodal pathway

In patients with multiple AV nodal pathways (figure 3) the AH jump occur for more than one sudden increase for A2H2 (200ms, 290ms, 300ms and 400

ms) at 360ms, 320ms and 310ms extrastimulus, result in two or three discontinuation in the AV nodal curve.



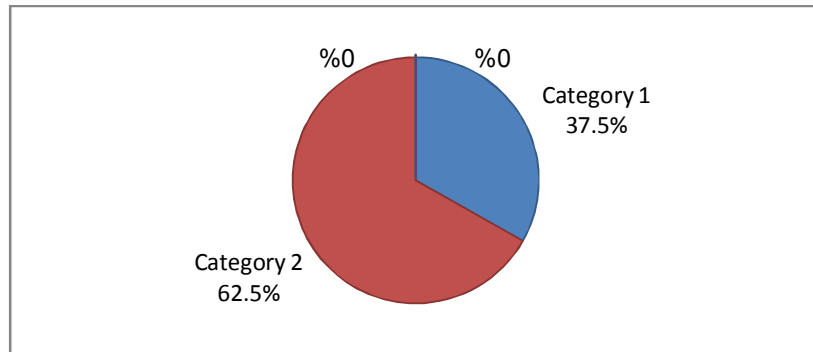
**Figure 3:** AV conduction curve in patients with multiple AV nodal pathway

The gender distribution between the groups, It was clear that female patients

suffered from typical AVNRT more than male (28; 70%) female versus 12 (30%)

male), it was statistically significant difference within all patients in this study and female between two groups. While there is no clear significant between male distribution of two group, whether it dual or multiple AV nodal physiology as well as the male patients seen to be more in

group II. Although the number of patient with dual AV node pathways more than those with multiple in this study which usual but unexpected the percentage of multiple pathways (37.5%) consider higher (Figure 4).



**Figure 4:** Percentage of multiple pathways in sample group.

The cycle lengths of patients with double AV nodal pathways ( $345 \pm 65$ ) seem to be faster than the cycle lengths of patients with multiple AV nodal pathways ( $410 \pm 70$ ). So that mean the cycle lengths

of typical AVNRT patients with multiple pathways were significantly longer compared with the other forms of typical AVNRT ( $P=0.043$ , Table (1)).

**Table 1:** The clinical and electrophysiological data between two groups

|                                       | Group I<br>(n=25) | Group II (n=15) | P. value |
|---------------------------------------|-------------------|-----------------|----------|
| Age                                   | 49± 9.4           | 54± 8.6         | 0.084    |
| Sex: male                             | 5(12.5%)          | 7(17.5%)        | 0.64     |
| female                                | 20(50%)           | 8(20%)          | 0.026    |
| TCL (ms)                              | 345 ±65           | 410±70          | 0.043    |
| Number RF                             | 7.8± 4.6          | 14± 5.6         | 0.027    |
| Use of isoprenaline                   | 7(17.5%)          | 4(10%)          | 0.187    |
| CHB                                   | 0                 | 0               |          |
| 1 <sup>st</sup> or 2 <sup>nd</sup> HB | 0                 | 1(2.5%)         |          |
| Procedure time (min)                  | 66 ± 12.4         | 79 ± 11.8       | 0.074    |

**Table 2:** compares ablation and modulation between two groups

|                 | <b>Ablation</b> | <b>Modulation</b> |                          |
|-----------------|-----------------|-------------------|--------------------------|
| <b>Group I</b>  | 19 (47.5%)      | 6 (15%)           | 25 (62.5%)* <sup>1</sup> |
| <b>Group II</b> | 5 (12.5%)       | 10 (25%)          | 15 (37.5%)* <sup>2</sup> |
| <b>Total</b>    | 24 (60%)        | 16 (40%)          | 40 (100%)* <sup>3</sup>  |

\*<sup>1</sup>p=0.032 group I (ablation vs modulation)\*<sup>2</sup>P= 0.039 group II (modulation vs ablation)\*<sup>3</sup>P=0.048 (ablation versus modulation)

Catheter ablation was performed in all 40 patients using electro anatomic approach, Comparing the number of energy deliveries required for successful ablation in patients with only two AV nodal pathways ( $7.8 \pm 4.6$ ) versus patients with more than two AV nodal pathways ( $14 \pm 5.6$ ), there was significance ( $P=0.027$ ) supporting the assumption that the existence of more pathways would require more energy deliveries for successful treatment of AV nodal reentrant tachycardia (table 1).

Then was applied the same atrial programmed stimulation protocol that was induced AVNRT in the beginning, acute success rate was achieved in all patients (100%), no AVNRT induced again after ablation, Noninducibility of AV nodal reentrant tachycardia was the primary endpoint. But jump and/or echo beat was noticed in patients with group II more than group I while complete ablation occur in group I more than group II in this patients mainly modification of the pathways had achieved, and the result was significant regarding ablation of the pathways in group I, So 'ablation' was achieved with fewer energy deliveries than 'modulation', in patients with two compare to patients with more than two AV nodal pathways ( $P=0.048$ )(Table 1, 2). There is high tendency ( $P=0.094$ ) that the procedure time in Group II patients more than group one ( $79 \pm 11.8$  versus  $66 \pm 12.4$ ) and also there is no significance to the used of orciprenalin in induction of the AVNRTs between two groups.

## Discussion

The results of this study revealed high percentage (37.5%) of patients with typical AV nodal reentrant tachycardia

have multiple atrioventricular conduction pathways was defined as being present, if more than one sudden increase in A2–H2 interval during atrial extrastimulus testing was detected (Figures 1,2,3), resulting in two or three discontinuities in the atrioventricular conduction curve which is unexpectedly. These data are in contrast to data previously reported by Tai *et al.*[11] with only (5.2%). And proximately in agreement with Heinroth *et al.*[12] that say (40%).

There is clear difference in gender distribution in this study and between two groups as well as group II seem to be older, mostly male and electrophysiological characteristics of typical AVNRT with relatively slow tachycardia rates below the average value compared to faster ones (group I) in this study the mean cycle lengths in patients with multiple AV nodal pathways (Group II) versus patients with dual AV nodal pathways were longer may be due to the participation of the slower of the two slow pathways within the reentrant circuit in this group and that explain by Evrengulet *al.* Which demonstrates that clinical and electrophysiologic characteristics of AVNRT patients with relatively slower tachycardia rates were quite different compared to the faster AVNRT [13, 14].

Catheter ablation of slow pathway maintain during sinus rhythm and achieved acute success rate in all patients in this study (100%), Noninducibility of AV nodal reentrant tachycardia after ablation and after repeated the stimulation protocol with used of Orciprenalin was consider the primary endpoint of procedure. Noninducibility of

the arrhythmia is the widely accepted endpoint of successful ablation of atrioventricular nodal reentrant tachycardia (AVNRT)[10]. Ablation vs modulation between two groups show high rate of ablation and complete elimination of slow pathway in group I (47.5%) while modulation occur mostly in patients with group II (25%), that explain why The number of RF energy deliveries required to achieve ablation was higher in group II Comparing the number of energy deliveries required for successful ablation in patients with only two AV nodal pathways. There was a significant supporting that assumption the existence of more pathways would require more energy deliveries for successful treatment of AV nodal reentrant tachycardia. And that also may be due most of the doctor wish to achieve ablation rather than modulation so they were increases RF application number and that also explain why the procedure time in group II was longer than group I. Radiofrequency (RF) ablation of the slow pathway for treatment of atrioventricular nodal reentrant tachycardia (AVNRT) is conventionally performed during sinus rhythm and can achieve acute success rate [15] and slow pathway ablation in the superior septum seemed to be a potential risk for atrioventricular nodal injury during ablation [16], and that explain the one patients that develop transient AV block in our study may be the ablation done mostly near the septum.

### **Conclusion**

There is unexpectedly high percentage of typical AVNRTs (37.5%) with more than two AV nodal pathways and that required good electrophysiological evaluation using a standard stimulation protocol before and after catheter ablation. The slow pathway SP ablation of typical AVNRTs using radiofrequency energy is a highly effective procedure with an extremely low risk of development AV block. And catheter

ablation in patients with multiple pathways is more difficult and may require more energy applications.

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