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Multiple AV Nodal Pathways in Patients with AV Nodal Reentrant Tachycardia More Common than Expected

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ABSTRACT

Introduction: Atrioventricular nodal reentrant tachycardia (AVNRT) is an established septal arrhythmia considered to rise from dual nodal AV pathways. However, the fact that there are multiple pathways within the AV node has not received much attention. **Objectives:** To investigate the prevalence and clinical significance of multiple AV nodal pathways in patients with AVNRT, utilizing advanced electrophysiological techniques. **Materials and Methods:** This descriptive study was carried out at the Punjab Institute of Cardiology Lahore during the year of January 2023 to December 2023. Electrophysiological studies and electrophysiological mapping catheter ablation were done on 200 patients. Demographic, clinical, and procedural information were used and scrutinized to determine additional AV nodal pathways. **Results:** AV nodal pathways were found to be multiple in 38 per cent of patients. This group had a noticeably prolonged VA interval, increased conduction variability, and longer ablation times as well. The success rate in obtaining ablation was higher at 96%, and complications were few, but procedural AF was more complex in patients with multiple pathways. **Conclusion:** It is concluded that Multiple AV nodal pathways are more prevalent than previously recognized, influencing diagnostic and therapeutic strategies for AVNRT.

INTRODUCTION

One of the most prevalent forms of supraventricular tachycardia in clinical practice is atrioventricular nodal reentrant tachycardia (AVNRT), which involves the reentrant mechanism inside or close to the atrioventricular node. New findings in electrophysiology testing and catheter ablation published recently have provided a better understanding of this arrhythmia's anatomical and physiological basis, which is otherwise under-appreciated. In the current mobile planet, the historical view of AVNRT is that the slow pathway and the fast pathway are the primary physiology. However, these findings, such as the multiple inputs and exit paths in the AV node, have given rise to new doubts regarding the diagnosis, management, and prognosis of this disease, which have actually been answered.

AVNRT involves a reentrant circuit in the AV nodal tissue where the impulses that move through the slow pathway in an antegrade manner are effectively conducted through the fast path by disorganized electrical impulses in a retrograde manner (1). This model has been well supported by those studies that have used late atrial premature depolarization for mapping conduction pathways (1). Recent high-resolution maps again support the fine and broad structure of the circuit and show overlay structures that were previously unknown (11). From these studies, the following complexities might lead to extra AV nodal pathways different from the regular two-pathways model (11). Confirmation of atypical fast-slow AVNRT and its probable connection with atrial tachycardias has been provided by data from electrophysiological tests and results of catheter ablation (10).

Observations from clinical practice have shown that it is not easy to diagnose atypical forms of AVNRT. As with orthodromic reciprocating tachycardia and atypical AVNRT, VA timing differences during tachycardia initiation may also be fine and are distinctive based on recent investigations (4). Moreover, the association of

AVNRT with other rhythm disorders like atrial fibrillation proves that nodal tissue interaction is not a dual linear black box concept and that there may be an upper common pathway (13). From these data, it is clear that these notions have significant implications for the exacting fine-tuning of diagnostic algorithms and the singling out of target ablation pathways that can be instrumental in the modification of procedural results.

Catheter ablation has been widely established as the definitive therapy for AVNRT, with slow pathway ablation yielding high success rates (8). The development of new panoramic visualization has made the accurate location of slow pathways in procedures safer and more effective (12). However, the unpredictable pattern of the junctional rhythms during ablation procedures reduces the ability to forecast long-term results (8). From studies involving slow pathway ablation, it has been ascertained that junctional beats during the procedure may hold the potential to explain the functional nature of the atypical pathways (3). These observations are in congruence with data derived from other studies employing left atrial ablation views for details of atypical mechanisms of AVNRT (5).

All these provide additional levels of complexity, particularly the role of the specialized atrioventricular ring tissues in the reentrant circuit. The morphological study of these tissues has shown that they play critical roles in circuit generation, suggesting that their structural soundness is crucial to arrhythmogenesis (2). This knowledge narrows the gap between structural and functional electrophysiology and can explain the mechanisms underlying AVNRT more effectively. These findings are particularly significant in patients with congenital heart disease, where anatomical variations are often encountered and determine the diagnostic and therapeutic algorithm (7). The understanding of AVNRT has also changed over time, with each fresh development regarding its diagnostic approaches. Some observational studies using systematic mapping discovered hidden nodoventricular pathways, enhancing the diagnostic challenge (14). These results emphasize that in order to make a correct diagnosis during most electrophysiological studies and in order to individualize the approach to the patient, the work should be done in strict conformity with the adequately developed technique. Furthermore, the presence of His bundle potentials in patients with AVNRT has evolved as a potential diagnostic factor due to the appearance of differentiated characteristics of his bundle potentials in various pathological conditions. Notably, it means additional precision to examine complex combinations of interactions and relations between pathways of the disease (15).

However, several questions still remain concerning the fundamental characterization of the frequency and importance of multiple AV nodal pathways. The differences in the number of reported cases may be due to differences in diagnostic criteria, study design, and populations under study. In particular, experiences obtained from a number of clinical settings and the latest report from Pakistan show that presenting features and management outcomes of AVNRT are related to geographic and demographic variables (8). Such regional variations, therefore, indicate the direction towards regional data requirements for formulating clinical data inputs for use around the globe. Last, new data on the presence of multiple AV nodal pathways in patients with AVNRT shed new light on the key issue of this arrhythmia. Subsequent studies are required to apply knowledge from structural, functional and clinical studies to explain more of the topographical and functional intricacies involved and aid in diagnostic development and therapeutic improvement. This emerging knowledge offers a clue on how to try to find an individual method for managing the irregular AVNRT flow.

Objective

To examine the frequency and implications of the biatrial connectivity to differentiated or multiple AV nodal pathways in patients with the AV nodal reentrant tachycardia scenario, which questions the traditional concept and rational for diagnosis and treatment approaches.

MATERIALS AND METHODS

Study Design: The type of study conducted in this study was descriptive, and the type of analysis was observational with a view of identifying the frequency and significance of multiple atrioventricular nodal pathways in patients diagnosed with atrioventricular nodal reentrant tachycardia (AVNRT). This study was based on the examination of electrophysical parameters during the diagnostic and frequently performed ablation procedures.

Study Setting and Duration: The research was undertaken at Cardiology Department, Punjab Institute of Cardiology, Lahore, Pakistan, which is a vast teaching hospital dedicated to cardiac electrophysiology. The study was carried out over a period of one year, from January 2023 to December 2023.

Inclusion Criteria

Inclusion criteria in this study included patients with first-degree AVNRT, diseases diagnosed through ECG or electrophysiological study, and those patients who were 18 years and above in age. Potential subjects could be patients who have survived the ablation process performed to treat patients with AVNRT. Section participants were selected based only on individual willingness to enrol in the research and contribute their data to the study. Indeed, the effort was directed at enrolling patients with clinical features that could not

easily be explained by a single AV nodal pathway in order to determine the presence of two pathways.

Exclusion Criteria

Only those patients without structural heart disease or congenital heart disease or a history of prior cardiac surgeries were included in this study in order to minimize confounding variables. Sixty-five patients with AVNRT caused by pharmacological or metabolic disorders and 28 patients with incomplete files were excluded. Pregnant women were also excluded from the research results because it is dangerous to expose women in this status to certain electrophysiological techniques.

Methods

Initial electrophysiological studies of all patients were carried out with reference to control benchmarks for diagnosis and differential of AVNRT. Because of this, during the characterization of the nodal region's acoustics, the methods that tested the properties of nodal conduction used PES and singled out multiple conduction pathways by changing the atrial and ventricular conduction intervals. RON, done for those requiring intervention, was via catheter ablation with an emphasis on slow pathway ablation. Junctional beats with ablation were evaluated to further understand probable atypical pathway involvement. Conventional mapping with enhanced spatial resolution was used in selected cases to further explore nodal connections or hidden substrates. The patients ' descriptive demographic details, clinical history, and procedural data were captured. The presence of multiple AV nodal pathways was assessed with descriptive statistics where revisions incorporated additional age, gender, and comorbid analyses. ,The Research Ethical Committee approved the study and permission was sought from the participants.

RESULTS

Altogether, 200 patients with a confirmed diagnosis of atrioventricular nodal reentrant tachycardia (AVNRT) were enrolled in the study. Of the 120 females, 60% were female, and 80 males, 40% were male, and the mean age and standard deviation were 45 ±12 years. Electrophysiologic investigations showed that all the participants had dual AV nodal physiology. Indeed, further AV nodal pathways were confirmed in 38% (76/200) of patients in the study, indicating even a higher prevalence than has earlier been described.

Demographic and Clinical Characteristics

The characteristics of the hundred patients at the beginning of the study are reported in Table 1. Patients with multiple pathways were significantly older than those with dual and conventional pathways (mean age, 48 ± 10 vs 42 ± 14; $p < 0.05$). The frequency of hypertension and diabetes mellitus was significantly higher in this subgroup.

Table 1

Characteristic	Total (n=200)	Dual Pathway (n=124)	Multiple Pathways (n=76)
Mean Age (years)	45 ± 12	42 ± 14	48 ± 10
Female (%)	60%	62%	58%
Hypertension (%)	35%	28%	47%
Diabetes Mellitus (%)	25%	19%	34%

Electrophysiological Findings

Table 2 shows the differences in electrophysiological values between groups. We have also found that patients with multiple pathways had longer VA intervals and higher coefficient of variation in nodal conduction during programmed stimulation. In this subgroup, junctional beats during ablation were detected more frequently than in other patients (68 % vs 31 %, $p < 0.01$).

Table 2

Parameter	Dual Pathway	Multiple Pathways	p-value
Mean VA Interval (ms)	50 ± 12	62 ± 15	<0.05
Conduction Variability (%)	22%	37%	<0.01
Junctional Beats (%)	31%	68%	<0.01

Ablation Success and Complications

The overall catheter ablation success rate was 96%, and there was not much difference between the two groups. However, patients with multiple pathways needed longer ablation time (mean time = 18 ± 5 minutes vs. 12 ± 4, $p < 0.01$). The procedural outcomes are presented in Table 3.

Table 3

Outcome	Dual Pathway	Multiple Pathways	p-value
Success Rate (%)	95%	96%	0.75
Ablation Time (minutes)	12 ± 4	18 ± 5	<0.01
Complication Rate (%)	2%	3%	0.58

Lastly, previous reports showed that multiple AV nodal pathways were present in nearly a third of patients with AVNRT. These findings underscore the need for comprehensive and individualized electrophysiological testing, as well as selective ablation approaches to maximize the benefits of intervention.

DISCUSSION

Atrioventricular nodal reentrant tachycardia [AVNRT] is a supraventricular arrhythmia known to present in many patients referred for electrophysiological studies. Earlier, most researchers referred to the classic dual-pathway model, in which the slow and fast pathways were viewed as the primary mediators of the disease. However, the study results are in concordance with recent reports that question the existence of a single slow pathway in a significant percentage of patients, and critical paradigms have to be revisited when approaching diagnostics and therapy.

The presence of multiple AV nodal pathways in our study was higher at 38% than that noted in previous investigations. These differences may be because of improvements in finer methods of electrophysiological tracing, including higher definition mapping, systematic observation diagnosis, etc., Which offers increased clarity in the detection of unconventional signals (14). For instance, investigations have found that atypical connections can be latent in regular QTSG testing but manifest when the tissue has been prepared to respond to specific stimulation or during ablation therapies (2). These observations are paralleled by our study, where the value of a systematic and detailed electrophysiologic assessment in patients with AVNRT has been underscored.

The consequences of having multiple pathways are significant on a clinical level. The patients with the additional pathways were also older and had a higher proportion of hypertension and diabetes mellitus than patients in the dual pathways. These results indicate that ageing and chronic disease-related structural or functional alterations can play a role in the establishment of additional nodal pathways. Such correlations have been observed in other investigations, suggesting that there are relations between the system and nodal tissue modularity (5,7). These lead to prompting questions regarding the effectiveness of primary interventions, including strict controlling of cardiovascular risk factors, in preventing and managing arrhythmias. The electrophysiological features of patients with multiple pathways were entirely distinct from those solely with dual pathways. As in other studies (3, 14), the present investigations demonstrated that prolonged VA intervals and increased variability in nodal conduction occur. These features contribute to the challenging identification of atypical AVNRT and require the application of complex diagnostic criteria. For example, the observation of junctional beats during slow pathway ablation has been suggested in previous studies as a good way to diagnose atypical pathways (3, 12). As expected, we have found in the current research that patients with multiple pathways demonstrated more junctional beats, which confirmed the value of this as a marker of the procedure.

The management of patients with multiple pathways presenting with AVNRT is not easy. Five patients had various pathways, and although the overall success rate of the planned procedure at catheter ablation was high at 96% for all patients, patients undergoing ablation for multiple pathways consistently took longer procedural times and more extensive ablations. This is in agreement with other findings, which have indicated that lesioning through atypical pathways occurs in areas that are known to be architectonically composite and thus require fine temporospatial targeting (6, 12). These techniques have helped to overcome these challenges since, with the recent development of the panoramic slow pathway visualization general, the localization of the slow pathway has been made more accurate, and there is a low occurrence of complications (12). However, procedural risks are not entirely mitigated, especially in case of additional pathways in the patients. Although overall complication rates in our study were low and similar between groups, the increased procedural time associated with MWS may contribute to procedural fatigue and potential technical mistakes by the operator, whether using the guide or having multiple pathways to contend with. It is also remarkable that proficiency depends on training, experience and institutional support needed to achieve maximal results (7, 10). Additionally, since complete elimination of the target tissue or the development of new pathways may be possible after ablation, constant post-procedure surveillance is advised.

It also provided more pathways for risk stratification and patient education regarding patient choices, though recommendations were lacking. These possibilities may result in confused diagnoses and lateral illnesses that, in turn, cause delayed diagnosis or improper treatment. Therefore, early identification and recognition of these features are of paramount importance if favourable patient outcomes are to be achieved. Also, the patients should be informed that there is a possibility of recurrence and hence more interventions, particularly when signs and symptoms continue after the first ablation. Cognitive planning about patient preferences and comorbidities is crucial to creating sustainable treatment strategies (8, 9). This is particularly the case because our study also revealed the indications for further research on the underlying development of multiple pathways. It has been observed that these pathways are frequently encountered in elderly patients and those with one or more coexisting medical conditions, supporting the mechanism based on structural and electrophysiological re-modelling of the atrioventricular node. To some extent, these processes could be explained by recent developments in imaging and molecular biology, which may lead to improved preventive and therapeutic interventions in the future (10,15). Secondly, research investigating the genes and environmental correlations with multiple pathways may link the different markers of the genetic risks and environmental conditions to high-risk populations who require early intervention.

Finally, it is necessary to look at the limitations of this author's study. Because this study was conducted in a single centre in Pakistan, the results may not be easily transportable to other populations with distinct demography or genetics. In addition, since the study is observational, it is necessary to be cautious when concluding causal relationships between clinical characteristics and the detected multiple pathways.

Further larger, multicenter, prospective investigations are required to confirm our results and establish their relevance to other settings. The last, multiple AV nodal pathways are observed in patients with AVNRT more frequently than previously described and have important implications for diagnosis, treatment, and prognosis. Consequently, these data and enhanced understanding of atrioventricular node complexity constrain the necessity of sophisticated diagnostic approaches, complex and extensive preparation of the procedure, and patient management. New investigations need to clarify the remaining issues concerning the pathways' functions and the scope of clinical impact, thereby enhancing the patient's prognosis of this intricate arrhythmia.

CONCLUSION

This study points to the fact that there are multiple atrioventricular nodal pathways in patients with atrioventricular nodal reentrant tachycardia (AVNRT) and questions the concept of its dual-pathway model. In 38% of patients, further pathways were discovered using sophisticated electrophysiologic methods, thus underlining the importance of GURL and careful diagnostic assessments. This multilateral correlation was identified in the patient groups with older age, high number of comorbid conditions, longer VA intervals, and increased procedural complexity at catheter ablation. A significant success was achieved with the general ablation procedures, although patients with multiple pathways may warrant more prolonged procedures because precision is required to accomplish the task. These results call for individualized management planning, post-procedure surveillance, and studies of the factors underlying the development of new pathways.

REFERENCES

1- Park, S., Park, J., Kim, S., Kim, H., Kim, S., Oh, Y., & Choi, Y. (2024). Upper common pathway analysis using late atrial premature depolarization in atrioventricular nodal reentry tachycardia. *Heart Rhythm*, *21*(9), 1729-1734. https://doi.org/10.1016/j.hrthm.2024.03.1788

2- Katritsis, D. G., Calkins, H., & Anderson, R. H. (2021). The specialized atrioventricular ring tissues participate in the circuit of atrioventricular nodal Reentrant tachycardia. *Journal of the American Heart Association*, *10*(22). https://doi.org/10.1161/jaha.121.022811

3- Thanh Nguyen, P. N., Katsume, Y., Ueda, A., Matsuo, S., Nonoguchi, N., Ikewaki, H., Mohri, T., Hoshida, K., Tashiro, M., Sato, T., Togashi, I., & Soejima, K. (2024). Analysis of junctional beats during slow pathway ablation: Illuminating the mechanism of typical and atypical AV nodal re-entrant tachycardia. *Heart Rhythm O2*, *5*(12), 910-916. https://doi.org/10.1016/j.hroo.2024.09.021

4- Hadid, C., Celano, L., Di Toro, D., Antezana-Chavez, E., Gallino, S., Iralde, G., Calvo, D., Ávila, P., Atea, L., Gonzalez, S., Maldonado, S., & Labadet, C. (2022). Variability of the VA interval at tachycardia induction: A simple method to differentiate orthodromic reciprocating tachycardia from atypical atrioventricular nodal reentrant tachycardia. *Journal of Interventional Cardiac Electrophysiology*. https://doi.org/10.1007/s10840-022-01376-w

5- Wang, N. C. (2021). Catheter ablation via the left atrium for atrioventricular nodal reentrant tachycardia: A narrative review. *Heart Rhythm O2*, *2*(2), 187-200. https://doi.org/10.1016/j.hroo.2021.01.007

6- Koulouris, S., & Ahmed, I. (2023). Electrophysiology Study and Ablation of Atrioventricular Nodal Reentrant Tachycardia. *StatPearls [Internet]*. https://www.ncbi.nlm.nih.gov/books/NBK594260/

7- Waldmann, V., Hebe, J., Walsh, E. P., Khairy, P., & Ernst, S. (2022). Catheter ablation of atrioventricular nodal Reentrant tachycardia in patients with congenital heart disease. *Circulation: Arrhythmia and Electrophysiology*, *15*(2). https://doi.org/10.1161/circep.121.010631

8- Ahmad, S., Khan, Z. A., & Ullah, I. (2022). Success rate in patients with atrioventricular nodular re-entrant Tachycarida (AVNRT) slow pathway catheter ablation with and without Junctional Rythym. *Pakistan Journal of Medical and Health Sciences*, *16*(11), 626-628. https://doi.org/10.53350/pjmhs20221611626

9- Ahmad, S., Khan, Z. A., & Ullah, I. (2022). Success rate in patients with atrioventricular nodular re-entrant Tachycarida (AVNRT) slow pathway catheter ablation with and without Junctional Rythym. *Pakistan Journal of Medical and Health Sciences*, *16*(11), 626-628. https://doi.org/10.53350/pjmhs20221611626

10- Kaneko, Y., Tamura, S., Kobari, T., Hasegawa, H., Nakajima, T., & Ishii, H. (2022). Atrioventricular ring tachycardias: Atypical fast-slow atrioventricular nodal Reentrant tachycardia and atrial tachycardia share a common Arrhythmogenic substrate—A

unifying proposal. *Reviews in Cardiovascular Medicine*, *23*(11). https://doi.org/10.31083/j.rcm2311369

11- Katritsis, D. G., Fragakis, N., Katritsis, G., Doukas, V., Marine, J. E., Desmukh, A., Latchamsetty, R., Anderson, R. H., & Calkins, H. (2023). High-resolution mapping of the circuit of typical atrioventricular nodal reentrant tachycardia. *Journal of Interventional Cardiac Electrophysiology*, *67*(3), 599-607. https://doi.org/10.1007/s10840-023-01632-7

12- Ding, L., Weng, S., Zhang, H., Yu, F., Qi, Y., Zhang, S., & Tang, M. (2022). Slow-pathway visualization by using panoramic view: A novel ablation technique for ablation of atrioventricular nodal Reentrant tachycardia. *Journal of Cardiovascular Development and Disease*, *9*(4), 91. https://doi.org/10.3390/jcdd9040091

13- Munawar, D. A., Arstall, M., & Lypourlis, D. (2021). The existence of upper common pathway: Evidence from concomitant atrioventricular nodal reentrant tachycardia and atrial fibrillation. *HeartRhythm Case Reports*, *7*(1), 21-25. https://doi.org/10.1016/j.hrcr.2020.10.004

14- Nagashima, K., Maruyama, M., Kaneko, Y., Sakai, S., Sekihara, T., Kawaji, T., Iwakawa, H., Egami, Y., Ota, C., Nagase, S., Yagi, T., Suzuki, K., Fukaya, H., Nakamura, H., Mori, H., Ueda, A., Soejima, K., Watanabe, R., Wakamatsu, Y., … Okumura, Y. (2023). Systematic observation-based diagnosis of atrioventricular nodal reentrant tachycardia with a bystander concealed nodoventricular pathway. *Journal of Arrhythmia*, *40*(1), 131-142. https://doi.org/10.1002/joa3.12976

15- Guan, F., Saguner, A. M., Hofer, D., Wolber, T., Breitenstein, A., Krasniqi, N., Eriksson, U., Steffel, J., Brunckhorst, C., & Duru, F. (2023). Distinctive characteristics of his bundle potentials in patients with atrioventricular nodal reentrant tachycardia. *Cardiology Journal*, *30*(3), 431-439. https://doi.org/10.5603/cj.a2021.0107