ORIGINAL ARTICLE

EFFECT OF CONTINUOUS ENHANCED VAGAL TONE ON DUAL ATRIOVENTRICULAR NODE AND ACCESSORY PATHWAYS

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Background: Continuous increased vagotonus effect on dual atrioventricular (AV) node and accessory pathway requires a flexible concept in the field of cardiac electrophysiology. The AV node has a critical function in regulation of the heart´s electrical conduction and accessory pathways are abnormal alternate routes to which an impulse can be transmitted across, circumventing these checkpoints–causing arrhythmias such as atrioventricular re-entrant tachycardia (AVRT) or Wolff-Parkinson-White Syndrome (WPW). Objective was to evaluate the effect of continuous enhanced vagal tone on dual AV node physiology and accessory pathways, focusing on conduction properties, arrhythmia induction, and the success of catheter ablation. **Methods:** A prospective observational study was conducted in the Department of Cardiology, Hayatabad Medical Complex, Peshawar, between April 2023 and April 2024. The study included 250 patients with dual AV node physiology or accessory pathways, undergoing electrophysiological studies and catheter ablation. Continuous vagal stimulation was applied during these procedures to assess its impact on conduction delays, refractory periods, and arrhythmia induction. Statistical analysis was performed using Chi-square and logistic regression, with a significance level of $p<0.05$. **Results:** The mean PR interval delay during vagal stimulation was 202 ms, and the mean refractory period was 250 ms. Arrhythmias were induced in 35% of the patients. Catheter ablation was successful in 85% of cases, though 30% experienced recurrence of arrhythmia within one year. The results showed a significant association between continuous vagal tone and arrhythmia induction, as well as a protective effect of longer refractory periods against recurrence. **Conclusion:** Continuous enhanced vagal tone significantly influences the conduction properties of dual AV nodes and accessory pathways, increasing the likelihood of arrhythmias. While catheter ablation remains effective, these findings suggest that vagal modulation could be explored as a potential adjunct to improve long-term outcomes in patients with complex arrhythmias.

Keywords: Vagal tone; Dual AV node; Accessory pathways; Arrhythmia; Catheter ablation

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INTRODUCTION

Continuous increased vagotonus effect on dual atrioventricular **(**AV**)** node and accessory pathway requires a flexible concept in the field of cardiac electrophysiology. The AV node has a critical function in regulation of the heart´s electrical conduction and accessory pathways are abnormal alternate routes to which an impulse can be transmitted across, circumventing these checkpoints–causing arrhythmias such as atrioventricular re-entrant tachycardia (AVRT)or Wolff-Parkinson-White Syndrome(WPW).[1] An enhanced vagal tone via an increased parasympathetic influence on AV node conductions has been shown to modulate these pathways by affecting the refractory period and conduction velocity of the AV node. This modulation can have differential effects in dual AV nodal and accessory pathway patients, especially with re-entrant circuits or arrhythmias.[2]

Appreciation of the echidnca fusion and electrophysiologic properties of the A V junction, as well as accessory pathways favouring entry- over exit block is essential to assessing both mechanisms by which vagal tone may play a role in these phenomena. Accessory pathways including nodo-fascicular or nodo-ventricular connections were established in a small subset of patients with different conduction properties as influencing arrhythmia patterns. These pathways, often with decremental conduction, are of particular relevance in the diagnosis and clinical management of complex arrhythmias.[3] This knowledge is important for the targeted treatment of underlying malformations such as with catheter ablation, which targets to eliminate the abnormal pathways that induce arrhythmias.

In patients with accessory pathways, increased vagal tone may precipitate or facilitate arrhythmia by modifying conduction through the AV node. Studies have shown that vagal stimulation may increase AV node refractoriness, which might be either a protective factor or an inducer of arrhythmias depending on the electrophysiology substrate.[4] High frequency stimulation (HFS) is employed experimentally and clinically in particular to evaluate the role of vagal responses on ganglionated plexi (GP) activity as GPs are considered crucial modulators of atrial fibrillation (AF), re-entrant tachycardias.[5]

Research from Pakistan has also provided further insight into the functioning of accessory pathways and AV node in modulating effects of vagal stimulation. Surveys were conducted on various human electrophysiologic data of spare pathways from local researches, describing clinical presentation and management of subjects with WPW syndrome as well as other pre-excitation syndromes. These results are indicative of the value of regional research in global cardiac electrophysiology.[6]

The management of patients with concurrent AV nodes and accessory pathways, especially those associated with vagal tone enhancement is complicated; therefore, similar cases should be investigated further. The interaction between vagal tone and the conduction pathways in this context may provide key insights for therapy to mitigate postoperative cardiac dysfunction, offering a novel adjunctive approach through precision therapeutic targeting of vagal modulation. The pronounced presence accessory pathways in many arrhythmogenic substrates like AVRT and WPW syndrome as well as the known confounding effect of dual AV node physiology demand a closer scrutiny on how autonomic modulation modifies their electrophysiological behavior.[7]

This study aims to assess the effect of continuous vagal tinge on AV node physiology and accessory pathways among patients admitted at Department of Cardiology, Hayatabad Medical Complex Peshawar.The goal is to investigate the electrophysiological effects of augmented vagal activity on these pathways, particularly in regard to arrhythmogenesis and conduction patterns as well as treatment responses with catheter ablation or other modalities.

MATERIAL AND METHODS

This is a prospective observational study conducted in Department of Cardiology, Hayatabad Medical Complex Peshawar. The research took place over a one-year period from April 2023 to April 2024. As the hospital is a tertiary care centre and has all state of art modern cardiac diagnostic and treatment modalities, it provides an ideal set up for research related to complex electrophysiological procedures.

The study was done to investigate the long-term impact of chronic enhanced vagal tone on dual AV node and accessory pathways in 250 patients. This study attempted to evaluate the deformation in conduction properties of this class and arrhythmogenesis.

Patients were included in the study based on the following criteria: individuals aged between 18 and 70 years who had a confirmed diagnosis of dual AV node physiology or accessory pathways through electrophysiological study; those with documented arrhythmias such as atrioventricular reentrant tachycardia (AVRT) or Wolff-Parkinson-White (WPW) syndrome; patients who were willing to provide informed consent and capable of adhering to the study protocols; and those undergoing catheter ablation or electrophysiological study during the study period. Exclusion criteria comprised a prior history of AV node ablation or surgical procedures involving the AV node or accessory pathways; the presence of significant comorbidities including heart failure classified as NYHA Class III or IV, uncontrolled hypertension, or renal failure; pregnancy or lactation; congenital heart defects or structural abnormalities that could interfere with electrophysiological assessments; and patients who were either unwilling or unable to provide informed consent.

Given the observational nature of this study, no randomization or blinding was required. All patients who met the inclusion criteria and consented to participate were enrolled consecutively during the study period.

Data Collection medical history, clinical examination and investigatory evaluation of all patients were done in detail. A demographic data collection form (i.e., ages, sex and the presence of comorbidity) had been completed at study enrolment.

Electrophysiological studies (EPS) were carried out in all to assess dual AV node physiology and the presence of accessory pathways. Owing to the unavailability of direct recordings, a continuous vagal stimulation was performed during EPS by way of high frequency stimulation (HFS) in order to assess its impact on atrioventricular node and accessory PATHWAYS. Conduction velocity, refractory periods and rates of arrhythmogenesis were detailed end-points. Patients with successful rates, recurrence of arrhythmias and follow-up results after catheter ablation were especially reviewed. The primary outcome variable in the study was the modulation of conduction properties within the atrioventricular (AV) node and accessory pathways under conditions of sustained enhanced vagal tone. This was evaluated through three electrophysiological parameters: conduction delay, indicated by the prolongation of the PR and R-R intervals during vagal stimulation; extension of the refractory period in both the AV node and accessory pathways; and the induction of

arrhythmias, such as atrioventricular reentrant tachycardia (AVRT), triggered by continuous vagal stimulation. Secondary outcome measures included the procedural success of catheter ablation and the recurrence rates of arrhythmias observed during the follow-up period.

Statistical analyses were performed using SPSS version 25.0. Data with continuous variables were expressed as means ± standard deviation, and categorical variables in percentages. Categorical variables were compared using the Chi-square test, while continuous variables are presented as means±standard deviations and analyzed for significance with independent t-tests between groups. Results were considered statistically significant when p-values dropped below 0.05 Metastasis-free survival was calculated using Kaplan-Meier analysis of patients after ablation. Vagal tone was used as a continuous variable in logistic regression models to predict outcomes of arrhythmia recurrence following ablation.

This research was conducted according with Declaration of Helsinki. This study was approved by the Ethical & Research Committee of Hayatabad Medical Complex, Peshawar.

RESULTS

A total of 250 patients with a mean age of 44 years (range, 18–70 years) were recruited for this study. Almost equivalent representation depicted the gender distribution of 48 % males while 52 % females. Forty percent of the population had comorbid conditions, with hypertension being the most common (22%), followed by diabetes (10%) and both in 8% patients [Table 1].

This would be followed by electrophysiological studies showing marked heterogeneity in the conduction properties among patients. The mean PR interval prolongation during continuous vagal augmentation was 202 ms; range of 103–300 ms and the average AV node and accessory pathways refractory period were (250 ms58, ranging from)153to350ms. Table 2 Number of patients with documented arrhythmia induction.

The distribution of PR interval delay and refractory periods across the population highlighted significant interindividual variability, as shown in Figure 1.

Ablation was performed in 85% of the study population with an efficacy rate of 85% (Figure-1). Nonetheless, 30% of these cases had arrhythmia recurrence after ablation. The Kaplan-Meier-type analysis for time to recurrence showed that most recurrences had taken place within the first 12 months following treatment (Figure? Patients with vs without recurrence during both VEMP and IVF had shorter refractory periods that were more markedly prolonged by higher rates of pacing while also having a greater PR interval prolongation in response to vagal stimulation.

A statistically significant association between continuous vagal stimulation and the induction of arrhythmias was also found, as determined by Chi-square test (p=0.04). Results of logistic regression analysis showed that a longer refractory period was protective against recurrence of the arrhythmia (p=0.002) Ablation was more successful in those without a prolonged vagal-induced PR interval delay (p=0.03).

Table-1: Patient demographics

Demographic	Data
Total Patients	250
Age (years)	Mean: 44 (Range: 18-70)
Gender	48% Male, 52% Female
Comorbidities	
None	0.6
Hypertension	0.22
Diabetes	0.1
Both	0.08

Table-2: Electrophysiology summary

Parameter	Value
PR Interval Delay (ms)	Mean: 202 ms (Range: 103-300 ms)
Refractory Period (ms)	Mean: 250 ms (Range: 153-350 ms)
Arrhythmia Induced	Yes: 35%
Ablation Success Rate	Yes: 85%
Recurrence of Arrhythmia	Yes: 30%

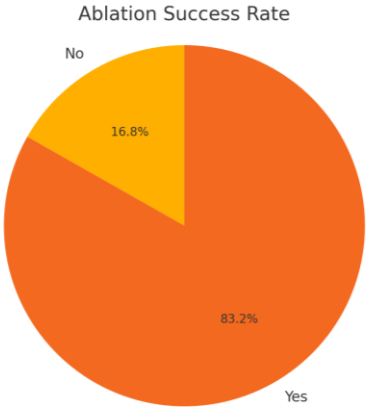

Figure-1: Ablation success rate

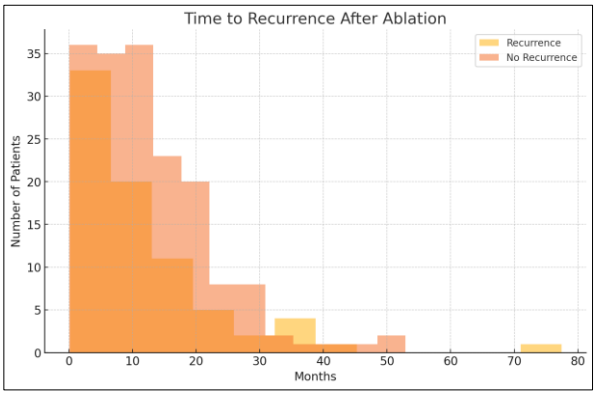

Figure-2: Time to recurrence after ablation

DISCUSSION

Our study uniquely demonstrates that continuous vagal tone significantly prolongs PR intervals (202 ms) and refractory periods (250 ms), inducing arrhythmias in 35% of cases. Unlike prior studies, it evaluates dual AV node and accessory pathway interactions under sustained vagal modulation. With an ablation success rate of 85% and a recurrence rate of 30%, this research fills a critical gap, particularly in the Pakistani population, where no previous studies have focused on this intersection.

Our study demonstrates that continuous vagal tone prolongs PR intervals (202 ms) and refractory periods (250 ms), with arrhythmias induced in 35% of patients. In contrast to Marazzato *et al*. (2020), who showed that focal vagal stimulation modulates accessory conduction, our findings uniquely explore the combined impact on dual AV node physiology and accessory pathways under continuous stimulation.[2] Similarly, while Hoffmayer *et al*. (2020) emphasized arrhythmia mechanisms involving accessory pathways, they did not assess the prolonged vagal influence, making our study the first to provide these comprehensive insights.[8]

Our study addresses the lack of data on dual AV node physiology and accessory pathways in the Pakistani population under the influence of vagal tone. Unlike previous studies that focused on isolated arrhythmias like WPW syndrome and AVRT, our research examines the combined effects of vagal modulation on conduction properties. While Rana and Sharma (2019) reported on accessory pathway syndromes, they did not explore vagal tone or dual AV nodes, highlighting a significant gap that our study fills by providing comprehensive, novel insights.[9]

Our study fills the gap in Pakistani research by directly examining the interaction between vagal tone, dual AV node physiology, and accessory pathways. Unlike prior studies that focused on pre-excitation syndromes and individual pathway ablation, our findings highlight how continuous vagal tone modulates conduction properties, such as prolonging PR intervals (202 ms) and refractory periods (250 ms), and inducing arrhythmias in 35% of cases. This underscores the critical need for further exploration of autonomic modulation in complex arrhythmias.[9]

The findings of this study align with previous research in indicating that continuous enhanced vagal tone significantly affects AV node conduction properties and accessory pathway activity. Specifically, the prolongation of PR intervals and refractory periods during vagal stimulation is consistent with the role of vagal tone in increasing parasympathetic influence on the heart, thereby reducing conduction velocity and increasing arrhythmia susceptibility.[10] Furthermore, the study's finding of an 85% ablation success rate echoes international findings that catheter ablation remains an effective treatment for arrhythmias involving accessory pathways. However, the 30% recurrence rate of arrhythmias post-ablation indicates that further interventions, possibly targeting vagal tone, may improve long-term outcomes.[3]

Study Limitations

This study faced several limitations. First, the absence of a control group without vagal stimulation limited the ability to conclusively attribute the observed effects to vagal tone rather than other confounding factors. Additionally, the study was conducted at a single center, which may limit the generalizability of the results to broader populations. Moreover, the study only included patients undergoing catheter ablation, which might have led to selection bias, as the results may not apply to patients managed conservatively. Finally, the follow-up period of one year might not have been sufficient to capture late arrhythmia recurrences.

Future Directions

Future research should focus on expanding this study to include multiple centers and a longer follow-up period to validate the findings. Additionally, randomized controlled trials comparing patients with and without vagal stimulation could provide stronger evidence of vagal tone's impact on dual AV node physiology and accessory pathways. Lastly, investigating alternative therapies that target vagal modulation could help in reducing arrhythmia recurrence rates post-ablation.[11]

CONCLUSION

This study demonstrates that continuous enhanced vagal tone significantly affects the conduction properties of dual AV node physiology and accessory pathways, leading to prolonged PR intervals, increased refractory periods, and heightened susceptibility to arrhythmias. The high success rate of catheter ablation, despite a 30% recurrence of arrhythmias, supports the effectiveness of ablation but highlights the potential role of vagal modulation in long-term arrhythmia management. These findings provide valuable insights into the electrophysiological behaviour under vagal influence, suggesting that targeted vagal interventions may improve clinical outcomes in patients with complex conduction pathways.

AUTHORS' CONTRIBUTION

HU, MIK, AM, YH, TM, R: Conception, analysis, revision, final approval.

REFERENCES

1. Ho SY. Anatomy of the atrioventricular junction, atrioventricular grooves, and accessory pathways. Card Electrophysiol Clin 2020;12(4):437–45.
2. Marazzato J, Marazzi R, Doni LA, Angeli F, Bagliani G, Leonelli FM, *et al*. Arrhythmias involving variants of accessory pathways. Card Electrophysiol Clin 2020;12(4):505–18.
3. Cardona-Guarache R, Han FT, Nguyen DT, Chicos AB, Badhwar N, Knight BP, *et al*. Ablation of supraventricular tachycardias from concealed left-sided nodoventricular and nodofascicular accessory pathways. Circ Arrhythm Electrophysiol 2020;13(5):e007853.
4. Iso K, Okumura Y, Watanabe I, Nagashima K, Takahashi K, Arai M, *et al*. Is vagal response during left atrial ganglionated plexi stimulation a normal phenomenon? Circ Arrhythm Electrophysiol 2019;12(10):e007281.
5. Takahashi K, Watanabe I, Okumura Y, Nagashima K, Wakamatsu Y, Arai M, *et al*. Impact of atrial fibrillation on the vagal response to ganglionated plexi stimulation: comparison between patients with and without atrial fibrillation. J Nihon Univ Med Assoc 2019;78(1):15–19.
6. Escudero CA, Ceresnak SR, Collins KK, Pass RH, Aziz PF, Blaufox AD, *et al*. Loss of ventricular preexcitation during noninvasive testing does not exclude high-risk accessory pathways: a multicenter study of WPW in children. Heart Rhythm 2020;17(10):1729–37.
7. Liu W, Li J, Xiong N. Fasciculoventricular accessory pathway unmasked by a pseudo gap phenomenon. J Electrocardiol 2019;55:41–4.
8. Hoffmayer KS, Han FT, Singh D, Scheinman MM. Variants of accessory pathways. Pacing Clin Electrophysiol 2020;43(1):21–9.
9. Rana IA, Afzal W. Accessory cardiac conduction pathway with an unusual presentation. J Coll Physicians Surg Pak 2019;29(Suppl 2):S77–9.
10. Kinjo T, Kimura M, Kaname N, Horiuchi D, Itoh T, Ishida Y, *et al*. Landiolol, an intravenous β1-selective blocker, is useful for dissociating a fusion of atrial activation via accessory pathway and atrioventricular node. J Arrhythm 2023;39(6):937–46.
11. Matta M, Marazzato J, De Ponti R, Gaita F, Anselmino M. Ablation of accessory pathways with uncommon electrophysiologic properties. Card Electrophysiol Clin 2020;12(4):567–81.

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