Current Science
CS 5 (4), 3906-3913 (2025)
Received 10 May 2025 | **Revised 12 June** 2025 | **Accepted 13 July**. 2025 | **Online Available 11 August** 2025
https://doi.org/ 10.52845/CS/2025-5-4-47

Current Science
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OPEN ACCESS
ISSN(O)2795-8639

Original Article

Two Cases of SVT Induced by Combined Exercise Test during Esophageal Cardiac Electrophysiological Examination

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Abstract:

Background: Transesophageal cardiac electrophysiology is a safe, effective, and noninvasive cardiac electrophysiologic test. Combined with the supine position power treadmill exercise test, modulation of autonomic function and adjustment of the myocardial tissue conduction system due period can significantly improve the success rate of TECEE evocation and has important applications in risk stratification of ventricular preexcitation syndrome..

Case Presentation: Case 1: A 34-year-old male presented with recurrent palpitations that had persisted for 10 years. No supraventricular tachycardia (SVT) was recorded on the electrocardiogram (ECG), and the type of SVT could not be definitively diagnosed. Transesophageal electrophysiological study (TEEPS) with atrial stimulation failed to induce SVT. However, after performing the supine bicycle exercise test in combination, slow-fast atrioventricular nodal reentrant tachycardia (AVNRT) was successfully induced. **Case 2:** A 59-year-old female presented with recurrent palpitations for three years. The duration of the SVT episodes was short, and the diagnosis was unclear. TEEPS with atrial stimulation showed occasional premature atrial contractions; however, SVT was not induced. However, after performing the supine bicycle exercise test in combination, sinoatrial nodal reentrant tachycardia (SANRT) was successfully induced.

Conclusion: Transesophageal cardiac electrophysiology is a noninvasive cardiac electrophysiological examination technique used for diagnosing paroxysmal supraventricular tachycardia and terminating tachycardia. In particular, when combined with supine bicycle exercise testing, it can increase the success rate of inducing supraventricular tachycardia, further evaluate the mechanism of tachycardia, and provide an important reference value for clinical risk stratification of radiofrequency catheter ablation and surgery.

Keywords: TEEPS, supine bicycle exercise test, PSVT.

Introduction

Background: Transesophageal electrophysi - ological study (TEEPS) is a safe, effective, and noninvasive cardiac electrophysiological technique that has been widely used in clinical practice since 1979. This technique is simple to perform and can preliminarily assess the electrophysiological type and mechanism of paroxysmal supraventricular tachycardia (PSVT)[1]. Moreover, it can terminate reentrant supraventricular tachycardia that is refractory to medication and restore sinus rhythm. Among patients undergoing radiofrequency catheter ablation, atrioventricular nodal reentrant tachycardia (AVNRT) is the most common, followed by atrial flutter and atrioventricular reentrant tachycardia[2-4]. In recent years, studies have shown that radiofrequency ablation of the vagal nerve ganglion plexus can effectively treat symptomatic bradycardia, atrioventricular

conduction block, and cardioinhibitory vasovagal syncope resulting from increased vagal nerve tone [5]. However, in clinical practice, patients undergoing transesophageal cardiac electrophysiological testing may also be affected by autonomic nervous system tone. Specifically, increased vagal nerve tone can lead to a lowered pseudo-Wenckebach point (<130 bpm), resulting in the unsuccessful induction of abnormal electrophysiological phenomena and paroxysmal supraventricular tachycardia. Through supine exercise stress testing (Figure 1), wherein sympathetic nervous system excitation and vagal nerve inhibition methods were employed, we successfully induced reentrant supraventricular tachycardia, clarified the type and mechanism of tachycardia, and provided diagnostic and therapeutic guidance for radiofrequency ablation.

Figure 1: The equipment used for the supine bicycle exercise test

CASE summary

Case1: Patient, male, 34 years old, presented with recurrent palpitations for 10 years. The patient had no significant medical history. Cardiac ultrasound and 12-lead electrocardiography (ECG) showed no abnormalities. He was 180 cm tall and weighed 85 kg, with a BMI of 26.2 kg/m^2, blood pressure of 150/93 mmHg, and heart rate of 65 bpm. Transesophageal cardiac electrophysiological examination was performed using a DF-5A cardiac electrophysiological stimulator. A 5-pole bipolar esophageal electrode catheter was used. The pre-examination exclusion criteria were also excluded. Atrial stimulation with S1S1 incremental pacing was performed at a frequency of 210bpm, with two pacing cycles (Figure 2). S1S2 premature pacing was conducted with cycle lengths of S1 700 ms and S2 400 ms, with a decrement of -10 ms scanning, no evidence of dual pathway phenomenon in the atrioventricular node, atrial echo, or reentry phenomenon, and no reentrant tachycardia was induced. The atrial effective refractory period was 230/700 ms, and the atrioventricular conduction effective refractory period was 270/700 ms. Subsequently, the patient underwent supine bicycle exercise testing. Initially, there was no load for 2 min, followed by a gradual increase in power every 2 min with an increment of 22 W/min. The total exercise time was 7 min, with a peak power output of 130 W, peak heart rate of 113 beats/min, and peak blood pressure of 180/98 mmHg. Exercise was terminated because of muscle fatigue in the lower

limbs, preventing continued cycling. Immediately after exercise termination, atrial stimulation with S1S1 pacing at 210 bpm was performed, which resulted in the induction of slow-fast atrioventricular nodal reentrant tachycardia (Figure 3). Tachycardia was terminated with rapid atrial pacing at 170 bpm (Figure 4).

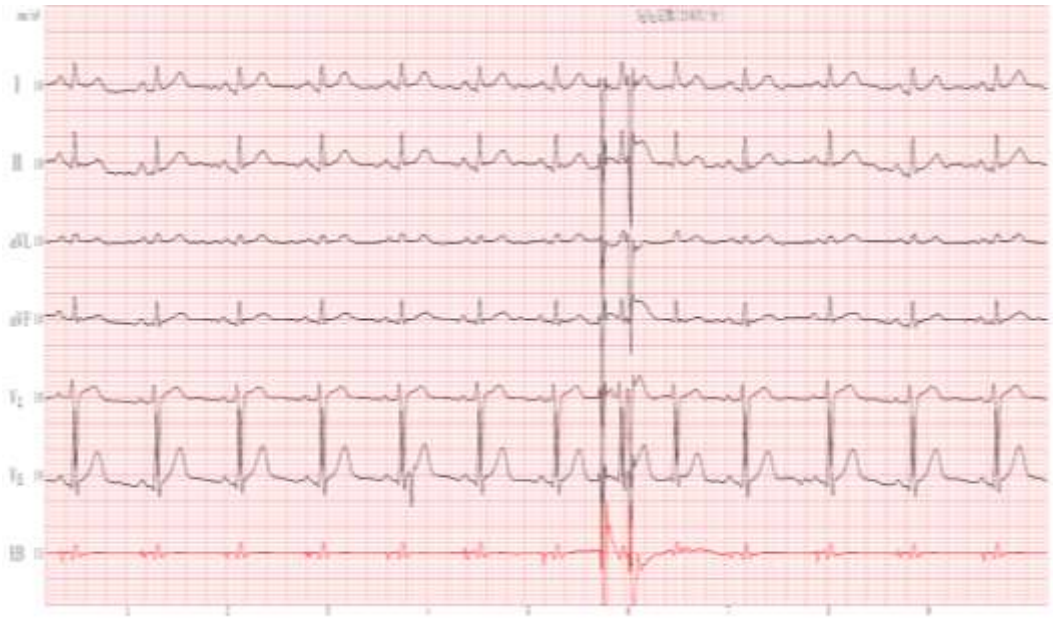

Figure 2 shows the sinus rhythm before exercise, with a cardiac cycle length of 600 ms. Atrial stimulation with S1S1 pacing at a frequency of 210 bpm, with two pacing cycles, did not induce tachycardia. EB, esophageal electrode.

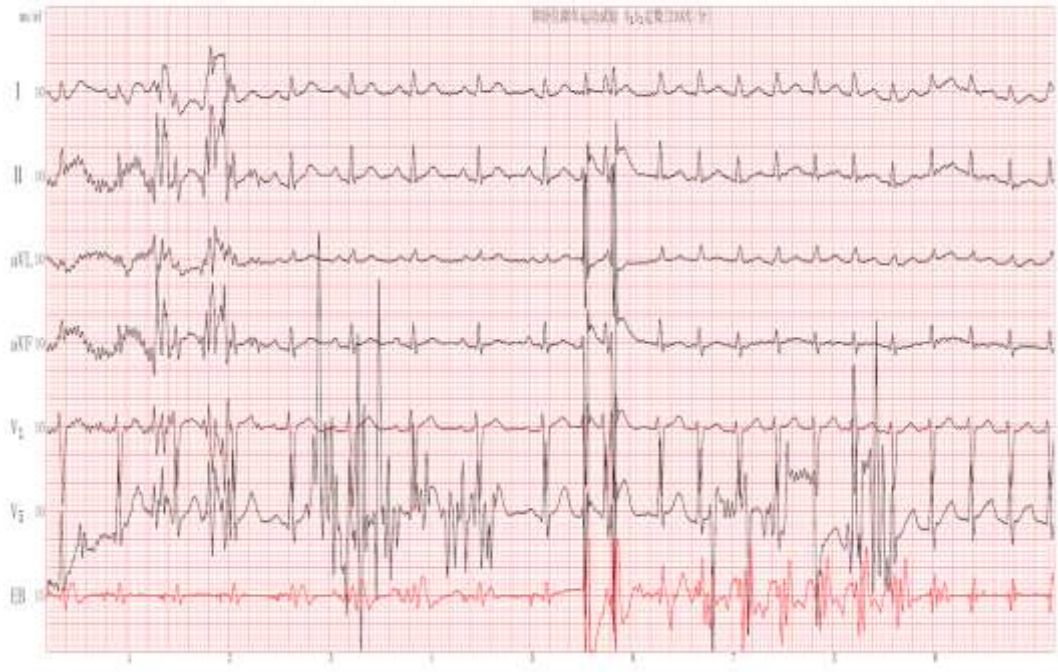

Figure 3 shows sinus rhythm after supine bicycle exercise, with a cardiac cycle length of 640 ms. Atrial stimulation with S1S1 pacing at a frequency of 210 bpm, with two pacing cycles, induced slow-fast atrioventricular nodal reentrant tachycardia after doubling of the second S-R interval. The tachycardia cycle length was 392 ms, the QRS duration was 80 ms, and no P waves were observed on the 12-lead electrocardiogram. In lead V1, a pseudo r-wave was observed at the end of the QRS complex. The esophageal electrode (EB) showed fusion of atrial and ventricular waves with an R-P interval of ≤70 ms.

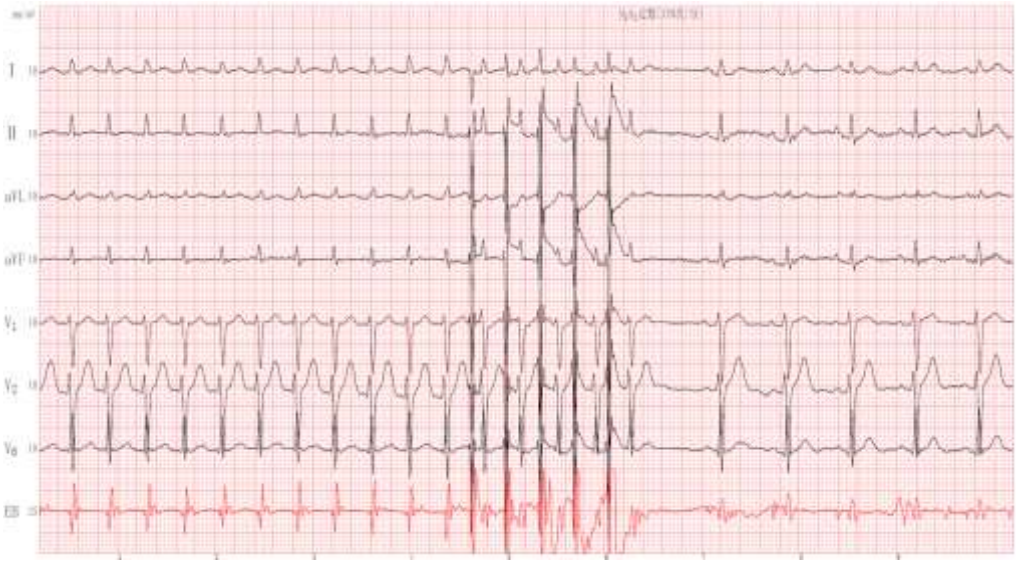

Figure 4: Atrial stimulation at a frequency of 170 bpm with a pacing cycle length of 5 beats, terminating the tachycardia with overdrive stimulation and restoring sinus rhythm. EB: Esophageal electrode.

Case 2: patient, female, 59 years old, presented with recurrent palpitations for three years. In the previously healthy subjects, no abnormalities were found on echocardiography or 12-lead ECG. Height 155 cm, weight 57 kg, BMI 23.7 kg/m^2, blood pressure 137/89 mmHg, heart rate 81 bpm; underwent transesophageal cardiac electrophysiological examination, with atrial stimulation using S1S1 incremental pacing at a frequency of 200 bpm, pacing cycle length of 2 beats (Figure 5), did not induce tachycardia; S1S2 programmed stimulation, pacing cycle lengths S1 700 ms, S2 400 ms, single atrial premature contraction observed during -10 ms scanning (Figure 6), measured atrial effective refractory period 220/700 ms, atrioventricular conduction effective refractory period 310/700 ms. No **evidence of dual pathway phenomenon in the atrioventricular node, atrial echo, or reentry phenomenon, and no reentrant tachycardia was induced, the patient underwent supine exercise stress testing on a bicycle ergometer, starting with 2 min of no load, followed by incremental workload every 2 minutes, increasing by 8 W/min. The total exercise time was 5 min, peak workload was 50 W, peak heart rate was 115 bpm, peak blood pressure was 150/95 mmHg, and exercise was terminated owing to fatigue of the lower limb muscles. Immediately after exercise termination, atrial stimulation using S1S1 pacing at 200 bpm, pacing cycle length of 2 beats, induced sinoatrial reentrant tachycardia (Figure 7), and occasional atrial premature contractions observed during tachycardia (Figure 8), followed by termination of tachycardia with overdrive S1S1 pacing at 200 bpm (Figure 9).**

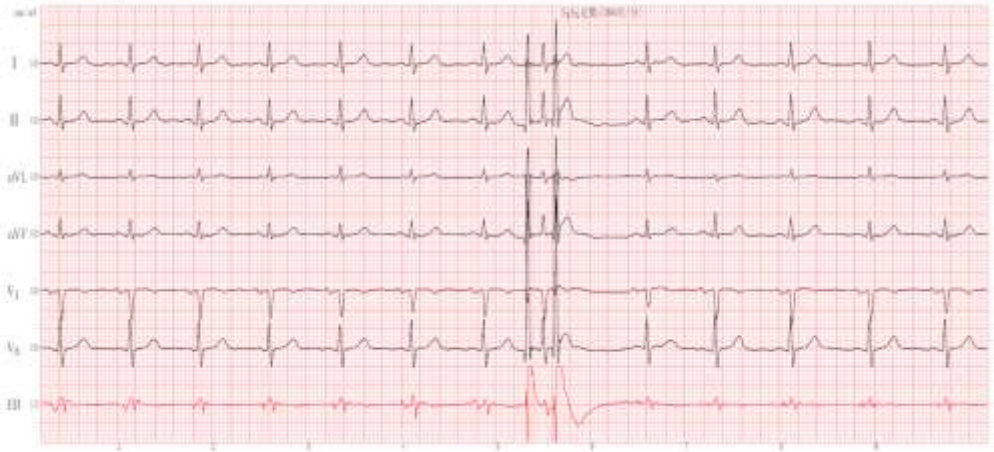

Figure 5: Prior to exercise, sinus rhythm with a cardiac cycle length of 760 ms; atrial S1S1 pacing at a

frequency of 200 bpm, pacing cycle length of 2 beats, did not induce tachycardia. EB: Esophageal electrode.

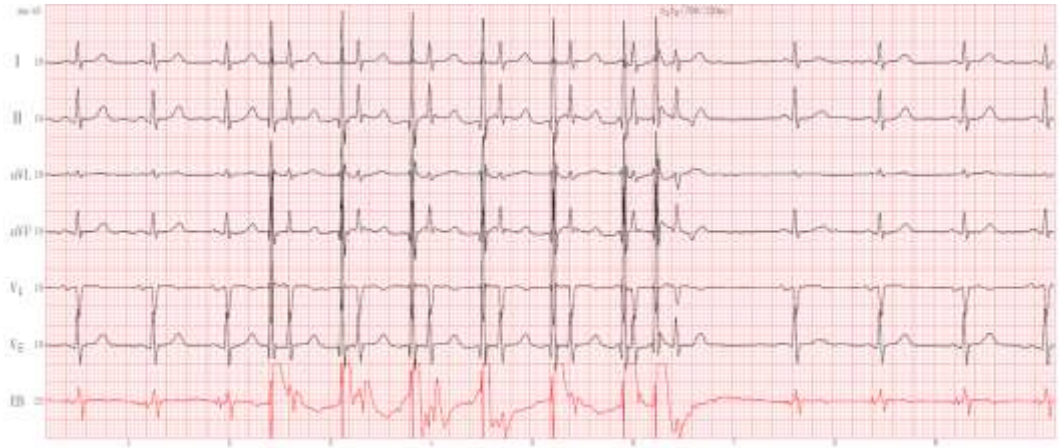

Figure 6: Atrial S1S2 pacing with S1 700 ms, S2 400 ms; during -10 ms scanning, a single atrial premature contraction is observed at a coupling interval of 320 ms, with inversion of P wave in lead II and an R-P interval of 160 ms. EB: Esophageal electrode.

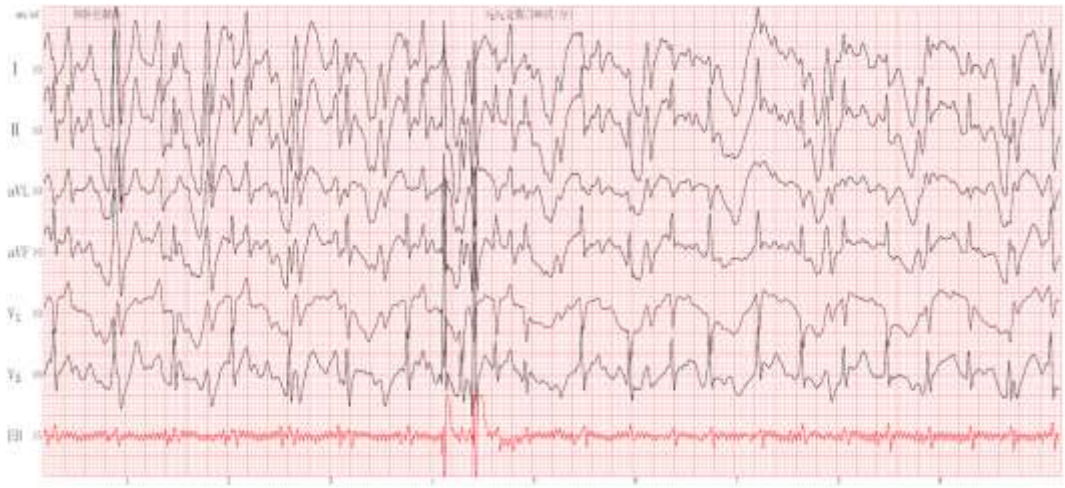

Figure 7: Post-supine exercise stress testing on a bicycle ergometer, sinus rhythm with a cardiac cycle length of 600 ms; atrial S1S1 pacing at a frequency of 200 bpm, pacing cycle length of 2 beats, without observed jump in S-R interval, inducing sinoatrial reentrant tachycardia, with a tachycardia cycle length of 500 ms, P-R interval of 120 ms, QRS duration of 80 ms, upright P waves in leads I, II, aVF, V5, and biphasic P wave in lead V1. EB: Esophageal electrode.

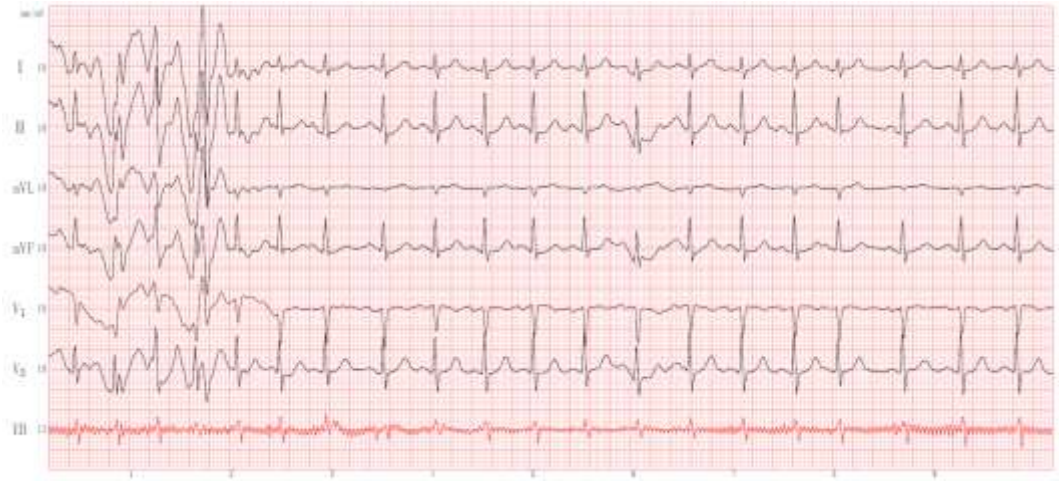

Figure 8: During the episode of sinoatrial reentrant tachycardia, atrial premature contraction is

observed which does not invade the reentrant circuit, failing to terminate the tachycardia. EB: Esophageal electrode.

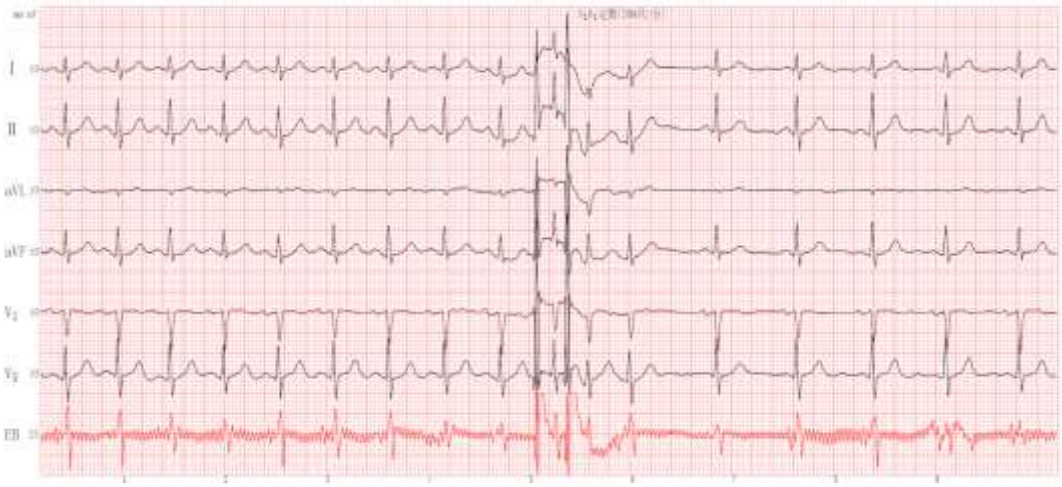

Figure 9: During the episode of sinoatrial reentrant tachycardia, overdrive S1S1 pacing at 200 bpm, pacing cycle length of 2 beats, captures the atrium and terminates the tachycardia, restoring sinus rhythm. EB: Esophageal electrode.

Discussion:

Paroxysmal supraventricular tachycardia (PSVT) is a common type of rapid cardiac arrhythmia that requires emergency treatment in clinical practice. It is characterized by a sudden onset and variable duration lasting from seconds to hours. Occasionally, the electrocardiogram fails to capture the PSVT pattern during an episode. When diagnosing PSVT using a 12-lead electrocardiogram, unclear P waves make it difficult to determine the type and mechanism of tachycardia[6]. Additionally, during PSVT episodes, drug therapy, vagal nerve stimulation (such as the Valsalva maneuver), or situations in which medication cannot be administered (such as in pregnant women), transesophageal cardiac electrophysiological techniques can be used to induce or terminate tachycardia.

The re-entrant substrate of paroxysmal supraventricular tachycardia (PSVT) caused by re-entrant mechanisms is significantly correlated with the initiation and maintenance of tachycardia. Transesophageal electrophysiological techniques can capture clear atrial waves and, by analyzing atrioventricular relationships and providing atrial stimulation to induce tachycardia, enable precise diagnosis of the type and mechanism of tachycardia.

The autonomic nervous system has a significant effect on the myocardial refractory period. Increased vagal nerve tension leads to prolongation of the atrioventricular node-refractory period and shortening of the atrial refractory period. Sympathetic nervous system stimulation accelerates heart rate, causing shortening of the refractory periods of the atrial muscle, ventricular muscle, and accessory pathways, as well as prolongation of the atrioventricular node refractory period.In invasive intracardiac electrophysiological testing, intravenous administration of medications (such as atropine, isoproterenol) is used to observe the response of the atrioventricular nodal fast and slow pathways to drugs. Improving retrograde conduction of the fast pathway and antegrade conduction of the slow pathway with drugs facilitates tachycardia induction [7].Atropine is a competitive M-cholinergic receptor-blocking drug that alleviates the inhibitory effect of the vagus nerve on the heart. The atropine test is commonly used to evaluate high vagal tone-related sinoatrial node dysfunction, as well as the effects of atrioventricular node conduction blockage and excessive vagal nerve tension[8].However, research has shown that there are differences in both the quantity and quality of cholinergic receptors among individuals, leading to variations in individual responses to atropine [9].Isoproterenol exerts powerful stimulatory effects on β1 receptors in the heart and is used to treat cardiac arrest and atrioventricular conduction blockages.

In clinical practice, when patients are in sinus rhythm, non-invasive transesophageal cardiac electrophysiological testing is performed to induce tachycardia and elucidate the type and mechanism of arrhythmia. Alternatively, in cases where induction fails, drug provocation may be considered (e.g., intravenous injection of atropine or isoproterenol) to induce reentrant supraventricular tachycardia. However, medication use has contraindications, including the occurrence of adverse reactions such as acute hypertensive crisis and patient non-acceptance[10].We employed supine exercise stress testing to stimulate the sympathetic nervous system and to inhibit the vagal nerve. By increasing the heart rate and adjusting the refractory period of the myocardium, adjacent tissues, or accessory pathways, we could enhance the success rate of inducing re-entrant supraventricular tachycardia. In this study, we applied this novel non-invasive cardiac electrophysiological examination method, combining transesophageal cardiac electrophysiological techniques with supine exercise stress testing, in two cases. This approach safely and effectively induced tachycardia, elucidated the mechanism of arrhythmia,and played a significant role in risk stratification for dominant atrioventricular accessory pathways[11]. We believe that it is worth recommending clinical diagnosis and treatment.

Author contributions

Xianchao Sun: Writing the original draft.**, Ying Yu:** Investigation.**, Yingqian Wang:** Conceptualization, Supervision, review, and editing.

Funding

Medical and Health Research Project of Zhejiang Province (2024KY1677).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The raw data supporting the conclusions of this article will be madeavailable by the authors on request.

Acknowledgements: Not applicable.

Declaration of competing interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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