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Recurrent Atrial Fibrillation After Cryoballoon Ablation in a 23-Year-Old Man

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Abstract

Atrial fibrillation (AF) is exceptionally uncommon before age 30. Exercise-triggered tachyarrhythmias require a structured approach because of the broad differential diagnosis. A 23-year-old man with exertional palpitations, dizziness, and syncope had an exercise-provoked rapid supraventricular tachyarrhythmia with intermittent wide-QRS conduction. An electrophysiological study (EPS) excluded an accessory pathway, identified no other inducible supraventricular or ventricular tachycardia, and documented spontaneous AF. Cryoballoon pulmonary vein isolation was successful and relieved symptoms. Recurrent symptoms and documented relapse atrial tachyarrhythmias two months later led to a redo procedure, which identified reconnection at the posterior left pulmonary vein antra. Radiofrequency re-isolation guided by the CARTO system was performed, with no recurrent symptoms or findings during the six-month follow-up. In young adults with palpitations and tachyarrhythmias, physicians should perform a thorough evaluation, including EPS when appropriate. AF ablation should be first-line treatment in severely symptomatic young patients.

Categories: Cardiology, Medical Education
Keywords: atrial fibrillation, cryoballoon ablation, exercise, pulmonary vein reconnection, radiofrequency ablation, young adult

Introduction

Atrial fibrillation (AF) is predominantly a disorder of aging and is uncommon in young adults. Its estimated incidence and prevalence among individuals younger than 30 years are 0.002%-0.02% and 0.002%-0.05%, respectively [1]; a Danish nationwide analysis identified AF in only 146 of 526,698 (0.03%) residents aged 18-24 years [2]. In a 20-year cohort of 6,813 elite athletes (mean age, 22 years), 21 (0.31%) had AF, although the study did not quantify highly symptomatic, reproducible, rapid AF during exercise [3]. Its clinical relevance extends beyond symptoms, as early-onset AF may also be associated with adverse long-term outcomes, including heart failure [1]. Early-onset AF has a broader etiologic spectrum than AF that appears later in life. Potential contributors other than pulmonary vein (PV) and non-PV triggers include accessory pathways, other reentrant supraventricular tachycardias, autonomic system disorders, intense endurance exercise, alcohol or stimulant exposure, obesity, paroxysmal sleep apnea, channelopathies, congenital or inherited disease (Brugada syndrome, short and long-QT syndromes, Wolff-Parkinson-White syndrome, familial-isolated AF and other isolated conduction diseases specific to gene mutations), and cardiomyopathies [1,4-8]. Vagally mediated AF has also been described in young patients [1]. We report an unusually severe, exercise-dominant presentation of AF in a 23-year-old man.

Case Presentation

Clinical history and initial investigations

A 23-year-old man (height 179 cm, weight 90 kg; body mass index 28.1 kg/m²) with no previous history of heart disease presented to our outpatient clinic with palpitations during exercise. For approximately six years, he had experienced brief episodes of rapid palpitations, predominantly during exercise and at times on a near-daily basis. Episodes were sometimes accompanied by weakness and dizziness, and he reported two syncopal events. The patient specified that those brief syncopal events occurred immediately after intense exercise and were preceded by palpitations and a markedly elevated heart rate (HR). The rest of the patient’s medical history was unremarkable; he denied alcohol use or exposure to stimulants. A detailed three-generation family history was negative for atrial fibrillation, cardiomyopathy, inherited arrhythmia syndromes, and sudden cardiac death. Given the absence of a suggestive familial or structural phenotype, genetic testing was not pursued during the initial evaluation. A resting 12-lead electrocardiogram (ECG) showed sinus rhythm at 68 beats/min with a PR interval of approximately 120 ms (Figure *1*). Serial rest ECGs showed no Brugada pattern of any type.

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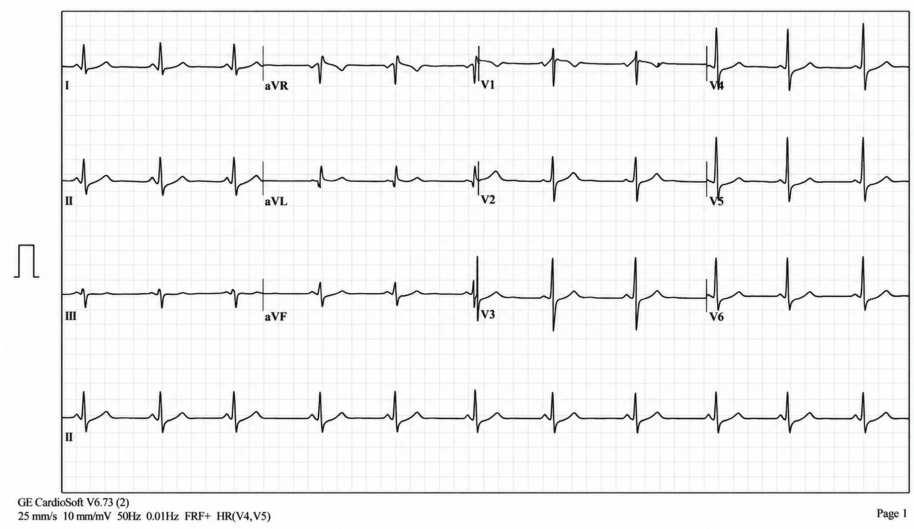


FIGURE 1: Resting 12-lead ECG showing sinus rhythm at approximately 68 beats/min

A complete blood count, comprehensive metabolic panel, and thyroid function tests were within normal limits.

A 24-hour Holter recording showed more than 10,000 premature atrial complexes and approximately 500 premature ventricular complexes. Earlier ambulatory strips from 2019 demonstrated frequent atrial ectopy, couplets or short supraventricular runs, and intermittent ventricular ectopy. At that time, bisoprolol 2.5 mg and flecainide 200 mg once daily were administered and the patient reported partial symptomatic improvement.

Transthoracic echocardiography showed normal chamber dimensions and wall thickness, no regional wall-motion abnormality, normal right ventricular function, no significant valvular disease, and a left ventricular ejection fraction (LVEF) of 55%. Cardiac magnetic resonance (CMR) imaging showed borderline increased left ventricular (LV) volumes (LV end-diastolic volume 227 mL; 107 mL/m² within normal range) with normal systolic function (LVEF 56%), normal right ventricular size and function (right ventricular ejection fraction (RVEF) 54%), normal biatrial dimensions (left atrial volume index 30 mL/m² and right atrial area index 12 cm²/m²), and no edema on T2-weighted short-tau inversion recovery (T2-STIR) imaging, abnormalities in native T1, T2, or extracellular volume, thrombus, or late gadolinium enhancement (LGE). No atrial fibrosis was reported.

Exercise testing

A Bruce protocol treadmill test reproduced the clinical syndrome. At stage three, HR reached 187 beats/min with a rapid, predominantly narrow-complex supraventricular tachycardia (SVT) (Figure *2A*). During early recovery, transient broad-complex conduction appeared at high rates, with a right bundle branch block-like morphology and reported rates up to 240 beats/min (Figure *2B*). The QRS complexes were partly regular and therefore did not independently establish AF. The differential diagnosis at that time included AF or another type of SVT with rate-related aberrancy, pre-excited AF, and ventricular tachycardia (VT).

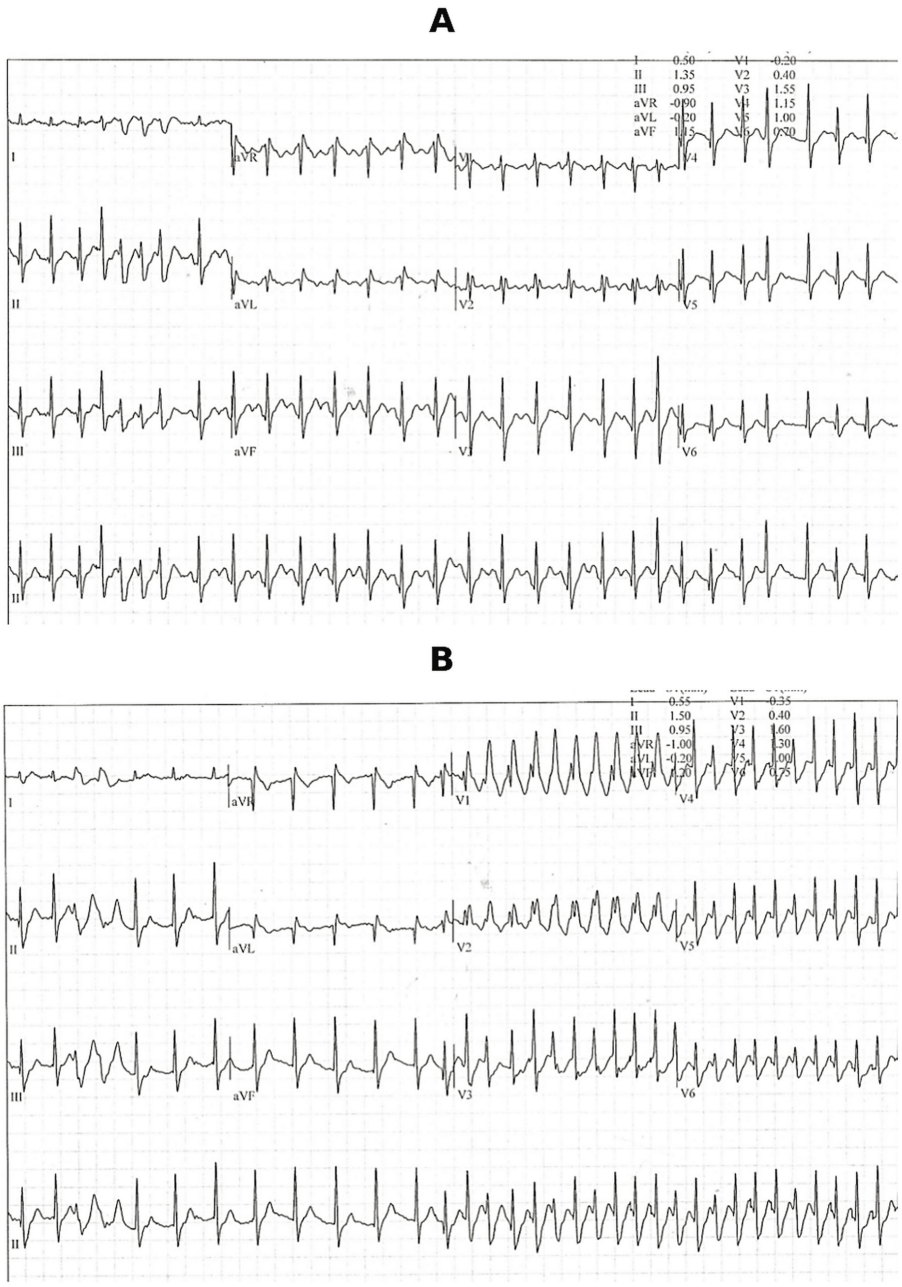


FIGURE 2: Exercise-related rapid supraventricular tachyarrhythmia and transient wide-QRS conduction. (A) Bruce stage three ECG at 187 beats/min showing a rapid, predominantly narrow-complex supraventricular rhythm. (B) Early recovery tracing showing transient wide-QRS conduction at ~240bpm, with a RBBB-like morphology.

Abbreviations: ECG, electrocardiogram; HR, heart rate; RBBB, right bundle branch block.

Initial electrophysiology study and cryoballoon ablation

An electrophysiological study (EPS) was performed on December 18, 2025, after withdrawal of antiarrhythmic therapy (flecainide 20 days prior and bisoprolol three days prior).

EPS excluded an accessory atrioventricular pathway; no other reentrant or focal SVT or VT was induced. During the study, multiple spontaneous, self-terminating episodes of AF occurred without programmed atrial stimulation or catheter manipulation (Figure *3A*,B).

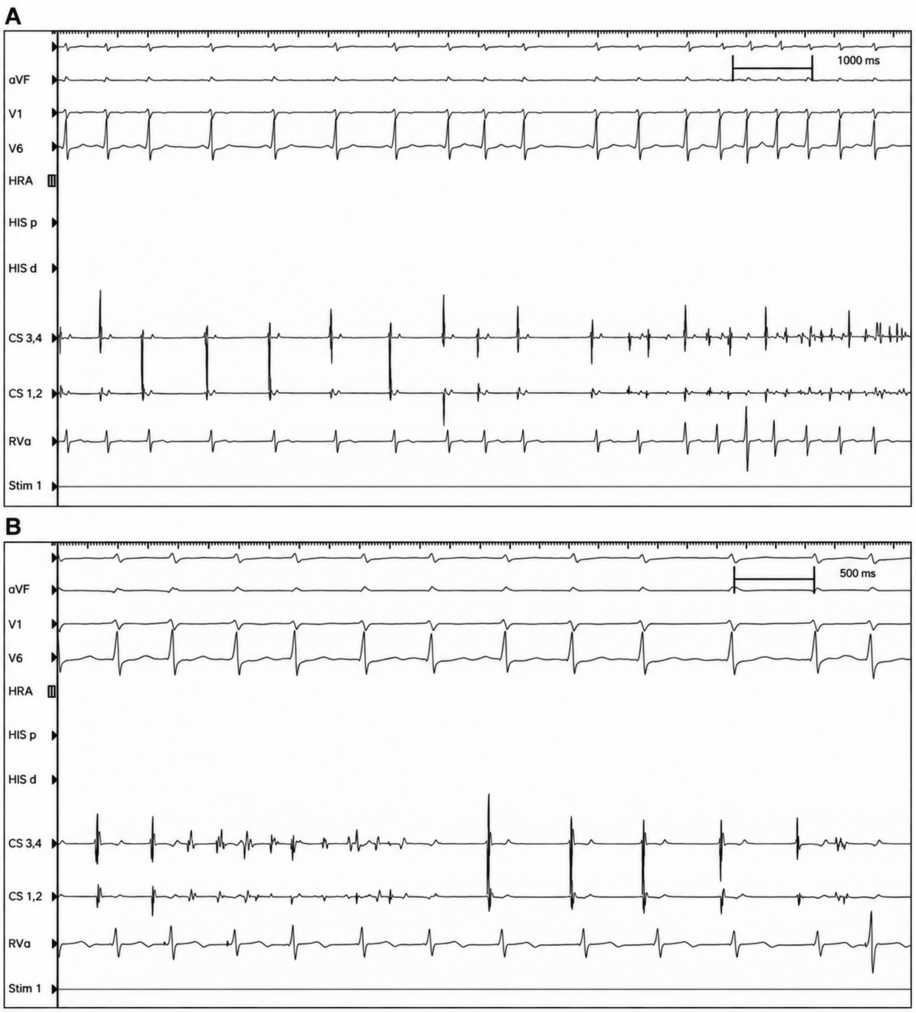


FIGURE 3: Intracardiac documentation of spontaneous atrial fibrillation during the diagnostic electrophysiological study. (A,B) Representative intracardiac recordings demonstrating fibrillatory atrial activity. AF occurred spontaneously without programmed atrial stimulation or catheter manipulation.

Abbreviations: AF, atrial fibrillation.

AF episodes occurred during anxiety-associated sympathetic activation, and additional pharmacological provocation with isoproterenol was not considered necessary. Notably, a brief run of wide-complex tachycardia exhibiting right bundle branch block (RBBB) morphology, resembling the tachyarrhythmia observed during exercise testing, was recorded. Intracardiac electrograms demonstrated a 1:1 atrioventricular relationship, with findings revealing a supraventricular origin with aberrant ventricular conduction (Figure *4*).

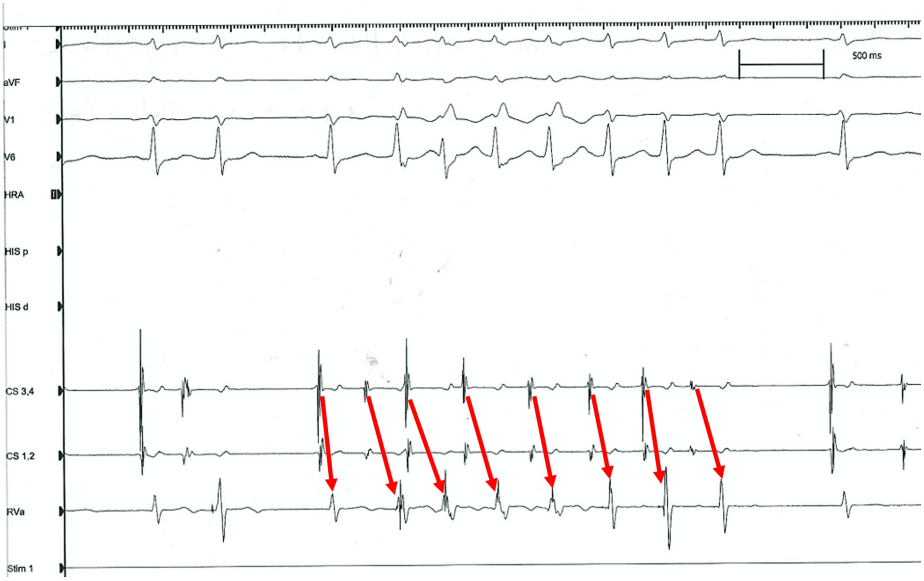


FIGURE 4: Intracardiac recordings illustrating a short run of transient wide-QRS conduction with RBBB morphology, electrograms demonstrate a 1:1 atrioventricular relationship, suggestive of supraventricular origin with aberrant ventricular conduction.

Abbreviations: right bundle branch block, RBBB.

Given the young age of the patient, his substantial symptom burden, and his desire to remain off medication, we elected to proceed with AF ablation. Therefore, cryoballoon pulmonary vein isolation (PVI) was performed successfully without complications, approximately three weeks after the diagnostic EPS. Cryoablation was performed using a 28-mm fourth-generation Arctic Front Advance Pro cryoballoon (Medtronic, Minneapolis, MN). A single 240-second freezing application was delivered to each of the four pulmonary veins, achieving appropriate nadir temperatures within the expected effective range. Intravenous unfractionated heparin was administered at 100 IU/kg, targeting an activated clotting time (ACT) >300 seconds. Bidirectional pulmonary vein conduction block was confirmed.

After the procedure, the symptoms resolved and the patient resumed his usual activities, including his normal exercise regimen without palpitations or other symptoms. A repeat treadmill study produced sinus tachycardia without recurrence of the presenting arrhythmia or exercise-related symptoms (Figure *5*). He remained clinically well for at least the first month.

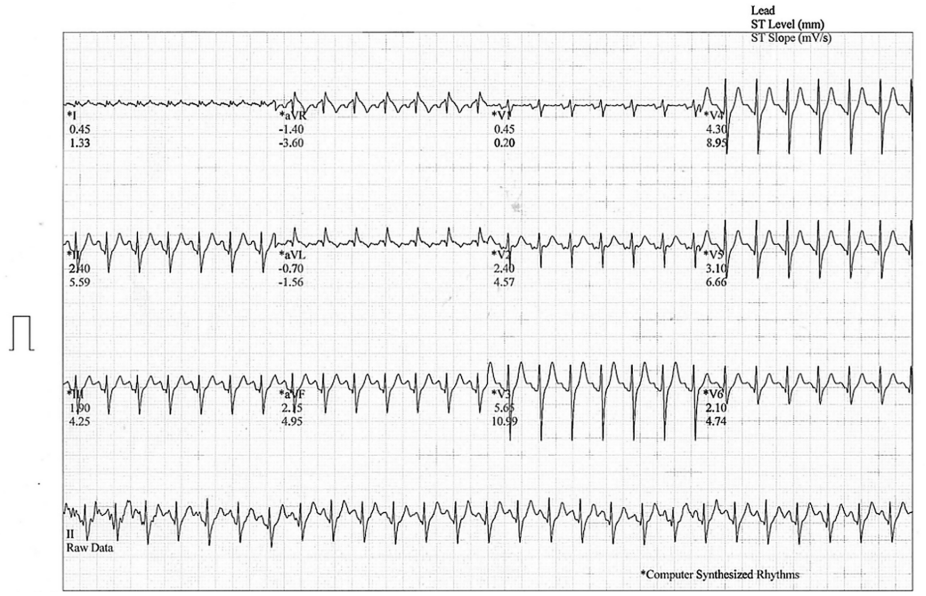


FIGURE 5: Recovery tracing from repeat treadmill testing after cryoballoon PVI, showing sinus tachycardia without reproduction of the presenting arrhythmia or symptoms.

PVI: Pulmonary vein isolation.

Recurrence and redo ablation

Approximately two months after the procedure, exertional palpitations gradually recurred. A repeat 24-hour Holter report described sinus rhythm interrupted by multiple atrial tachyarrhythmia events. The maximum, minimum, and mean heart rates were 214, 52, and 95 beats/min, respectively. The report included 3,916 premature atrial complexes, 813 premature ventricular complexes, including 11 couplets, no VT, and no pauses lasting ⩾2.5 seconds.

After obtaining informed consent from the patient, we elected to perform a redo AF ablation procedure using three-dimensional (3D) mapping with the CARTO electroanatomic mapping system (Biosense Webster, Diamond Bar, CA, USA). Three-dimensional electroanatomical voltage mapping demonstrated preserved atrial bipolar voltage amplitudes without atrial fibrotic findings (i.e. low-voltage areas). Recovered conduction was identified between the posterior aspect of the left PV antra, while the right PVs remained isolated from the previous procedure (Figure *6A*). Targeted point-by-point radiofrequency (RF) lesions were delivered, and the left PVs were successfully re-isolated (Figure *6B*). No additional ablation target was identified.

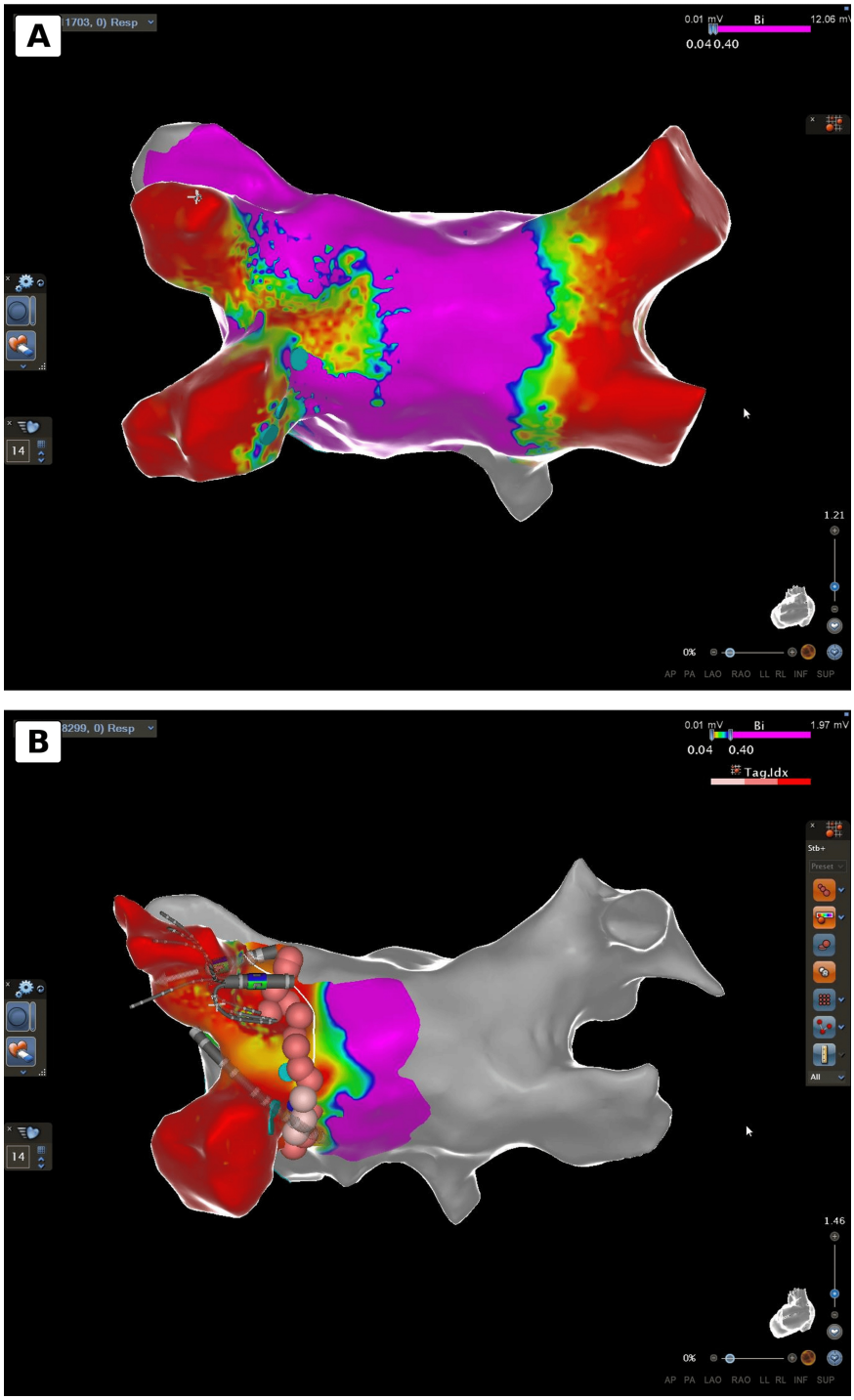


FIGURE 6: Electroanatomic remapping and targeted redo ablation. (A) CARTO LA bipolar map demonstrating recovered conduction at the posterior left PV antra. (B) Redo ablation map with RF ablation tags, confirming left PV re-isolation.

Abbreviations: LA, left atrial; PV, pulmonary vein; RF, radiofrequency.

Following the redo procedure, the patient remained asymptomatic. Repeat ambulatory monitoring showed sinus rhythm, and exertional palpitations did not recur during a follow-up period of six months. Clinical follow-up is performed at three-month intervals.

Table *1* summarizes the clinical timeline, key findings, and interventions.

Date/interval	Event	Key findings
June 2019	Historical Holter	Frequent atrial ectopy, couplets/short supraventricular runs, and intermittent ventricular ectopy.
2019-2025	Symptoms	Predominantly exertional palpitations, sometimes daily; weakness/dizziness and two syncopal episodes.
February 17, 2025	Treadmill exercise test	Rapid supraventricular tachyarrhythmia at 187 beats/min; transient wide-QRS conduction in recovery at reported rates up to approximately 220-240 beats/min.
February 26, 2025	Cardiac magnetic resonance	Borderline increased LV volume, LVEF 56%, RVEF 54%, normal biatrial dimensions, no edema, late gadolinium enhancement, or detectable atrial fibrosis.
April 8, 2025	Resting ECG	Sinus rhythm with a short PR interval of 120 ms.
December 18, 2025	Electrophysiology study	Accessory pathway excluded; no other tachycardia induced; spontaneous AF documented by intracardiac recordings.
January 9, 2026	Cryoballoon PVI	Isolation of all four pulmonary veins.
January 28, 2026	Post-ablation treadmill test	Sinus tachycardia without reproduction of the presenting arrhythmia.
March 11, 2026	Recurrence Holter	Atrial tachyarrhythmias; maximum heart rate 214 beats/min.
April 12, 2026	Redo CARTO-guided procedure	Posterior left pulmonary vein antral reconnection; RF re-isolation.
Six months after redo ablation	Follow-up	No recurrent symptoms; sinus rhythm on repeat Holter monitoring; clinical review every three months.

TABLE 1: Clinical Timeline

Abbreviations: AF, atrial fibrillation; ECG, electrocardiogram; LV, left ventricular; LVEF, left ventricular ejection fraction; PVI, pulmonary vein isolation; RF, radiofrequency; RVEF, right ventricular ejection fraction.

Discussion

The diagnosis of young-onset AF should follow a structured evaluation addressing congenital and acquired structural disease, thyroid and electrolyte disturbances, sleep-disordered breathing, obesity, alcohol and stimulants, exercise load, family history, and genetic cardiomyopathy or channelopathy. Pediatric and young-adult cohorts also show that atrioventricular nodal reentrant tachycardia or an accessory pathway may coexist with AF and that treating the non-AF substrate can reduce recurrence [4,6].

Inherited disorders

Early-onset AF may reflect genetic predisposition, inherited cardiomyopathy, primary atrial cardiomyopathy, or an ion-channel disorder, even before overt structural abnormalities develop [1]. In our case, normal atrial dimensions, negative atrial fibrosis assessment and preserved atrial bipolar voltages reduced suspicion of a detectable fibrotic atrial substrate but do not exclude functional atrial disease or an occult inherited disorder. Brugada syndrome is often considered in young patients with AF. Serial ECGs of our patient showed no Brugada-type pattern and no polymorphic VT, or relevant family history was documented. EPS was totally suggestive of AF, without any indication of focal tachycardia, other SVT, or VT. Genetic testing and provocation testing with ajmaline were considered but deferred due to their low clinical impact since the initial clinical, imaging, and familial assessment did not suggest a specific inherited condition. Given the very early AF onset, these tests may be reconsidered during follow-up, particularly if new clinical or familial findings emerge [1]. In our case, clinical, imaging, and electrophysiological findings were compatible with the diagnosis of lone atrial AF.

Given the exertional syncope and transient wide-QRS tachycardia, catecholaminergic polymorphic ventricular tachycardia (CPVT) was also an important differential diagnosis [9]. In our patient, ambulatory monitoring recorded no VT, the exercise and ambulatory tracings did not show the characteristic catecholamine-dependent progression from ventricular ectopy to bidirectional or polymorphic VT. Intracardiac recordings instead documented AF with rate-related aberrant conduction similar to the clinically recorded episode. Together, these findings argued against CPVT.

AF with extremely rapid ventricular response was the only plausible arrhythmic explanation for syncope identified during this evaluation. Nevertheless, the syncopal events were not captured on ECG, so their

causal relationship with AF remains inferential.

Ablation and recurrence

After exclusion of an accessory pathway, cryoballoon PVI was selected. Catheter ablation has shown efficacy in younger patients [10-13]. In the 1STOP project, freedom from AF recurrence after cryoballoon PVI in 368 patients aged 45 years or younger was 88.9% at 12 months and 72.4% at 36 months [12]. After the initial procedure, treatment success was supported by symptom relief and a repeat treadmill test that no longer reproduced the arrhythmia.

Palpitations after AF ablation do not always indicate arrhythmia recurrence; however, ambulatory monitoring suggested recurrent atrial tachyarrhythmia in our patient. Recovered PV conduction was suspected because it is a common mechanism of AF recurrence after cryoballoon PVI [14]. In a patient who had obtained clear symptomatic benefit from the first procedure, current guidelines support consideration of repeat ablation [15]. In our case, repeat EPS with 3D mapping helped determine whether PV reconnection had occurred or another tachyarrhythmia substrate required treatment.

Current evidence further reinforces this approach. In a 2025 systematic review and meta-analysis of 57 studies and 8,243 patients undergoing redo ablation, PV reconnection was found in 81.9% of patients. RF ablation was used for 95.4% of redo procedures, and 32.0% experienced recurrent AF during a median follow-up of 11.5 months [16]. These pooled data derive mainly from older, heterogeneous populations and cannot predict this patient's outcome, but they show why remapping the PVs was an appropriate first step.

Recurrence after ablation is also well documented among adolescents and young adults. In a cohort of 62 patients aged 21 years or younger, five of the 10 patients treated with PVI had documented recurrence [5]. In the multicenter Pediatric and Congenital Electrophysiology Society (PACES) study, AF recurred overall in 94 (39%) of 241 patients and in 14 (26.4%) of the 53 patients who underwent ablation during a follow-up period of 2.1±2.6 years [6]. Nanthakumar et al. mapped AF triggers to PVs, the left atrium, or crista terminalis in nine symptomatic adolescents [7]. Balaji et al. reported four teenage boys undergoing AF ablation: one focal-vein case recurred and was treated by isolation of an additional vein, whereas another patient continued to have paroxysmal AF after isolation of all PVs [8].

Larger young-adult series provide an even closer comparison. Among 57 patients younger than 40 years treated with second-generation cryoballoon ablation, seven had late recurrence at a mean of 5±3 months. Six underwent electroanatomic mapping-guided RF redo procedures; four had PV reconnection, including one gap at the left atrial appendage-left superior PV ridge, and two had durable PVI with superior vena cava isolation instead. After the second procedure, all but one maintained sinus rhythm [10].

In a study of adults aged 35 years or younger, 32 of 74 underwent a second procedure; recovered PV conduction was present in 28 of 32 (88%), and the single patient with recurrence after cryoballoon ablation was successfully treated by RF redo PVI [11]. In the 2026 Young-Onset Atrial Fibrillation (YOUNG-AF) cohort, recurrence followed ablation in 39% of treated patients, with a median time to recurrence of 4.3 months; LGE predicted shorter recurrence-free survival [13].

In our case, 3D mapping revealed recovered conduction at the posterior aspect of the left PV antra. Targeted RF ablation of that area achieved re-isolation of the left PVs. Since no additional target was identified, no additional lesions were delivered. Repeat cryoballoon ablation and pulsed-field ablation are alternatives supported by observational redo-procedure data [17-19].

Conclusions

Our case demonstrates that a young patient presenting with exercise-triggered rapid tachyarrhythmia, syncopal episodes and intermittent wide-QRS conduction at high rates warrants a comprehensive diagnostic workup. Initial evaluation should address structural heart disease and potential genetic, metabolic, and lifestyle-related contributors, followed, when appropriate, by electrophysiological assessment for accessory atrioventricular pathways and other supraventricular or ventricular arrhythmogenic substrates. Once AF has been definitively documented, cryoballoon PVI is a reasonable ablation strategy, even though the risk of recurrence remains. If the arrhythmia recurs, 3D mapping can identify sites of recovered PV conduction and guide targeted re-isolation. In this patient, reconnection of the posterior left PV antra was successfully treated with RF ablation, with no recurrent symptoms or findings during the six-month follow-up.

Appendices

Patient Perspective:

After the redo procedure, the patient reported substantial improvement in quality of life, including unrestricted exercise and no fear of syncope or arrhythmia.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Acquisition, analysis, or interpretation of data: Nikolaos P. Margos, Konstantinos Trachanas, Ilias Patsiotis, Konstantinos G. Kostopoulos

Drafting of the manuscript: Nikolaos P. Margos, Panagiotis N. Margos

Critical review of the manuscript for important intellectual content: Nikolaos P. Margos, Panagiotis N. Margos, Konstantinos Trachanas, Ilias Patsiotis, Konstantinos G. Kostopoulos

Supervision: Nikolaos P. Margos

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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