



Reshaping Prognosis: Atrial fibrillation ablation in a case of severe tachycardiomyopathy in a young patient

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Abstract

Tachycardiomyopathy, characterized by ventricular systolic dysfunction resulting from persistent tachycardia, poses a significant challenge in cardiovascular disease management. This article presents the case of a 31-year-old male patient with dilated cardiomyopathy and recurrent persistent atrial fibrillation, admitted due to heart failure decompensation. Ischemic and inflammatory etiologies for heart failure were ruled out in prior assessments. Despite multiple antiarrhythmic drugs and attempted electrical cardioversion, sinus rhythm was not maintained. Echocardiography confirmed a decline in the already reduced ejection fraction. Atrial fibrillation cryoablation was performed, and procedural specifics are detailed. Subsequent follow-up visits revealed a noteworthy improvement in exercise tolerance and ventricular function. This case underscores the importance of considering tachycardiomyopathy in the differential diagnosis of new-onset or worsening heart failure and highlights the potential for symptom resolution and ventricular function recovery with atrial fibrillation ablation.

Keywords

tachycardiomyopathy, atrial fibrillation, cryoablation

Rezumat

Tahicardiomiopatia, caracterizată prin disfuncție sistolică ventriculară secundară unei tahicardii persistente, reprezintă o provocare semnificativă în gestionarea bolilor cardiovasculare. Acest articol prezintă cazul unui pacient de sex masculin în vârstă de 31 de ani, diagnosticat cu cardiomiopatie dilatativă și fibrilație atrială persistentă recurentă, internat pentru fenomene de insuficiență cardiacă decompensată. Etiologia ischemică și cea inflamatorie a insuficienței cardiace au fost excluse în cursul evaluărilor anterioare. În pofida administrării multiplelor medicamente antiaritmice și a încercărilor de cardioversie electrică, ritmul sinusal nu a fost menținut. Ecografia cardiacă a confirmat un declin al fracției de ejeție deja reduce. S-a efectuat crioblație pentru fibrilație atrială, iar detaliile procedurale sunt prezentate. Consulturile periodice ulterioare au relevat o îmbunătățire semnificativă a toleranței la efort și a funcției ventriculare. Acest caz subliniază importanța luării în considerare a tahicardiomiopatiei în diagnosticul diferențial al insuficienței cardiace nou descoperite sau agravate și evidențiază potențialul rezoluției simptomatologiei și recuperării funcției ventriculare prin procedura de ablație a fibrilației atriale.

Cuvinte cheie

tahicardiomiopatie, fibrilație atrială, crioablație

Introduction

Tachycardiomyopathy (TCM) is characterized by a reversible left ventricle (LV) dysfunction mainly due to increased ventricular rates. Multiple chronic or incessant tachyarrhythmias have been linked to TCM pathogenesis, the most common being atrial fibrillation (AF), atrial flutter, incessant supraventricular tachycardia, and premature ventricular contractions.¹⁻³ The most common presentation is with dilated cardiomyopathy with or without the responsible tachycardia.⁴

Although atrial fibrillation is frequent in patients with heart failure, the challenge remains to establish whether it is fully, partially, or at all responsible for the observed LV dilatation and dysfunction.⁴ A TCM diagnosis also needs to be suspected in patients with preexisting left

ventricular dysfunction from underlying structural heart disease that suffer a worsening in the setting of prolonged tachycardia.¹

Since it was first described in a patient with AF in 1913 and proved to cause left ventricular dysfunction in animal models in 1962 even in structurally normal hearts,¹ TCM remained a major cause of heart failure, with a high burden of morbidity and mortality.⁵ AF catheter ablation is currently the first-line treatment recommendation when tachycardia-induced cardiomyopathy is highly probable.⁶

Increasing awareness regarding the inclusion of TCM in the differential diagnosis of new-onset or worsening heart failure holds significance, as timely treatment results in symptom resolution and recovery of ventricular function.

Case presentation

We present the case of a 31-year-old male admitted for progressive dyspnea due to less than ordinary physical activity and palpitations. His medical history is relevant for NYHA class II heart

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failure with reduced ejection fraction with multiple decompensation episodes in the last year. One year ago, he was diagnosed with dilated cardiomyopathy during hospital admission for acute cardioembolic ischemia of the right lower limb. Embolectomy was performed as part of the treatment, and during that hospitalization, paroxysmal episodes of high-rate atrial fibrillation were observed with spontaneous conversion to sinus rhythm. At the time of diagnosis, coronary angiography indicated the absence of stenotic lesions, and cardiac magnetic resonance imaging (MRI) revealed diffuse fibrosis of the left ventricle, along with a left ventricular ejection fraction of 29%. There was no recent history indicative of infection, and inflammatory markers were negative during the assessment. Furthermore, the patient had no documented familial history of cardiovascular disease. In the last year, the patient had recurrent persistent high-rate atrial fibrillation, with two prior unsuccessful attempts to maintain sinus rhythm following electrical cardioversion.

On clinical examination, the patient was afebrile, hemodynamically stable, and without signs of hypoperfusion. Initial vital signs upon referral indicated a blood pressure of 95/60 mmHg with an elevated heart rate of 120 beats per minute and an oxygen saturation of 99% on room air. Heart sounds were irregular, and there were no murmurs. There were no signs of pulmonary or systemic congestion, and no particular phenotypic features were observed.

The electrocardiogram on admission showed atrial fibrillation. Laboratory examination revealed elevated values of the natriuretic peptides (NTproBNP—4421 pg/mL), mild renal dysfunction (creatinine—1.48 mg/dl), and dyslipidemia (LDL cholesterol—154 mg/dL). Electrolytes, glycemia, C-reactive protein, and thyroid hormone levels were within reference limits. A transthoracic echocardiography revealed a dilated left ventricle with severe systolic dysfunction and a calculated ejection fraction of 15% without segmental wall motion abnormalities (Figure 1). The left atrium was dilated with an indexed volume of 37.4ml/m². The right ventricle showed no dilation but exhibited mild systolic dysfunction. No significant valvular involvement was detected.

Given the persistent and increased frequency of atrial fibrillation, consistently documented through multiple 24-hour ECG Holter monitoring, and the lack of sufficient control achieved with antiarrhythmic drugs—amiodarone was discontinued after three months due to newly occurred thyroid dysfunction—along with high-dose beta-blocker therapy and the subsequent decline in ejection fraction despite optimal neurohormonal therapy for heart failure, a tachycardiomyopathic component was deemed likely.

In this context, following a transesophageal echocardiography that excluded a thrombus in the left atrial appendage, an initial attempt at electrical cardioversion was made, albeit unsuccessful in maintaining sinus rhythm. Consequently, pulmonary vein isolation was pursued.

A computed tomography (CT) of the pulmonary veins was performed to define the anatomy of the posterior left atrium; it also ruled out intracardiac thrombus.

The procedure commenced with the patient in atrial fibrillation (Figure 2). After the placement of a coronary sinus catheter, a transseptal puncture was performed under intracardiac echocardiography

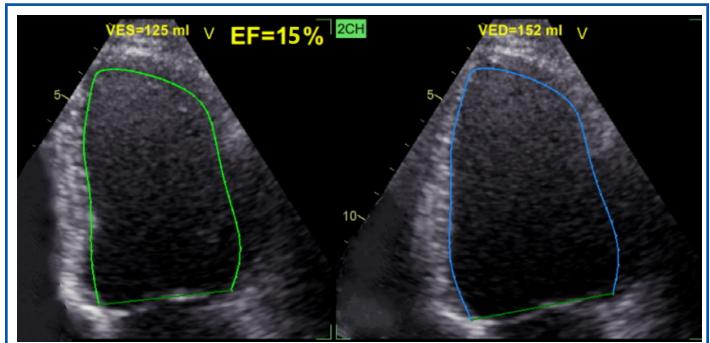


Figure 1 - Transthoracic Echocardiography at admission – Apical two-chamber view of the dilated left ventricle with a calculated ejection fraction of 15%.

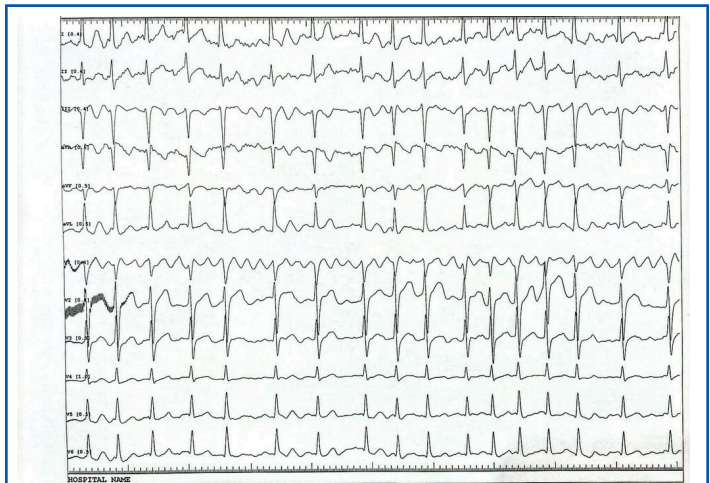


Figure 2 - Preprocedural electrocardiogram showing atrial fibrillation.

(ICE) guidance (Figure 3). The Arctic Front Medtronic cryoablation catheter was introduced into the left atrium, followed by selective catheterization of the pulmonary veins, balloon occlusion, and application of cryoablation energy (Figure 4). Successful elimination of pulmonary vein signals was evident on the Achieve catheter. At the conclusion of the procedure, conversion to sinus rhythm was achieved through direct current cardioversion, with successful maintenance of sinus rhythm. Bidirectional pulmonary vein isolation was verified and confirmed (Figure 5). No periprocedural complications occurred.

Three months later at the follow-up visit, a de-escalation to NYHA class I was noted with no AF recurrence, and left ventricular systolic function was completely recovered with 56% calculated ejection fraction (Figure 6).

Post-discharge follow-up includes a new MRI evaluation to assess the regression of fibrosis and long-term surveillance to evaluate the possible recurrence of arrhythmia. Anticipated outcomes of a forthcoming MRI evaluation include partial resolution of fibrosis, a reduction in left ventricular volumes, and a subsequent improvement in systolic function. However, this evaluation has not yet been conducted. A redo procedure of ablation can be performed if necessary.

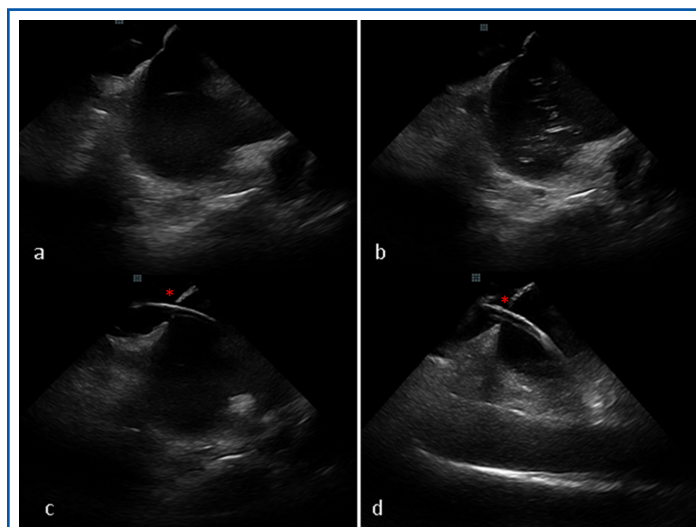


Figure 3 - Intracardiac Echocardiography (ICE) image capturing the moment of transseptal puncture (a – tenting of the fossa ovalis upon contact with the needle; b – injection of saline bubbles confirming needle placement in the left atrium; c,d – transseptal sheath insertion). Red asterisk (*) showing the sheath through the interatrial septum.

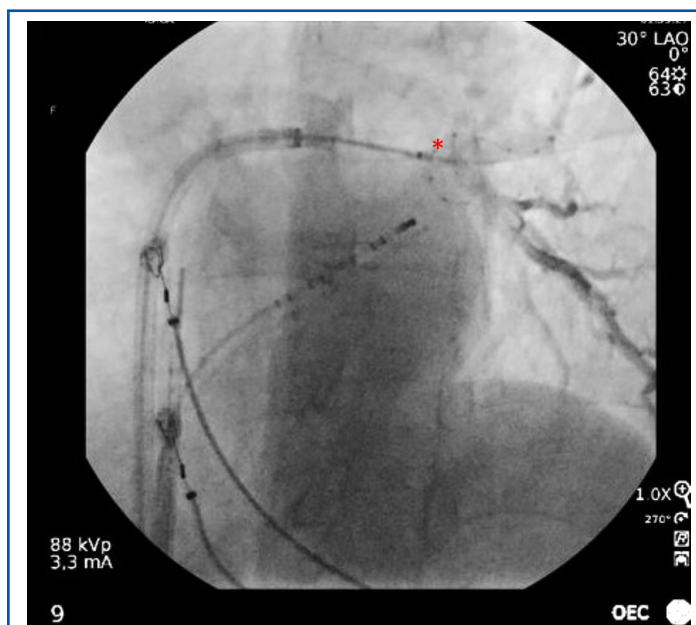


Figure 4 - Intraprocedural fluoroscopy image showing contrast medium into the lumen at the tip of the balloon (red asterisk) that confirms left inferior pulmonary vein occlusion.

Discussion

This case illustrates the role of atrial fibrillation (AF) ablation in a young patient where tachycardia-induced cardiomyopathy is highly probable. Furthermore, it highlights the significant diagnostic challenge of discerning whether the identified arrhythmia is the cause or the result of cardiomyopathy.

His medical journey is intricate, characterized by numerous hospitalizations due to decompensated heart failure, an embolic



Figure 5 - Intraprocedural Electrogram demonstrating exit block (orange arrow showing absence of conduction to the atria after pacing from the left inferior pulmonary vein).

complication, and recurrent episodes of high-rate atrial fibrillation. Upon initiation and escalation of heart failure guideline-directed medical therapy, there was an initially favorable clinical response, yet no substantial improvement in left ventricle ejection fraction was observed. Within this framework, a tachycardiomyopathic component was considered, and subsequent to unsuccessful maintenance of sinus rhythm via electrical cardioversion, cryoablation was conducted. At the three-month follow-up visit, the patient reported a significant improvement in exercise tolerance, being able to engage in physical activity without experiencing any dyspnea. Furthermore, a complete recovery of left ventricular function was noted.

The underlying mechanisms of TCM are not completely understood, but there is evidence showing that abnormalities in myocyte calcium, inflammation, and subclinical ischemia play a role, and atrial flutter and atrial fibrillation are the most common causes of it.⁷ Persistently high ventricular rate triggers cardiac dilation and mitral regurgitation, both of which correlate with increased filling pressures and diminished contractility, ultimately leading to heart failure and neurohormonal activation.⁸ Studies report a prevalence of AF-associated TCM between 10% and 50% in patients with a heart failure diagnosis at admission.^{5,9} A tachyarrhythmia interval ranging from three to 120 days is reported to be necessary for the development of TCM.⁴

The correct diagnosis of TCM is of utmost importance, given that it is a potentially reversible disease with a good prognosis when treated effectively; it should be suspected in cases with evidence of

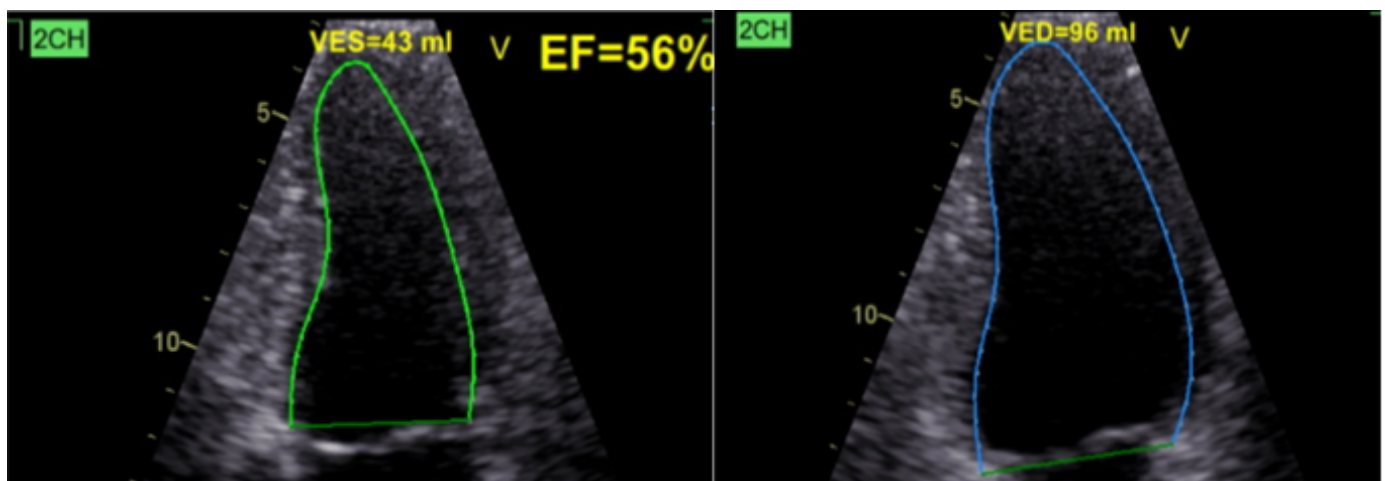


Figure 6 - 3-month Follow-up Transthoracic Echocardiography – Apical two-chamber view of the left ventricle showing a calculated ejection fraction of 56% and significant reverse remodelling.

persistent or frequently occurring tachycardia with newly diagnosed left ventricle dysfunction.⁷

Although classically defined by the reversibility of ventricular dysfunction induced by persistent arrhythmia,⁷ TCM lacks universally recognized diagnostic criteria or specific cut-off values. Multiple studies have investigated the role of echocardiographic parameters,^{10–12} NT-pro BNP levels, and resting heart rate⁹ in more accurately identifying AF or atrial flutter (AFL) induced TCM compared to heart failure with reduced ejection fraction accompanied by AF/AFL. Patients with TCM, compared to patients with dilated cardiomyopathy and AF typically had a younger age, smaller left ventricular end-diastolic diameter, reduced NT-pro-BNP levels, and higher resting heart rate upon admission (the ventricular rate that causes tachycardia-induced cardiomyopathy has not been determined, but any prolonged heart rate greater than 100 beats per minute may be important).^{7,10–12}

While atrial fibrillation ablation is typically considered an elective procedure within heart failure management, it extends its benefits beyond conventional criteria. Patients with tachycardiomyopathy with markedly reduced ejection fraction (<25%) present an apparent challenge for AF ablation due to their compromised cardiac function.¹³ Additionally, patients with a dilated left atrium are frequently not taken into consideration for ablation. Contrary to initial perceptions of severity, these patients remarkably benefit from AF ablation.¹⁴ Thus, individuals with tachycardiomyopathy emerge as substantial beneficiaries of AF ablation, showcasing the profound impact of this procedure on improving both cardiac function and patient outcomes. Consequently, the 2020 ESC Guidelines for the Diagnosis and Management of Atrial Fibrillation recommend AF catheter ablation as the first-line therapy when tachycardia-induced cardiomyopathy is considered highly probable (Class I, level of evidence B).⁶ The success rate following AF ablation is reported between 50% and 88% in both paroxysmal and persistent AF patients with heart failure and TCM.⁴ In contrast, antiarrhythmic treatment manages to maintain sinus rhythm in 30% to 50% of patients, in part secondary to frequent discontinuation due to side effects.¹⁵

Pulmonary vein isolation (PVI) is the most used approach in ablation of AF. Catheters are inserted from the right atrium through a transseptal puncture into the left atrium, and high-frequency energy sources, such as radiofrequency or cryotherapy, are utilized to electrically isolate the pulmonary veins from the rest of the left atrium and restore sinus rhythm.¹⁶ Alternative ablation lines (such as roof lines or mitral isthmus lines) or targeting atrial areas exhibiting high degrees of fractionated atrial electrograms could be utilized; however, their efficacy in persistent AF ablation remains insufficiently quantified¹⁷.

The time from successful heart rate control to recovery of systolic function is estimated, based on several studies, to be around four weeks^{11,18} and usually not beyond six months.¹⁹

It is crucial to note that patients recovering from TCM still face a risk of recurrence, indicating the persistence of structural changes caused by left ventricle remodeling, even after LV function normalization. This emphasizes the significance of long-term active surveillance.^{4,20}

In this young patient with a one-year history of heart failure, discerning whether tachycardiomyopathy solely represents the etiology or intricately coexists with a genetic component or idiopathic cardiomyopathy remains challenging. Both AF and idiopathic cardiomyopathy have been independently associated with diffuse fibrosis.²¹ Studies indicate that the improvement in left ventricular ejection fraction and reverse remodeling subsequent to catheter ablation in AF-induced TCM coincides with a regression of diffuse fibrosis.²⁰ Nonetheless, a greater extent of fibrosis persists compared to normal patients, suggesting a potential genetic predisposition to adverse remodeling. This suggests that despite the restoration of sinus rhythm, structural abnormalities in the heart may endure, necessitating ongoing medical therapies for heart failure²⁰.

Conclusion

This case underscores the critical role of atrial fibrillation ablation in patients suspected of having tachycardiomyopathy and emphasizes the substantial advantages of this procedure in

individuals experiencing incessant atrial fibrillation, particularly when conventional pharmacological and electrical rate and rhythm control strategies prove inadequate.

Early intervention not only links with the recovery of left ventricular function and a reduction in heart failure-related morbidity, mortality, and healthcare costs but also results in enhanced quality of life and offers a favorable long-term prognosis.

Ethics Compliance Statement

The authors affirm no conflict of interest related to this article. All procedures in this study adhere to the ethical standards outlined in the Helsinki Declaration of 1975, as revised in 2008(5), and comply with national laws. Informed consent was obtained from the patient.

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Conflict of interest

none declared.