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Case report

Left atrium remodeling after catheter ablation of atrial fibrillation

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ABSTRACT

Atrial fibrillation (AF) is the most common arrhythmia. Its association with the occurrence of cardiovascular embolic events and heart failure is high. Structural and functional changes are a fundamental part of the pathophysiological process, leading to left atrial myopathy and progressive left ventricular dysfunction that modifies the prognosis of patients. We present the case of a 75-year-old patient with symptomatic paroxysmal AF with adequate functional class who was referred for pulmonary vein ablation after antiarrhythmic therapy failure. The baseline echocardiogram showed preserved biventricular systolic function, mild diastolic dysfunction, and normal left atrium (LA) volumes. However, functional LA impairment was observed with decreased reservoir phase strain. Pulmonary vein isolation was successfully performed without evidence of new arrhythmic events, in addition to an improvement in LA reservoir strain, left ventricular (LV) global longitudinal strain, and myocardial work index at three-month follow-up. The patient has remained asymptomatic and is under clinical follow-up. LA and LV strain as new advanced echocardiography techniques are useful in the assessment of reverse remodeling of atrial myopathy and LV structural damage.

Keywords: Atrial Fibrillation; Heart Failure; Echocardiography; Catheter Ablation (source: MeSH-NLM).

Introduction

Atrial fibrillation (AF) is currently the most common arrhythmia, and reports show that it affects about 2% of the general population [1]. Its presence is related to the occurrence of embolic cerebrovascular events [2], left ventricular (LV) systolic dysfunction with the consequent onset or worsening of heart failure (HF) [3,4], decreased quality of life and a greater incidence of death from cardiovascular causes [5]. Therefore, early diagnosis is crucial to avoid adverse outcomes.

The rhythm control strategy of restoring and maintaining sinus rhythm is currently the option of choice, especially in early stages of the disease. This can include a combination of treatment approaches, including electrical cardioversion, antiarrhythmic medication and catheter ablation, together with adequate rate control, anticoagulation therapy and comprehensive cardiovascular prophylactic therapy [1]. In this regard, catheter ablation has been shown to be effective for the maintenance of sinus rhythm in patients with paroxysmal and persistent AF. Catheter ablation is generally recommended as first-line (IIa) or second-line (Ia) therapy after failure (or intolerance) of antiarrhythmic drugs. This recommendation is based on the results showing the catheter ablation superiority with respect to the absence of recurrent arrhythmia, symptoms improvement, exercise capacity and quality of life after medication failure with the highest level of

recommendation and scientific evidence in accordance with current guidelines (class I recommendation, level of evidence A) [1].

On the other hand, the performance of a transthoracic echocardiogram is indicated in all patients with a recent diagnosis of AF, since it allows us to evaluate the anatomical and functional impact of the arrhythmia [6]. Initially, the evaluation focused on left atrial (LA) structure and size, valvular anatomy, and LV systolic and diastolic function. However, new echocardiographic techniques, such as myocardial deformation, have proven to have an added value in the evaluation. The study of myocardial deformation based on speckle tracking is currently the most widely used technique in this regard. We report the impact on LA reverse remodeling by advanced echocardiographic techniques in an early stage of atrial myopathy in a patient with paroxysmal AF after radiofrequency ablation of pulmonary veins by determining the LA reservoir strain value at follow-up. LA strain is a novel cardiac imaging method for the study of atrial function and the different phases of atrial filling. Reservoir strain is the most studied parameter and its normal value in a meta-analysis was estimated at 39% (95% confidence interval [CI]: 38-43) [7].

Case report

We present the case of a 75-year-old male patient with a history of arterial hypertension, who was referred for cardiological study and follow-up due to palpitations. He reported a history of paroxysmal AF of 8 months of evolution, without pharmacological treatment. He had New York Heart Association (NYHA) functional class I. Cardiovascular physical examination was normal. The baseline electrocardiogram (ECG) showed sinus rhythm, signs of left atrial enlargement, narrow QRS complex with left anterior hemiblock, right bundle branch conduction delay, with repolarization and corrected QT interval **(Figure 1).**

Rate control was started with bisoprolol 5 mg once a day and rhythm control with propafenone 150 mg every 12 h. Because of high thromboembolic risk (CHA2DS2-VASc score = 3) and low bleeding risk (HASBLED score 1), oral anticoagulation (apixaban 5 mg every 12 h) was indicated. A few weeks later, the patient presented with a new arrhythmic event despite treatment and was admitted to the emergency room where a new episode of AF was observed **(Figure 2),** requiring successful pharmacological cardioversion.

A transthoracic echocardiogram (TTE) in sinus rhythm performed prior to the last arrhythmic recurrence showed normal cardiac chamber size, preserved LV systolic function with an estimated LV ejection fraction (LVEF) of 58% and an estimated global longitudinal strain (GLS) of -18%. Diastolic dysfunction was observed with a prolonged relaxation pattern without signs of increased LV filling pressures, with an E/e' ratio of less than 8. LA with normal end-systolic volume of 36 mL, (21 mL/m2); however,

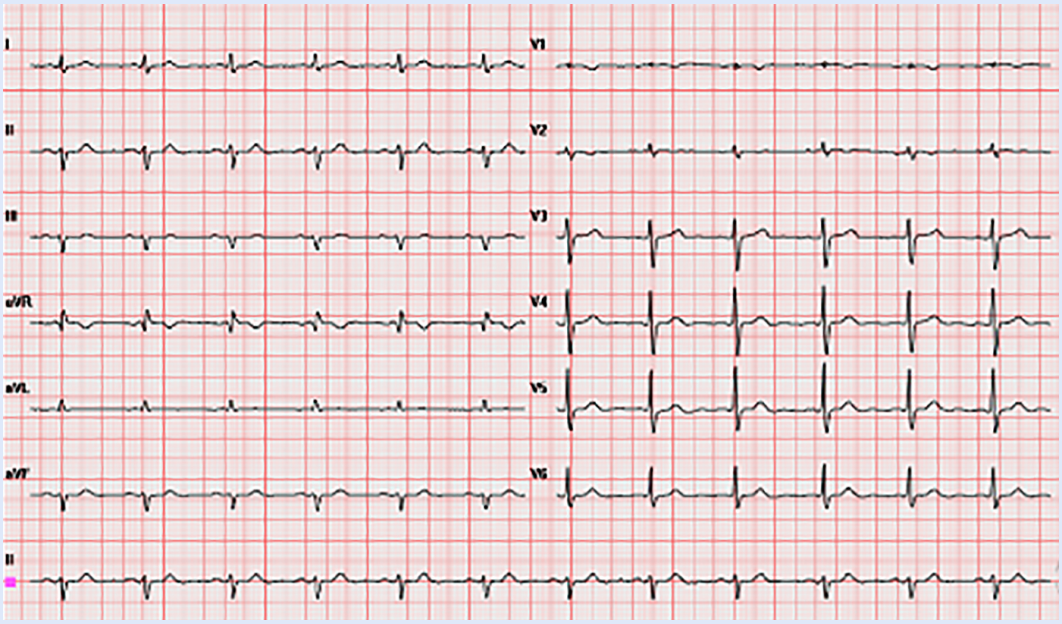

Figure 1. Baseline 12-lead electrocardiogram.

a decreased reservoir strain of 18% and no evidence of significant valvular heart disease or pulmonary hypertension were observed **(Figure 3).**

As part of the rhythm control strategy, it was decided to perform pulmonary vein isolation, a procedure that was successfully performed. The post-ablation voltage map showed electrical isolation of the four pulmonary veins, showing low voltage in the posterior wall, probably secondary to the extensive antral isolation during catheter ablation **(Figure 4).**

The echocardiogram at 3-month follow-up after catheter ablation (blanking period) showed an LA end-systolic volume of 30 mL (17.6 mL/m^2) and an improvement in LA reservoir strain of 27%, as well as an improvement in LV-GLS and myocardial work index (MWI) **(Figures 5 and 6).** After antiarrhythmic therapy (propafenone) was completed during the blanking period, the patient progressed from a European Heart Rhythm Association classification of EHRA IIb (moderate symptoms without quality-of-life impairment) to EHRA I (no symptoms) and has remained in that classification. Serial electrocardiograms have shown sinus rhythm [1].

Discussion

Recently, the term "AF-mediated cardiomyopathy" has been established to express an important reversible cause for the development of HF that is underdiagnosed in current cardiological practice. It describes AF as the cause of *de novo* ventricular dysfunction or worsening functional class in previously diagnosed patients. This, in turn, could lead to structural and functional remodeling of the left atrium and irreversible ventricular dysfunction if not treated early [8]. In this regard, radiofrequency AF ablation is currently the most effective treatment for rhythm control [9], with a success rate of 60-90% after two years in paroxysmal AF and 50-80% in persistent AF, compared to 20-40% demonstrated with pharmacological therapy. Therefore, it constitutes the best current strategy for rhythm control.

The new techniques in echocardiography, such as the study of myocardial deformation with GLS, LA reservoir strain and MWI using speckle tracking have proven to be useful in identifying early- stages alterations in different clinical scenarios. Despite its limitations, the LVEF remains the most used parameter for assessing systolic function in clinical practice [10]. On the other hand, LV-GLS has shown to be a sensitive marker of subclinical myocardial dysfunction since it reveals abnormalities in myocardial deformation under conditions where LVEF remains normal [11]. However, it also has limitations as it is dependent on load conditions. Recently, a non-invasive method for evaluating regional MWI has been incorporated using the tension/pressure deformation loop analysis of the LV through echocardiography.

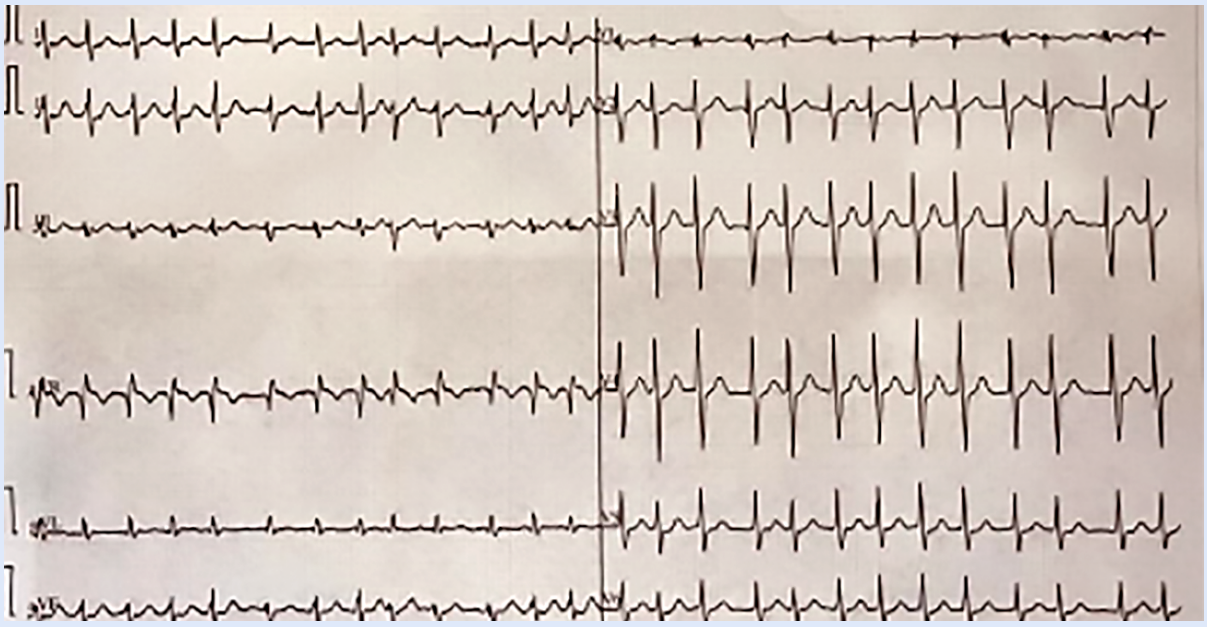

Figure 2. 12-lead ECG in the context of palpitations showing paroxysmal AF. ECG: electrocardiogram, AF: atrial fibrillation.

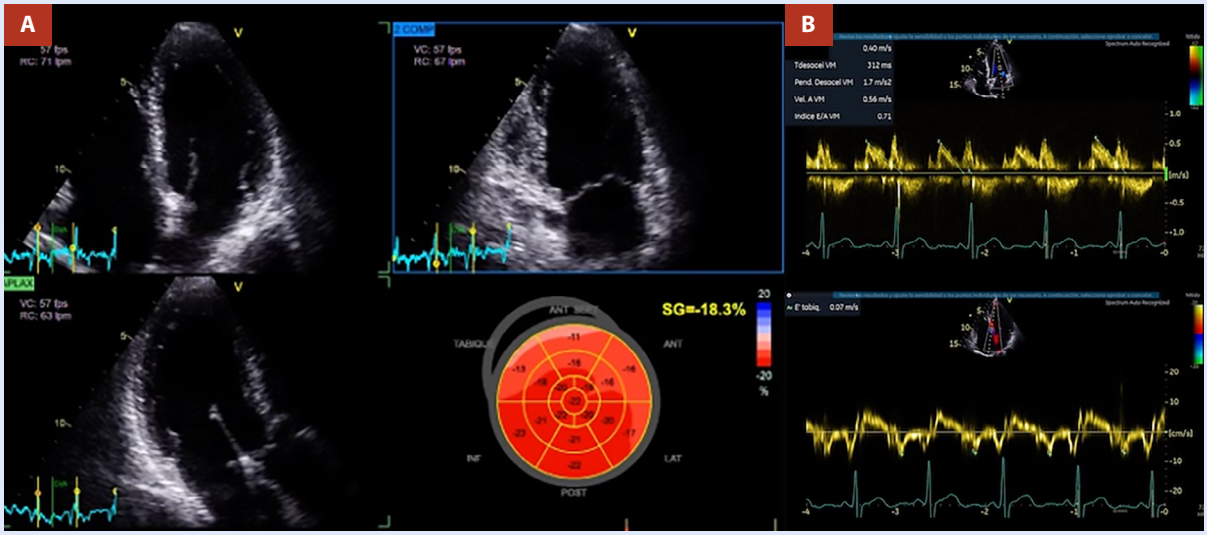

Figure 3. EInitial transthoracic echocardiogram. **A.** Four-chamber, two-chamber, and three-chamber views of the left ventricle (LV) with normal volumes and preserved LV ejection fraction (LVEF) of 58%. **B.** Prolonged relaxation pattern of the LV and an E/e ratio of 5, consistent with the absence of increased LV filling pressures.

Since the MWI incorporates LV pressure, it provides incremental information on LVEF and strain, which are sensitive to LV afterload. Furthermore, since the area of the tension-pressure loop reflects myocardial metabolic demand and oxygen consumption, this method provides information on myocardial energy used [12]. The evaluation of parameters such as "constructive work" analyzes LV segments that contract synchronously and efficiently in order to contribute to systolic volume during LV contraction. In pathological situations, there may be systolic lengthening of different segments during LV contraction, a condition referred to as "wasted work" as it does not contribute to LV ejection. Similarly, systolic shortening after aortic valve closure (postsystolic contraction) is termed "lost work" as it also does not contribute to efficient contraction and effective systolic volume. Finally, "myocardial work efficiency" is known as the ratio between

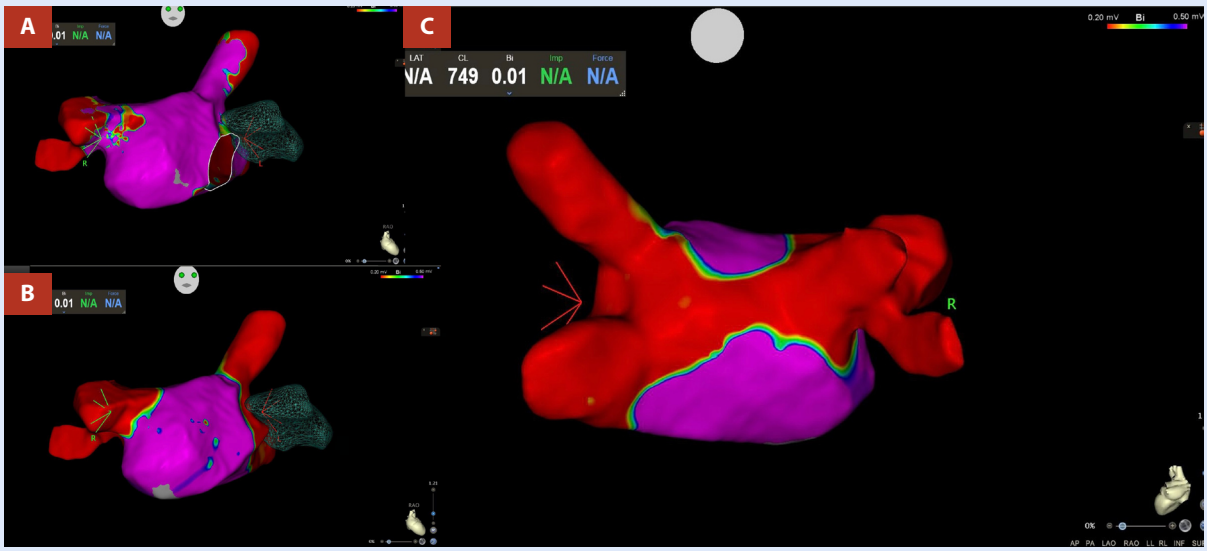

Figure 4. Pulmonary vein isolation. **A.** Voltage map of the LA showing electrical connection between PVs and LA. **B.** and (C) Voltage map showing electrical disconnection between PVs and LA post-ablation. PVs: pulmonary veins. LA: left atrium.

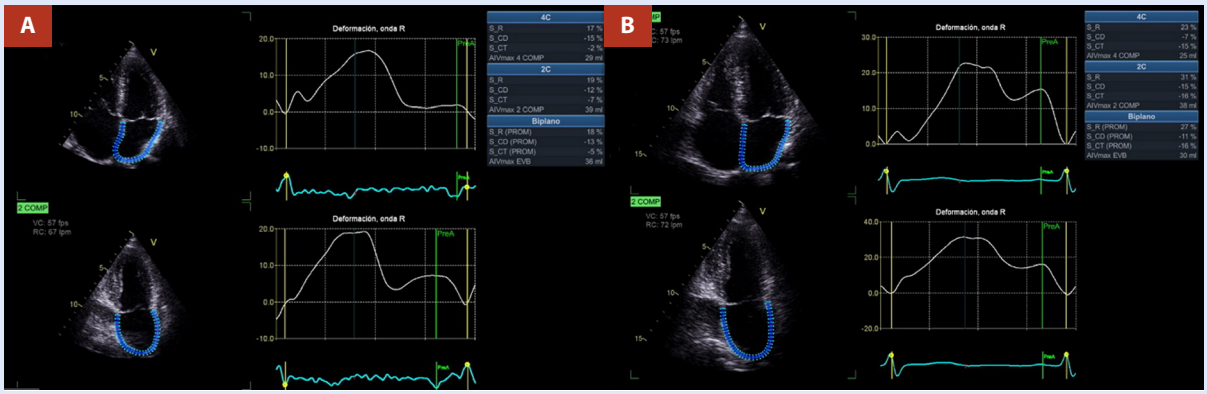

Figure 5. Comparative reservoir strain of the left atrium (LA) pre- and post-pulmonary vein isolation. **A.** Pre-ablation four-chamber and two-chamber apical views of LA in atrial fibrillation (AF) with an estimated volume of 36 mL and reservoir strain estimated at 18%. **B.** Post-ablation four-chamber and two-chamber apical views of LA in AF with an estimated volume of 30 mL and reservoir strain of 27%.

constructive work and the sum of wasted and constructive work, reported as a percentage or as a relationship to 1 as the maximum value [12].

The evaluation of LA strain has become a novel imaging method with superior prognostic value compared to left atrial volume indices and tissue Doppler diastolic function assessment parameters. The LA has three functions, with the reservoir function being the most important. Recently published data suggest the prognostic value of left atrial reservoir function in HF, AF, stroke, and valvular heart disease.

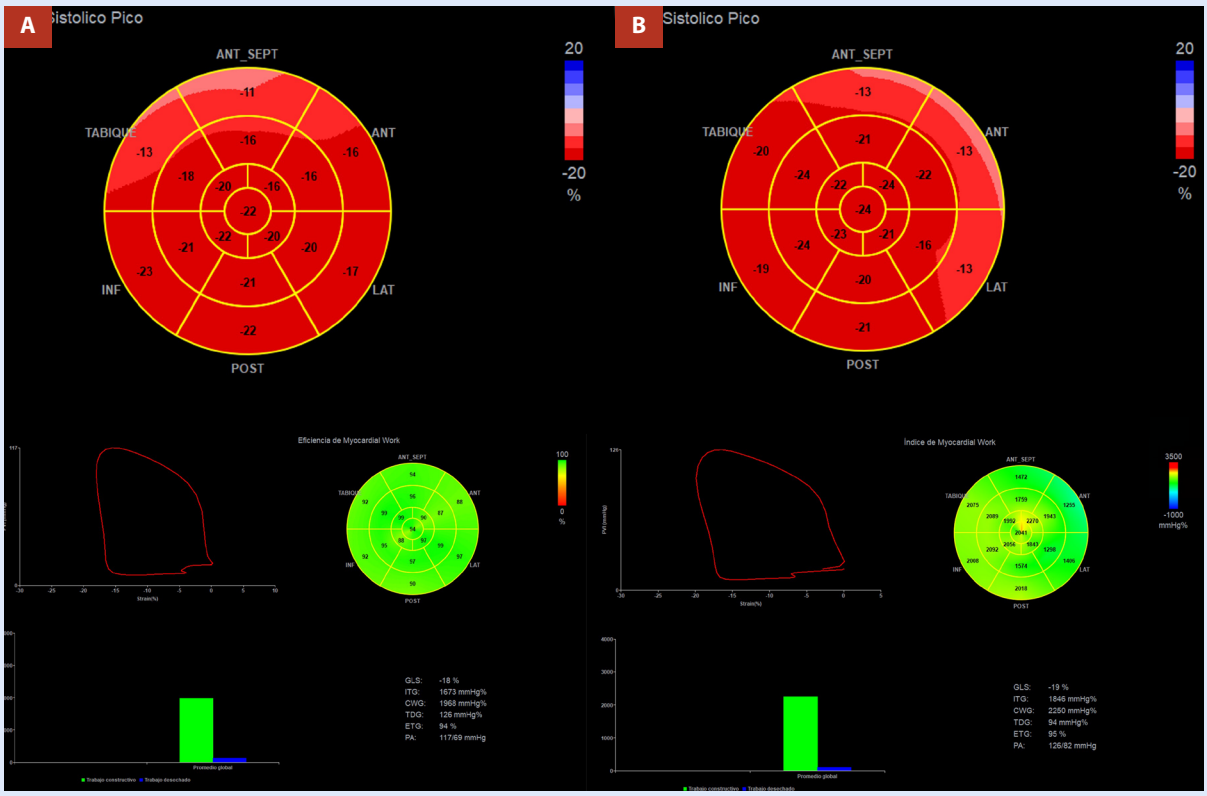

Figure 6. Comparative analysis of myocardial efficiency parameters of the left ventricle (LV) pre- and post-ablation of atrial fibrillation (AF). **A.** Pre-ablation LV global longitudinal strain (GLS) with GLS value of -18.3%, myocardial work index (MWI) of 1673 mmHg%, and myocardial work efficiency of 94%. **B.** Post-ablation LV GLS with GLS value of -19.9%, MWI of 1846 mmHg%, and myocardial work efficiency of 95%.

In addition, left atrial reservoir overload was shown to be a predictor of cardiovascular morbidity and mortality in the general population [12]. This parameter is estimated by TTE by processing LA filling curves acquired from four- and two-chamber apical views. Lastly, it is worth noting that LA strain is dependent on loading conditions and is strongly influenced by the LA by LV function, indicating a clear relationship between the two.

In our case report, we highlight the contribution of these new myocardial deformation techniques in the context of radiofrequency ablation of AF. In addition to the patient's symptomatic improvement and the disappearance of symptoms after the procedure, although the follow-up is short and longer observation time is required, it was related to improvement of LA reservoir function parameters, even without evident changes in volumes or diastolic function parameters. In addition to improvement of systolic function parameters without changes in LVEF, such as improvement in GLS, MWI, a lower value of wasted myocardial work, and subsequent improvement in myocardial work efficiency.

In conclusion, the new echocardiographic strain techniques make it possible to reveal subclinical structural and functional damage that may be reversible on follow-up beyond conventional parameters. The present case shows a marked improvement of LA strain at short-term follow-up in a patient after AF ablation, suggesting reverse remodeling, suggesting a regression of atrial myopathy that may be associated with a higher rate of cardiovascular events.

Author contributions

Conceptualization: DXCA and JFPV; Writing - Original draft preparation/Writing - Review and editing: DXCA, JFPV, CT, XP, JC, and JR.

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