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ADVANCED

CASE REPORT: CLINICAL CASE

Long-Term Follow-Up of Cardioneuroablation to Treat Second-Degree Block After Slow Pathway Ablation

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ABSTRACT

We present the long-term follow-up of a 31-year-old woman who underwent cardioneuroablation (for atrioventricular (AV) block. Slow pathway ablation was performed in September 2017 with normal follow-up until April 2018, when the patient started noticing symptoms of palpitations at rest, and the electrocardiogram showed a Mobitz I AV block. A cardiac stress test and 24-h Holter monitoring demonstrated first- and second-degree block and normal AV conduction during times of higher heart rate. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2020;2:1781-8)

HISTORY OF PRESENTATION

The patient was a symptomatic 31-year-old woman with no comorbidity who presented with new symptoms of palpitations, fatigue, dizziness, and irregular cardiac rhythm on physical examination. She underwent cardioneuroablation (CNA) to treat a first- and second-degree atrioventricular (AV) block that occurred after undergoing slow pathway ablation (SPA) 9 months earlier.

LEARNING OBJECTIVES

- AV after SPA may be functional and can be treated with CNA in selected cases.
- CNA can be reproduced in electrophysiology laboratories in selected patients with good results by using an anatomic approach.

PAST MEDICAL HISTORY

The patient described a long history of tachycardic palpitations with shortness of breath and the need to perform vagal maneuvers or go to the emergency department (ED) to convert tachycardia to sinus rhythm. Treatment with beta-blockers and propafenone failed, and the patient was referred back to our center (Santa Rita de Cassia Hospital) to perform

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ABREVIATIONS AND ACRONYMS

AV = atrioventricular

CNA = cardioneuroablation

ED = emergency department

EPS = electrophysiological study

FFT = fast Fourier transform

SPA = slow pathway ablation

catheter ablation of supraventricular tachycardia. In September 2017, the patient underwent SPA with success and no complications. Eight months later, she started experiencing fatigue, dizziness, fainting, and abnormal heartbeats. She became highly symptomatic and went to the ED, where she was found to have an irregular cardiac rhythm with several pauses during auscultation. The electrocardiogram at this time showed a first-degree AV block.

DIFFERENTIAL DIAGNOSIS

After the ED visit, during a regular appointment, a new resting electrocardiogram (Figure 1) was performed. Second-degree Mobitz I block was diagnosed (documentation of consecutive AV prolongation). In normal and young patients, the obvious diagnosis would be a functional AV block. However, in our case, the first thought was a lesion in the fast pathway because the patient no longer reported her previous symptoms.

INVESTIGATIONS

The patient underwent a stress treadmill test and 24-h Holter monitoring to detect higher degrees of AV block. Holter monitoring showed the presence of first- and second-degree AV blocks, including a 2:1 AV block during sleep (Figure 2) and normal AV conduction when the heart rate was higher (Figure 3, Table 1). To our surprise, there was an improvement in AV conduction during higher exercise velocity in the Ellestad protocol, a change suggesting parasympathetic behavior of the AV node. On the basis of these findings, in June 2018, we decided to perform CNA.

MANAGEMENT

We performed CNA (1) on an anatomic basis and by indirect spectral analysis with the fast Fourier transform (FFT), targeting the ganglionic plexus localized in the right and left atria and the coronary sinus (2) (Figures 4 to 7) to increase and normalize AV conduction and avoid vagal effects and, consequently, functional blockades. The procedure was performed with the patients in a fasting state under general anesthesia, by using the EP Tracer recording system (CardioTek, Sittard, the Netherlands), and EnSite Velocity 5.0 (St. Jude Medical [now Abbott], Abbott Park, Illinois).

Before CNA, we performed a basal electrophysiological study (EPS) and administered 3 g of atropine to prove that the AV conduction normalized during the drug effect. After that, we conducted a new EPS with and without atropine. Major EPS findings pre-ablation were normal. Her His-ventricle interval was normal, with no AV jump or echo beats. There was an increase in heart rate after atropine by 114%, from 56 to 103 beats/min, and there was normal AV conduction. The Wenckebach point decreased from 520 to 410 ms, and the AV refractory period decreased from 500 to 310 ms before and after atropine, respectively. Finally, at this point we started the ablation procedure. Electrical targets for ablation were high frequency, and long fractionated signals were seen in the distal and proximal catheter dipoles and at abnormal FFT signals. Heart rate increase during radiofrequency applications was higher at these sites than at other sites without these characteristics.

After CNA, the final heart rate was 97 beats/min (Figure 8). EPS with and without atropine showed no heart rate increase, a Wenckebach point at 430 ms, and an atrial refractory period of 340 ms, thereby displaying a loss of parasympathetic behavior.

DISCUSSION

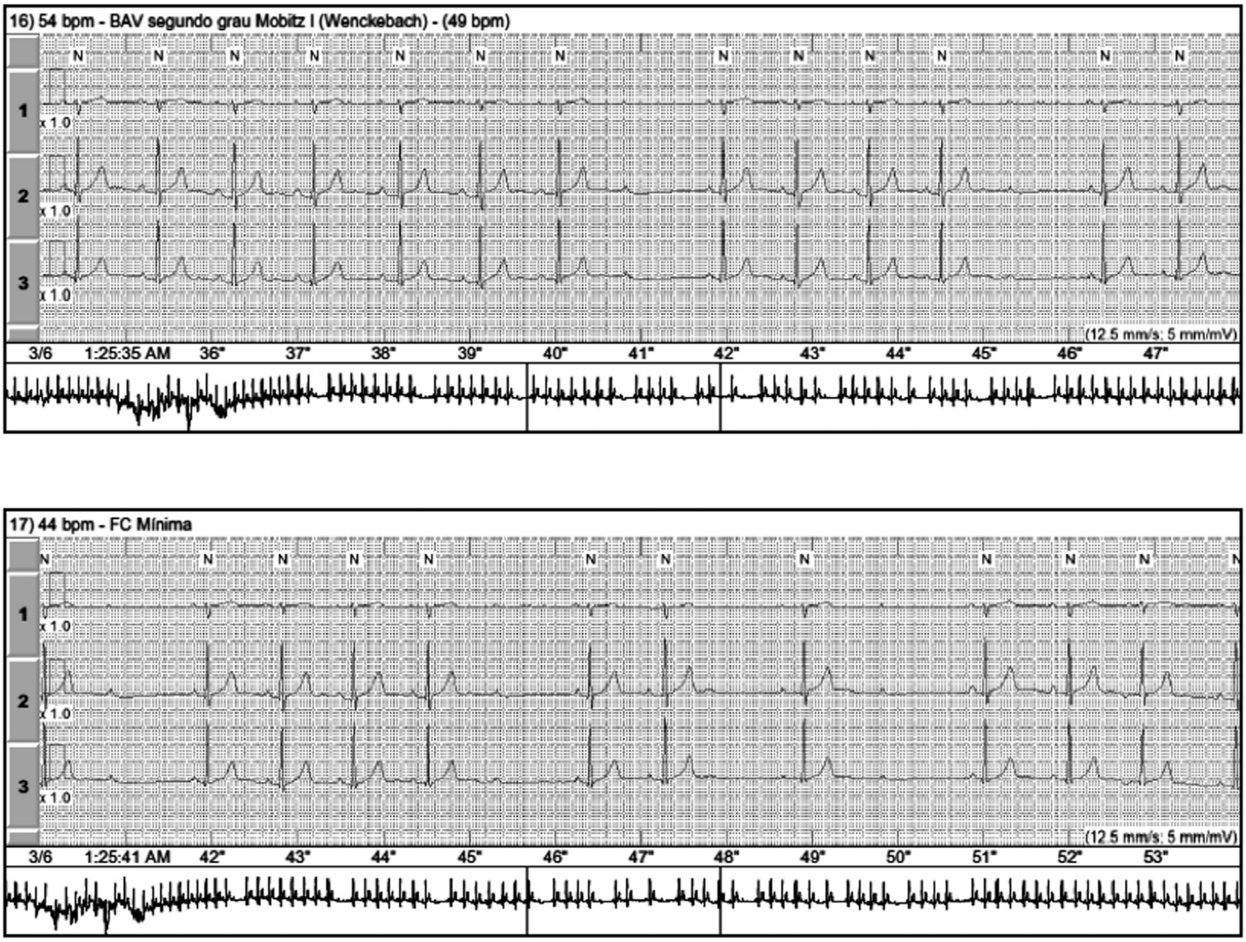
Three main parasympathetic ganglia are found outside the atrial wall in paracardiac fat pads that provide innervation to the heart (2), and they are subdivided into ganglia A, B, and C. Ganglion A is located between the aorta and the superior vena cava (Figure 7), ganglion B is located between the right pulmonary veins and the right atrium (Figures 4 to 6), and ganglion C is located between the inferior vena cava and at the wall between the right atrium and left atrium (Figures 4 to 6). Ganglion A appears to be the most important of the vagal fibers, traveling to the atria and to the sinus and AV nodes. Bilateral vagal fibers to the sinus and AV nodes converge first at ganglion A and then project to ganglia B and C, which provide vagal innervation to the sinus and AV nodes, respectively.

Pachon et al. (1) were the first to report CNA through catheter ablation guided by FFT analysis as an alternative treatment for functional high-degree AV block. In 7 of the 21 patients included in their study, the diagnosis was intermittent high-degree AV block. The procedural endpoint was normalization of AV conduction. In 3 patients, the procedure was performed only through the right atrium, and 1 of

FIGURE 1 Resting Electrocardiogram

Atrioventricular block with progressive atrioventricular prolongation.

FIGURE 2 **Holter Monitoring**

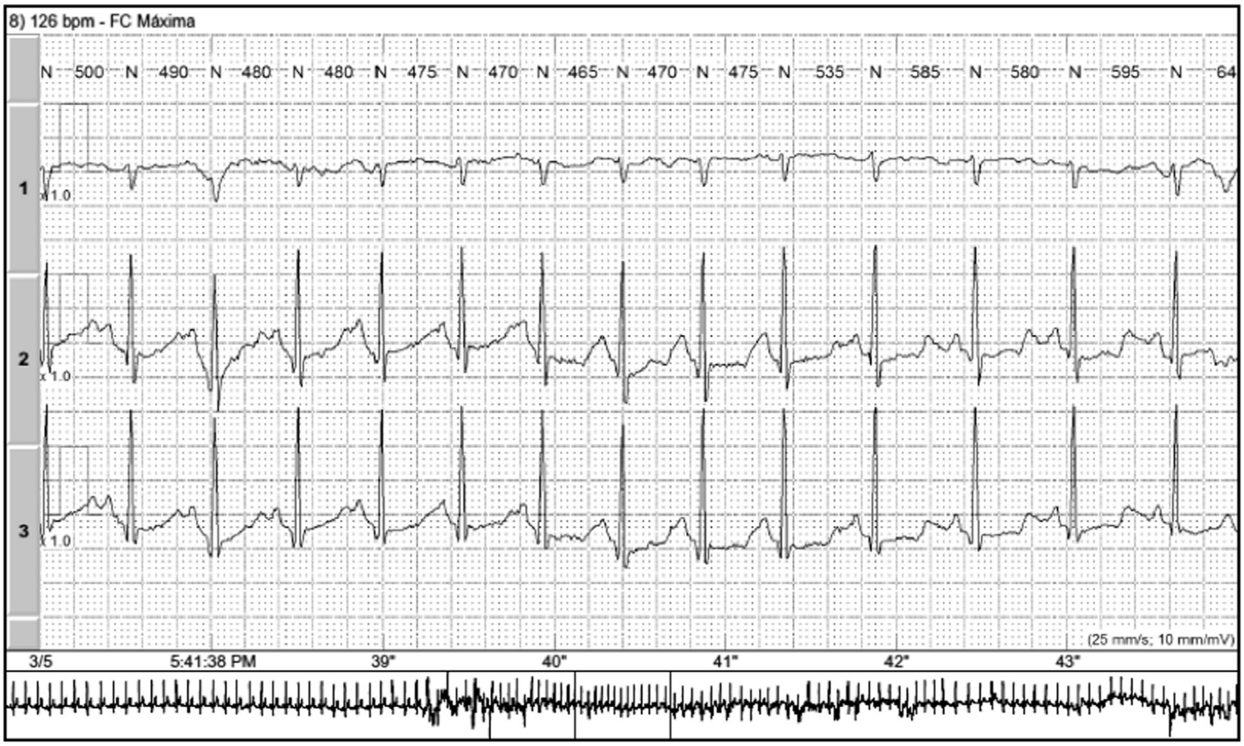


Second-degree atrioventricular block (Mobitz I [Wenckebach]) at the **top** and a 2:1 atrioventricular block at the **bottom** (lower heart rate of 44 beats/min during sleep).

these patients still experienced nocturnal Mobitz type I AV block after the procedure. Long-term follow-up results presented in another study (3) concluded that endocardial radiofrequency ablation of neurally mediated reflex syncope through both atria has excellent results in some patients and may prevent the need for pacemaker implantation.

Anatomically mediated CNA has been increasingly used to treat severe vagally related arrhythmias worldwide (1,3-6). Although guidelines (7) indicate pacemaker implantation for cases of symptomatic AV block, when patients are mostly young and otherwise healthy, we encourage a conservative approach. The intrinsic cardiac nervous system forms a complex neural network composed of the ganglia plexus and interconnecting axons. Larger ganglia are observed close to the pulmonary vein and serve as autonomic integration centers, modulating cardiac excitability. This widely distributed structure cannot be entirely targeted. A comprehensive and selective approach is required and is meant to promote attenuation instead of total vagal blockade, and a step-by-step test with extracardiac vagal stimulation can be a much wiser approach to management during this type of

FIGURE 3 Holter Monitoring



Higher rate with normal atrioventricular conduction.

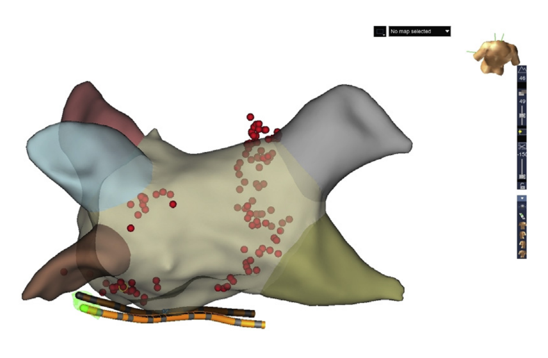
procedure. With anatomic knowledge and previous descriptions, Aksu et al. (8) successfully performed a similar procedure to treat 2:1 AV block induced after an SPA in a 54-year-old woman. The major difference between the 2 approaches was that we targeted the 3 ganglia localized in both atria because of their interactions. The pitfall of our method was the atropine test performed during the procedure, before CNA.

TABLE 1 Pre- and Post-Ablation 24-h Holter Monitoring

24-h Holter Monitoring, Duration	Heart Rate, beats/min			Long Pause, s	First-Degree Block	Second-Degree Block	High-Degree Block	SDNN, ms	PNN50, ms
	Lower	Medium	Maximum						
Pre-ablation	44	72	126	2.13	Yes	Yes	Yes	123	25
7 days	57	83	124	1.12	No	No	No	114	1.15
30 days	54	80	139	1.31	No	No	No	138	1.38
6 months	62	79	131	0.97	No	No	No	83	0.5
12 months	51	74	120	1.34	No	No	No	127	1.76
18 months	54	76	132	1.11	No	No	No	88	1
24 months	56	81	140	1.07	No	No	No	82	1

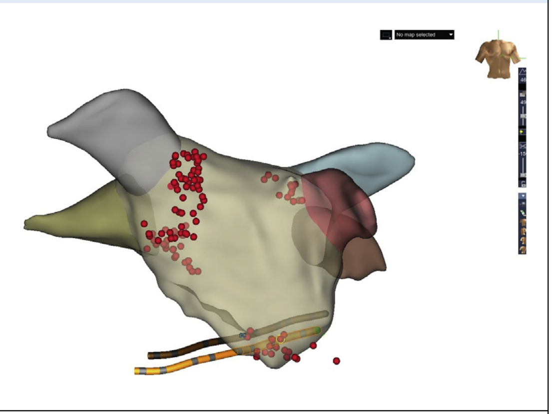
PNN50 = proportion of NN50 divided by the total number of NN (R-R) intervals; SDNN = standard deviation of the NN (R-R) intervals.

FIGURE 4 Posteroanterior View of 3-Dimensional Mapping



Red dots indicate radiofrequency applications on the left side parasympathetic plexus (posteroanterior view).

FIGURE 5 Anteroposterior View of 3-Dimensional Mapping



Red dots indicate radiofrequency applications on the left side parasympathetic plexus (anteroposterior view).

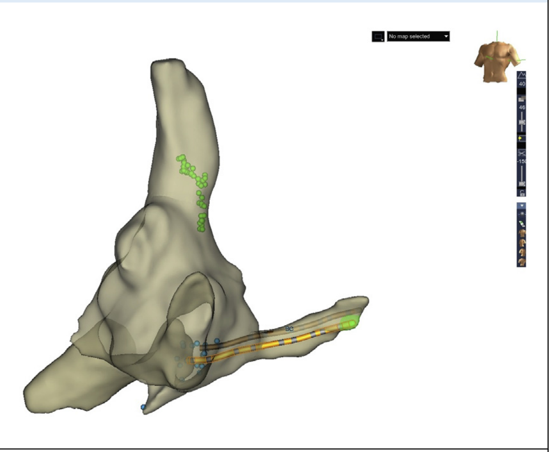
The major explanation for this is that the atropine test is not a procedure that can be done routinely in public and private hospitals in Brazil. However, the way that we addressed the vagal ablation response, even with the residual atropine effect, is the heart rate increase during radiofrequency application. In this specific case we show the 2-year follow-up of the patient that may prove that the AV conduction was normalized and stayed normal after the procedure.

Targeting all the ganglionated plexus could be a risk if continuous monitoring by extracardiac vagal stimulation is not performed because AV block can become more severe if you denervate only the sinus node with the heart rate increase. Therefore, an individualized approach to ensure the objectives and success of the CNA is mandatory.

FOLLOW-UP

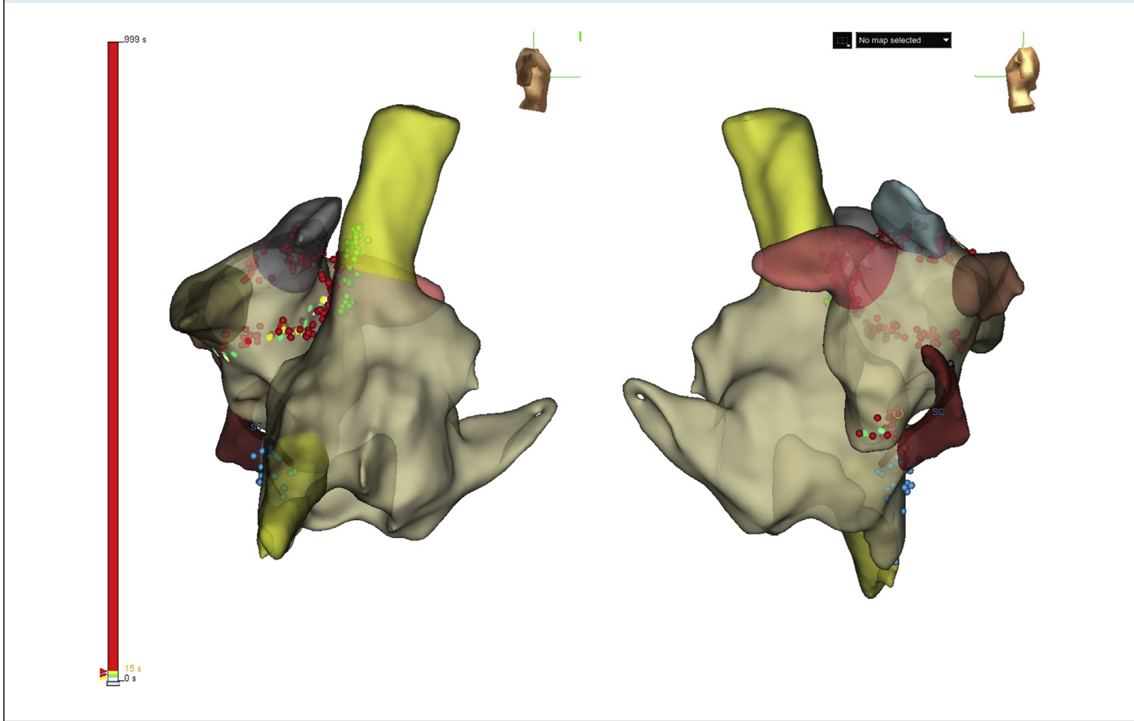
This is 1 of few reported cases of catheter ablation-based treatment to improve AV conduction to avoid pacemaker implantation. Like the case reported by Bulava et al. (9), our case involved a young woman with second-degree AV blocks after an SPA. The 2 cases showed complete resolution of the AV blocks at times of higher heart rate and after atropine infusion. Our follow-up was longer and included 24-h Holter monitoring at 7 and 30 days and at 6, 12, 18 and 24 months. Follow-up results were completely within normal parameters, thereby showing that the CNA approach resulted in successful treatment.

FIGURE 6 3-Dimensional Right Atrium Map



Green dots indicate radiofrequency applications in the superior vena cava and aorta, and **blue dots** indicate the atrioventricular plexus (posterior coronary sinus).

FIGURE 7 **3D View of RA and LA With RF Applications**



Combined 3-dimensional mapping of the left and right atrium with radiofrequency lesions in the parasympathetic plexus (**red and yellow dots** indicate left atrium radiofrequency lesions; **green dots** indicate right atrium radiofrequency lesions; **blue dots** indicate coronary sinus radiofrequency lesions).

CONCLUSIONS

As in other investigators' case series, our results of CNA for the treatment of functional sinus bradycardia and AV blocks are encouraging and excellent. They enable us to avoid pacemaker implantation in a selected group of patients.

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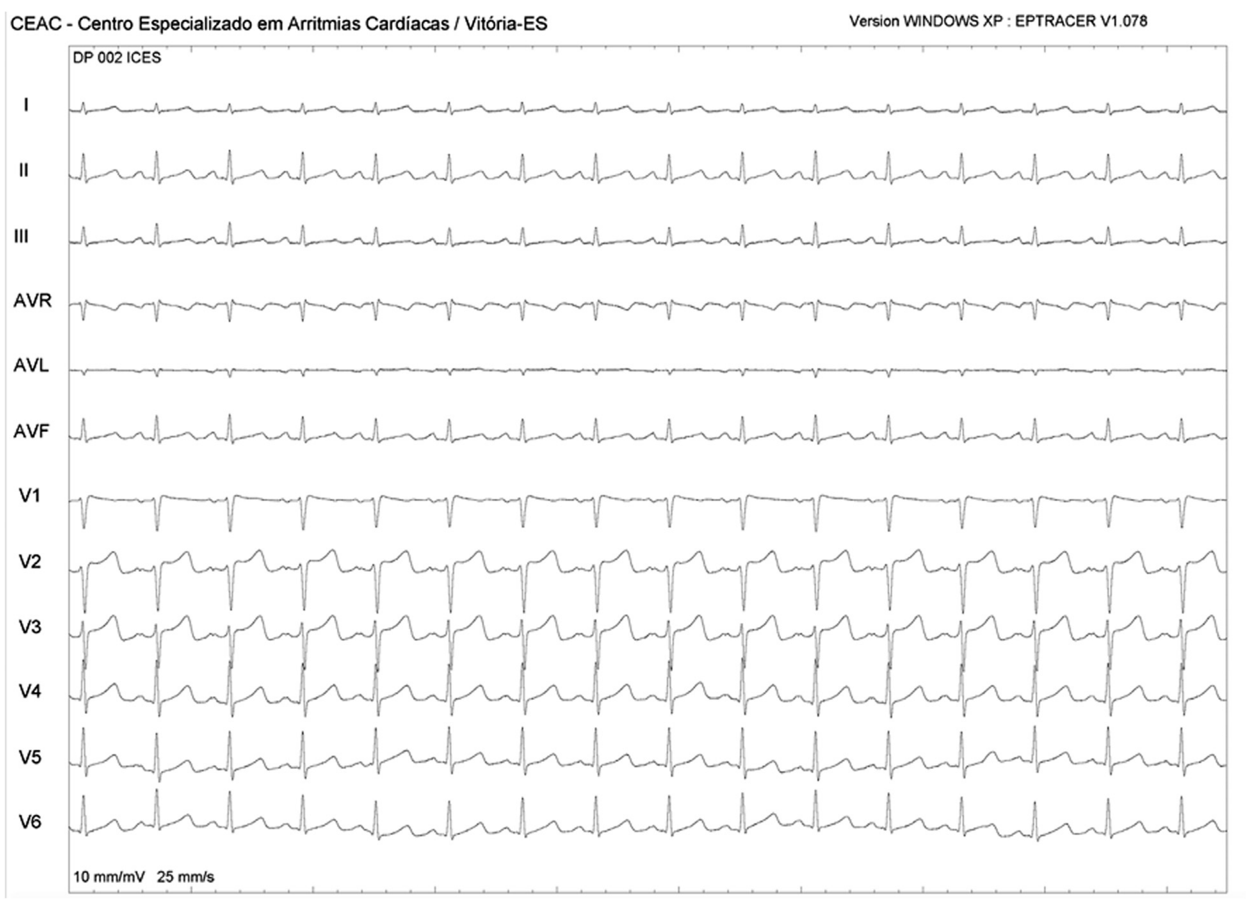
FIGURE 8 Final ECG



Post-cardioneuroablation negative atropine response (heart rate, 97 beats/min). ECG = electrocardiogram.

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KEY WORDS ablation, bradycardia, cardiac pacemaker, electroanatomic mapping