JACC: CASE REPORTS VOL. 3, NO. 18, 2021

CASE REPORT

INTERMEDIATE

CLINICAL CASE

Atrial Fibrillation Originating in the Inferior Vena Cava

A Typical Presentation of an Atypical Location

Concepción Alonso-Martín, MD, PhD, Santiago García Mancebo, MD, Bieito Campos García, MD, Jose Guerra Ramos, MD, PhD, Zoraida Moreno Weidman, MD, Francisco Méndez Zurita, MD, Rodolfo Montiel Quintero, MD, Andrés Betancur Gutiérrez, MD, Xavier Viñolas, MD, PhD, Enrique Rodríguez Font, MD

ABSTRACT

Recurrence of atrial fibrillation (AF) despite successful isolation of the pulmonary veins (PVs) represents a great challenge. We present a patient with recurrent episodes of paroxysmal AF despite PV isolation in which a non-PV trigger was identified in the inferior vena cava. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2021;3:1918–1923) © 2021 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

INTRODUCTION

Triggers outside the pulmonary veins (PVs) may be responsible for atrial fibrillation (AF) recurrence despite successful PV isolation (1). Previous studies have shown that non-PV triggers can be elicited in 11% of patients at the first AF ablation procedure and in up to 45% of patients who undergo a second AF ablation procedure (2,3).

LEARNING OBJECTIVES

- To highlight the value of the electrocardiogram in the recognition of premature atrial complexes that originate apart from PVs, even when the clinical presentation remains that of focal AF originating from PVs.
- To recognize the importance of non-PV triggers in patients with recurrent AF despite PV isolation.
- To show, in high-density mapping, a very unusual anatomical origin as a trigger for AF.

HISTORY OF PRESENTATION

A 47-year-old male patient was evaluated in the Hospital de la Santa Creu i Sant Pau in Barcelona, Spain, with recurrent episodes of paroxysmal AF despite 2 previous AF ablation procedures. His physical examination was normal, and the electrocardiogram (ECG) showed normal sinus rhythm at the time of the outpatient consultation.

PAST MEDICAL HISTORY

Circumferential PV isolation in combination with cavotricuspid isthmus ablation was first performed in 2016. During follow-up, recurrence of AF was documented, and 2 years later, the patient

From the Arrhythmia Unit, Department of Cardiology, Santa Creu i Sant Pau Hospital, CIBERCV, HSCSP-IIB Sant Pau Research Institute, Autonomous University of Barcelona, Barcelona, Spain.
The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

Manuscript received August 3, 2021; revised manuscript received September 24, 2021, accepted November 2, 2021.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2021.11.001

underwent a new ablation procedure in which PV reconnection was identified in 2 of 4 PVs. After complete reisolation of the PVs, the presence of any dormant conduction was ruled out by a rapid infusion of adenosine triphosphate (30 mg). In addition, programmed atrial stimulation at different cycle lengths (500, 400, and 350 ms) with coupling of up to 3 extrastimuli and rapid atrial pacing (shortest cycle length of 250 ms) were performed at baseline and during isoproterenol infusion (4 μg/min) without induction of AF or non-PV triggers. The patient was discharged with antiarrhythmic treatment (flecainide 100 mg twice daily). During follow-up, the patient continued to report episodes of palpitations lasting hours.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis of paroxysmal AF at that time included reconnection of previous isolated PVs, arrhythmogenic foci outside the PVs, or other causes related to systemic disorders.

INVESTIGATIONS

The results of laboratory testing, ECG, and echocardiography were unremarkable. Interestingly, a 24-hour Holter monitor showed repetitive monomorphic premature atrial complexes (PACs), some of them not conducted to the ventricle and some of them triggering AF (Figure 1). Finally, a new ablation procedure was scheduled.

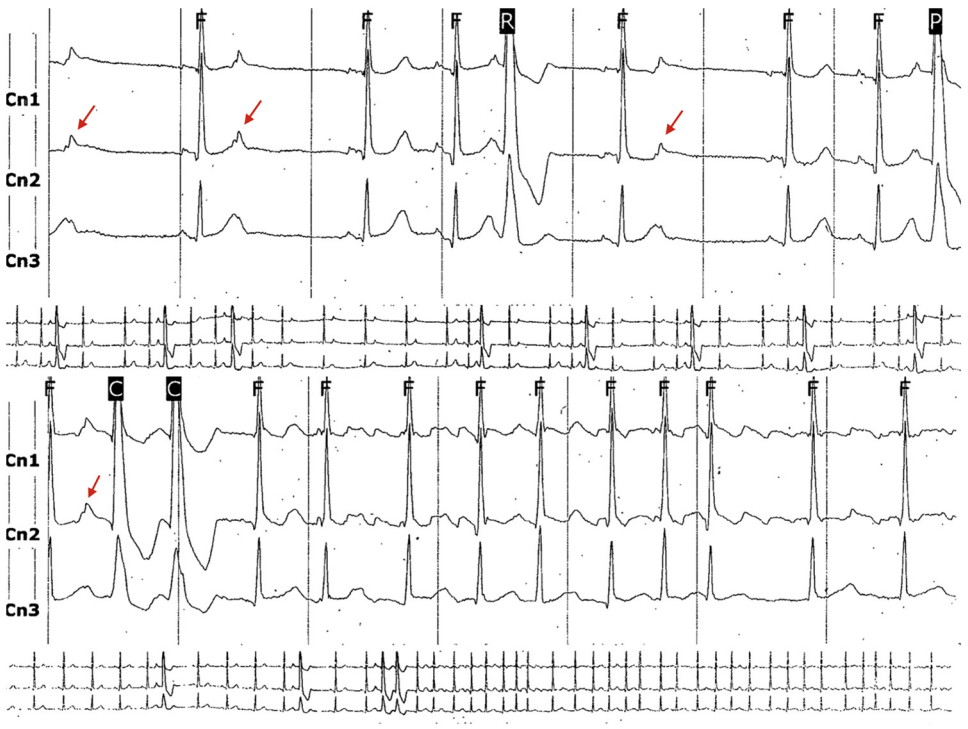
MANAGEMENT

The patient presented in the electrophysiology laboratory with repetitive PACs, some of them nonconducted to the ventricle, that exhibited a P-wave configuration negative in inferior leads, positive in lead V_1, and negative from leads V_2 to V_6, with a proximal-to-distal activation pattern in the coronary sinus catheter (Figure 2). The decision was made to start mapping the right atrium (RA) before accessing the left atrium (LA). A high-density activation map of the RA was created using the CARTO 3 system with

ABBREVIATIONS AND ACRONYMS

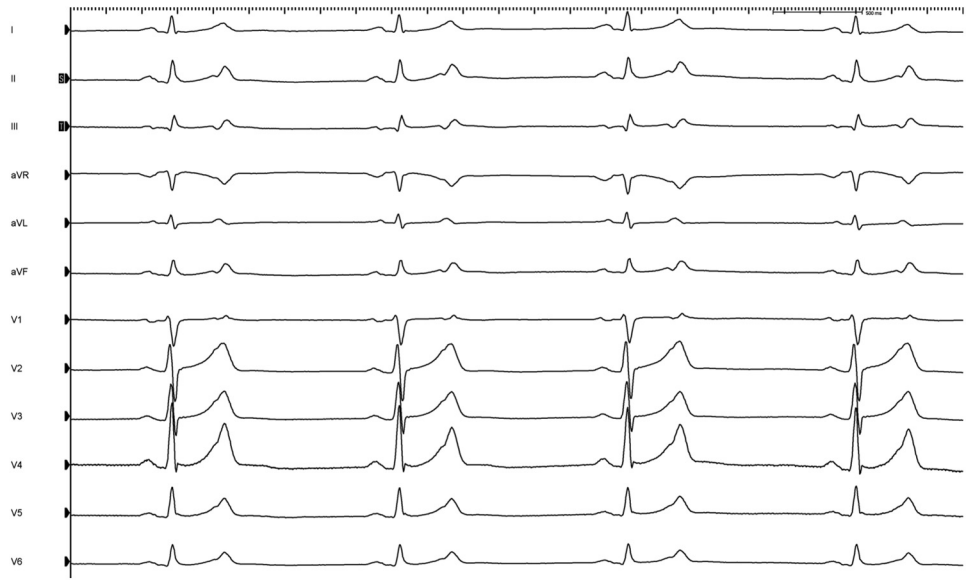
AF = atrial fibrillation
ECG = electrocardiogram
IVC = inferior vena cava
LA = left atrium
PAC = premature atrial complex
PV = pulmonary vein
RA = right atrium

FIGURE 1 Holter Monitoring



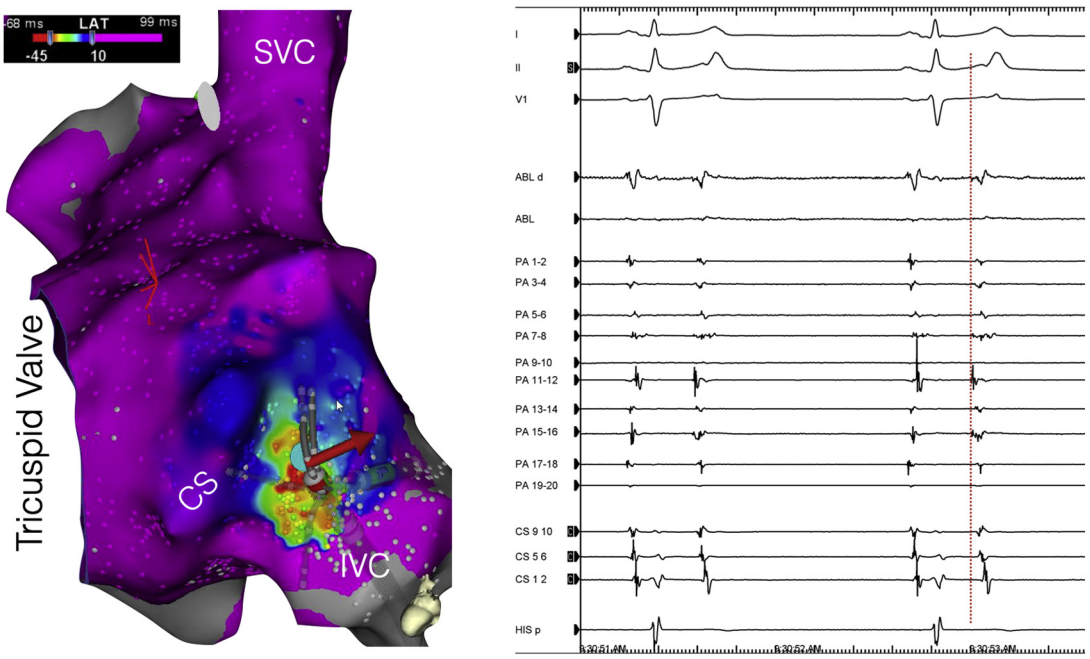
This monitoring shows repetitive premature atrial complexes, some of them not conducted to the ventricle but visible in the upper part of the T-wave **(red arrows)** and some of them aberrantly conducted. At the **bottom,** one of the premature atrial complexes **(red arrow)** is triggering atrial fibrillation.

FIGURE 2 Baseline Electrocardiogram at the Time of the Ablation Procedure



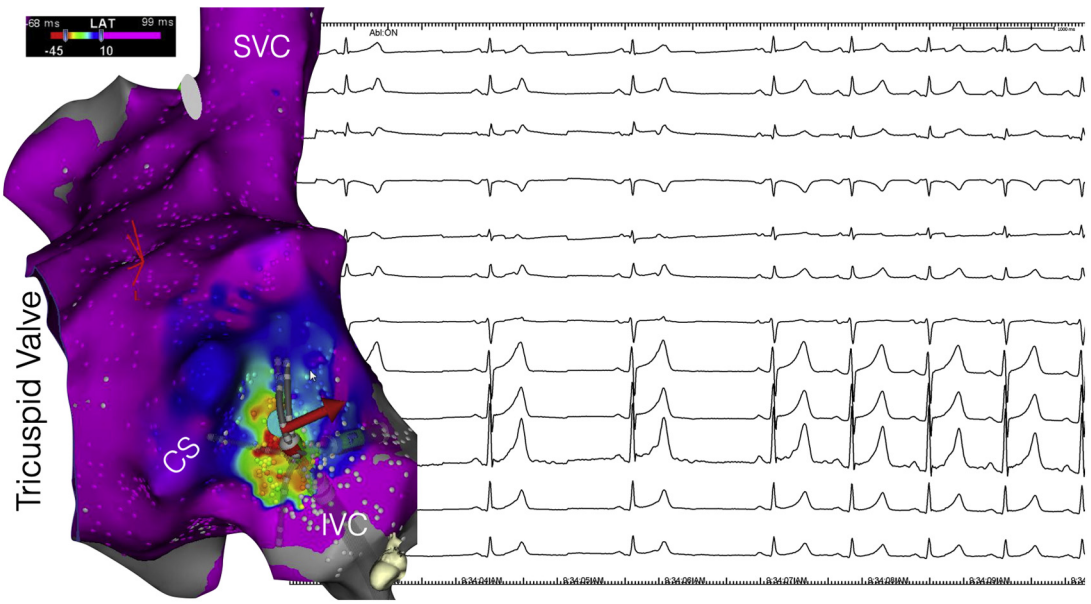
Repetitive premature atrial complexes not conducted to the ventricle are visible on the top of the T-wave similar to the Holter monitoring findings.

FIGURE 3 Activation Map and Electrograms



(Left) Activation map showing the earliest activation at the posteromedial aspect of the inferior vena cava (IVC). **(Right)** Electrograms recorded from the steerable mapping catheter and the ablation catheter at the earliest activation site before radiofrequency ablation. CS = coronary sinus; SVC = superior vena cava.

FIGURE 4 Radiofrequency Application



Radiofrequency application at the earliest activation point immediately terminated the bigeminated premature atrial complexes, and sinus rhythm was restored. Abbreviations as in Figure 3.

the 20-pole steerable mapping catheter PentaRay (Biosense Webster). The earliest activation during PACs was located at the posteromedial inferior vena cava (IVC) (Figure 3). Radiofrequency application with a power of 30 W, a maximum temperature of 43 °C, and a flow rate of 20 mL/min, at this site definitely suppressed the PACs (Figure 4). Additional radiofrequency applications were delivered adjacent to the effective application point. After ablation, atrial pacing from inside the IVC showed local capture dissociated from the RA (Figure 5). Cavotricuspid isthmus block was also confirmed by pacing maneuvers. Programmed atrial pacing during isoproterenol infusion and adenosine administration did not induce any clinical PACs or other tachyarrhythmias. Therefore, access to the LA was not performed.

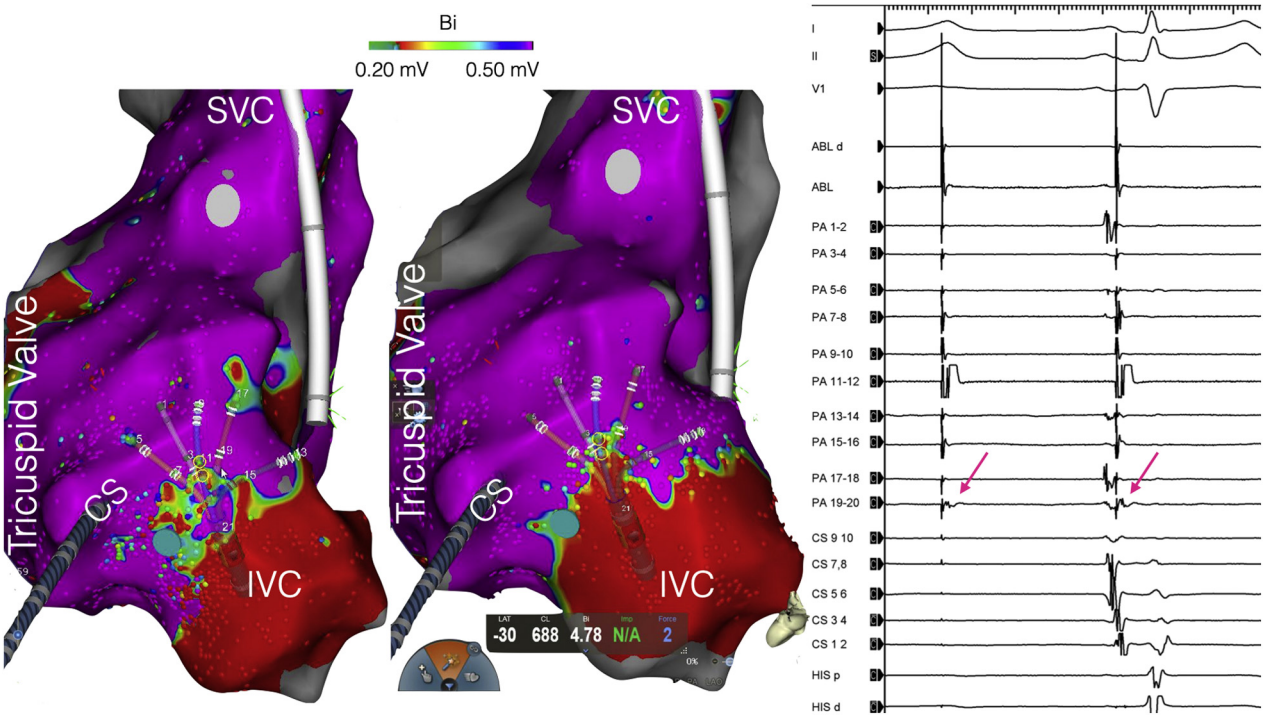
DISCUSSION

The present case shows the challenge of AF recurrence after PV isolation triggered by a focal source that clinically behaves like a typical PV focus but nevertheless originates in an extremely rare location, such as the posteromedial aspect of the IVC.

Focal AF typically originates in the PVs and manifests as monomorphic early ectopic beats, some of which trigger AF. In our case, the 24-hour Holter findings were consistent with the typical focal AF, but surprisingly, the focus was found in the IVC. The repetitive ectopic beats at the time of the procedure were key to guiding the ablation because a negative P-wave in the inferior leads is unusual for a PV origin but strongly suggests a focus in the inferior part of the atrium. A high-density map of the RA was first performed and allowed us to define the exact location of the arrhythmogenic focus at the posteromedial aspect of the IVC.

We know of only 2 previous reports of IVC foci triggering AF. Mansour et al (4) reported 2 patients with arrhythmogenic foci at the posterolateral aspect of the IVC ostium in 2002, and Scavée et al (5) reported a patient with a trigger at the posteromedial aspect of the IVC in 2003. The anatomical substrate behind this very unusual origin can be found in histologic studies that have shown extensions of myocardial tissue into the IVC similar to those described in the PVs. However, it is rare to identify these muscular extensions when mapping the RA-IVC

FIGURE 5 Voltage Map of the Septal and Posterior Aspect of the IVC Before and After Ablation



The voltage map on the **left side** shows a low-voltage area in the posteromedial inferior vena cava (IVC). The voltage map on the **right side** was generated after ablation and shows homogenization of this area. Intracardiac recordings during pacing from the steerable mapping catheter show local capture at PA 19-20 not conducted to the atrium and demonstrating electrical isolation of the ablated area **(arrows).** N/A = not applicable; other abbreviations as in Figure 3.

junction (6). In the case presented, the high-density mapping clearly showed the earliest activation in the continuity of the posteromedial RA toward the IVC; this corresponds to a small area of low voltage. Even with a high-density map, it is difficult to determine whether this area may correspond to an extension of the atrial myocardium toward the IVC. However, the elimination of the focus with the application of radiofrequency and the subsequent demonstration of dissociated local capture when pacing from inside the IVC suggest at least a behavior similar to that of the PVs.

FOLLOW-UP

During follow-up, the patient has remained asymptomatic, and no atrial arrhythmia has been documented in 24-hour Holter monitoring at 1-, 3-, and 6-month follow-up.

CONCLUSIONS

The case illustrates a typical focal AF presentation that originates from a very unusual location such as the IVC area. The particular behavior of repetitive PACs favored a precise definition of the site of origin by using high-density mapping.

FUNDING SUPPORT AND AUTHOR DISCLOSURES

The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

ADDRESS FOR CORRESPONDENCE: Dr Concepcion Alonso-Martin, Arrhythmia Unit. Department of Cardiology, Hospital de la Santa Creu I Sant Pau, St Antoni M. Claret, 167, 08025 Barcelona, Spain. E-mail: calonso@santpau.cat.

REFERENCES

1. Hojo R, Fukamizu S, Kitamura T, et al. Development of nonpulmonary vein foci increases risk of atrial fibrillation recurrence after pulmonary vein isolation. *J Am Coll Cardiol EP*. 2017;3:547–555.

2. Santangeli P, Zado ES, Hutchinson MD, et al. Prevalence and distribution of focal triggers in persistent and long-standing persistent atrial fibrillation. *Heart Rhythm*. 2016;13:374–382.

3. Takigawa M, Takahashi A, Kuwahara T, et al. Impact of non-pulmonary vein foci on the outcome of the second session of catheter ablation for paroxysmal atrial fibrillation. *J Cardiovasc Electrophysiol*. 2015;26:739–746.

4. Mansour M, Ruskin J, Keane D. Initiation of atrial fibrillation by ectopic beats originating from the ostium of the inferior vena cava. *J Cardiovasc Electrophysiol*. 2002;13:1292–1295.

5. Scavée C, Jais P, Weerasooriya R, Haissaguerre M. The inferior vena cava: an exceptional source of atrial fibrillation. *J Cardiovasc Electrophysiol*. 2003;14:659–662.

6. Hashizume H, Ushiki T, Abe K. A histological study of the cardiac muscle of the human superior and inferior venae cavae. *Arch Histol Cytol*. 1995;58:457–464.

KEY WORDS **atrial fibrillation, catheter ablation, inferior vena cava, non-PV trigger**