

# Idiopathic Ventricular Fibrillation in a 29-Year-Old Man

## ECG CHALLENGE

A 29-year-old man with a recent history of cardiac arrest and placement of an implanted cardiac defibrillator (ICD) presented with palpitations and defibrillation shocks. Five months earlier, he had experienced ventricular fibrillation (VF) while seated at his desk job. After resuscitation, an extensive diagnostic evaluation for the etiology of his arrest was undertaken, including left heart catheterization with coronary angiography, a transthoracic echocardiogram, and cardiac magnetic resonance imaging. All of these studies were unremarkable, revealing no evidence of ischemic or structural cardiac disease. He was subsequently discharged after placement of a single-lead endocardial ICD.

After discharge, the patient remained asymptomatic until this presentation, when he reported palpitations, light-headedness, and multiple device shocks while awake. These symptoms were coincident with the onset of a febrile, upper respiratory tract infection. Vital signs, physical examination, complete blood count, and electrolyte panel were normal. The patient's 12-lead ECG is shown in Figure 1. What is the most likely diagnosis for this patient, and what is the best course of treatment?

Please turn the page to read the diagnosis.

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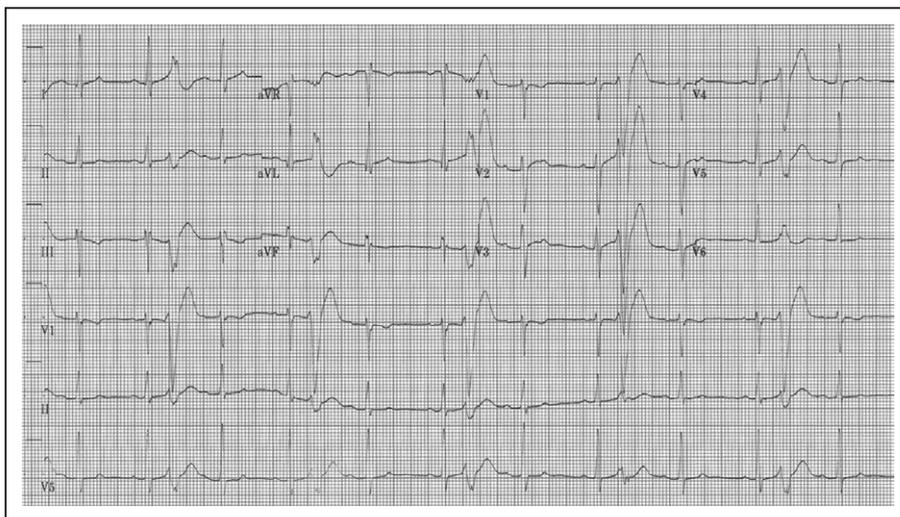
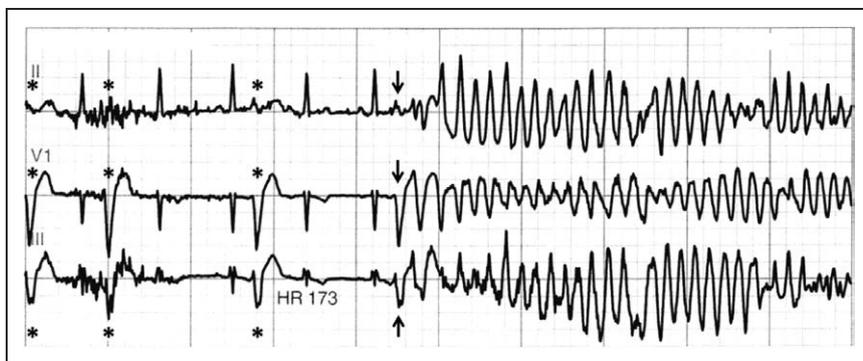


Figure 1. ECG obtained on admission.

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**Figure 2. Annotated telemetry coinciding with an in-hospital syncopal episode.**

The beginning of the telemetry tracing shows a sinus rhythm with frequent premature ventricular depolarizations (asterisks). One of these premature ventricular depolarizations (arrow) then triggers an episode of sustained polymorphic ventricular tachycardia. HR indicates heart rate.

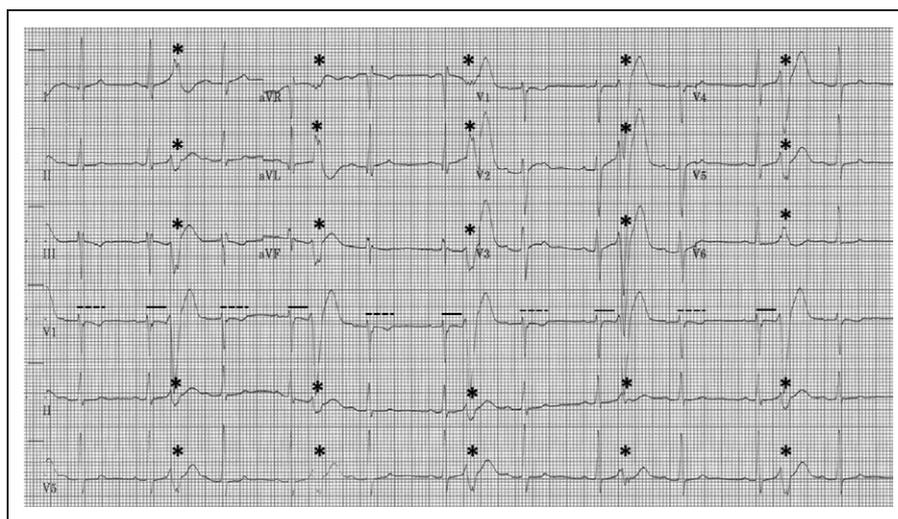
## RESPONSE TO ECG CHALLENGE

The patient's telemetry tracing from an in-house syncopal episode demonstrates polymorphic ventricular tachycardia (PVT) triggered by premature ventricular depolarizations (PVCs) (Figure 2). The triggering PVCs are identical to those seen on the patient's 12-lead ECG (Figure 3). All have a left bundle-branch block morphology with a superior axis and a late R:S transition point at V6 indicating a single ectopic focus that localizes to the inferior wall of the right ventricle. The coupling intervals of the PVCs are exceedingly short at 240 milliseconds, with each PVC falling on the ascending limb of the preceding sinus T wave. The QT interval and QTc are normal at 340 milliseconds and 380 milliseconds, respectively. This analysis suggests that the patient's initial VF arrest resulted from PVT triggered by short-coupled PVCs, which subsequently degenerated into VF.

Given the absence of structural heart disease and a lack of evidence suggesting a primary arrhythmia syndrome (eg, the Brugada syndrome, the long and short

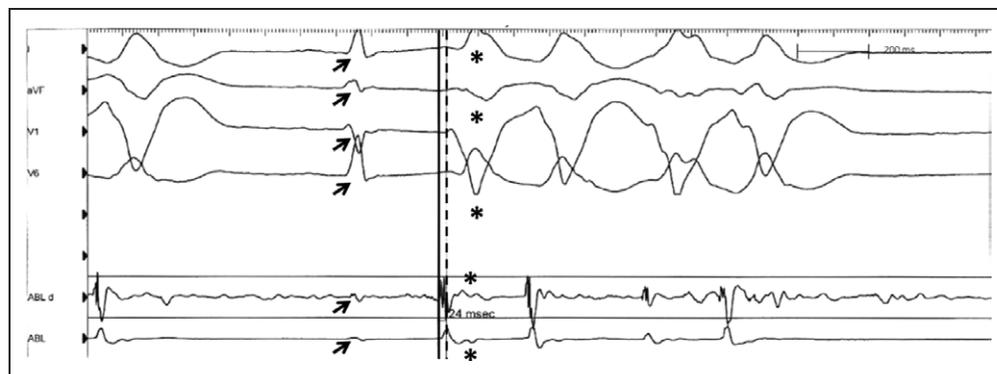
QT syndromes), this patient's VF arrest is appropriately classified as idiopathic VF (IVF). In 1994, Leenhardt and colleagues<sup>1</sup> described a new electrocardiographic entity on the IVF spectrum characterized by episodes of PVT triggered by short-coupled PVCs ( $\leq 300$  milliseconds). This entity, termed short-coupled torsades de pointes (scTdP), had the characteristic "twisting of the points" appearance of torsades. Unlike typical torsades, however, it occurred in the setting of a normal QT interval. More than 35% of the scTdP patients in Leenhardt's original case series experienced sudden cardiac death, and  $\approx 30\%$  had a familial history of sudden death. Our patient had no family history of sudden cardiac death but exhibited the hallmark electrocardiographic features of scTdP, namely, episodes of PVT triggered by short-coupled PVCs and an otherwise normal ECG.

Calcium channel-blocking agents, and verapamil in particular, are the only medical therapy that have demonstrated efficacy in scTdP. They lengthen the coupling interval and suppress short-coupled PVCs.<sup>1</sup> Short-cou-



**Figure 3. Annotated admission ECG.**

The patient's episodes of PVT and VF are triggered by the same short-coupled premature ventricular depolarizations (asterisks) seen on this ECG. The coupling interval of these premature ventricular depolarizations (solid line) is exceedingly short at 240 milliseconds. The QT interval (dotted line) is normal at 340 milliseconds. The premature ventricular depolarizations have left bundle-branch block morphology, indicating a right ventricular origin. Their superior axis and late R:S transition point at V6 further localize the ectopic focus to the inferoseptal right ventricle. PVT indicates polymorphic ventricular tachycardia; and VF, ventricular fibrillation.



**Figure 4. Intracardiac electrogram at the site of ablation.**

Surface ECG leads I, aVF, V1, and V6 together with endocardial electrogram tracings from mapping/ablation catheters in the inferoseptal right ventricle. A sinus-conducted beat (arrow) is followed by a premature ventricular depolarization (asterisk). The solid vertical line marks the initial endocardial activation of the premature ventricular depolarization, and the dashed vertical line marks the earliest ventricular activation detected on the surface ECG. It is important to note that the endocardial potential precedes the surface QRS complex by 24 milliseconds and triggers a short flurry of ventricular beats.

pled TdP is also amenable to radiofrequency catheter ablation. Ablation of the triggering PVCs, thought to result from early afterdepolarizations, prevents recurrence of VF or PVT in >80% of IVF patients at 5 years.<sup>2</sup> However, it is important to note that neither calcium channel blockers nor ablation completely eliminate the risk of recurrent ventricular arrhythmias or sudden cardiac death.<sup>1,2</sup> Therefore, ICD placement remains critical in all patients with IVF.

Our patient's ICD indeed proved lifesaving, aborting multiple episodes of PVT and VF that occurred in the context of a likely predisposing febrile illness. We initiated treatment with oral verapamil, which entirely suppressed his PVCs. He subsequently underwent ablation of the triggering focus in the inferoseptal right ventricle (Figure 4). Thereafter, his triggering PVCs did not recur.

Genetic testing revealed a variant of unknown significance in the gene encoding the cardiac ryanodine receptor (*RyR2*). *RyR2* is found in the sarcoplasmic reticulum of cardiac myocytes and mediates the calcium-induced calcium release that facilitates myocyte contraction. Gain-of-function *RyR2* mutations are implicated in catecholaminergic PVT, and 2 loss-of-function missense *RyR2* variants associated with scTdP were recently reported.<sup>3,4</sup> The functional consequence of our patient's *RyR2* variant, a missense mutation with a change in a single amino acid, is unknown. Although the pathogenicity of this variant remains speculative, it is currently undergoing functional studies. This testing will determine whether it also interferes with proper calcium handling to yield the early afterdepolarizations that give rise to scTdP.

In summary, scTdP is characterized by short-coupled PVCs, which trigger episodes of PVT that may degenerate into VF. It should be considered as a cause of IVF. Prompt recognition of scTdP is necessary to facilitate

appropriate management with calcium channel blockers, ablation, and ICD placement.

## DISCLOSURES

None.

## AFFILIATIONS

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## FOOTNOTES

*Circulation* is available at <http://circ.ahajournals.org>.

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