A 35-year-old man presented to the emergency department after having an episode of syncope while playing soccer. Loss of consciousness lasted only seconds and was preceded by a brief period of light-headedness. When he regained consciousness, he had no nausea, diaphoresis, chest pain, or dyspnea. He was not injured and had no bowel or bladder incontinence. Witnesses reported no tonic–clonic movements. The patient had no history of fainting or light-headedness.

In the evaluation of syncope, the history of the episode is critical; particular attention should be paid to any symptoms that occurred before loss of consciousness, the context within which syncope occurred, and any consequences (e.g., injury or postictal confusion). Neurally mediated, or vasovagal, syncope is typically associated with a prodrome of nausea, diaphoresis, and tunnel vision. In the absence of a prodrome, a diagnosis of cardiac syncope is more likely, although the presence of a prodrome does not rule out cardiac syncope. Cardiac syncope is generally related to inadequate cardiac output, which may be a consequence of an outflow-tract obstruction, tachycardia, or bradycardia. The occurrence of an injury with syncope is also suggestive of — though not specific for — cardiac syncope. However, the absence of injury does not rule out cardiac syncope.

Vasovagal syncope is often situational, occurring in association with specific activities (e.g., coughing or micturition) or with pain, and it generally occurs when the patient is standing. It is atypical for vasovagal syncope to occur when a person is seated or reclining and even more atypical during exercise, which further supports a diagnosis of cardiac syncope in this patient. The patient’s normal mental status on recovery of consciousness and the absence of bowel or bladder incontinence argue against seizure. The patient did not have tonic–clonic jerks, but their presence is in any case not specific for seizure as the underlying cause. A more detailed history should be obtained to identify any risk factors for cardiac disease, including a family history of heart disease or sudden death.

The patient did not take medications, did not use tobacco or illicit drugs, and drank alcohol only occasionally. He was born in Mexico, immigrated to the United States as a teenager, and lived with his wife in western Massachusetts, where he worked as a dairy farmer. He did not recall any major childhood illnesses. His maternal grandmother and a maternal uncle had both died suddenly at 65 years of age without known antecedent cardiovascular disease. He had five siblings and three children, all of whom were well.

The fact that the patient took no medications eliminates one point of concern, since some medications, particularly beta-blockers, calcium-channel blockers, anti-hypertensive agents, and QT-prolonging medications, can cause syncope. The ab-
sence of risk factors for coronary disease argues against myocardial ischemia, and a seemingly healthy childhood lowers the index of suspicion for undiagnosed congenital heart disease. Although the patient had two relatives who died suddenly, neither death occurred at a young age.

At initial presentation, the patient had normal vital signs, and the physical examination was unremarkable. An electrocardiogram (ECG) was normal. Echocardiography showed a structurally normal heart. The patient was discharged with an event monitor, and 2 weeks later he had an episode of monomorphic wide-complex tachycardia, with a heart rate of almost 300 beats per minute, while playing soccer. At the time, he noted mild dyspnea and neck discomfort but reported no chest pain, palpitations, or light-headedness. He was admitted for further evaluation and management of his condition.

Monomorphic wide-complex tachycardias include supraventricular tachycardia with aberrant conduction, supraventricular tachycardia with pre-excitation, and ventricular tachycardia. Although ventricular tachycardia is the most common cause of wide-complex tachycardia, in a young healthy patient, supraventricular tachycardias remain a distinct possibility. In general, however, patients should be presumed to have ventricular tachycardia until proved otherwise. A history of coronary artery disease increases the likelihood of ventricular tachycardia, whereas structural cardiac abnormalities can be associated with an increased likelihood of preexcitation, ventricular tachycardia, or both. Accordingly, evaluation for both ischemia and structural heart disease is warranted in patients presenting with wide-complex tachycardia.

In a patient with sustained, hemodynamically stable wide-complex tachycardia, physical findings suggestive of atrioventricular dissociation can be diagnostic. In most cases, however, the diagnosis is made on the basis of ECG or invasive testing. A finding of atrioventricular disso- ciation on ECG is diagnostic of ventricular tachycardia; other features, such as the QRS axis, width, and morphologic characteristics, are informative but not definitive. Unfortunately, recordings obtained by means of ambulatory monitoring rarely provide diagnostic information. In such cases, programmed stimulation (an electrophysiological study) can often induce the tachycardia, allowing for definitive diagnosis and appropriate treatment.

This patient's clinical course underscores the risk of discharging a patient with possible cardiac syncope with a plan for ambulatory monitoring. The intensity of the initial evaluation of syncope depends on clinical risk stratification. In a patient presenting with exercise-associated syncope, an exercise stress test should be performed as part of the initial evaluation; in this patient, a stress test might have reproduced the arrhythmia in a controlled environment.

The results of coronary angiography were normal. An invasive electrophysiological study showed a ventricular tachycardia originating from an endocardial, inferolateral focus in the left ventricle; an endocardial voltage map did not reveal significant scarring. After radiofrequency endocardial ablation, ventricular tachycardia could no longer be induced.

In assessing monomorphic ventricular tachycardia, the first consideration is the presence or absence of structural heart disease. In this young, healthy patient whose echocardiogram showed a structurally normal heart, the leading diagnosis is idiopathic ventricular tachycardia, which frequently occurs with exercise or emotional stress and is most often explained by an automatic focus, although reentrant circuits involving the Purkinje fibers can also produce idiopathic ventricular tachycardia. It tends to be paroxysmal and spontaneously terminating and is often associated with premature ventricular beats from the same automatic focus. Syncope is not typical of idiopathic ventricular tachycardia but can be associated with it. Although the most common site of origin is the right ventricular outflow tract, resulting in a pattern of left bundle-branch block with an inferior axis, inferolateral idiopathic ventricular tachycardias can be observed. There are no findings suggestive of a more sinister cause of arrhythmia, such as multiple ventricular tachycardia involving different circuits (which would suggest processes such as sarcoidosis), an electroanatomical map suggestive of marked scarring (which would be manifested as reduced voltage level), or concomitant conduction abnormalities.

Given that the patient spent his childhood in Mexico, Chagas' disease is an important consideration. In Chagas' disease, conduction abnor-
malities (right bundle-branch block or left anterior hemiblock, high-grade atrioventricular nodal block, sinus-node dysfunction, or a combination of these conduction abnormalities) often precede other abnormalities. In the absence of conduction abnormalities, idiopathic ventricular tachycardia remains the most likely diagnosis, but it must be considered a diagnosis of exclusion. Cardiac magnetic resonance imaging (MRI), which has greater sensitivity for detecting subtle abnormalities than echocardiography, should be considered to rule out structural heart disease. Although ischemia is associated with polymorphic ventricular tachycardia and ventricular fibrillation rather than monomorphic ventricular arrhythmias, given its high prevalence and the ready availability of treatments, ischemia should be ruled out in patients with new ventricular arrhythmias. As in this case, cardiac catheterization is often performed in patients with wide-complex tachycardia, since it can be used to rule out obstructive coronary artery disease or anomalies.

A cardiac MRI scan showed no abnormalities other than the lesions created by radiofrequency ablation. On follow-up exercise stress testing, the patient achieved 17.8 metabolic equivalents; he had frequent premature ventricular contractions with the same morphologic features as his ventricular tachycardia, but there was no sustained arrhythmia. Given continued ectopy, which was consistent with his clinical arrhythmia, and given the hemodynamically significant nature of that arrhythmia, the decision was made to place an implantable cardioverter–defibrillator (ICD) before discharge.

Whereas ICDs are clearly indicated for the secondary prevention of cardiac events related to structural heart disease, idiopathic ventricular tachycardia is rarely an indication for ICD placement, since these arrhythmias are generally nonlethal and can in most cases be eliminated by means of catheter ablation. However, alternative approaches to the management of care should be considered when there is concern that the arrhythmia will recur after an initial attempt at ablation; options include a second attempt at ablation, particularly if there is a substantial ectopic burden, or long-term pharmacologic therapy. The choice of pharmacologic agent for the suppression of ventricular arrhythmias depends in part on the proposed mechanism of ventricular tachycardia. Beta-blockers may prevent exercise-induced ventricular tachycardia by suppressing reentry, reducing automaticity, or reducing myocardial oxygen demand. Some idiopathic left ventricular tachycardias are exquisitely sensitive to verapamil; these “verapamil-sensitive ventricular tachycardias” are typically induced by exercise and in classic cases are characterized by a pattern of right bundle-branch block with a superior axis. Antiarrhythmic agents (e.g., amiodarone or sotalol) may be considered, since they can both reduce the burden of the arrhythmia and slow its rate. Some patients are reluctant to undergo long-term treatment with medication. In considering treatment options, the risks associated with the medications and with ICD placement must be discussed, the latter including inappropriate shocks and post-traumatic stress disorder.

A year later, during sexual intercourse, the patient had an episode of monomorphic ventricular tachycardia, which was terminated by a single shock from his ICD.

Given the recurrence of ventricular arrhythmias, another catheter ablation should be strongly considered. Although antiarrhythmic therapy could be contemplated, catheter ablation is preferable as the next therapeutic intervention, given the patient’s young age. A repeat echocardiogram should be obtained to reassess the patient for structural heart disease, since the recurrent arrhythmia raises the question of whether the initial diagnosis of idiopathic ventricular tachycardia was incorrect or (although much less likely) whether a different, unrelated arrhythmia may have developed. Unfortunately, the presence of an ICD precludes repeat cardiac MRI, but voltage mapping in the electrophysiology laboratory can be very informative with respect to the burden of scarring.

On admission, the patient was afebrile, with a heart rate of 92 beats per minute, blood pressure of 125/66 mm Hg, and oxygen saturation of 99% while he was breathing ambient air. Notable findings on physical examination included a nondisplaced precordial impulse and a widely split second heart sound without a murmur or a gallop. An
ECG revealed a new right bundle-branch block (Fig. 1). An echocardiogram showed normal left ventricular size and thickness, with minimally reduced systolic function (ejection fraction, approximately 50 to 55%); it was otherwise normal. An electrophysiological study showed a large endocardial and epicardial scar in the lateral wall of the left ventricle that was consistent with myocardial fibrosis (Fig. 2). After endocardial and epicardial ablation along the scar, ventricular tachycardia was no longer inducible.

The development of a new structural abnormality, a clinically significant scar, suggests a progressive cardiomyopathy. Although ventricular tachycardia can lead to a transient depression in global systolic function, the abnormalities observed on electroanatomical mapping cannot be attributed to the arrhythmia or to the earlier ablation. In the absence of coronary heart disease, these findings are suggestive of certain cardiomyopathies, including cardiac sarcoidosis, giant-cell myocarditis, genetic cardiomyopathies, and Chagas’ disease.

The cause of Chagas’ disease is the protozoal parasite Trypanosoma cruzi, which is endemic in Central and South America. Infection with T. cruzi should be suspected in persons who have emigrated from these areas, including this patient, who was born in Mexico. Although acute infection often goes unrecognized, chronic disease will develop in up to 30% of patients with acute infection. A hallmark of chronic disease is cardiomyopathy. Conduction abnormalities, such as the right bundle-branch block observed in this patient, are characteristic of Chagas’ disease, and involvement of the posterolateral wall of the left ventricle is very common.

Cardiac sarcoidosis can also cause conduction abnormalities and ventricular arrhythmias, but it is typically a patchy process that is less likely than Chagas’ disease to produce a single large region of fibrosis. Nonetheless, sarcoidosis must be considered in patients with unexplained, recurrent ventricular arrhythmias. When sarcoidosis is a possibility, cardiac MRI (which is contraindicated in this patient because of his ICD) or combined positron-emission tomography and computed tomography (PET-CT) should be performed. Other, less likely possibilities include giant-cell myocarditis, an autoimmune disease that results in severe heart failure and refractory ventricular arrhythmias characterized by a much more accelerated course than that observed in this patient, and genetic cardiomyopathies, including those caused by mutations in the lamin A (LMNA) and desmosomal genes.

Combined $^{18}$F-fluorodeoxyglucose (FDG) PET-CT did not show FDG avidity but did reveal a trans-
mural perfusion defect extending from the basal to the midlateral wall, suggesting the formation of an aneurysm (Fig. 3). Tests for *T. cruzi* with both an immunofluorescence assay and an enzyme-linked immunosorbent assay (ELISA) were positive. The patient was referred to an infectious-disease specialist for the initiation of antiparasitic therapy and was treated with a 60-day course of benznidazole. At follow-up 9 months later, he remained symptom-free.

**COMMENTARY**

Approximately 10 million people worldwide are infected with *T. cruzi*, the parasite responsible for Chagas’ disease, which is endemic in rural parts of Latin America. Although historically Chagas’ disease has been rare in developed countries, its prevalence is expected to increase in the United States and other developed countries as more people emigrate from regions where the disease is endemic.

Chronic Chagas’ disease, the hallmarks of which are cardiomyopathy, megaesophagus, and megacolon, occurs in 10 to 30% of infected persons, usually manifested 10 to 30 years after initial infection. Cardiac manifestations predominate; gastrointestinal manifestations are much less common and are usually restricted to patients in the southern part of South America. The mechanism of cardiac damage in Chagas’ disease remains elusive. Inciting factors may represent a response to the persistence of *T. cruzi* within the myocardium or an autoimmune process triggered by its presence. No matter what the cause, ongoing inflammation results in progressive cardiac dysfunction.

In Chagas’ disease, arrhythmia and conduction abnormalities (particularly right bundle-branch block, left anterior hemifascicular block, and ventricular tachycardia) typically precede overt myocardial dysfunction, apical aneurysm, and the progressive biventricular systolic dysfunction that culminates in heart failure. Patients with advanced disease may die from heart failure, whereas those with earlier stages of cardiac involvement may die from sudden arrhythmia. This pattern of conduction disease and arrhythmia accompanying or preceding structural heart disease is not unique to Chagas’ disease; it may also be seen in persons with ischemic, inflammatory, genetic, or infiltrative diseases.

The diagnosis of Chagas’ disease is generally based on serologic testing for IgG antibodies to *T. cruzi* antigens in a patient with supportive clinical findings. No one of the available assays (ELISA, immunofluorescence assay, and hemagglutination assay) has adequate sensitivity and specificity for the diagnosis. Two tests, in which different antigens or techniques are used, are required to make the diagnosis; when the results are discordant, additional testing must be performed. Potential causes of the clinical manifestations other than Chagas’ disease should also be ruled out with appropriate testing (e.g., 18F-FDG PET-CT would be used to rule out sarcoidosis).

The best management strategy for chronic Chagas’ cardiac disease remains uncertain. Most management guidelines for Chagas’ cardiomyopathy are extrapolated from data on ischemic and nonischemic dilated cardiomyopathy. Owing to the resource-poor nature of the regions in which Chagas’ disease is endemic, primary data are limited to retrospective studies and small registries. Whereas sustained ventricular tachy-
cardia is an accepted indication for ICD implantation, the annual mortality rate is high among patients with Chagas’ disease who have an ICD, and there is uncertainty regarding the efficacy of an ICD as compared with amiodarone (the preferred antiarrhythmic medication for patients with Chagas’ cardiomyopathy). In patients with Chagas’ disease who have sustained ventricular tachycardia, the occurrence of syncope does not appear to portend a poor prognosis, but moderate or severe ventricular systolic dysfunction does portend a poor prognosis for patients with unsustained or sustained ventricular tachycardia; the relatively preserved ejection fraction in this patient is reassuring. Cardiac transplantation has been successfully performed in a few patients with Chagas’ disease.

Antitrypanosomal medications are now being used in the management of Chagas’ disease. Observational data indicate that their use is associated with a reduced likelihood of progression of cardiomyopathy, although gastrointestinal problems may not resolve. Benznidazole and nifurtimox have established antitrypanosomal efficacy; neither agent is widely available in the United States. Benznidazole generally has fewer side effects than nifurtimox and is recommended as first-line treatment. Adults younger than 50 years of age who have acute or chronic infection without end-stage cardiac disease should generally be treated with antitrypanosomal medications. An ongoing blinded, randomized trial of benznidazole (ClinicalTrials.gov number, NCT00123916) should further clarify the role of antitrypanosomal medications in patients with chronic Chagas’ infection and cardiac involvement. Anticoagulation is not indicated in the absence of intracavitary thrombus. Whereas idiopathic ventricular tachycardia was the most likely diagnosis at the time of this patient’s initial presentation, the clinical features of recurrent arrhythmia and the patient’s region of origin argued for a more complicated process. It is essential in such cases to perform a reassessment for the presence of structural heart disease, which can evolve over time. This case underscores the importance of such a reassessment and of the consideration of diseases endemic to a patient’s region of origin.

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Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

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