

## Brief Report

## CLINICAL CONSEQUENCES OF ELECTROCARDIOGRAPHIC ARTIFACT MIMICKING VENTRICULAR TACHYCARDIA

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**E**LECTROCARDIOGRAPHIC artifact can simulate ventricular tachycardia. The literature regarding electrocardiographic artifact is limited to case reports,<sup>1-7</sup> proposed classifications,<sup>8,9</sup> and diagnostic criteria.<sup>10</sup> There is little information regarding the clinical implications of the misdiagnosis of artifact as ventricular tachycardia. We describe 12 patients who underwent unnecessary diagnostic or therapeutic interventions as a result of such a misdiagnosis.

### METHODS

We included in this series patients who were seen in consultation by a cardiac electrophysiologist at our institution between 1995 and 1999 and who underwent a diagnostic procedure or received treatment unnecessarily, solely as a result of the misdiagnosis of artifact as ventricular tachycardia. We obtained information on the characteristics of the patients, features of the artifact, and the interventions from the medical records. For patients who had more than one documented recording of artifact that simulated ventricular tachycardia, we selected for analysis the longest recording. Continuous variables are presented as means  $\pm$ SD.

### RESULTS

#### Characteristics of the Patients

Twelve patients received at least one unnecessary intervention solely because of the misdiagnosis of artifact as ventricular tachycardia (Table 1). In seven cases, artifact that mimicked ventricular tachycardia was recorded during telemetric monitoring of inpatients. Five of these patients had been admitted to the hospital after presenting with cardiac symptoms (syncope or presyncope in three patients, palpitations in one, and chest pain in one); one patient had been admitted after cardiac arrest, and the remaining

patient was recovering from cardiac surgery. Three patients were undergoing electrocardiographic monitoring in the emergency department when the artifact was recorded, after presenting with chest pain (one patient), acute respiratory failure in the context of chronic obstructive pulmonary disease (one patient), or a constellation of neurologic symptoms (one patient). Artifact was also recorded in a patient who was undergoing outpatient 24-hour Holter monitoring for the evaluation of palpitations and in another patient who was undergoing an exercise treadmill test for the evaluation of atypical chest pain.

The mean age of the patients was  $57 \pm 14$  years, and 6 of the 12 patients were men. Five patients had structural heart disease. The mean left ventricular ejection fraction was  $49 \pm 17$  percent. When the artifact was recorded, nine patients were asymptomatic, one patient was experiencing chest pain, one patient was unresponsive because of acute respiratory failure, and one patient had paresthesias of the left arm.

#### Characteristics of the Artifact

Artifact simulated monomorphic ventricular tachycardia in five patients (Fig. 1) and polymorphic ventricular tachycardia in seven patients (Fig. 2). The mean rate of simulated ventricular tachycardia was  $226 \pm 35$  beats per minute (range, 180 to 280), and the mean number of apparent tachycardia complexes was  $22 \pm 7$  (range, 11 to 33). Six patients had more than one episode of artifact that simulated ventricular tachycardia. The onset of the artifact was recorded in 75 percent of the patients, and the termination was recorded in 92 percent. Each recording could be recognized as artifact by the presence of native QRS complexes at the cycle length of the base-line rhythm within the artifact.

#### Clinical Consequences of Misdiagnosis

Diagnostic cardiac catheterization was performed in three patients solely because of the incorrect diagnosis of ventricular tachycardia. Unnecessary medical therapies included intravenous lidocaine in seven patients, intravenous nitroglycerin in one patient, and sublingual nitroglycerin in one patient. Two patients were given a precordial thump that was interpreted as a successful cardioversion. One patient in whom torsade de pointes was incorrectly diagnosed underwent implantation of a permanent pacemaker to prevent a recurrence by keeping bradycardia, which typically precedes polymorphic ventricular tachycardia, from occurring. One patient underwent placement of an implantable cardioverter-defibrillator after an episode of artifact was misdiagnosed as polymorphic ventricular tachycardia. Another patient was given a blood transfusion because it was thought that his ventricular tachycardia had been caused by anemia.

The misdiagnosis of artifact increased the use of health care resources. Two patients were transferred

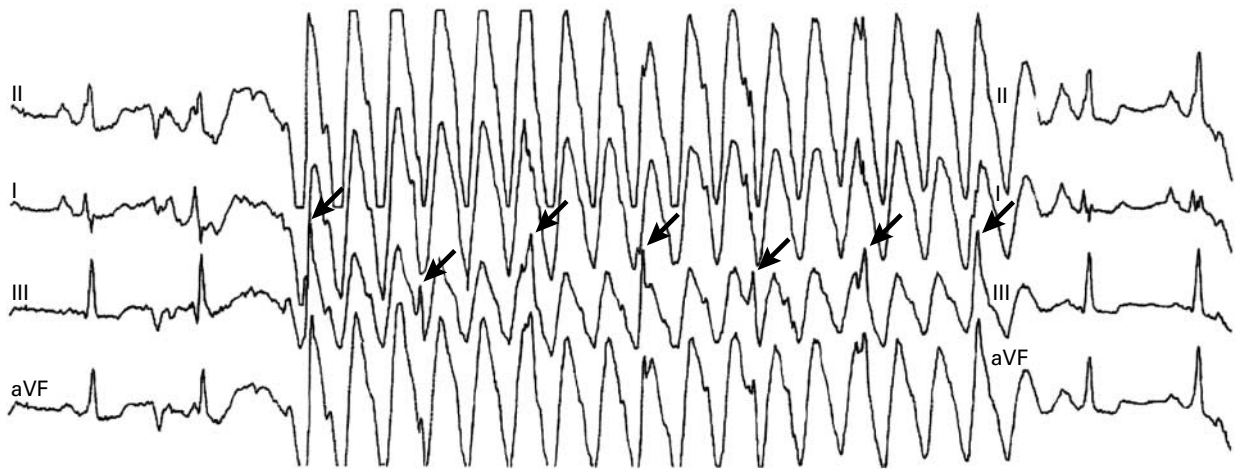
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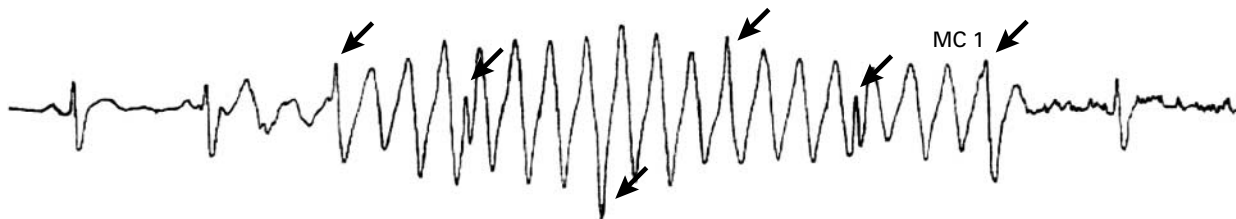
**TABLE 1.** CHARACTERISTICS OF THE PATIENTS, FEATURES OF THE ELECTROCARDIOGRAPHIC ARTIFACT, AND CONSEQUENCES TO THE PATIENT OF THE MISDIAGNOSIS OF ARTIFACT AS VENTRICULAR TACHYCARDIA.\*

PATIENT NO.	CHARACTERISTICS OF THE PATIENT				FEATURES OF THE ARTIFACT					CONSEQUENCES			
	AGE (YR)/SEX	PROBLEM AT ADMISSION	HEART DISEASE	LVEF (%)	LOCATION	MONOMORPHIC OR POLYMORPHIC	ASSOCIATED SYMPTOMS	NO. OF BEATS	RATE (bpm)		ONSET RECORDED	TERMINATION RECORDED	RECURRENT
1	74/F	Syncope	None	60	Ward	Polymorphic	None	11	200	Yes	Yes	No	Lidocaine, implantation of permanent pacemaker
2	54/M	Syncope	CAD	25	Ward	Monomorphic	None	18	180	Yes	Yes	Yes	Lidocaine
3	41/F	Presyncope	None	60	Ward	Polymorphic	None	24	280	Yes	Yes	No	Placement of ICD
4	40/M	Palpitations	None	60	Ward	Monomorphic	None	24	220	Yes	Yes	Yes	Lidocaine, admission to ICU, referral for electrophysiologic test
5	38/F	Chest pain	None	—	Ward	Polymorphic	Arm paresthesias	31	220	No	Yes	Yes	Sublingual nitroglycerin, referral for electrophysiologic test
6	53/M	Cardiac arrest	DCM	20	Ward	Monomorphic	None	13	250	Yes	Yes	No	Blood transfusion
7	59/F	Post-CABG	CAD	25	Ward	Polymorphic	None	19	280	Yes	Yes	No	Lidocaine
8	71/F	Chest pain	None	60	Emergency department	Polymorphic	Chest pain	26	220	Yes	Yes	Yes	Precordial thump, lidocaine, transfer for electrophysiologic test
9	65/M	Respiratory arrest, COPD	None	60	Emergency department	Polymorphic	Unresponsive	33	250	No	No	No	Precordial thump, lidocaine, aspirin, intravenous nitroglycerin, cardiac catheterization, referral for ICD
10	54/F	Visual changes, confusion	CAD	55	Emergency department	Monomorphic	None	15	190	Yes	Yes	Yes	Lidocaine, cardiac catheterization, transfer for electrophysiologic test
11	84/M	Abnormal Holter-monitor recording	CAD	—	Outpatient Holter-monitor recording	Monomorphic	None	26	240	No	Yes	No	Admission to hospital from home, referral for electrophysiologic test
12	50/M	Not applicable	None	60	Outpatient treadmill test	Polymorphic	None	18	180	Yes	Yes	Yes	Cardiac catheterization

\*LVEF denotes left ventricular ejection fraction, bpm beats per minute, CAD coronary artery disease, ICD implantable cardioverter-defibrillator, ICU intensive care unit, DCM dilated cardiomyopathy, CABG coronary-artery bypass grafting, and COPD chronic obstructive pulmonary disease.



**Figure 1.** Rhythm Strip of Electrocardiographic Artifact That Mimicked Monomorphic Ventricular Tachycardia and Led to the Patient's Being Treated with Lidocaine. Portions of the QRS complexes are visible within the artifact at the sinus-cycle length (arrows).



**Figure 2.** Rhythm Strip of Electrocardiographic Artifact That Mimicked Polymorphic Ventricular Tachycardia and Led to the Patient's Being Treated with Lidocaine. Portions of the QRS complexes are visible within the artifact at the sinus-cycle length (arrows). MC 1 denotes modified chest lead 1.

to a tertiary care institution for electrophysiologic testing, one patient was transferred to an intensive care unit from a telemetry ward, and one patient was admitted to the hospital from home after a Holter-monitor recording was misinterpreted as showing ventricular tachycardia.

#### Characteristics of the Physicians

An initial misdiagnosis of ventricular tachycardia was made by a cardiologist in four cases, a medical house officer in four, an emergency-medicine physician in three, and an electrophysiologist in one. A board-certified cardiologist agreed with the diagnosis of ventricular tachycardia in 10 cases before an electrophysiologist was consulted. A board-certified cardiologist referred an additional patient for a second opinion several months after the patient underwent placement of an implantable cardioverter-defibrillator by a practicing electrophysiologist.

#### DISCUSSION

These cases demonstrate that when artifact is misdiagnosed as ventricular tachycardia, patients may be subjected to a broad range of unnecessary diagnostic and therapeutic procedures, including cardiac catheterization and the implantation of cardiac devices.

Arrhythmias are unique among transient pathologic states because, even in the absence of symptoms, they often lead to intensive investigations and treatments that have long-term repercussions. Because unsustained ventricular tachycardia can be a sign of structural heart disease, acute ischemia, electrolyte abnormalities, or drug toxicity, its identification often prompts a thorough cardiac evaluation that includes blood analysis, stress testing, echocardiography, and angiography.

Several therapies may be prescribed for patients in whom transient ventricular tachyarrhythmias are diagnosed. Patients with impaired ventricular function

after myocardial infarction who are found to have unsustained ventricular tachycardia are often referred for electrophysiologic testing for risk stratification. If sustained ventricular tachycardia is induced at the time of electrophysiologic testing, a prophylactic implantable cardioverter–defibrillator is usually implanted.<sup>11,12</sup> However, the Multicenter Unsustained Tachycardia Trial found a 4 to 5 percent risk of cardiac arrest or death from arrhythmia per year among patients with coronary artery disease, a left ventricular ejection fraction of 40 percent or less, and asymptomatic unsustained ventricular tachycardia who did not have inducible sustained ventricular tachycardia (Buxton A: personal communication). Therefore, unsustained ventricular tachycardia alone, regardless of the results of electrophysiologic testing, may become an indication for an implantable cardioverter–defibrillator. If so, an erroneous diagnosis of unsustained ventricular tachycardia in a patient with ischemic cardiomyopathy may lead to the placement of an implantable cardioverter–defibrillator — a consequence that underscores the importance of correctly identifying artifact that simulates unsustained ventricular tachycardia.

Pacing therapy may also be instituted in some patients who have ventricular tachycardia in the context of bradycardia. For example, a pacemaker is often implanted in patients with torsade de pointes to prevent the bradycardia that typically precedes the polymorphic ventricular tachycardia.<sup>13</sup>

Episodes of ventricular tachycardia may lead to increased use of health care resources. Patients are often transferred to an intensive care unit for closer monitoring after an episode of ventricular tachycardia. A diagnosis of ventricular tachycardia may also result in transfer to a tertiary care medical center, where electrophysiologic testing and defibrillator therapy are available.

Electrocardiographic artifact with sufficient amplitude and duration can closely simulate ventricular tachycardia. Therefore, artifact can readily lead to unnecessary testing and therapy. The results of this study demonstrate that patients in whom ventricular tachycardia is incorrectly diagnosed on the basis of electrocardiographic artifact may be subjected to much the same testing and treatment as patients with actual ventricular tachycardia.

Characteristics that differentiate artifact from ventricular tachycardia include the absence of hemodynamic deterioration during the event; normal QRS complexes within the artifact; an unstable base line on the electrocardiogram before the event, after the event, or both; and an association with body movement.<sup>10</sup> In this study, the cases of artifact that mimicked ventricular tachycardia and resulted in unnecessary interventions were usually not associated with symptoms and could be distinguished from ventricular tachycardia by the presence of QRS complexes

that were visible in the electrocardiographic artifact at intervals that coincided with the cycle length of the base-line rhythm.

The phenomenon of electrocardiographic artifact was recognized and categorized shortly after electrocardiographic monitoring became available.<sup>1-10</sup> Artifact has been categorized as pseudoarrhythmic and non-arrhythmic.<sup>8</sup> Artifact can simulate ventricular tachycardia, supraventricular tachycardia, Mobitz type II atrioventricular block, and sinus arrest. The potential clinical effect of each type of artifact was categorized by one group of researchers as possible, minimal, or serious.<sup>8</sup> However, the outcomes of patients in whom arrhythmia is incorrectly diagnosed because of artifact have been unclear.

Previous studies have concluded that the most likely causes of electrocardiographic artifact that mimics ventricular tachycardia are body movement and intermittent skin–electrode contact.<sup>8</sup> The rapid manipulation of a recording electrode on the skin has been shown to simulate ventricular tachycardia.<sup>7</sup> Although body movement or a poor skin–electrode contact may have caused the electrocardiographic artifacts described in this series, the actual causes of the artifacts could not be determined.

Although the magnitude of the problem remains unclear, the cases in this report demonstrate that physicians with a broad spectrum of expertise in the diagnosis and treatment of arrhythmia, including board-certified cardiologists and practicing electrophysiologists, at times may mistake artifact for ventricular tachycardia. Furthermore, these cases show that the misdiagnosis of electrocardiographic artifact as ventricular tachycardia may lead to unnecessary interventions as drastic as the implantation of a permanent pacemaker or an implantable cardioverter–defibrillator. These findings indicate the importance of improved training in the recognition of artifact and the need for a heightened index of suspicion among physicians who treat patients with arrhythmias.

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