

Electrical storm in a patient with Takayasu arteritis and inferior myocardial scar



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Introduction

Electrical storm is a state of electrical instability defined by 3 or more separate episodes of sustained ventricular tachycardia (VT) within 24 hours, each requiring termination by an intervention.¹ It can be triggered by structural heart disease, acute myocardial infarction, and inherited arrhythmia syndromes. In the worst-case scenario, an electrical storm leads to sudden cardiac death. A comprehensive diagnostic approach is required to understand the arrhythmia mechanism and to evaluate therapeutic options.

In this case report, we present a young female patient with an electrical storm caused by a myocardial scar induced by Takayasu arteritis (TA). The patient was successfully treated by radiofrequency ablation.

Case report

A 31-year-old, previously healthy woman was admitted to our institution for progressive exercise-induced dyspnea and intermittent palpitations for about 2 weeks.

The initial electrocardiogram (ECG) showed a right axis deviation with pre-terminal T-wave inversion in II, III, aVF, V₄₋₆ in sinus rhythm, and polymorphic ventricular extrasystoles with a bigeminal pattern (Supplemental Figure 1). Several episodes of nonsustained VT could be detected by telemetric monitoring of the patient. Laboratory parameters did not provide any conclusive hint. Particularly, cardiac enzymes including high-sensitivity troponins were negative. Thyroid function parameters and electrolytes, as well as procalcitonin, were within normal range. C-reactive protein (CRP) was slightly increased. Screening for toxic substances was negative. The patient was initially treated with high-dose beta-blockade and as this proved ineffective, intravenous amiodarone was initiated.

KEYWORDS Catheter ablation; Electrical storm; Electrophysiological intervention; Pacemaker; Rare events; Subcutaneous ICD; Takayasu arteritis; Vasculitis; Ventricular tachycardia
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Owing to continuous ventricular arrhythmia, acquisition of reliable transthoracic echocardiographic images was challenging. However, reduced left ventricular systolic function owing to inferior and inferoseptal wall motion abnormalities was detected (Figure 1). Subsequently, the patient underwent coronary angiography, which ruled out coronary pathology. In particular, no signs of spontaneous coronary artery dissection or vasculitic changes were seen (Supplemental Figure 2). A diagnostic workup for myocardial infarction with nonobstructive coronary arteries was initiated. Cardiac magnetic resonance imaging (MRI) confirmed the presence of a transmural inferior myocardial scar (Figure 1). The laboratory analysis showed an elevated erythrocyte sedimentation rate of 54 mm/h and a slightly increased CRP of 3.0 mg/dL. Specific vasculitis serology was negative. Clotting disorders were ruled out by laboratory chemistry.

A highly mobile mass in the aortic root adjacent to the origin of the right coronary artery (RCA) was detected by transesophageal echo (Figure 2). The patient underwent urgent surgical exploration; however, the mass had disappeared. The exact etiology of the mobile mass remained unclear. Macroscopically, a “rough” appearance of the aorta suggestive of inflammatory changes was seen. Owing to these intraoperative findings, a further workup for seronegative large-vessel vasculitis was initiated. Anticoagulation with edoxaban was initiated to avoid the risk of a possible recurrent thromboembolic event.

Intima media complexes of both carotid arteries were thickened in carotid ultrasound (Figure 3). The MRI showed an enlargement of the intima media complex of the left and the right subclavian arteries and both axillary arteries (Figure 4). TA was diagnosed according to the international Chapel Hill Consensus Conference 2012 definition.² Subsequently, high-dose prednisolone therapy was initiated.

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A Case for Education Quiz

- 1.) According to the most recent guidelines, which of the following statements on management of ventricular arrhythmia (VA) in ischemic heart diseases (IHD) is true (select one)?
 - a.) For patients with IHD and VT storm refractory to antiarrhythmic drug therapy, a catheter ablation is recommended.
 - b.) Escalation with mexiletine in patients with reoccurring VT in IHD and baseline amiodarone therapy is superior to catheter ablation.
 - c.) An ICD implantation after catheter ablation is indicated in every patient with VA in IHD.
 - d.) Bilateral cardiac sympathetic denervation is superior to catheter ablation in patients with reoccurring VA in IHD

According to the 2019 HRS/EHRA/APHRS/LAHS expert consensus statement on catheter ablation of ventricular arrhythmias, antiarrhythmic drug therapy is universally used as first-line therapy for patients with ventricular arrhythmia in ischemic heart diseases. In fact, catheter ablation is a particularly important therapy when VA recurs and is superior to drug escalation therapies.
- 2.) Which of the following statements is true with regard to signs and symptoms in Takayasu arteritis (TA) (select one)?
 - a.) Takayasu arteritis mainly affects men above 40.
 - b.) Myocardial perfusion defects are the most common cause for myocardial ischemia in patients with TA.
 - c.) TA is a necrotizing arteritis of medium or small arteries without glomerulonephritis or vasculitis in arterioles, capillaries, or venules, and is not associated with antineutrophil cytoplasmic antibodies (ANCA)s.
 - d.) Patients with TA are not associated with an increased risk of both venous and arterial thrombosis. Comarmond and colleagues^{9,10} showed a significantly higher prevalence (85%) of myocardial perfusion defects in patients with Takayasu arteritis in comparison to a low rate of coronary stenosis (18.2%).
- 3.) Which of the following statement is false regarding implantable cardioverter-defibrillator (ICD) therapy (select one)?
 - a.) Subcutaneous ICDs are superior to transvenous ICDs with respect to device-related complications or inappropriate shocks in patients with an indication for defibrillator therapy, but with no indication for pacing.
 - b.) Patients with transvenous ICDs have a higher cumulative incidence of device-related complications than patients with a subcutaneous ICD.
 - c.) Patients with subcutaneous ICDs have a higher cumulative incidence of inappropriate shocks than patients with a transvenous ICD.
 - d.) Transvenous ICDs can incorporate pacing for bradycardia or cardiac resynchronization. The PRETORIAN trial among patients with an indication for ICD therapy but not for pacing therapy showed that subcutaneous ICD therapy was noninferior to transvenous ICD therapy. The primary endpoint of the trial was device-related complications or inappropriate shocks. The trial showed that both devices prevent arrhythmic sudden death with a comparable complication rate specific for each device.
- 4.) Which of the following diagnostic modalities are essential to diagnostic a new onset of Takayasu arteritis (TA) with cardiac manifestation (multiple answers are possible)?
 - a.) PET-CT
 - b.) Cardiac scintigraphy
 - c.) CT-angiography
 - d.) MRI-angiography
 - e.) Laboratory findings (especially CRP, ESR)
 - f.) All of the above

All of the above. Cardiac scintigraphy and PET-CT are suitable diagnostic tools to evaluate the extent of TA manifestation. CT angiography helps to differentiate between a myocardial perfusion deficit or a possible coronary stenosis in patients with TA. MRI-angiography or CT angiography are diagnostic tools of first choice to determine the exact localization of TA. Unspecific laboratory findings such as slightly elevated CRP or elevated ESR can give a hint for TA as a possible diagnosis for the experienced clinician.

Initially, the patient remained stable under oral amiodarone and beta-blockade; however, after a withdrawal trial of amiodarone electrical instability with ventricular arrhythmias re-occurred. Thus, the patient was scheduled for urgent electrophysiological investigation. A 3D high-definition voltage map of the left ventricle identified a large inferior and inferoseptal scar. The electroanatomical mapping identified a low-voltage area with an amplitude < 0.5 mV, extending from the inferior to mid and apical inferoseptal aspects of

the left ventricle (**Figure 5**) in accordance with the results from cardiac MRI.

Within this low-voltage area (local voltage <0.5 mV) late potentials were identified (**Figure 5**) representing areas with slow local electrical impulse propagation, which served as a prerequisite for the induction of polymorphic VT. Programmed electrical stimulation during the electrophysiological investigation could not induce a VT. Therefore, the goal of the ablation was to eliminate all late potentials. As

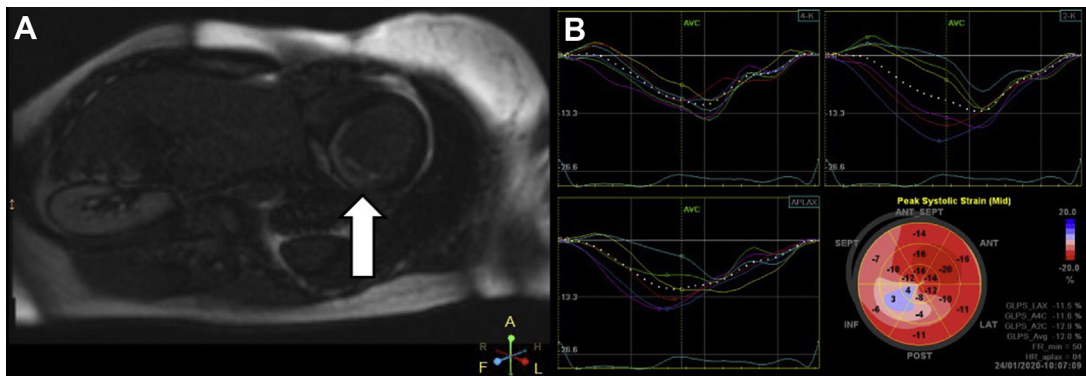


Figure 1 **A:** Cardiac magnetic resonance imaging. In the late phase after administration of contrast medium, there is evidence of subendocardial, nearly transmural myocardial scarring mid to apical inferior, inferoseptal, and inferolateral, including the posteromedial papillary muscle. Fibrosis covers about 75% of the wall thickness; the subepicardial parts are vital. **B:** Transthoracic echocardiography with speckle tracking detection of an inferobasal septal scar.

a result of noninducible VT an activation mapping could not be performed. Extensive ablation of late potentials and dechanneling of the scar was performed (Figures 5 and 6). After catheter ablation no recurrence of ventricular arrhythmia was documented. Amiodarone therapy was recommended following ablation for 3 months. A subcutaneous implantable cardioverter-defibrillator (s-ICD) was implanted 2 days after ablation (Supplemental Figure 3).

The following MRI and ultrasound examinations suggested a good response to the prednisolone therapy with regression of vasculitic changes. A stable clinical course was documented at 6-month follow-up.

Discussion

Young patients with an electrical storm pose a diagnostic and therapeutic challenge.

This case presents a young female patient without risk factors who presented with an electrical storm and was diagnosed with a myocardial scar owing to TA. Furthermore, it

shows the significance of stepwise escalation of diagnostic approaches to determine the origin of the electrical storm. Initially, it is essential to categorize the patients according to hemodynamic stability (stable vs unstable) and risk category (low-risk or high-risk with serious comorbidities). High risk or hemodynamically unstable patients need continuous ECG monitoring in a coronary care unit/intermediate care unit/intensive care unit.

Rapidly available diagnostic measures such as 12-channel ECG, blood gas analysis, laboratory chemical analysis including troponins and natriuretic peptides, toxic screening, and bedside echocardiography are used to rule out reversible causes of electrical storm. Reversible causes of electrical storm are electrolyte disturbances, infections, hyperthyroidism, intoxication and substance abuse, decompensated heart failure, and acute myocardial infarction. Nonreversible causes of electrical storm are structural heart disease and primary electrical disease, eg, catecholaminergic polymorphic ventricular tachycardia (CPVT), Brugada syndrome, or the long and short QT syndromes.

Our case presented a complex scenario: Reversible causes of electrical storm were ruled out. Using echocardiography we detected a myocardial scar with moderately reduced left ventricular systolic function without the elevation of cardiac biomarkers. Since troponin levels were not elevated, the time of myocardial infarction likely preceded the admission by more than 2 weeks and could not be elucidated further by the patient's history. The next diagnostic step in this scenario could be a coronary angiography or a computed tomography (CT) to rule out coronary artery disease. Although coronary artery disease and atherosclerosis is unlikely in a 31-year-old female patient, invasive coronary angiography was the preferred over CT angiography or noninvasive tests in our case, as alternative coronary pathologies such as spontaneous coronary artery dissection, vasospastic angina, and vasculitic changes can be excluded simultaneously and percutaneous coronary intervention can be performed timely in a hemodynamically unstable patient. If necessary, additional diagnostic modalities such as intravascular ultrasound or optical

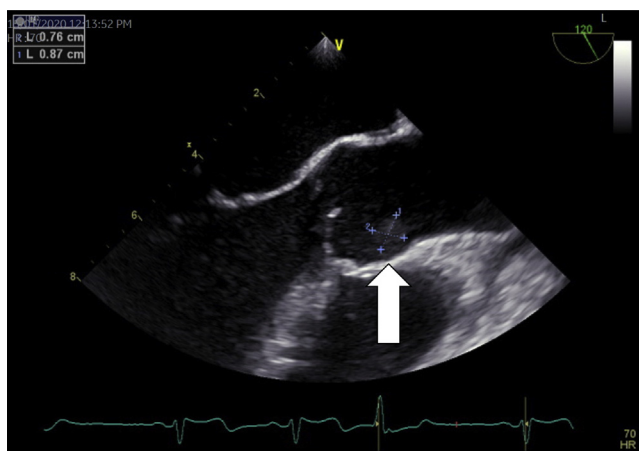


Figure 2 Transesophageal echocardiography directly distal to the aortic valve at the level of the right coronary cusp in the area of the right coronary artery ostium detectable echo-poor mobile structure of 0.76 cm × 0.87 cm diameter.

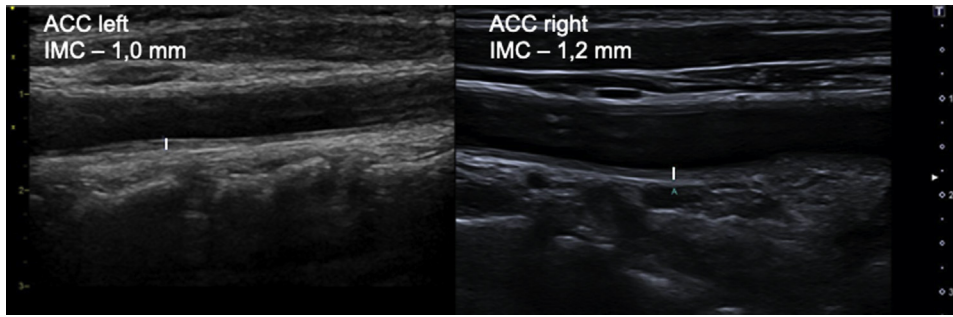


Figure 3 Duplex sonography: left carotid artery with relatively echo-rich wall thickening up to 1.0 mm; right carotid artery with relatively echo-rich wall thickening up to 1.2 mm.

coherence tomography can be used to reach a diagnosis. Our patient did not show any sign of coronary pathology; in particular, no vasculitic changes were seen.

Cardiac MRI is essential in the further diagnostic workup and confirmed a transmural myocardial scar as a possible arrhythmogenic substrate. Clotting disorders were excluded in our patient. Serology including antineutrophil cytoplasmic antibodies, RF, and cyclic citrullinated peptide antibodies did not hint at any vasculitis. CRP was still only mildly elevated and was deemed to be unspecific in an acutely hospitalized patient at this point. A transesophageal echocardiogram was performed to exclude thromboembolic cardiac sources. Surprisingly, a highly mobile mass was seen in the right coronary sinus. As the patient was continuously arrhythmic, MRI was artefact-prone, and the mass could not be detected. Differential diagnosis in this setting includes atypical myxomas and to a lesser extent fibroelastoma, as well as inflammatory masses and iatrogenic causes following catheterization. As this mass was deemed to be at high risk for embolization and was adjacent to the ostium of the RCA, urgent surgical exploration was initiated. Only after the cardiac surgeon reported a “rough” appearance of the aorta, a possible diagnosis of TA was taken into account. Ultrasound of the carotid vessels and MRI of the large vessels in conjunction with the slightly elevated CRP confirmed the diagnosis of TA according to international Chapel Hill Consensus Conference 2012 definition.² In retrospect, carotid duplex prior to surgery would have shifted the diagnostic focus towards a vasculitis and would have deferred the need for urgent cardiac surgery.

A positron emission tomography / CT to evaluate the exact extent of the vasculitis was also discussed. However, owing to previous surgical exploration of the aorta, imaging would not have been analyzable. Brain MRI was not performed following cardiac surgery, as the neurological status of the patient was uneventful. However, since the initial assumption was that the source of the myocardial scar was thromboembolic, brain MRI would have potentially yielded additional diagnostic information.

TA can be manifested in several organ systems. Myocarditis, aortic valvular regurgitation, aortitis, coronary vessel stenosis, or myocardial perfusion deficits can lead to serious

cardiac complications such as myocardial infarction, heart failure, and sudden death.^{3,4} Electrical storm is a rare complication in patients with TA owing to ischemia-mediated VT. Myocardial ischemia is one of the major causes of death in TA.⁵ It mainly affects young women under 40. Myocardial ischemia in patients with TA can be triggered either by arteriopathy of coronary vessels or by a defect in myocardial perfusion.^{6–8} Multiple studies showed a high prevalence of myocardial perfusion defects on myocardial scintigraphy and myocardial scarring on cardiac MRI ranging from 53% to 78% in patients with TA, while the incidence of coronary artery stenosis is relatively low (18.2%).^{9,10} Systemic inflammatory diseases such as TA are also associated with an increased risk of both venous and arterial thrombosis.¹¹ In our case a highly mobile mass adjacent to the right coronary vessel was detected during transesophageal echo. MRI confirmed that the distribution of the myocardial scar was congruent with the blood supply of the RCA and the scar was transmural. Thus, an embolic origin was deemed most likely in our case, as opposed to diffuse perfusion defects, which are a more frequent feature of TA, and an indication for therapeutic anticoagulation was established.¹²

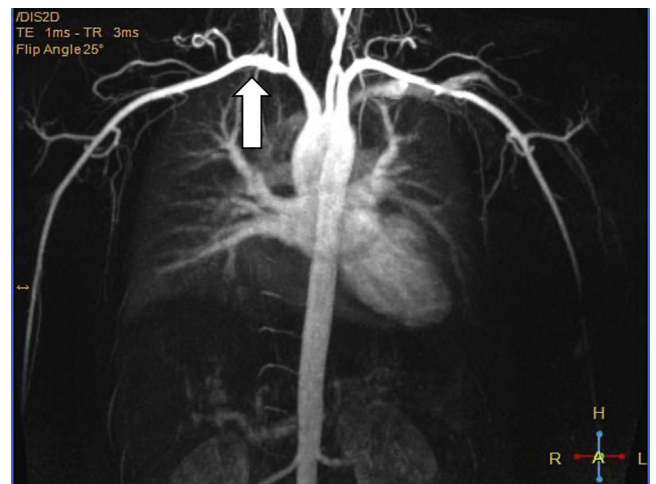


Figure 4 Magnetic resonance angiography of supra-aortic cervical vessels: vasculitic changes in the course of the subclavian and axillary arteries on both sides with moderate diminution of the right proximal subclavian artery, as well as a moderate tandem stenosis of the left subclavian–axillary junction.

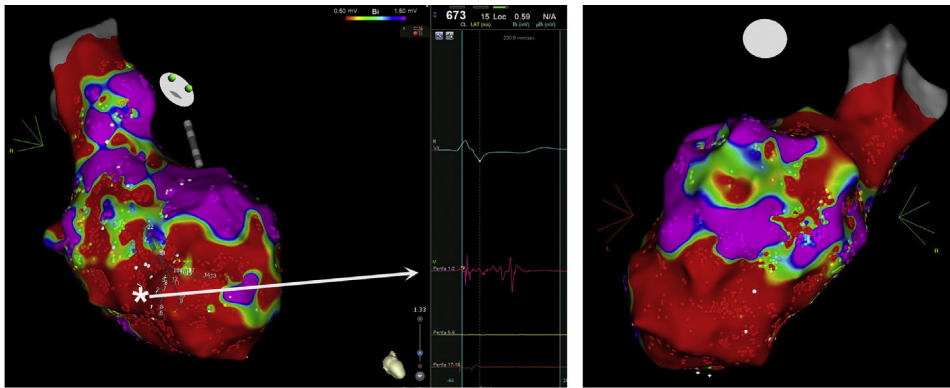


Figure 5 Voltage map of the left ventricle in right anterior oblique caudal (*left*) and posteroanterior view (*right*). Red: scar (<0.5 mV); purple: healthy myocardium (>1.5 mV). Scar extension from mid to apical inferoseptal and inferior and circumscribed inferior basal. Star: late potential at the HD mapping catheter within the scar.

Owing to the transmural nature of the myocardial scar, we did not expect additional diagnostic information from performing a myocardial biopsy.

Initially, we chose intravenous amiodarone to terminate the electrical storm and added a beta-blocker to suppress beta-adrenergic stimulation. The patient underwent successful catheter ablation after a failed amiodarone withdrawal trial.¹³ The 3D voltage map showed late potentials around the margin of the myocardial scar, which were deemed responsible for the disrupted electrophysiological conduction, resulting in electrical storm. Following electrophysiological therapy, prevention of sudden cardiac death had to be addressed in our patient. A possible strategy in our patient could have been watchful waiting in combination with a wearable external defibrillator; however, we opted for an s-ICD in our patient for 2 reasons. The patient had a large transmural scar, which might serve as an anatomic substrate for future hemodynamic instability. More importantly, TA is a dynamic disease with a 10-year relapse rate of 50% after first diagnosis with a future potential for diffuse myocardial perfusion defects and myocardial scarring. Thus, hemodynamic stability in a

TA patient in a secondary-prevention setting is difficult to predict.¹⁴ As our patient was at no time hemodynamically unstable and nearly asymptomatic, we decided to implant an s-ICD owing to the lower incidence of device-related complications in comparison to transcutaneous ICDs.¹⁵ A further advantage in a very young patient is the avoidance of a possible endoluminal source of infection and thus the reduction of the risk of endocarditis. Until now no VTs re-occurred and the maintenance therapy with amiodarone was discontinued after 3 months.

A common initial treatment for TA is the use of high-dose orally administered glucocorticoids alone or in combination with a glucocorticoid-sparing agent.

In our case, an initial dose of 1 mg/kg oral prednisone was indicated owing to the affection of primary branches of the aorta (Aa. carotis communis) and severe cardiac complications. In the short-term course, a significant decrease in disease activity was observed and tapering of the glucocorticoid dose was initiated.

This case reports indicates several pitfalls that the clinician might face in the diagnosis of TA. Although TA is rare, the clinician should be aware of its clinical presentation and

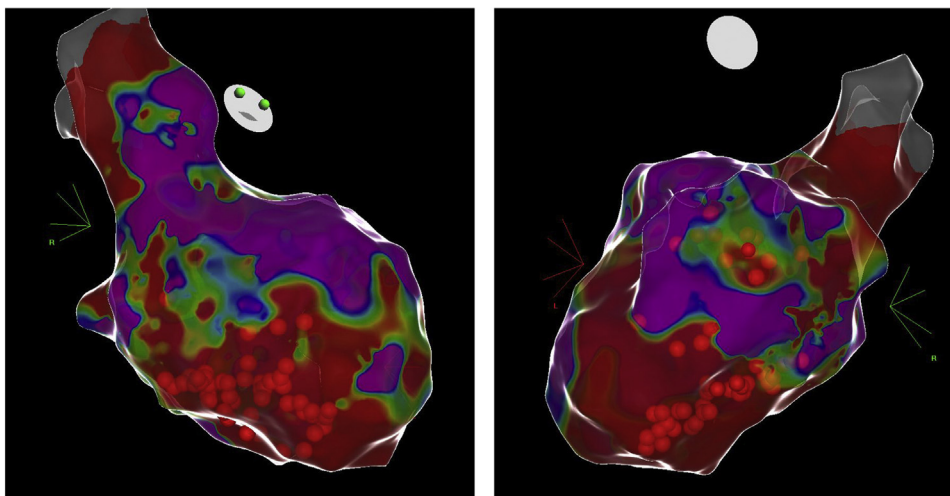


Figure 6 Ablation points at the end of the procedure, right anterior oblique caudal (*left*) and posteroanterior view (*right*). Ablation was performed with contact force and irrigated tip 40–50 W.

potential complications. Mild increase of inflammatory markers with negative vasculitis serology and normal coronary arteries does not exclude cardiac manifestation of TA. An elevated erythrocyte sedimentation rate should ring alarm bells and carotid ultrasound might be a good screening investigation. TA can be confirmed by MRI or CT angiography of the large vessels. Contrary to conventional wisdom, vasculitis of the coronary arteries is not the main cardiac complication. Diffuse perfusion defects, which may be detected by myocardial scintigraphy or positron emission tomography myocardial perfusion imaging, are more common in patients with TA.

Conclusion

In case of electrical storm, a fast and structured diagnostic approach is necessary to initiate a specific treatment. TA might affect the myocardium through diffuse perfusion defects or myocardial scarring caused by affected coronary vessels or thromboembolic events that might serve as the anatomic substrates for ventricular arrhythmia and hemodynamic instability. Catheter ablation of electrical storm caused by TA-mediated myocardial scar can be performed successfully and should be considered as an early treatment option.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.hrcr.2021.02.008>.

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