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CASE REPORT

Multiple Implantable Cardioverter-Defibrillator Shocks in Ischemic Cardiomyopathy Compels Coronary Vascularization Reassessment

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ABSTRACT

The increasing number of patients with heart failure and implantable cardioverter-defibrillators (ICD) has led to a growing of the emergency presentations for ICD internal shocks. Appropriate shocks are sometimes caused by acute events in the course of disease and could be one of the earliest symptoms contributing to the diagnosis and timely treatment of these acute conditions. We present the case of a 64-year-old male patient with ischemic cardiomyopathy, ICD carrier, who presented to the emergency department for recurrent appropriate ICD shocks caused by episodes of polymorphic ventricular tachycardia and ventricular fibrillation. Even if he did not have chest pain, he was referred to cath lab, where the coronary angiography has shown a severe stenosis at the origin of the left anterior descending artery and a moderate stenosis at the proximal left circumflex artery. The percutaneous revascularization of both lesions resulted in the eradication of the sustained ventricular arrhythmias and the improvement of the clinical status. The case argues for the need for coronary vascularization assessment in ICD carrier patients with ischemic heart failure and adequate recurrent shocks, also emphasizing the importance of remote monitoring in early diagnosis of acute conditions in these patients.

Keywords: implantable cardioverter-defibrillator, ischemic cardiomyopathy, acute coronary syndrome, ventricular arrhythmias

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INTRODUCTION

Since the first decades of its use, the implantable cardioverter-defibrillator (ICD) has proven its efficacy in reducing the incidence of arrhythmic sudden cardiac death by up to 30%.[1] Among the ICD carriers, patients with heart failure and reduced left ventricular ejection fraction (LVEF) due to ischemic heart disease, encounter some of the greatest benefits in terms of survival.[2]

The ICD shocks however can impair the patients' quality of life by increasing the general anxiety and reducing the patient's daily activities.[3] For this reason, whenever the internal shocks are recurrent (more than three in a few hours), the interrogation of the device is recommended.[4] The inappropriate ICD shocks, often caused by supraventricular tachyarrhythmias either by oversensing or by lead failure, require reprogramming of the device or the revision of the lead. The appropri-

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ate ICD shocks, even if life-saving, could have similar unpleasant consequences on the patient's general status; therefore these shocks must be avoided as much as possible through the optimal programming of the device (less aggressive anti-tachycardia algorithms) and through drug therapy or radiofrequency ablation of the ventricular arrhythmias.[5] Sometimes these sustained arrhythmias result from the worsening of coronary perfusion and a reduction in the number of shocks could be achieved by revascularization.

CASE PRESENTATION

A 64-year-old male patient, known with ischemic cardiomyopathy (i-CM) and cardiac resynchronization therapy with defibrillator (CRT-D) came to the emergency department for three internal shocks that have occurred the previous day. The shocks were not preceded by syncope or chest pain. A couple of days before he noted the worsening of dyspnea on exertion. His personal history consisted of diabetes mellitus (2006), arterial hypertension (2006), percutaneous coronary revascularization for ST-elevation myocardial infarction (STEMI) and for unstable angina (UA), and CRT-D implantation, as presented in Table 1.

At the time of the consultation, the patient was under treatment with carvedilol, aspirin, atorvastatin, furosemide, spironolactone, ramipril, metformin, and combined insulin regimen.

At the initial assessment, his blood pressure was 110/80 mmHg, HR 60 bpm, O_2 saturation 96%. The standard 12-lead ECG showed sinus rhythm and biventricular paced QRS complexes (Figure 1). The laboratory tests revealed two consecutive TnI values within normal range (0.027 ng/mL and 0.028 ng/mL) and elevated NT-proBNP (1,153 pg/mL). HbA1c (6.8%) suggested a good control of the diabetes with the current metformin and insulin regimen. The kidney function tests, electrolytes and hematology tests were all normal. On cardiac ultrasound we found the decrease of the ejection fraction towards 25%, akinesia of the LV apex and hypokinesia of the anterior wall of the LV.

The ICD interrogation revealed three episodes of high-rate polymorphic ventricular tachycardia (VT) and ventricular fibrillation (VF) that have occurred during the last 24 h, and were interrupted by appropriate shocks (Figure 2). The patient was referred to the cath lab, and the coronary angiography showed a severe, unstable stenosis at the origin of the LAD, proximal to the pre-existing stent, and a moderate stenosis at proximal left circumflex artery (LCX) (Figure 3). The LAD stenosis was considered the culprit lesion of the acute coronary syndrome, and angioplasty with stent implantation was performed. Due to the left dominance and major myocardial distribution, angioplasty of the LCX was also considered necessary (Figure 4). A second antiplatelet agent (clopidogrel) and a SGLT2 inhibitor (dapagliflozin) were added, according to the current guidelines. The symptoms and LV contractility improved with revascularization, without recurrence of the ventricular arrhythmias.

DISCUSSION

Since the first internal defibrillator implantation in 1980, the number of ICD carriers has continuously increased and different prediction algorithms estimate a further increase during the following years.[6] In line with this, the number of patients experiencing ICD shocks will also increase. According to previously published research, up to 10–25% of the ICD shocks are inappropriate.[7] However, up to 90% still remain appropriate, and a significant percentage of these shocks occur in patients with i-DCM, given the high prevalence of ischemic heart disease among defibrillator wearers.[8] Sustained monomorphic VT is well recognized as the

TABLE 1. The course of coronary artery disease–related events

Year	Event	Intervention	LVEF / NYHA class
2006	STEMI	PTCA – BMS implanted on LAD (proximal)	45% / NYHA II
2017	UA	PTCA – DES implanted on M1	45% / NYHA II
2019	NYHA class worsening	Coronary angiography – no additional stenosis CRT-D implantation (Medtronic Protecta CRTD)	30% / NYHA III LBBB, QRSd = 160 ms
2021	Follow-up	Clinical and echo assessment Device follow-up	35%, NYHA II/III BiV = 99%, no VA
2022 oct	Three internal shocks		

BiV, bi-ventricular pacing percentage; BMS, bare metal stent (implantation); DES, drug-eluting stent (implantation); LAD, left anterior descending artery; LBBB, left bundle branch block; M1, first marginal coronary artery; PTCA, percutaneous coronary angioplasty; VA, ventricular arrhythmias

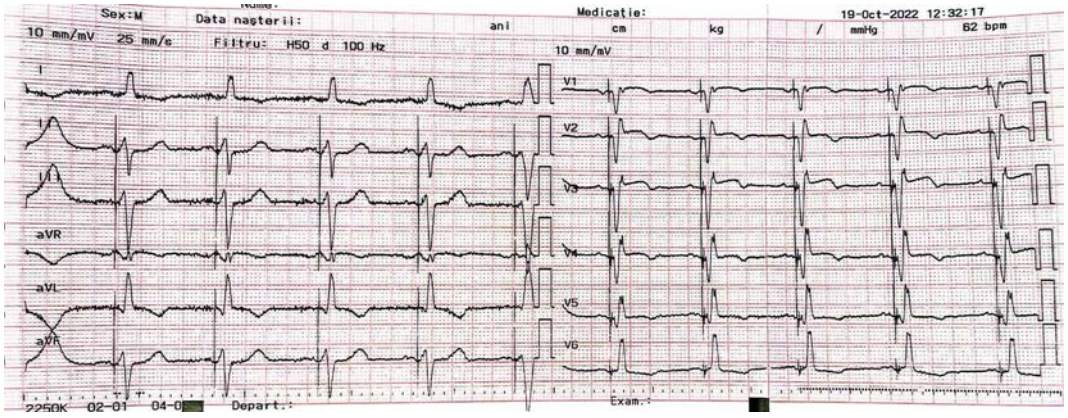

FIGURE 1. ECG on admission. Sinus rhythm and biventricular paced QRS complex

most frequent cause of appropriate ICD shocks in patients with previous myocardial infarction.[9] The electrophysiological substrate of these monomorphic VTs results from LV remodeling during the subacute phase of a myocardial infarction (first week). The macroreentry circuit, involving the myocardial scar and surrounding tissue, seems to remain unchanged during the chronic phase. This stable reentry circuit could be addressed by radiofrequency ablation if the recurrent arrhythmia is poorly controlled by antiarrhythmic drugs and leads to unpleasant repetitive ICD shocks.

On the other hand, it is well-known that the acute myocardial ischemia induces heterogeneity in refractoriness and conduction, favoring both reentry and abnormal automaticity. Even if reperfusion within the first 30 min completely restores myocardial viability, it is estimated that up to 50% of fatal ventricular arrhythmias occur within this time interval and consist of polymorphic VT and VF. Beyond the first 30 min and up to 48 h afterwards, the persistent coronary occlusion results in irreversible myocardial necrosis. The myocardial cells in the border zone of the infarcted area, as well as the more resistant, viable, subendocardial Purkinje cells within the infarcted area will get altered electrophysiological properties (decreased resting potential, prolonged conduction, delayed refractoriness), resulting in the aforementioned polymorphic VT or VF. Moreover, studies have shown that previous myocardial scars will favor the onset of these malignant ventricular arrhythmias in the setting of a new acute ischemic event.[10]

ICDs have complex data logging capacities. This allows for the ventricular arrhythmia events to be recorded and stored into the device's internal memory as electrograms (EGMs). Both near-field and far-field EGMs are further used as valuable diagnostic tools. The near-field EGMs collect the bipolar signals from the electrode tip and the proximal electrode ring and are especially used for the detection of the arrhythmias. The far-field EGMs allow for the description of the arrhythmia morphology because the recorded signals are coming from the case of the ICD, the right ventricle coil and sometimes from a second, proximal, superior vena cava coil of the transvenous ICD lead.

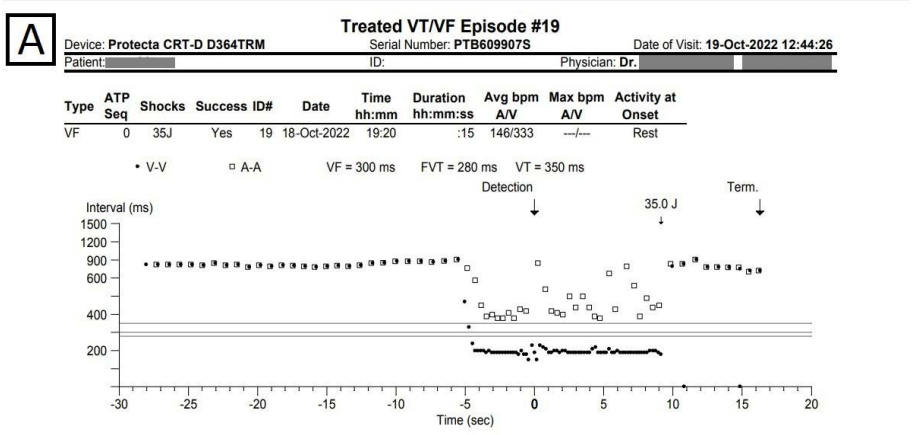

FIGURE 2. One of the VF episodes interrupted by CRT-D shock

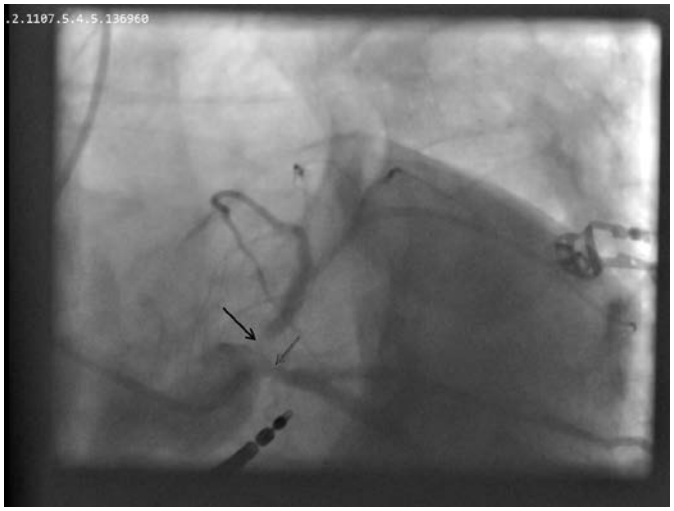

FIGURE 3. Coronary angiography. Severe stenosis at the origin of the LAD and moderate stenosis on the proximal LCX

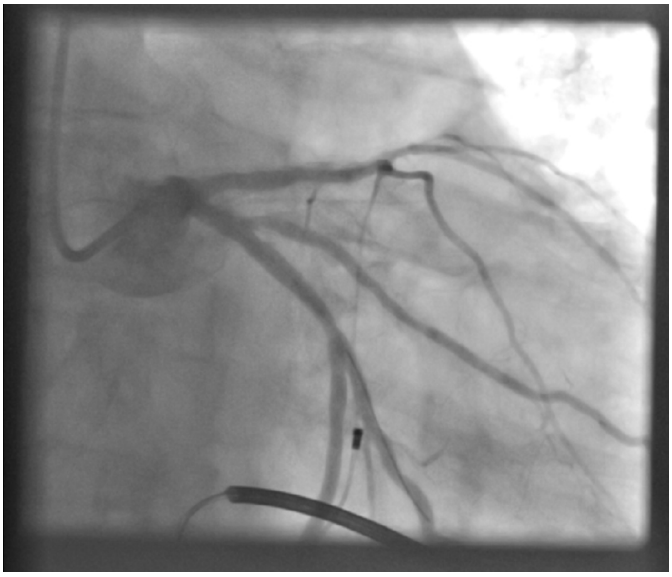

FIGURE 4. Coronary angiography after PCI of the LAD and LCX

This far-field EGM significantly improves the accuracy of the ICD therapies (in terms of appropriateness) by introducing a second algorithm designed to discriminate between the QRS complexes of the arrhythmia and those of the base rhythm.[5] Moreover, in the light of the above, the far-field EGM allows the assessment of the arrhythmia substrate, by differentiating the polymorphic VT or VF from monomorphic VT.

Our case supports once again the emergency to assess the device by interrogation whenever three or more shocks occur in 24 h.[4] Beyond the appropriate nature of the shocks, the analysis of the stored EGMs in the device's memory, suggested the substrate of the arrhythmia by revealing polymorphic VT or VF (acute myocardial ischemia) instead of monomorphic VT (a previous scar of the left ventricle).[5] In our patient, these VF episodes and the significant worsening of myocardial kinetics on echocardiography argued for coronary angiography, even though the cardiac enzymes were normal and there was no chest pain. Finally, we can say that ICD shocks brought the patient to the emergency room and hastened the proper diagnostic approach.

The angiographic characteristics of the coronary lesions confirmed the acute coronary syndrome and mandated revascularization. The coronary anatomy allowed for both percutaneous and surgical revascularization. Taking into account the feasibility of percutaneous angioplasty and the possibility of achieving revascularization in a timelier manner, percutaneous revascularization was chosen. The increased operative risk and the interventional team's experience[10] were also factors taken into consideration.

Along with revascularization of the culprit vessel, according to current guideline recommendations in the management of acute coronary syndromes without ST-segment elevation, complete revascularization was performed. This decision was supported by the large myocardial distribution of the LCX and the presence of left coronary dominance.

Early outcomes after the revascularization, were favorable – the improvement of the ejection fraction and the reduction of the arrhythmic events. However, the rapid progression of the coronary stenosis throughout the prior 5 years (since the angiographic evaluation in 2017) required additional strategies for risk factor control: statin dose increase, SGLT2 inhibitor addition,[11,12] physical training programs.[13]

Last but not least, the importance of CRT-D remote monitoring should be mentioned.[14] Nowadays, the design of many ICDs allows their remote follow-up using a home modem, which interrogates the device and transmits data to a hospital server using a cellular phone line or the internet. There is a scheduled daily interrogation of the device and the data received by the central server is automatically analyzed and interpreted, providing early notifications if some alert events were recorded. Additional data transfer to the server could be achieved on patient's demand if any symptoms worry him.

The remote monitoring provides early diagnosis of device malfunction, especially battery end of life or lead damage. Inappropriate shocks due to lead malfunction or T-wave oversensing decreased significantly by remote follow-up in comparison with on-site evaluation of the device.[14] Moreover, the remote follow-up reduces the number of hospital visits by up to 50%[15] without jeopardizing the patient's safety. This leads to the improvement of patient's quality

of life and satisfaction by decreasing the travel costs and reducing the time spent for follow-up in-hospital visits.

Moreover, time from symptom onset to arrhythmia diagnosis decreases to a mean duration of 1 day, compared to 1 month in a regular outpatient care regimen. Accordingly, the time interval to clinical decision shortens, increasing the treatment efficacy, improving patient outcomes and reducing the costs of hospitalization.[16]

Our patient's CRT-D device had this feature, but it was not linked to a remote follow-up center. The patient presented to our department the next day after the arrhythmia onset. Remote identification of the arrhythmias would have allowed the assessment of their severity and morphology that could have suggested their substrate (acute ongoing myocardial ischemia) more promptly and would have led to an earlier therapeutic intervention.

CONCLUSION

Recurrent ICD shocks represent an increasing concern among ICD carriers. They compel the urgent interrogation of the device, regardless of the appropriateness of the shocks. For patients with underlying i-DCM, these shocks can represent not only the worsening course of heart failure but also an acute ischemic event, and it can be, sometimes, the sole symptom, for example in diabetic patients. It is an additional proof of the necessity of a remote monitoring of these devices in order to establish an early diagnosis and to timely address the patient to therapeutic interventions.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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