Case report

UDC: 616.12-008.315-089.843:615.817
doi:10.5633/amm.2019.0210

WHEN ELECTRIC SHOCK CAN MEAN LIFE - IMPLANTABLE CARDIOVERTER DEFIBRILLATOR AND ITS EFFECT: A CASE REPORT

Tomislav Kostić[1,4], Zoran Perišić[1], Dragana Stanojević[1], Goran Koraćević[1,2], Vladimir Mitov[2], Mladjan Golubović[3], Predrag Cvetković[1], Mirko Krstić[1], Aleksandar Stojković[1], Sonja Šalinger[1], Stefan Momčilović[4], Sanja Banković[4]

Sudden cardiac death (SCD) caused by ventricular fibrillation (VF) remains a major cause of mortality in the Western world. The majority of VF and cardiac arrest occur outside the hospital. Implantation of an ICD is strongly supported by evidence from many randomized trials for the primary and secondary prevention of sudden cardiac death. Current ICDs have multiple features to enhance diagnostics, minimize unnecessary pacing, conserve energy use, and deliver pain-free therapy such as anti-tachycardia pacing (ATP). The most important of above-mentioned features remains the ability of pacemaker to recognize a life-threatening ventricular arrhythmia and terminate it with shock. The benefit and significance of an ICD shock are dependent on the type of heart disease, and the presence of structural heart disease. These concepts are illustrated in a brief overview of ICD trials in patients with ischemic and non-ischemic heart disease. We present a patient with dilated cardiomyopathy and a reduced left ventricular ejection fraction (LVEF) who had an ICD implanted 1 year ago, as a primary prevention of SCD. The patient was admitted to the Clinic for cardiovascular diseases after a brief loss of consciousness. The electrical control of the device showed that a VF suddenly occurred and was successfully interrupted by a shock as a type of ICD-based therapy.

Acta Medica Medianae 2019;58(2):56-61.

Key words: *implantable cardioverter defibrillator, shock, sudden cardiac death*

[1]Clinic for Cardiovascular diseases, Clinical Centre Niš, Serbia
[2]Health Centre Zaječar, Zaječar, Serbia
[3]Clinic for cardiothoracic and transplantation surgery, Clinical Centre Niš, Niš, Serbia
[4]University of Niš, Faculty of Medicine, Niš, Serbia

Contact: Tomislav Kostić
Blvd. dr Zoran Djindjić 48, 18000 Niš, Serbia
E-mail: tomislav.kostic1977@gmail.com

Introduction

Sudden cardiac death (SCD) due to ventricular fibrillation (VF) remains a major cause of mortality in the Western world. The majority of VF and cardiac arrest occur outside of the hospital. Implantation of an ICD is strongly supported by the evidence from many randomized trials for the primary and secondary prevention of SCD. In these high - risk patients from industrialized countries, coronary artery disease is the most common cause of left ventricular dysfunction and heart failure (1, 2).

Ventricular fibrillation occurs when an electrical wave-break induces re-entry which results in the propagation of new wave-breaks. Tissue heterogeneity in patients with underlying cardiomyopathy results in a predisposition to wave-break, reentry and ultimately to VF. These wandering wavelets of VF are generally self-sustaining once they are initiated (3). There have been significant advances in the technology required for defibrillation of VF. However, less is known about the basic underlying mechanism of defibrillation. Contemporary theories about the mechanisms of electrical shock that terminates VF are similar. These theories are broadly defined as "critical mass", "the upper limit of vulnerability", "progressive depolarization", and "virtual electrode depolarization". The theories underscore the two most import ant components of an ICD shock. First, the shock must successfully terminate the arrhythmias. Second, the ICD shock must not restart the arrhythmia in the mentioned process.

Current ICDs have multiple features to enhance diagnostics, minimize unnecessary pacing, conserve energy use, and deliver pain-free therapy such as anti-tachycardia pacing (ATP). Of all of these features, the most important remains the ability to recognize a life-threatening ventricular arrhythmia

and terminate it with a shock. The benefit and significance of an ICD shock are dependent on the type of heart disease, and on the presence of structural heart disease. These concepts are illustrated in a brief overview of ICD trials in patients with ischemic and nonischemic heart disease (4).

Case report

A 62 year- old patient was admitted to the Clinic for Cardiovascular Diseases, Clinical Centre Niš, due to a short-term loss of consciousness. The patient had an ICD implanted 1 year ago due to dilated cardiomyopathy with LVEF 25 %. During the PM implantation procedure, coronarography was also performed. The patient had normal coronary arteries, and therefore, ischemic heart disease was excluded as a cause of heart failure. On the 24-hour ECG Holter prior to pacemaker implantation, malignant arrhythmias were verified: frequent ventricular extrasystoles, couplets, and non sustained VT. Laboratory analyses did not indicate a myocardial inflammatory process. According to these findings, as part of the primary prevention of sudden cardiac death, the implantation of ICD pacemaker was performed. The patient came now due to the sudden loss of consciousness and electric shock caused by the current generated by the ICD. At the admission patient was conscious, oriented, blood pressure 110/70 mmHg, on the ECG sinus rhythm was recorded, and heart rate 78 beats per minute, without rhythm and conduction disturbances, without changes in the ST segment. Echocardiography finding showed a globally reduced contractile function, LVEF 25 %, without regional wall motion abnormalities. An emergency electrical control of the implanted ICD was performed. It showed that the detection and therapy of VF were successfully performed. Registered VF was 37 seconds in duration, heart rate was 227 bpm, and it was successfully resolved by the first delivered electrical shock with 34J (Figure 1 and 2). Cardiospecific enzymes were at the upper limit - 0.040 ng/mL. This was caused by the minimal myocardial necrosis due to electrical shock. After successful electrical control of the device (ICD control), we changed drug therapy. We introduced Amiodarone as an antiarrhythmic, as part of secondary prevention now, and the patient was discharged from our clinic.

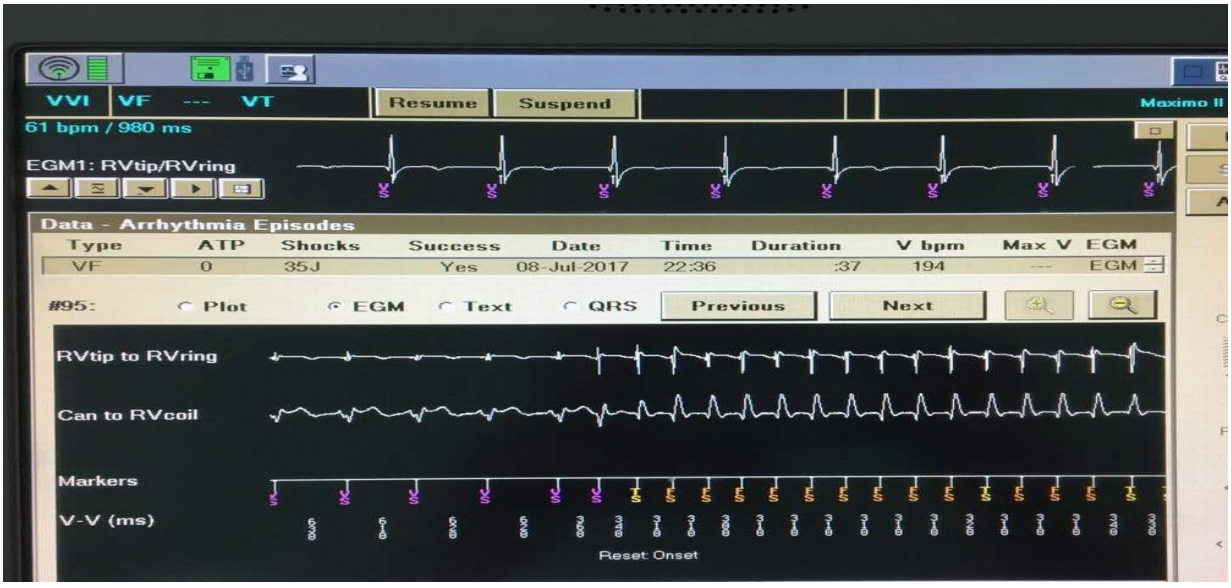

Figure 1. Start of VF recorded on intracardial ECG

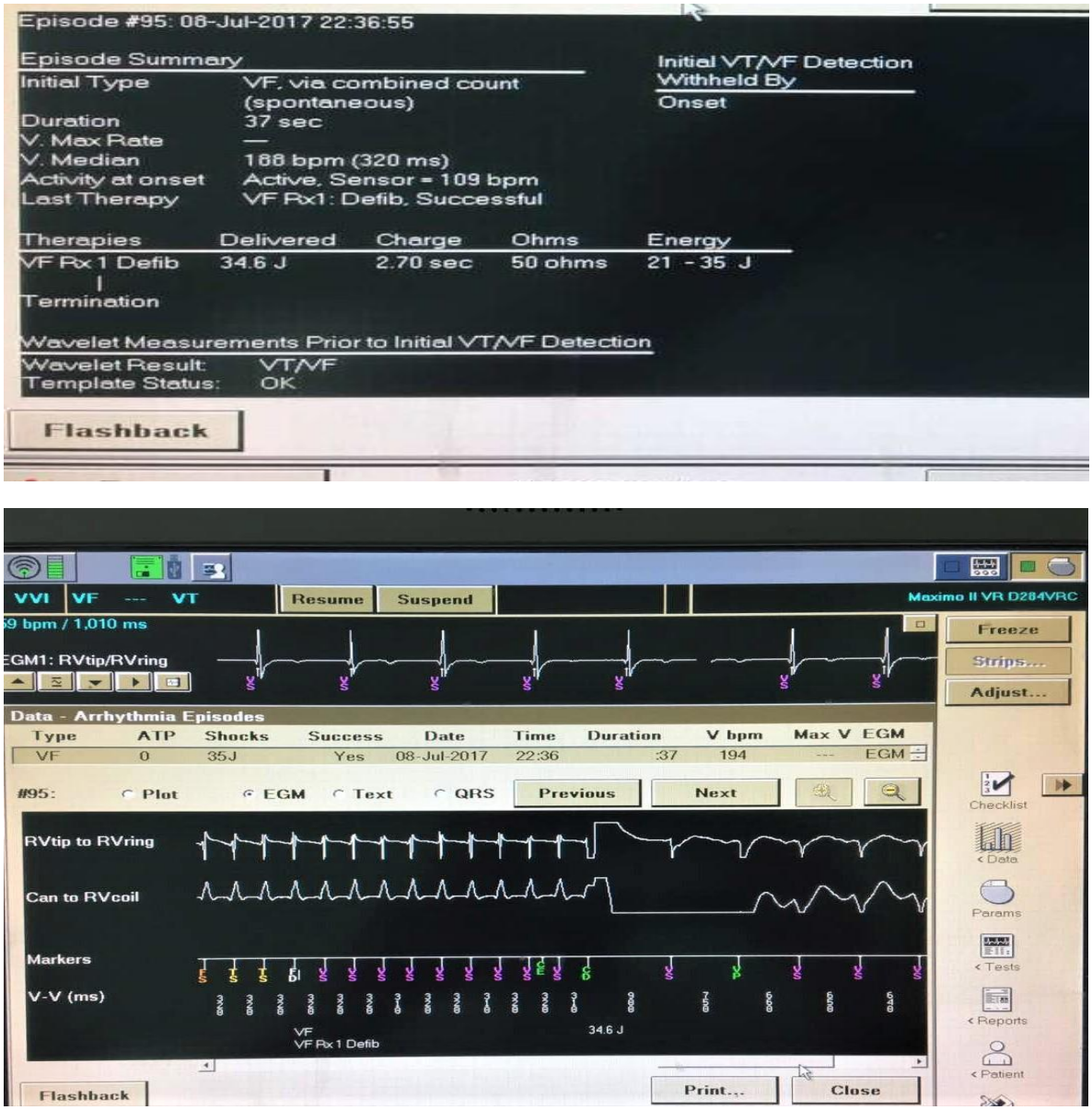

Figure 2. Detection of VF and DC therapy

Discussion

Implantable cardioverter defibrillators (ICDs) are devices that are designed primarily for the therapy of life-threatening heart rhythm disorders. In cooperation with electrical engineers, Mirovski started the project of creating an implantable device in 1980. The purpose of those devices was the ability to recognize and to stop the heart rhythm disorders, whose outcome could lead to SCD. In the period from 1980 to 1985, the device was called the Automatic Implantable Defibrillator and in 1985 its use was approved by the FDA. In Serbia, the first device with that purpose was implanted by Prof. Dr. Milan Bane Djordjevic in 1986 at the Clinical Center of Serbia. Today, modern ICD devices are very similar to standard bradycardic pacemakers regarding the size and purpose. They use a lithium-vanadium battery due to the reliability of the energy source and the need to deliver a higher amount of energy over a short period of time.

For earlier defibrillators, we used epicardial patch electrodes and that required operation with a thoracotomy approach. Today the implantation of the pacemaker's electrode is performed endovenously, practically as well as for standard anti-bradycardia pacemakers.

Detection of heart rhythm disorders is a specific and basic function of ICD. This detection is based on cardiac rhythm, frequency, but requires individual programming, practically for every patient. The detection criteria in ICD evolved as much as therapeutic. Initially, the only detection criterion was

the number of detected R-R intervals, however, today complex detection algorithms were designed. Those detection algorithms prevent un-detection of VT and VF, false detection of VT/VF (instead of atrial arrhythmias or sinus tachycardia). The greatest advancement in technology was the introduction of a gradual tiered therapy which implies that the detected VT is treated with the least aggressive therapy, with the antitachycardic burst stimulation of the different duration of the V-V stimulus. After a series of progressively more aggressive ATP options, synchronous cardioversion with lower power is applied, and finally defibrillation with the maximum current (30-40J). In the case of VF, the maximum DC shock strength is immediately applied, with the possibility of polarity changes (3, 4).

For example, the benefit of ICD therapy in patients with ischemic heart disease is directly related to the time from myocardial infarction (MI) to its implantation. DINAMIT trial randomized patients to receive an ICD or standard medical therapy, 4 to 40 days after MI, and it showed no difference in overall mortality between the two treatment groups. This study was in contrast to the majority of prior trials with the patients with an ICD. That included patients with a recent MI (MUSSTT, MADIT II). The dramatic difference in outcomes with an ICD in these studies likely reflects the underlying significance of ventricular arrhythmias after MI. Early after MI, ventricular arrhythmias are surrogate markers of worsening myocardial function, recurrent ischemia, and infarction. By comparison, late ventricular arrhythmias are often related to alterations of the electrophysiological substrate in the setting of compensated heart failure due to scar and re-entry mechanism.

In comparison, those patients who have nonischemic cardiomyopathy have a benefit of an ICD implantation which depends on time. In the DEFINITE trial, 458 patients with nonischemic dilated cardiomyopathy were randomized to an ICD versus conventional therapy. In this trial, there was a significant reduction in sudden death and a trend toward a reduction in total mortality. In a subtrial of DEFINITE study, the benefit of ICD therapy was seen predominantly in those who had nonischemic dilated cardiomyopathy less than 3 months compared to those with longer duration of the disease. The findings of this study were opposite with those in the population with ischemic cardiomyopathy in which the benefit of ICD therapy is seen in late course of the disease (5-8).

Antitachicardia pacing, when appropriately programmed can significantly reduce ICD shocks as well as any reduced quality of life that results from shock therapy. Reduction in shocks has an important role in terms of patient acceptance and potentially the reduction of any deleterious effect of shock therapy. The routine use of ATP for the treatment of VT, including fast VT, should be considered in all patients with implantable cardioverter defibrillators. Although there are many ways to program ATP, it is important that the clinicians become familiar with the different algorithms and aspects of programming. The two most commonly applied and studied ATP schemes are burst and rump pacing. Burst pacing is a stimulation pattern whereby a train of pacing pulses is delivered with an equal interstimulus interval. Some manufacturers permit an increased duration of the train with each successive train. Ramp pacing is where the train of pacing pulses have an automatically decrementing interstimulus interval. Initially, avoidance of inappropriate ICD shocks was heralded to improve quality of life and improve device longevity. However, additional studies have shown that these shocks are also significant for both alterations in morbidity and mortality. In both patients who received an ICD for primary or secondary prevention, an inappropriate shock was associated with an increase in total mortality. The most common cause of inappropriate shock was atrial fibrillation, followed by supraventricular tachycardia, and abnormal sensing. The significance of new onset atrial fibrillation after ICD implantation has been investigated as well (7, 9-12).

Conclusion

As a conclusion, the use of ICD in primary and secondary prevention of SCD is the most effective therapy in patients with ischemic or non-ischemic cardiomyopathy. Unwanted effects of DC shock as syncope are rare, but the benefits of implanted device outweigh rare occurrence of uncomfortable feeling in patients.

References

1. Bardy GH, Lee KL, Mark DB, Poole JE, Packer DL, Boineau R, et al. Amiodarone or an implantable cardioverter defibrillator for congestive heart failure. N Engl J Med 2005; 352(3):225-37. [CrossRef] [PubMed]
2. Bunch Tj, Hohnloser SH, Gersh BJ. Mechanism of sudden cardiac death in myocardial infarction survivors: insights from the randomized trials of implantable cardioverter defibrillators. Circulation 2007; 115(18): 2451-7. [CrossRef] [PubMed]
3. Weiss JN, Qu Z, Chen PS, Lin SF, Karagueuzian HS, Hayashi H, et al. The dynamics of cardiac fibrillation. Circulation 2005; 112(8):1232-40. [CrossRef] [PubMed]
4. Bunch TJ, Hayes DL, Friedman PA. Clinically relevant basics of pacing and defibrillation. In: Hayes DL, Friedman PA, editors. Cardiac pacing, defibrillation, and resynchronization. A practical approach. Vol II. West Sussex:Wiley-Blackwell; 2008. p. 1-42. [CrossRef]
5. Wilber DJ, Zareba W, Hall WJ, Brown MW, Lin AC, Andrews ML, et al. Time dependence of mortality risk and defibrillator benefit after myocardial infarction. Circulation 2004; 109(9):1082-4. [CrossRef] [PubMed]
6. Daubert JP, Zareba W, Cannom DS, McNitt S, Rosero SZ, Wang P, et al. Inappropriate implantable cardioverter defibrillator shocks in MADIT II: frequency, mechanism, predictors, and survival impact. J Am Coll Cardiol 2008; 51(14):1357-65. [CrossRef] [PubMed]
7. Bunch TJ, Day JD, Olshansky B, Stolen KQ, Mulin CM. Newly detected atrial fibrillation in patients with an implantable cardioverter defibrillator is a strong risk marker of increased mortality. Heart Rhythm 2009; 6(1):2-8. [CrossRef] [PubMed]
8. Maron BJ, Spirito P, Ackerman MJ, Casey SA, Semsarian C, Estes NA 3rd, et al. Prevention of sudden cardiac death with implantable cardioverter-defibrillators in children and adolescents with hypertrophic cardiomyopathy. J Am Coll Cardiol 2013; 61(14): 1527-35. [CrossRef] [PubMed]
9. Earley A, Persson R, Garlitski AC, Balk EM, Uhlig K. Effectiveness of implantable cardioverter defibrillators for primary prevention of sudden cardiac death in subgroups a systematic review. Ann Intern Med 2014; 160(2):111-21. [CrossRef] [PubMed]
10. Satake H, Fukuda K, Sakata Y, Miyata S, Nakano M, Kondo M, et al. Current status of primary prevention of sudden cardiac death with implantable cardioverter defibrillator in patients with chronic heart failure--a report from the CHART-2 Study. Circ J 2015; 79 (2): 381-90. [CrossRef] [PubMed]
11. Pun PH, Al-Khatib SM, Han JY, Edwards R, Bardy GH, Bigger JT, et al. Implantable Cardioverter Defibrillators for Primary Prevention of Sudden Cardiac Death in CKD: A Meta-analysis of Patient-Level Data from 3 Randomized Trials. Am J Kidney Dis 2014; 64(1):32-9. [CrossRef] [PubMed]
12. Konstantinou DM, Efthimiadis GK, Vassilikos V, Paraskevaidis S, Pagourelias E, Maron BJ, et al. Implantable cardioverter defibrillators for primary prevention of sudden death in hypertrophic cardiomyopathy. J Cardiovasc Med (Hagerstown) 2016; 17(6):433-9. [CrossRef] [PubMed]

Prikaz bolesnika **UDC: 616.12-008.315-089.843:615.817**
doi:10.5633/amm.2019.0210

KADA ELEKTRIČNI ŠOK ZNAČI ŽIVOT - IMPLANTABILNI KARDIOVERTER DEFIBRILATOR I NJEGOVI EFEKTI: PRIKAZ SLUČAJA

Tomislav Kostić[1,4], Zoran Perišić[1], Dragana Stanojević[1], Goran Koraćević[1,2], Vladimir Mitov[2], Mlađan Golubović[3], Predrag Cvetković[1], Mirko Krstić[1], Aleksandar Stojković[1], Sonja Šalinger[1], Stefan Momčilović[4], Sanja Banković[4]

[1]Klinika za kardiovaskularne bolesti, Klinički centar Niš, Srbija
[2]Zdravstveni centar Zaječar, Zaječar, Srbija
[3]Klinika za kardiotorakalnu hirurgiju i transplantaciju, Klinički centar Niš, Niš, Srbija
[4]Univerzitet u Nišu, Medicinski fakultet, Niš, Srbija

Kontakt: Tomislav Kostić
Bulevar dr Zorana Đinđića 48, 18000 Niš, Srbija
E-mail: tomislav.kostic1977@gmail.com

Iznenadna srčana smrt (SCD) uzrokovana ventrikularnom fibrilacijom (VF) ostaje glavni uzrok smrtnosti u zapadnom svetu. Većina VF i iznenadnih srčanih smrti javljaju se izvan bolnice. Implantacija inplantabilnog kardioverter defibrilatora (ICD) potkrepljena je dokazima iz mnogih randomizovanih studija za primarnu i sekundarnu prevenciju iznenadne srčane smrti. Aktuelni ICD-ovi imaju više mogućnosti za poboljšanje dijagnostike, smanjivanje nepotrebnog pejsinga, očuvanje upotrebe energije i pružanje terapije bez bolova, kao što je antitahikardni pejsing (ATP). Najvažnija od gore pomenutih osobina ostaje sposobnost pejsmejkera da prepozna po život opasnu ventrikularnu aritmiju i da je prekine isporučujući struju. Pogodnost i značaj ICD šoka zavisi od vrste srčanih bolesti i prisustva strukturnih bolesti srca. Ovi koncepti ilustrovani su u kratkom pregledu ispitivanja ICD-a kod bolesnika sa ishemijskom i neishemijskom bolesti srca. Predstavljamo bolesnika sa dilatativnom kardiomiopatijom i smanjenom ejekcionom frakcijom leve komore (LVEF) koji je imao ugrađeni ICD pre godinu dana, kao primarnu prevenciju SCD. Bolesnik je primljen u Kliniku za kardiovaskularne bolesti nakon kratkog gubitka svesti. Električna kontrola uređaja pokazala je da se VF iznenada desila i uspešno ju je prekinuo šok kao tip terapije ICD.

Acta Medica Medianae 2019;58(2):56-61.

Ključne reči: *implantabilni kardioverter defibrilator, šok, iznenadna srčana smrt*