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OVERSENSING AS A CAUSE OF INAPPROPRIATE IMPLANTABLE CARDIOVERTER- DEFIBRILLATOR THERAPY - CASE REPORT

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Technology development in the recent years has enabled that both prevention and treatment of life-threatening heart rhythm disorders are managed by implantable cardioverter-defibrillators. Clinical studies have confirmed the advantage of this type of therapy in the prevention of sudden cardiac death in the recent years, so the use of ICDs has became a clinical routine. Rarely functional disturbances of those devices could be seen as undetected malignant arrhythmias (undersensing) or false detection of a normal heart rhythm (oversensing).

Patient N.S. aged 67 years was admitted to Cardiology Clinic, Clinical Center Niš because of inappropriate sequential therapy of implantable cardioverter-defibrillator (ICD) (12 shocks were delivered within 48 hours before admission). ICD pacemaker was implanted four years before the admission due to dilated cardiomyopathy (LVEF 25%). Based on a detailed analysis of the device's parameters the rapid increase in ventricular lead impedance was established (it was > 3000Ω; and the normal range is 250-2000 Ω). It was found that oversensing was the cause of sequential shocks delivery with energy of 35 J. The damaged lead of the ICD detected false signals as VF (ventricular fibrillation) and applied therapy. On the third day of hospitalization, the patient received an ICD Medtronic Maximo II device with the active electrode Medtronic Sprint Quattro 6947 but the left atrial electrode was not displaced. Prophylactic antibiotic therapy was given and patient was discharged 5 days after implantation. After one month at the control visit device parameters were satisfactory, the sensing function was appropriate with good impedance of the lead. Special feature of these devices is the need for individual programming, tailored to each patient, so it is necessary for a center that performs the implantation to have a medical team that has experience in the application of this type of therapy. *Acta Medica Medianae 2013;52(4):44-47.*

Key words: *implantable cardioverter defibrillator, therapy, oversensing*

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Introduction

Technology development in the recent years in the prevention and treatment of life-threatening heart rhythm disorders has been focused on implantable cardioverter-defibrillators. Clinical studies have confirmed the advantage of this type of therapy in the prevention of sudden cardiac death, which has become clinical routine in the recent years (1). There are well-defined and generally accepted indications for ICD therapy, both in the field of primary as well as secondary prevention. Implantation procedure is technically almost equal to those for the pacemakers for bradycardia treatment. Special feature of these devices is the need for individual programming, tailored to each patient, so it is necessary for a center that performs the implantation to have a medical team that has experience in the application of this type of therapy (2). Significantly positive results of this type of therapy lead to its increased use even in the area of primary prevention, and further technological development will allow its use in more specific indication (3).

Patient N.S.,aged 67 years, was admitted to Cardiology Clinic, Clinical Center Niš because of inappropriate sequential therapy of an implantable cardioverter-defibrillator (ICD) (12 shocks delivered within 48 hours before admission). ICD was implanted 4 years before admission due to dilated cardiomyopathy (LVEF 25%). Coronary angiography was performed before device implantation to exclude significant coronary artery disease. Based on 24 hour Holter (ECG) monitoring, which showed sinus node disease and pauses in heart rhythm up to 2.7 sec, it was decided to implant a two-chamber ICD pacemaker. After pacemaker implantation, the patient felt well and

one year before admission to the hospital he had one treatment of ventricular tachycardia in form of antitachycardia ICD pacing. After admission to clinic, an ICD device control was immediately done and it was found that the patient in the previous 48 hours received 12 electrical shocks with energy of 35 J. Additional detailed analysis of other parameters established the rapid increase in ventricular lead impedance over 3000 Ω (normal range is within 250-2000 Ω). It was determined that oversensing was the cause of repeated ICD discharge with electrical shocks of 35 J (Figure 1). ICD lead due to damage detected false signals as VF (ventricular fibrillation) and applied therapy (Figure 2). Radiography of the whole system did not verify the lead fracture which is a common cause of signal oversensing due to the presence of the bone and connective tissue under the clavicle where electrodes usually pass. However, radiography sometimes cannot show damage of the isolation around the lead, which was probably in this case the cause of the increased impedance of the same. Therefore, the lead replacement was the only solution. Extraction i.e. removing of the old electrode after 4 years of implantation requires special extractors (laser), which currently we do not have, so we decided to leave the old electrode inactive and to install the new one beside it. On the third day of hospitalization, the patient received new ICD Medtronic Maximo II pacemaker with the active electrode Medtronic Sprint Quattro 6947 and a new battery because the old one was running out. Left atrial electrode was not displaced (Figure 3 and 4). Patient received prophylactic antibiotic therapy and was discharged 5 days after pacemaker implantation. After one month during the regular visit, the checked parameters of the device were satisfactory, the sensing function was adequate with good lead impedance.

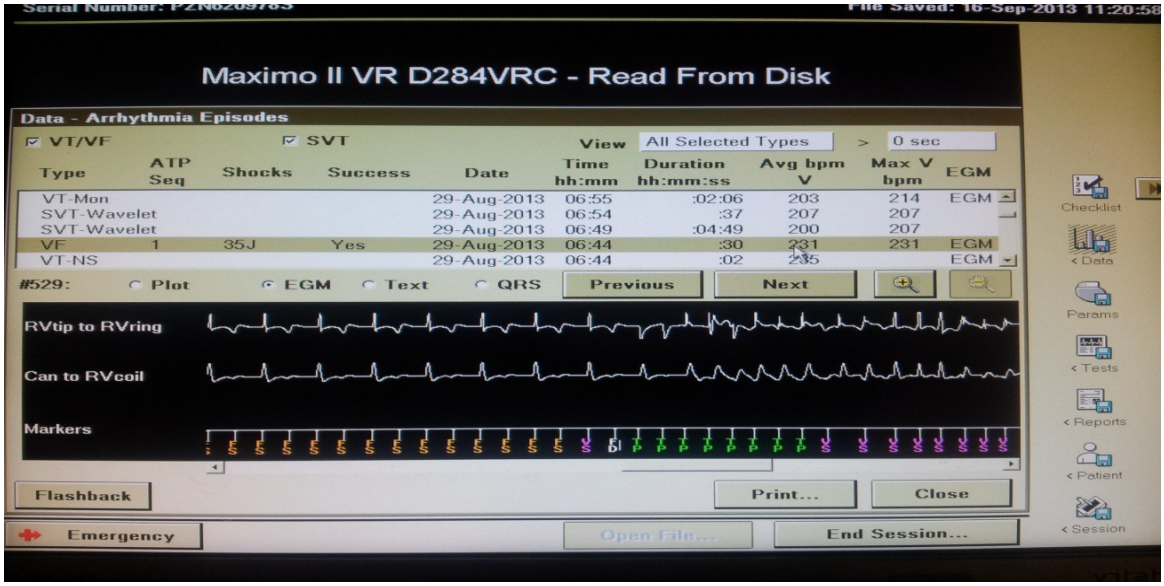

Figure 1.

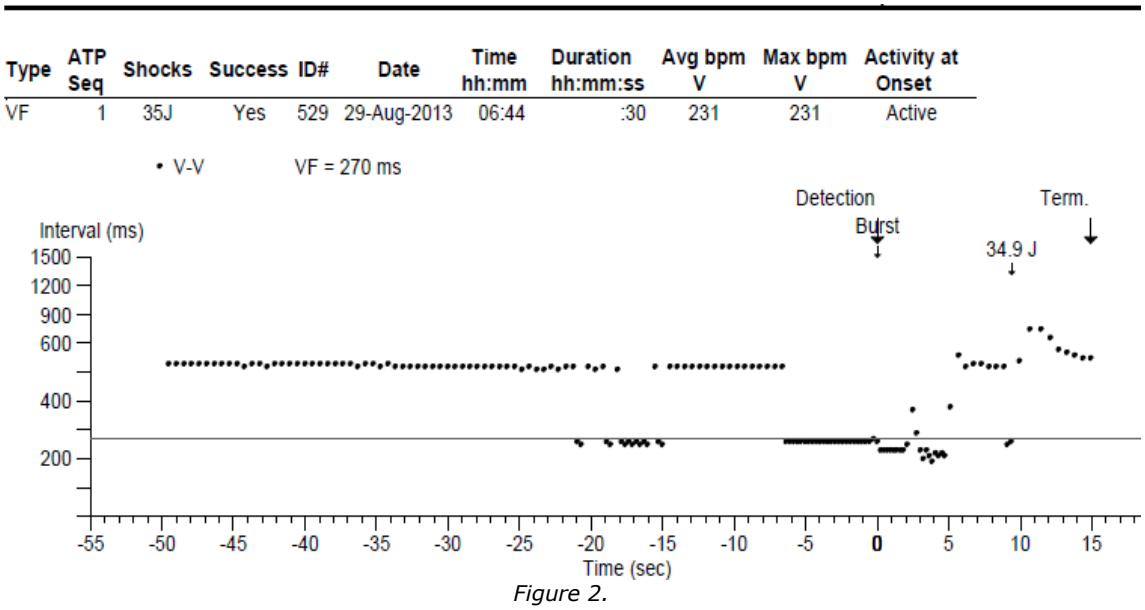

Figure 2.

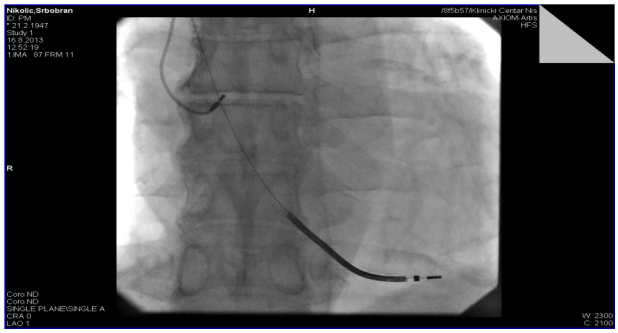

Figure 3.

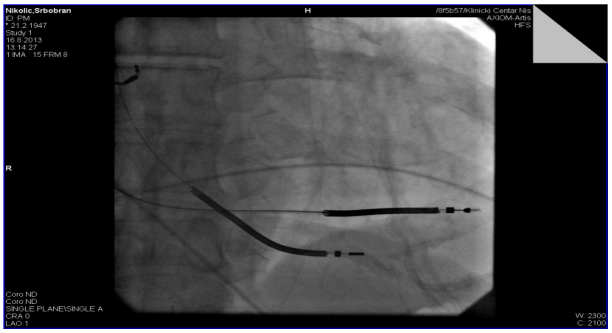

Figure 4.

Discussion

Tachyarrhythmia therapy is allocated on the basis of the interpretation of the signals presented to the generator (4). All current ICDs use ventricular heart rate as the cornerstone variable in tachycardia recognition. However, to determine heart rate, the interval between each depolarization of the ventricle must be measured. It is not interval recognition but the detection of individual electrogram events that become the basic building block in this process. The process begins with the placement of the sensing lead. The sensed electrogram depends on the health of the myocardium in close proximity to the lead, the far-field structures of the diaphragm and right atrium, and other electrical devices such as pacemakers, cellular phones, and other sources of electromagnetic interference. Detection of the ECG events completely depends on the quality of the signal, and the quality of the signal is determined only at the time of the lead placement. As defibrillation efficacy is almost always best at the right ventricular apex, the adequacy of sensing is sometimes compromised by the apical position of the lead. Additional aspects that potentially depend on the position of the lead are measures of ECG morphology such as electrogram event width. In dual chamber devices, the accurate recognition of arrhythmias is even more complicated with the inclusion of atrial lead data input into the generator. No longer will placement of the lead minimize the chances of miscounting arrhythmias; however, the atrial lead must be positioned so that there is no discernible ventricular electrogram. Sensing is an issue not only of signal to noise ratio in the ventricle but also of the exclusion of all non-atrial events on the atrial lead.

For many years, ICDs have been the treatment of choice for secondary prevention of VT or VF if the arrhythmia is likely to recur despite other therapy (5). In the 21st century, most ICDs have been implanted for primary prevention in high risk patients who have not experienced VT or VF. Primary prevention guidelines identify high risk primarily by heart failure class >2 and LVEF<30-35%. At present, more than 80% of ICDs are implanted for primary prevention. Secondary prevention guidelines are supported by an overwhelming consensus of experts and practicing cardiologists (6). They have been widely adopted. In contrast, primary prevention guidelines are applied variably in clinical practice. Experts vary in their level of concern about comorbidities as contraindications, complications and the high number of patients who need to receive ICDs to save one life.

ICD sensing and detection is imperfect: ICD detected VT or VF can represent either a tachycardia SVT or VT or oversensing of non-arrhythmic electrical signals. ICD also discriminate tachycardia imperfectly: true SVT episodes may be classified as VT or VF, and true VT may be classified as SVT. ICDs might also deliver unnecessary shocks for VT that could be terminated by antitachycardia pacing. The first step is to determine if therapy was delivered in response to oversensing or tachycardia.

Shocks occur in the absence of tachycardia because nonarrhythmic physiologic or non-physiologic signals are oversensed and detected as arrhythmias. Non-physiologic signals usually are extracardiac. Physiologic signals may be intracardiac (p, R, or T waves) or extracardiac (myopotentials). Oversensing accounts for approximately one third of inappropriate shocks in long term follow-up. Oversensing of physiological intracardiac signals results in two device-detected R waves for each cardiac cycle. P wave oversensing and R wave double counting occur as alternating cycle lengths (7). T wave oversensing occurs as alternating morphologies. P wave oversensing can occur if the distal coil of an integrated bipolar lead is too close to the tricuspid valve. R wave double counting occurs if the duration of the sensing electrogram exceeds the ventricular blanking period of 120 to 140ms. It causes all VTs to be detected in the VF zone so that no VT is treated with antitachycardia pacing, regardless of its cycle length. T wave oversensing often occurs in the setting of low amplitude R waves. In addition to causing inappropriate detection, T wave oversensing can cause inappropriate inhibition of bradycardia pacing or delivery of antitachycardia pacing at the wrong rate (8).

Conclusions

Oversensing can rarely cause inappropriate ICD shock delivery. In case of poor signal detection, especially when it involves electrode

malfunction, it is urgent to establish the cause and promptly resolve the problems due to the specificity of the system. Cardiac rhythm disturbance detection is a specific and fundamental function of an ICD. This detection is based on heart rhythm, frequency, but it also requires individual programming, tailored to every patient. In this way, continuous individual programming always adapts to the patients and their needs in order to reduce the number of defibrillations to an acceptable minimum but without compromising the patients' safety.

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OVERSENZING KAO UZROK NEADEKVATNE TERAPIJE IMPLANTABILNIM KARDIOVERTER-DEFIBRILATOROM

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Tehnološki razvoj je omogućio da se poslednjih godina pažnja prevencije i terapije ugrožavajućih poremećaja srčanog ritma usmeri ka implantabilnim kardioverter-defibrilatorima. Kliničkim studijama potvrđena je prednost ove vrste terapije u prevenciji iznenadne srčane smrti kod bolesnika, tako da se poslednjih godina ova vrsta terapije poveća do nivoa rutinske primene. Međutim, retko može doći do poremećaja funkcije ovih uređaja u vidu loše detekcije-nedetekcije malignih poremećaja ritma (undersensing) ili pogrešne detekcije normalnog ritma (oversensing). Bolesnik N.S., star 67 godina, primljen je na Kliniku za kardiologiju Kliničkog centra Niš zbog uzastopnih terapija implantabilnog kardioverter-defibrilatora (ICD) (12 isporučenih šokova unutar 48h do prijema). Pre četiri godine ugrađen je ICD zbog dilatantne kardiomiopatije (EF 25%). Na osnovu detaljne analize ostalih parametara ustanovljen je rapidan porast impedance ventrikularne elektrode na preko 3000 Ω (normalne vrednosti od 250-2000 Ω). Ustanovljeno je da je oversenzing bio uzrok ponavljane terapije u vidu šokova od 35J, jer je ICD detektovao lažne signale usled oštećenja elektrode kao VF (ventrikularna fibrilacija) i primenio terapiju. Trećeg dana hospitalizacije bolesniku je ugrađen ICD Maximo II Medtronik, sa aktivnom elektrodom Sprint quattro 6947 Medtronik i ostavljenom atrijalnom elektrodom. Bolesnik je pokriven antibiotskom terapijom i otpušten pet dana nakon ugradnje. Na kontroli, nakon mesec dana, parametri su bili uredni, senzing funkcija zadovoljavajuća, sa dobrim otporima elektroda. Posebna specifičnost ovih aparata je potreba za individualnim programiranjem, praktično za svakog bolesnika, tako da je neophodno da centar u kome se ugradnja vrši bude dobro opremljen timom koji ima iskustvo u primeni ove vrste terapije. *Acta Medica Medianae 2013;52(4):44-47.*

Ključne reči: *implantabilni kardioverter defibrilator, terapija, oversenzing*

