Stereotactic arrhythmia radioablation in recurrent ventricular tachyarrhythmias

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A 67-year-old male with a history of posteroinferior myocardial infarction in 1992, cardiac arrest, and single-lead implantable cardioverter-defibrillator (ICD-VR) implantation in 2015 was referred to the Department of Electrocardiology due to recurrent episodes of monomorphic ventricular tachyarrhythmias (VT) and electrical storms (Figure 1A). The patient had a history of paroxysmal supraventricular tachyarrhythmias (SVT) and post-amiodarone hyperthyroidism. In February 2021, he had undergone radiofrequency catheter ablation of the left ventricle (LV) arrhythmogenic substrate with little benefit (25 adequate high-voltage shocks until current admission).

On admission, the patient was in sinus rhythm and euthyroid. The LV ejection fraction (LVEF) was 35% (Supplementary material, *Figure S1*). The coronary angiography showed chronic total occlusion of the right coronary artery with no significant progression of the coronary artery disease. Mexiletine was introduced to decrease the ventricular arrhythmia burden, with moderate effect.

Rotational angiography and electrophysiology study (EPS) of the LV was performed using 3D EnSite™ Precision™ mapping system (Abbott Cardiovascular, Plymouth, MN, US; Supplementary material, *Video S1, S2*). During the procedure, five different morphologies of VT were identified. According to the literature [1], not only endocardial and left-sided substrates were possible. However, based on the arrhythmia morphologies, the left ventricular origin was most probable.

Fusion imaging of computed tomography (CT) and 3D electrophysiological mapping was used to delineate tissue scar with surrounding heterogeneous zone and define the target area for stereotactic arrhythmia radioablation (STAR; Figure 1B, C, Supplementary material, *Figures S2–S4*). The treatment was performed using the Varian EDGE™ radiosurgery system (Supplementary material, *Figure S5*) volumetric arc modulated radiotherapy (VMAT) to assure optimal dose distribution and the Deep Inspiration Breath Hold (DIBH) technique to account for respiratory movement during the irradiation. The cardiac motion was compensated by the internal target volume (ITV) approach based on available cardiac-gated CT data. Ablative energy was delivered transmurally using 6MV photons in one fraction of 25 Gy.

On the first day after the procedure, the patient experienced well-tolerated, incessant monomorphic VT of 105 bpm with occasional capture beats (Supplementary material, *Figure S6*), which was treated by electrical cardioversion. The ICD was reprogrammed to introduce anti-tachycardia pacing (ATP) up from 100 bpm — "Ramp" and "Ramp" + algorithms.

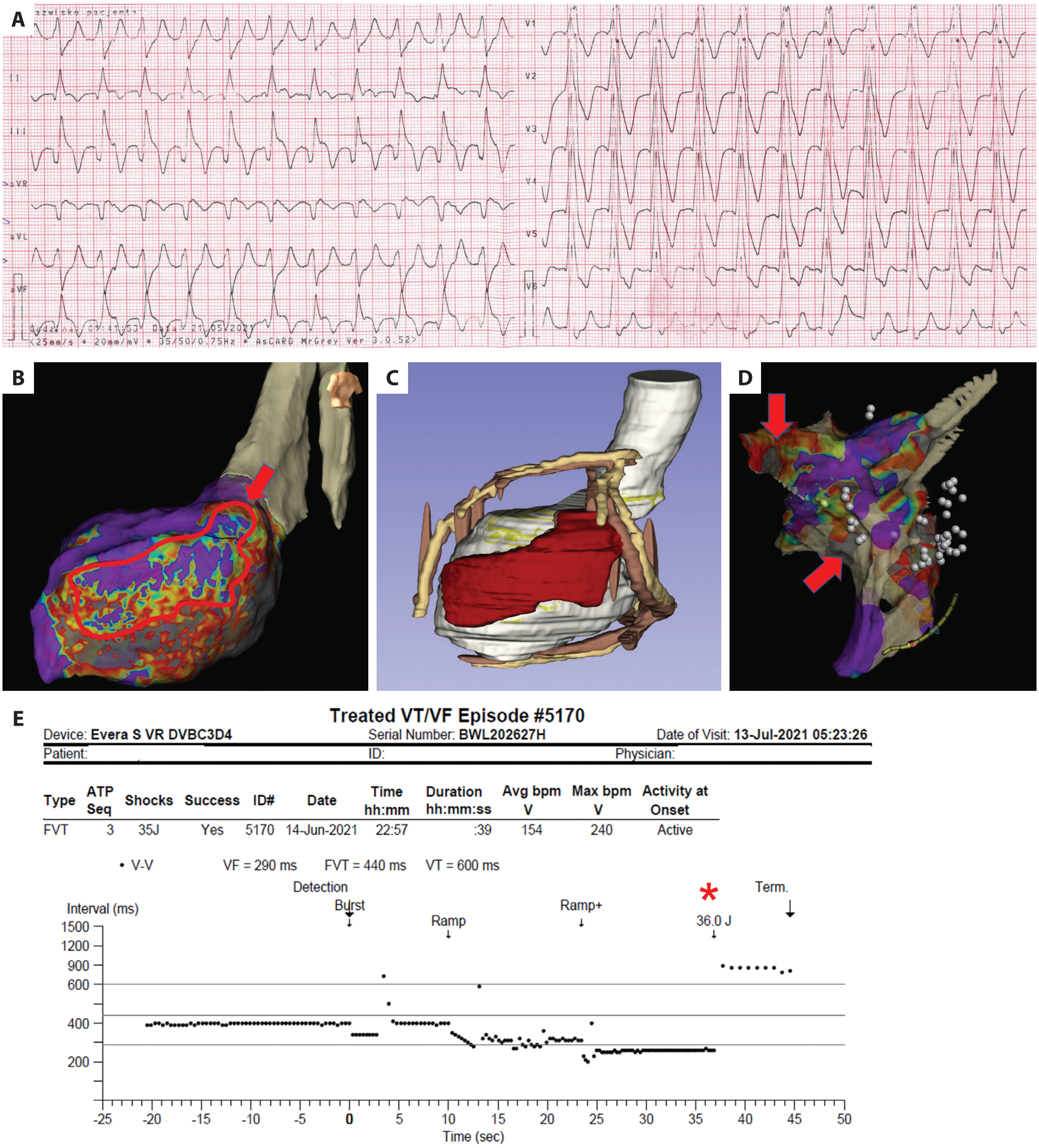

Figure 1. A. ECG of VT originating from the LV after the LV catheter ablation; **B.** The arrow shows scar and heterogenous zone in EPS; **C.** The arrows show the area covered by stereotactic radiotherapy infusion image of CT and EPS. **D.** EPS voltage map of the right atrium with ablation application markers (suboptimal effect due to low electrical activity) — the arrows show low voltage sites. **E.** ATP-triggered VT with subsequent high voltage (36J) shock (marked with an asterisk) as a result of SVT

Abbreviations: CT, computed tomography; ECG, electrocardiogram; EPS, electrophysiology study; LV, left ventricle; SVT, supraventricular tachycardia; VT, ventricular tachycardia

During the six-week post-ablation blanking period, the only VT detected by ICD was successfully terminated with ATP (Supplementary material, *Figure S7*). Moreover, ICD analysis revealed three episodes of paroxysmal SVT triggering VTs via ATP (Figure 1D, Supplementary material, *Figure S8*). Notably, a significant improvement in LV contractility was reported (LVEF ~50%; Supplementary material, *Figure S9*).

After consideration, the EPS was performed to treat the supraventricular arrhythmogenic substrate. Both atria revealed low electric activity (presumably post-ischemic; Figure 1E). Two ectopic foci were found in the right and the left atrium; nevertheless, only temporary termination of the arrhythmias was feasible. During programmed ventricular pacing no sustained VTs were induced.

The single-ventricle ICD was replaced three months after the STAR procedure due to elective replacement indicator (ERI). Up to this time, neither sustained nor non-sustained arrhythmias were recorded. The patient experienced significant clinical improvement. According to the literature and clinical experience, the device incorporating the FarFieldMD morphology discriminator algorithm was chosen [2]. Additionally, the patient was provided with a remote care transmitter.

The case shows multiple possibilities of arrhythmical foci and emphasizes the potency of cardiac implantable devices both in termination and triggering arrhythmias. With its transmural properties, STAR can become a potential challenger to complex epicardial ablation in the future. The reported excellent efficacy of STAR [3] was confirmed in the presented complex case and calls for further investigation.

Supplementary material

Supplementary material is available at https://journals.viamedica.pl/kardiologia_polska.

Article information

This clinical case is based on a medical history of a patient enrolled in the SMART-VT trial (Stereotactic Management of Arrhythmia — Radiosurgery in Treatment of Ventricular Tachycardia, NCT04642963).

Conflict of interest: None declared.

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