

REVIEW ARTICLE/ARTYKUŁ PRZEGLĄDOWY

## **Stereotactic Radiosurgery in the Treatment of Ventricular Arrhythmia**

Radiochirurgia stereotaktyczna w leczeniu arytmii komorowej

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### **Abstract**

Stereotactic radiosurgery (SRS) is gaining recognition as a promising treatment modality for ventricular arrhythmias, particularly in patients for whom conventional therapies, such as pharmacological management and catheter ablation, have failed or are contraindicated. SRS employs precise irradiation targeting of the arrhythmogenic foci, which enables the selective ablation of pathological cardiac tissues while preserving surrounding healthy tissue. Clinical studies, such as SMART-VT, have shown encouraging results, demonstrating significant reductions in ventricular tachycardia episodes and confirming the safety profile of this therapeutic approach. Despite these promising findings, further studies are needed to involve larger, more diverse patient populations and extended follow-up periods to thoroughly evaluate the long-term efficacy and safety of this method. The implementation of standardised treatment protocols and procedural guidelines could enhance therapeutic outcomes and improve the accessibility of SRS for a broader range of patients.

**Keywords:** Stereotactic radiosurgery, ventricular arrhythmia, arrhythmia treatment, SMART-VT, ablation

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### **Introduction**

Ventricular arrhythmias are arrhythmias occurring below the bifurcation of the bundle branch block [1]. Some of these arrhythmias are mild, causing no symptoms or hemodynamic

consequences for the patient. However, there exists a subset of ventricular arrhythmias that pose a direct threat to the patient's life. The four pathomechanisms of ventricular arrhythmia are recognised — impaired physiological automaticity, pathological automaticity, triggered activity, and the reentry phenomenon. In heart failure, where the myocardium undergoes pathological remodelling, often accompanied by post-infarction scarring, multiple overlapping mechanisms of arrhythmogenesis may coexist [2].

In the diagnostic process, the main focus is on identifying and eliminating reversible causes — complete revascularisation of coronary vessels in coronary artery disease, electrolyte imbalances, hormonal dysfunctions — primarily thyroid disorders, acid-base imbalances, anaemia, side effects of medications — mainly those prolonging the QT interval, infection, stress, and physical exertion.

After excluding reversible causes, the primary treatment approach is antiarrhythmic pharmacotherapy. Most chronically used drugs are associated with a high risk of adverse effects — one of them, Amiodarone can cause numerous side effects, including hyperthyroidism, skin changes, pulmonary interstitial fibrosis, and liver damage. An alternative treatment is catheter ablation — a procedure that involves the mechanical destruction of cardiac tissue responsible for the arrhythmia substrate.

Given the large patient population and treatment challenges, SRS (stereotactic radiosurgery) may be considered a second-line treatment option when pharmacotherapy and ablation have been ineffective.

### **What is stereotactic radiotherapy?**

This is one of the variants of radiation therapy that delivers highly precise irradiation to a targeted area, with millimetre accuracy, using high-energy beams. The aim is to destroy the targeted tissue while minimising damage to surrounding healthy tissues. The treatment can be administered in a single session with a single high-dose radiation fraction (stereotactic radiosurgery — SRS) or spread over multiple sessions with smaller radiation doses (stereotactic radiotherapy) [3].

### **Stereotactic radiosurgery in ablation of the arrhythmia source**

Research is currently being conducted on the use of stereotactic radiosurgery to treat ventricular arrhythmias. The National Cancer Institute in Gliwice, in collaboration with the Department of Cardiology and Structural Heart Diseases and the Department of Electrophysiology and Heart Failure at the Upper Silesian Medical Centre in Katowice, is participating in the SMART-VT

multicentre study. As part of the study, patients with ventricular tachycardia, after ineffective antiarrhythmic treatment, protected by a cardioverter-defibrillator, and after unsuccessful ablation (or with contraindications to ablation), are subjected to stereotactic radiation. To precisely locate the source of the arrhythmia, patients undergo electrophysiological testing and three-dimensional mapping. The identified location is then superimposed onto a computed tomography (CT) scan. Based on this information, a team of doctors and physicists selects the appropriate radiation dose and distribution to target the specific tissue responsible for the arrhythmia, while minimising exposure to critical structures (in this case, primarily coronary arteries) (Fig. 1).

### **Conclusions from the SMART-VT Study**

Despite the increasing prevalence of ventricular arrhythmias, including ventricular tachycardia, and the challenges in treatment, there is limited data on the use of radioablation for arrhythmias. The primary endpoint of the study was treatment safety, defined as two or fewer treatment-related adverse events of grade  $\geq 3$  within the first three months. The secondary endpoints included treatment efficacy, biomarkers of myocardial injury, and quality of life. The study demonstrated an 84.3% reduction in the burden of ventricular arrhythmias. Eight patients experienced a relapse of ventricular tachycardia, three required additional invasive treatment via conventional ablation, and three patients died from causes unrelated to the study (Fig. 2).

The STAR therapy appears to be safe and effective. However, there is a lack of studies involving large patient cohorts and long-term outcomes [4].

### **Stopstorm Platform**

In 2022, the first pan-European registry of patients with ventricular arrhythmias treated with stereotactic radiosurgery (SRS) was established across 31 centres in 8 European Union countries. The project is coordinated by the University Medical Centre in Utrecht, Netherlands, and the Polish entity involved is the National Cancer Institute in Gliwice. By 2025, clinical, laboratory, and imaging data will be gathered from over 300 patients with refractory ventricular tachycardia, resistant to both pharmacological and procedural treatments. The registry will provide valuable insights into the safety, efficacy, and patient selection criteria for this treatment approach. This data will also aid in the standardisation of treatment protocols. It seems that given the fact that different devices are used in radiotherapy, the methods of transferring data

from electrophysiological mapping to computed tomography, and the varying dose distribution, standardization and unification of this method are essential [5] (Fig. 3).

### **Summary**

Currently, research into the efficacy and safety of stereotactic radiosurgery for treating ventricular arrhythmias is still ongoing. It may become an alternative for patients in whom pharmacotherapy and ablation are ineffective or contraindicated. Currently, radiotherapy centres are equipped with advanced and precise technology that supports the refinement of this method. However, long-term studies and standardised treatment protocols are necessary to draw definitive conclusions about its effectiveness.

### **Streszczenie**

Radiochirurgia stereotaktyczna (SRS) staje się obiecującą metodą leczenia arytmii komorowych, szczególnie u pacjentów, u których tradycyjne metody, takie jak farmakoterapia i ablacja cewnikowa, okazały się nieskuteczne lub są przeciwwskazane. SRS polega na precyzyjnym napromienieniu źródła arytmii, co pozwala na zniszczenie patologicznych tkanek serca bez uszkodzania zdrowych. Badania, takie jak SMART-VT, pokazują obiecujące wyniki w zakresie redukcji częstoskurczu komorowego i bezpieczeństwa terapii. Pomimo pozytywnych wyników, potrzeba dalszych badań na większych grupach pacjentów oraz długoterminowej obserwacji, aby w pełni ocenić skuteczność i bezpieczeństwo tej metody. Wprowadzenie standardów leczenia i standaryzacja procedur mogą znacząco poprawić skuteczność terapii i jej dostępność dla szerszej grupy pacjentów.

Słowa kluczowe: radiochirurgia stereotaktyczna, arytmia komorowa, leczenie arytmii, SMART-VT, ablacja

### **Additional information**

#### **Author contribution**

Michał Tarnowski — 50%,

Monika Tarnowska — 50%.

#### **Conflict of interests**

The authors declare no conflict of interests.

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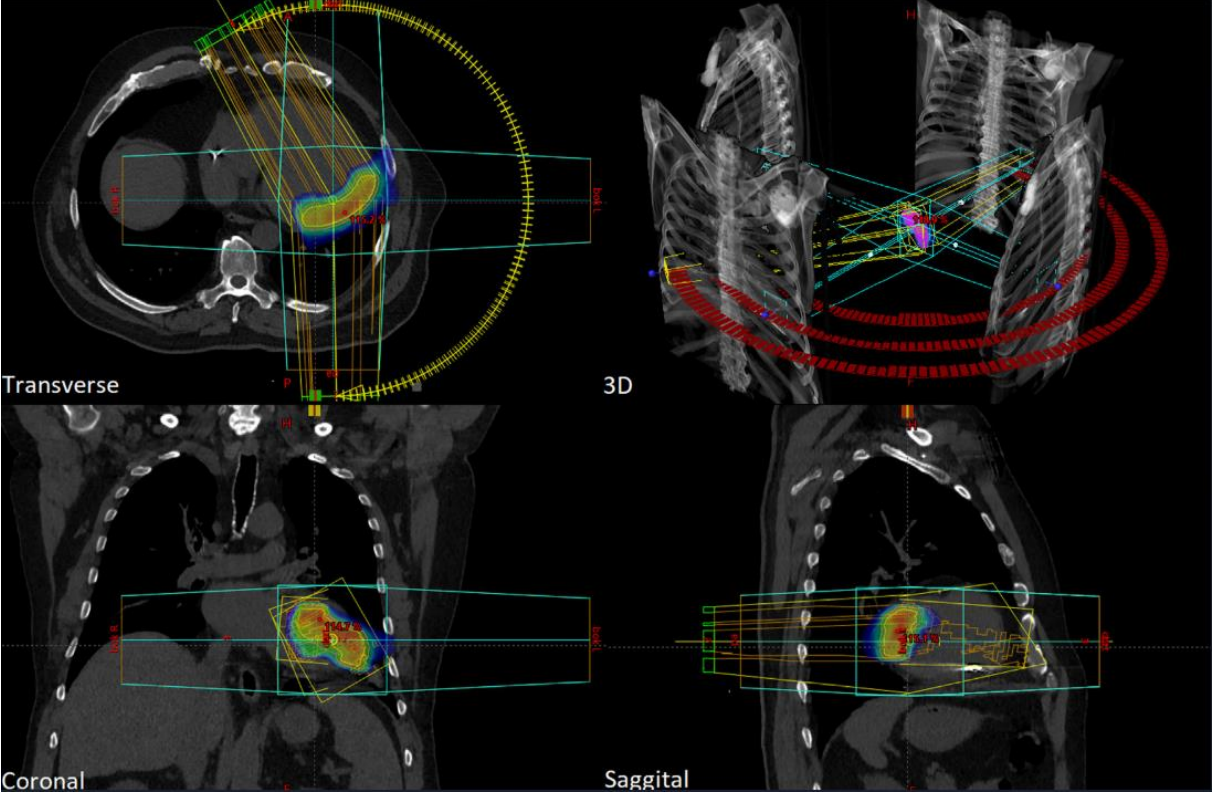
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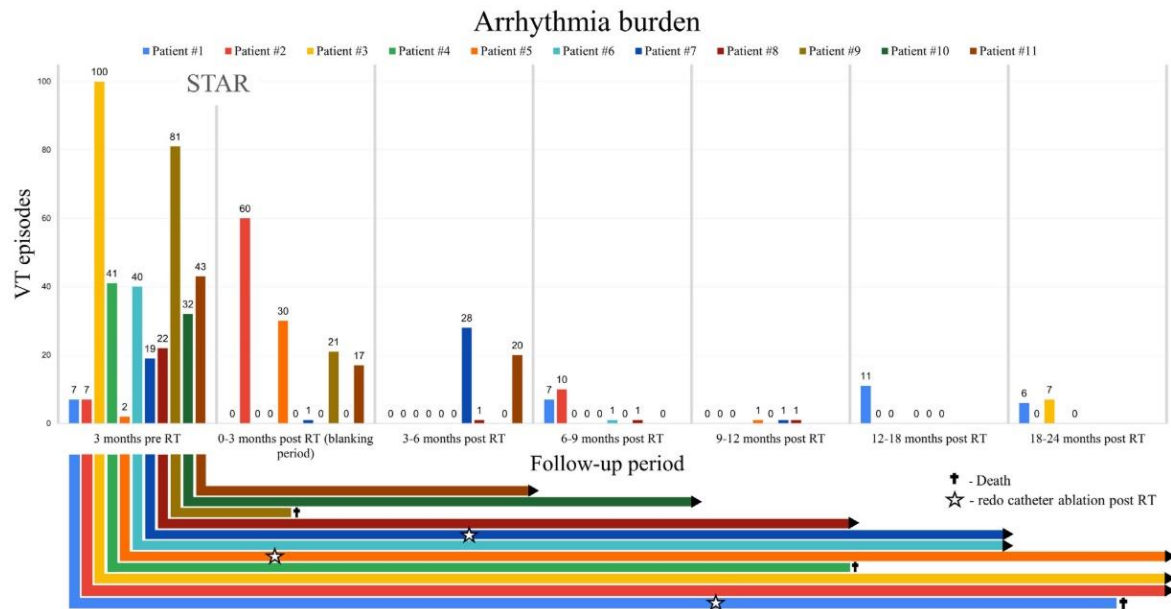
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Ryc. 1 Miszczyk M, Sajdok M, Bednarek J, et al. Stereotactic management of arrhythmia — radiosurgery in treatment of ventricular tachycardia (SMART-VT). Results of a prospective safety trial. Radiotherapy and Oncology. 2023;188:109857.



Ryc. 2 Miszczyk M, Sajdok M, Bednarek J, et al. Stereotactic management of arrhythmia — radiosurgery in treatment of ventricular tachycardia (SMART-VT). Results of a prospective safety trial. Radiotherapy and Oncology. 2023;188:109857.



Ryc. 3 Stopstorm, website: <https://www.stopstorm.eu/en>

