

## ECMO-Assisted Radiofrequency Ablation for Recurrent Ventricular Tachycardia: Case Series

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### Summary

Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) has emerged as a viable modality for supporting circulation in patients with severe ventricular arrhythmia and high risk of acute hemodynamic instability during radiofrequency ablation (RFA) procedure.

**Objectives:** (a) To demonstrate the feasibility and effectiveness of VA-ECMO as a mechanical circulatory support during radiofrequency ablation in patients with sustained-recurrent ventricular tachyarrhythmia, which allows to achieve control of arrhythmia and improves survival in this high-risk cohort; (b) to determine the patient-selection criteria for VA-ECMO.

**Case reports.** We analyzed 5 cases of sustained-recurrent ventricular tachycardia in patients (all men, mean age 59 years) who were hospitalized in the intensive care unit. All patients had multiple episodes of ventricular tachycardia despite continuous conservative therapy. Four patients underwent radiofrequency ablation of the arrhythmogenic substrate with VA-ECMO support, resulting in complete elimination of tachyarrhythmia. The patients were successfully weaned from ECMO and subsequently discharged. In the fifth patient with left ventricular ejection fraction of 17–20% due to dilated cardiomyopathy the invasive procedure was excluded due to the terminal stage of heart failure, extremely high perioperative risk, and anticipated RFA failure. After patient's condition stabilized, he was referred to a tertiary center for orthotopic heart transplantation (OHT).

**Results.** All patients who underwent ECMO-assisted RFA achieved complete control of arrhythmia without recurrence during the entire follow-up period. Successful weaning from ECMO and discharge from the hospital confirmed the effectiveness of this strategy. One case demonstrated the limitations of the method, i. e. in a patient with terminal myocardial damage RFA was considered palliative.

**Conclusion.** ECMO support during ablation procedure allows the use of RFA in patients with severe structural myocardial pathology and high risk of hemodynamic instability. Scrupulous selection of patients with localized arrhythmogenic substrate and the potential for restoring myocardial function after RFA are the key components for procedural success.

**Keywords:** *extracorporeal membrane oxygenation; recurrent ventricular tachycardia; electrical storm; radiofrequency ablation; mechanical circulatory support*

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### Introduction

Ventricular tachycardia (VT) remains one of the most dangerous forms of arrhythmia, associated with a high risk of sudden cardiac death [1].

According to modern registries, in patients with ischemic heart disease (IHD) and postinfarction cardiosclerosis, persistent VT develops in 5–10% of

patients, while in patients with severe congestive heart failure (CHF) and reduced left ventricular ejection fraction (LVEF) reaches 20–25% [2].

Continuously recurring (resistant) VT — a term applied to clinical scenarios where sustained or recurrent VT does not respond to standard emergency therapy (adequate antiarrhythmic therapy, usually

including a  $\beta$ -blocker/amiodarone/lidocaine, and, if necessary, electrical cardioversion), is accompanied by frequent discharges from an implanted cardioverter-defibrillator, or continues despite optimal drug therapy and/or repeated attempts at defibrillation. An «electrical storm» is defined as  $\geq 3$  separate episodes of sustained ventricular tachycardia/ventricular fibrillation within 24 hours, with episodes separated by an interval of at least 5 minutes and requiring either antitachycardia electrocardiostimulation, or electrical cardioversion/defibrillation. Electrical storms occur in 10–20% of patients with implanted devices (ICD/AICD), increasing 2–3-fold the risk of death during the first year [3–4].

Conservative therapy is used for newly diagnosed non-sustained/sustained VT, for potentially reversible causes (acute MI, electrolyte disturbances, drug interactions), and for treatable precipitating factors. Despite the widespread use of antiarrhythmic drugs, the recurrence rate of VT remains high. ICD is indicated for secondary prevention after an episode of VT/VF, as well as for primary prevention in patients with  $EF \leq 35\%$  on optimal therapy. Radiofrequency ablation (RFA) has been considered one of the most effective treatments in recent years. RFA is recommended for recurrent symptomatic VT (despite conservative therapy) and for «electrical storm» [5–6].

Large studies have shown that RFA is successful in 70–85% of cases [2], but in severe structural myocardial pathology (scarring, aneurysms, cardiomyopathies, myocarditis, ventricular remodeling, valvular defects, congenital abnormalities), this procedure is associated with a high risk of acute hemodynamic instability, since such conditions are accompanied by a decrease in cardiac contractility, electrophysiological heterogeneity of myocardial tissue, and a reduced reserve for adaptation to stress [7].

The main feature of performing RFA in patients is the need to induce sustained VT for accurate mapping, which can lead to a sharp drop in cardiac output and collapse [8].

Two approaches are used for such patients:

- general anesthesia with preparation for potential defibrillation;
- general anesthesia with prophylactic use of mechanical circulatory support (MCS) devices: Impella, Tandem Heart, VA-ECMO, IABP.

One of the most accessible types of MCS is VA-ECMO, which allows systemic blood circulation to be maintained and ablation to be performed in patients at extremely high risk. The use of ECMO during RFA in high-risk patients reduces the likelihood of complications and increases the proportion of successful procedures [6].

The aim of this study was to evaluate the efficacy and safety of using VA-ECMO during RFA in patients with refractory ventricular tachyarrhyth-

mia, as well as to determine the criteria for selecting patients for this procedure.

## Materials and Methods

It was a retrospective analysis of five VA-ECMO-supported RFA procedures in patients with continuously recurring ventricular tachycardia (VT) who were hospitalized at the V.M. Buyanov City Clinical Hospital and the N. I. Pirogov City Clinical Hospital in 2024–2025.

Inclusion criteria:

- documented episodes of sustained or recurrent VT confirmed by ECG or implantable cardioverter-defibrillator (ICD/AICD) recordings;
- presence of heart failure symptoms of functional class II–IV (NYHA);
- repeated episodes of VT resistant to drug therapy;
- patient's consent to invasive intervention (RFA) or refusal due to high risk.

Preoperative examination. All patients underwent:

- CBC and biochemistry panel;
- echocardiography to assess ejection fraction (EF) and structural changes in the myocardium;
- 12-lead electrocardiography (ECG);
- analysis of data from implanted devices (ICD/AICD);
- CAG, if necessary.

Anesthesiological support: all procedures were performed under general anesthesia with hemodynamic monitoring (Harvard standard) of the patient: invasive blood pressure monitoring via a catheter in the right radial artery, recording of the heart rate, pulse oximetry, arterial blood gas composition and lactate, ventilation parameters, and capnography.

Use of ECMO: The following criteria were used as indication for «preventive» connection of VA-ECMO: presence of continuously recurrent VT resistant to antiarrhythmic therapy (AAT) with the need for prolonged induction of VT during RFA and/or «electrical storm» with unstable hemodynamics. Cannulas for the ECMO system were placed before the start of VT induction according to the standard protocol: the left common femoral vein and artery were used for this purpose in the absence of anatomical restrictions. The right common femoral vein was used as access for RFA electrodes. The distal end of the venous cannula was placed in the right atrium, and the arterial cannula was placed at the level of the common iliac artery.

ECMO was performed using a Henioss Deltastream device (Xenios AG, Germany) with a HILITE 7000 LT oxygenator (Medos, Germany), using BioLine «Maquet» cannulas (Getinge Group, Germany). Cardio-hemodynamic support was provided throughout the procedure, with gradual reduction of parameters intensity after completion of the ablation.

The patients' vital signs were monitored using a GE Carescape B650 monitor (GE HealthCare, USA). A Dräger Perseus A500 anesthesia and ventilation machine (Dräger, Germany) was used for anesthesia.

Electrophysiological study and RFA: the CARTO 3 three-dimensional navigation system (Biosense Webster, Johnson & Johnson, USA) was used for electro-anatomical mapping. The choice of system was based on the availability of equipment and the preferences of the operating electrophysiologist.

For electrophysiological diagnosis and reference rhythm monitoring, a decapolar diagnostic catheter was inserted into the coronary sinus. To speed up the mapping process, multi-electrode mapping catheters (PentaRay, Biosense Webster) were used.

Irrigated catheters with integrated contact force sensor — Thermocool SmartTouch (Biosense Webster) with a 3.5 mm distal electrode — were used as ablation catheters. The use of contact force measurement technology allowed to optimize the effectiveness and safety of ablation, which is especially important when it is necessary to minimize the duration of the procedure in patients at high risk of hemodynamic instability.

The main mapping method in this series was activation mapping performed during ongoing ventricular tachycardia. This strategy was chosen because of the unique opportunity provided by ECMO support — the ability to maintain effective blood circulation during hemodynamically unstable VT for a period of time sufficient to construct a detailed electro-anatomical map.

Unlike other techniques, activation mapping provides direct visualization of the reentry mechanism, allowing precise determination of the sequence of myocardial activation, identification of critical tachycardia cycle bridges, and targeted ablation with the ability to immediately assess its effectiveness in terminating the arrhythmia.

Transseptal access was used to insert electrodes into the left ventricle by puncturing the interatrial septum in the oval fossa area. Programmed ventricular pacing was performed according to a standard protocol to induce tachycardia. Systematic mapping of the right and left ventricles was performed by sequentially moving the ablation catheter along the endocardial surface during ventricular tachycardia, with an emphasis on areas corresponding to scar locations according to previous imaging methods or echocardiography.

In addition to identifying the critical zone (the area of earliest myocardial activation), an analysis of late diastolic potentials and fragmented electrograms was performed. The most valuable finding was the visualization of a relatively narrow isthmus — a conduction corridor between anatomical or functional barriers through which the critical part of the reentry cycle passes. Ablation of such an isthmus usually led to immediate termination of tachycardia.

The following immediate endpoints of radiofrequency ablation were analyzed: termination of ventricular tachycardia during ablation with transition to sinus rhythm or organized paced rhythm; elimination of all target electrograms (disappearance of isolated diastolic and late potentials in the ablation zones); loss of capture during stimulation with an output of 10 mA and a pulse duration of 2 ms in the ablated zones, indicating transmural damage.

A delayed efficacy assessment was performed 30 minutes after completion of ablation (this waiting period was necessary to exclude the transient effect of myocardial stunning). Repeat programmed ventricular pacing was performed using an aggressive protocol. The ultimate goal was complete non-inductibility of any sustained VT.

Endpoints:

- success of the procedure (no induced VT after RFA);
- absence of VT recurrence/ICD activation in the early and medium term (6–12 months);
- complications associated with RFA or ECMO (bleeding, vascular damage, stroke, infection);
- length of stay in the ICU, in the specialized department;
- in-hospital mortality.

The risk of hospital complications was assessed using two prognostic scale, the EuroSCORE II [9], which takes into account the severity of comorbidities, the severity of patient's clinical condition, and the likelihood of surgical complications, and the PAINESD scale [10].

Weaning from ECMO was implemented using the following technique:

1. Verifying conditions under which weaning is possible:
  - Stable mean arterial pressure  $\geq 60$ –65 mmHg with low/moderate doses of vasopressor and/or inotropic support;
  - Lactate within reference values;
  - Diuresis greater than 0.5 ml/kg per hour.
2. Fixation of basic parameters: ECMO performance (L/min), ECMO pump speed — (rpm), mean BP (mmHg), pulse BP (mmHg), lactate (mmol/L), pH, PaO<sub>2</sub> (mmHg), PaCO<sub>2</sub> (mmHg), PvO<sub>2</sub>(mmHg), diuresis (mL/hour), echocardiography parameters (LVOT VTI, LVEF).
3. Flow decrease by 0.5 L/min (or equivalently, decrease RPM by a fixed number corresponding to  $\sim 0.5$  L/min). After 60 min, re-measure parameters.
4. Subsequent flow reduction by 0.5 L/min every 30–60 min, with repeated assessment of parameters.
5. Final assessment at an ECMO flow rate of 1–1.5 L/min with targeted Echo-CG assessment. Conditions: LVEF > 20–25%, LVOT VTI > 10 cm, TAPSE > 10 cm.

**Statistical data processing.** Given the small sample size ( $n=5$ ), the statistical analysis was mainly descriptive. Qualitative indicators were described as absolute values and percentages.

To assess the relationship between the duration of ECMO, the length of stay in the ICU and in the ward with the patient's age, the duration of surgery, and the time of mechanical support, a correlation analysis was performed with the calculation of Pearson's linear correlation coefficient ( $r$ ). Differences were considered statistically significant at a significance level of  $p < 0.05$ .

Statistical data processing was performed using Microsoft Excel 2019 software and built-in functions for calculating correlation coefficients.

**Ethical aspect.** We obtained written consent from patients for the publication of case reports, as well as a

signed «Patient Informed Consent» form (Appendix No. 2, approved by Order of the Ministry of Health of the Russian Federation No. 1051n dated November 12, 2021).

### Case reports

The characteristics and clinical data of the patients are presented in Tables 1–3 and Fig. 1.

Patients 1–4 had an extremely high risk of death associated with low LV ejection fraction (31–27%), age over 60 years, and the presence of electrical storm. Despite the high predicted mortality rates, RFA combined with VA-ECMO allowed for temporary stabilization of hemodynamics, effective mapping, and ablation of the arrhythmogenic substrate. This is consistent with current recommendations indicating the need for preventive mechanical support during RFA in patients at high risk of electrical myocardial instability [6].

Patient 5 had the most unfavorable prognosis: LVEF 17–20%, with use-dependence in antiarrhythmics (IV lidocaine 1.5 mg/kg/hour), indicating end-stage chronic heart failure with dilated cardiomyopathy (DCM) with diffuse post-infarction and fibrotic myocardial remodeling. In such cases, the arrhythmogenic substrate is often multifocal or diffuse, making radical ablation technically difficult or impossible, as it requires extensive myocardial involvement, associated with a high risk of procedural complications without a guarantee of long-term success [11, 12]. Although achieving temporary stabilization was possible in this case, RFA (even with ECMO) was considered a palliative measure that would not change the long-term prognosis. Given the extremely high EuroSCORE II and PAINESD scores (Table 1) and the presumed ineffectiveness of RFA, the procedure was declined and OHT was considered as the only radical treatment with a favorable long-term prognosis.

We performed a correlation analysis (Pearson's coefficient) between the duration of ECMO, the length of stay in the ICU/ward, and parameters such as patient age, duration of surgery, and duration of mechanical support (Tables 2, 3). There was no statistically significant correlation between patient's age and length of hospital stay ( $p > 0.05$ ). There was a direct moderate correlation between the length of ICU stay and the total duration of the procedure ( $r = 0.72$ ), and time of complete mechanical support during VT induction ( $r = 0.736$ ). This suggests that the duration of recovery was defined primarily by the extent and complexity of the intervention, rather than by the patient's baseline characteristics.

The diagram shown in Fig. 2 clearly illustrates the key pathophysiological concept: the «electrical storm» is sustained by a vicious cycle in which arrhythmia exacerbates ischemia, and ischemia, in turn, provokes new arrhythmia. The hybrid treatment strategy (ECMO + RFA) effectively breaks this loop on two sides: RFA eliminates the electrophysiological

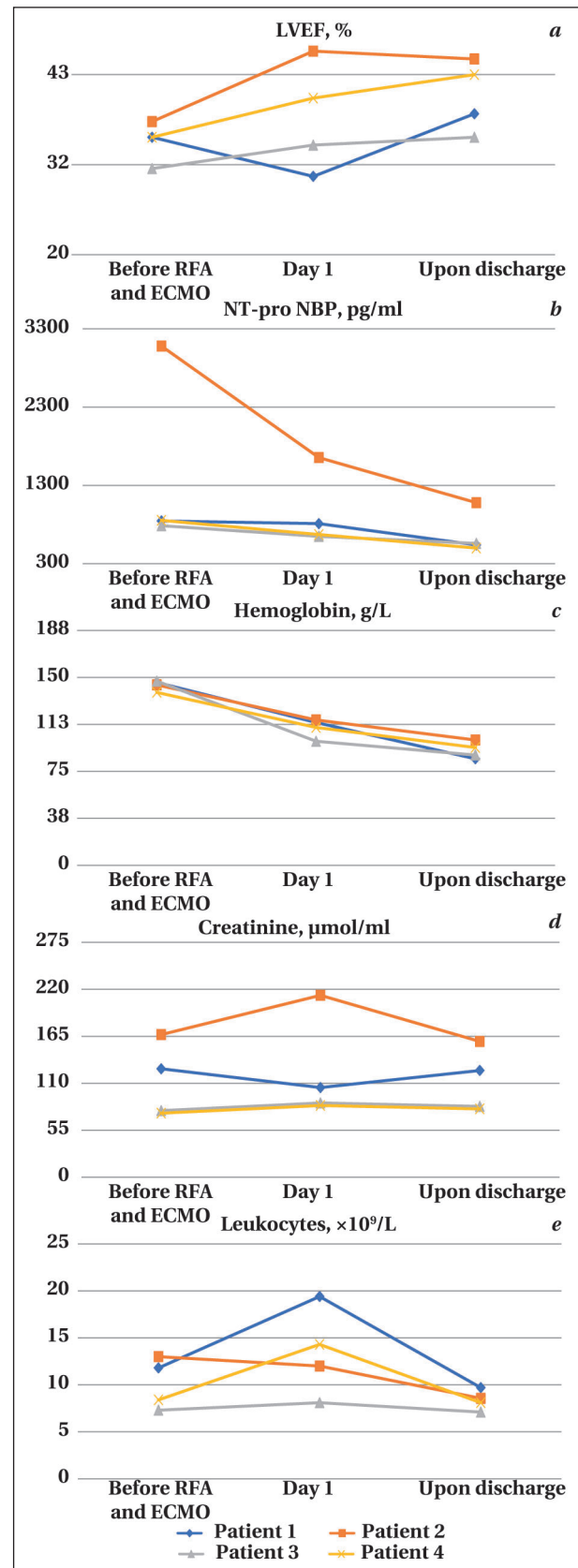


Fig. 1. Dynamics of key instrumental and laboratory parameters at the stages of analysis.

cause (the source of the arrhythmia), and VA-ECMO eliminates the hemodynamic consequences (decreased cardiac output and coronary perfusion).

**Table 1. Assessment of surgical and procedural risk.**

Parameters	Parameter values in patients №1–5				
	1	2	3	4	5
Diagnosis	IHD: PICS. LV aneurysm. VSD closure with a prosthesis patch (BASEX-Pach); CABG to the LAD and PDA/PIVVA from 16.05.2024	AH III. Paroxys-mal VT	IHD, ischemic cardiomyopathy PICS (1999, 03.03.2025). RCA stenting. Multiple lesions of the coronary arteries	Idiopathic VT	IHD: PICS (of unknown duration). CAG and PCI: LAD stenting in 2016. Type 2 diabetes mellitus. Dilated cardiomyopathy
Age, years	62	71	64	36	63
LVEF (%)	35	37	31	35	17–20
ICD	Yes	Yes	Yes	No	No
VT type	ES	ES	ES	ES	ES
EUROSCORE II, score	17,35	15,6	8	1,09	14
PAINESD, score	14	14	20	5	26
RFA	Yes	Yes	Yes	Yes	Yes
ECMO	Yes	Yes	Yes	Yes	No
OHT	No	No	No	No	Yes

**Note.** PICS — post-infarction cardiosclerosis; LVEF — left ventricular ejection fraction, %; ICD — implantable cardioverter defibrillator; ES — electrical storm; RFA — radiofrequency ablation; ECMO — extracorporeal membrane oxygenation; OHT — orthotopic heart transplantation.

**Table 2. Localization of the arrhythmogenic substrate and temporal parameters of the hybrid treatment procedure.**

Parameters	Parameter values in patients №1–4			
	1	2	3	4
Localization	Posterior basal segment of the interventricular septum, along the border of the LV aneurysm (from the scar/patch to the mitral annulus)	Anterobasal part of the left ventricle outflow tract (LVS — the left ventricle summit)	Interventricular septum, LV aneurysm, and scar area	Interventricular septum
Duration of surgery, hours : minutes	3:20	4:00	3:04	3:10
Duration of VT induction, full mechanical support, hours : minutes	2:20	3:00	2:00	2:00
ECMO duration, hours	48	120	24	24

**Table 3. Endpoints.**

Parameters	Parameter values in patients №1–4			
	1	2	3	4
Induced VT after RFA	No	No	No	No
VT recurrence	No	No	No	No
Complications of RFA	No	No	No	No
Complications of ECMO	No	No	No	No
Length of stay in the ICU, days	7	7	3	5
Length of stay in the ward, days	5	8	5	4
Mortality	No	No	No	No

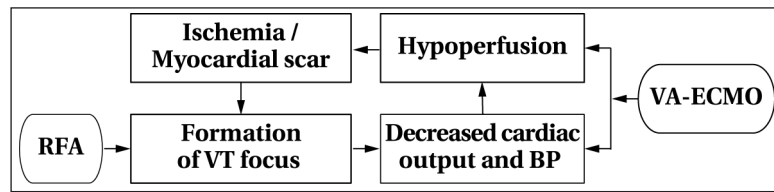


Fig. 2. Pathophysiological loop of «electrical storm» and ECMO and RFA application areas.

## Discussion

The selection criteria for the ECMO-supported RFA strategy were:

- Refractoriness to drug therapy. All patients received amiodarone and lidocaine without lasting effect. In the fifth patient, discontinuation of lidocaine infusion immediately led to recurrence of VT, indicating that the drug had only a symptomatic effect.
- Preserved recovery potential: despite the severity of their condition, patients 1–4 showed no signs of multiple organ failure or irreversible neurological damage at the time of decision-making. In patient 5, the main limiting factor was the diffuse nature of myocardial damage and concurrent DCM with a severe decrease of contractile function (LVEF 17–20%), which indicated the terminal stage of CHF, where RFA would be a palliative measure, and the only radical solution would be OHT.

Comparative analysis: The case 5 serves as the «control» in this study. It demonstrates the limitations of hybrid procedure in patients with end-stage heart failure and diffuse myocardial damage: attempting radical ablation in the absence of a localized substrate is unpromising and may worsen the prognosis. This proves that the ECMO support for RFA procedure is not only life-saving but also pathogenetically substantiated, allowing the ES cause to be eliminated only in the presence of a potentially removable electrophysiological substrate.

The analysis demonstrates that the hybrid treatment strategy is a highly effective method of saving the lives of patients with refractory ventricular tachycardia, allowing arrhythmia control to be achieved in 100% of cases, where drug therapy proved ineffective. The results obtained are consistent with data from recent studies confirming that attempts to stabilize the condition of such patients using exclusively conservative methods are associated with extremely high mortality rates of 40–70% [13].

A key aspect of success is the potential of VA-ECMO to ensure stable hemodynamics and adequate organ perfusion, primarily the myocardium, during VT induction and prolonged mapping process. This facilitates accurate identification and subsequent successful ablation of the arrhythmogenic substrate, which was impossible in unstable patients in the era before the widespread use of

mechanical circulatory support. As shown by the data presented, no recurrence of VT was recorded after the procedure in all four patients who underwent surgery, which directly corresponds to the conclusion of a large meta-analysis by J. Garg et al. on improved survival with the use of ECMO support during RFA [14].

However, as illustrated by case 5, the use of this tactic requires careful patient selection. High scores on the EuroSCORE II and PAINESD scales objectively reflect the extremely high perioperative risk in patients with end-stage heart failure secondary to dilated cardiomyopathy and serve as an important tool for making a well-considered decision [15].

It is critically important to assess not only the surgical risk, but also the possibility per se of eliminating arrhythmia through ablation. In DCM with total fibrosis and severely reduced EF, the success of RFA is unlikely. In such situations, when radical elimination of arrhythmia may not improve the prognosis of the underlying disease, the method of choice may be to consider OHT.

Hence, presented cases confirm the conclusions of recent international studies about the necessity of ECMO support programs in cardio-surgery hospitals for providing care to the most severely ill patients with life-threatening tachyarrhythmia [16].

Further prospective studies should focus on determining the optimal timeframe for initiating ECMO and developing precise algorithms for selecting patients for this high-tech care.

## Conclusion

The presented series of clinical cases clearly illustrates that the combined use of VA-ECMO and radiofrequency ablation is a highly effective and safe strategy for managing patients with refractory «electrical storm» and hemodynamic instability. This approach not only stabilizes the patient's condition, but also allows for the radical elimination of the cause of life-threatening arrhythmia, which is impossible with drug therapy alone. The key to success is making a timely decision to use mechanical circulatory support before irreversible multiple organ dysfunction develops.

Avoiding RFA procedure in case 5 emphasizes the importance of an individual approach and the need to assess the prospects of ablation surgery in

the context of terminal heart failure, when arrhythmia is a manifestation of diffuse irreversible myocardial damage rather than a localized problem. In such cases, OHT may be considered as the method of choice.

The introduction of hybrid technologies (ECMO combined with RFA) requires close collaboration

between cardiologists-arrhythmologists, cardiac surgeons, and specialists in extracorporeal support methods in a specialized hospital and should be based on strict selection criteria that take into account the pathophysiological nature of the arrhythmia and the operative and periprocedural risks.

## References

1. Martinez B. K., Baker W. L., Konopka A., Giannelli D., Coleman C. I., Kluger J., Cronin E. M. Systematic review and meta-analysis of catheter ablation of ventricular tachycardia in ischemic heart disease. *Heart Rhythm*. 2020; 17 (1): e206-e219. DOI: 10.1016/j.hrthm.2019.04.024. PMID: 31082362.
2. Gomes D. A., Paiva M. S., Matos D., Bello A. R., Rodrigues G., Carmo J., Ferreira J. Outcomes of ventricular tachycardia ablation in patients with ischemic and non-ischemic cardiomyopathy: a propensity-score matched analysis. *Rev Port Cardiol*. 2024; 43 (6): 341–349. DOI: 10.1016/j.repc.2024.04.002. PMID: 38615878.
3. Damonte J. I., Del Buono M. G., Thomas G. K., Mbualungu J., Clark B., Montone R. A., Berrocal D. H. Arrhythmic recurrence and outcomes in patients hospitalized with first episode of electrical storm. *Am J Cardiol*. 2022; 172: 40–47. DOI: 10.1016/j.amjcard.2022.02.032. PMID: 35365289.
4. Baldi E., Conte G., Zeppenfeld K., Lenarczyk R., Guerra J. M., Farkowski M. M., de Asmundis C., et al. Contemporary management of ventricular electrical storm in Europe: results of a European Heart Rhythm Association Survey. *Europace*. 2023; 25 (4): 1277–1283. DOI: 10.1093/europace/euac151. PMID: 36196613.
5. Li L., Ding L., Wu L., Zheng L., Zhou L., Zhang Z., Xiong Y., et al. Efficacy of catheter ablation for ventricular tachycardia in ischemic cardiomyopathy patients without an ICD implantation. *Heart Rhythm*. 2024; 21 (11): 2148–2156. DOI: 10.1016/j.hrthm.2024.05.011. PMID: 38734226.
6. Zeppenfeld K., Tfelt-Hansen J., de Riva M., Winkel B. G., Behr E. R., Blom N. A., Charron P., et al. 2022 ESC guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death. *Eur Heart J*. 2022; 43 (40): 3997–4126. DOI: 10.1093/eurheartj/ehac262. PMID: 36017572.
7. Su S., Li L., Peng X., Zhou L., Zhang Z., Xiong Y., Zhang Z., et al. Outcomes in catheter ablation of sustained ventricular tachycardia in myocarditis compared with ischemic heart disease. *Rev Cardiovasc Med*. 2025; 26 (1): 25604. DOI: 10.31083/RCM25604. PMID: 39867181.
8. Vallabhajosyula S., Vaidya V. R., Patlolla S. H., Desai V., Mulpuru S. K., Noseworthy P. A., Kapa S., et al. Venoarterial extracorporeal membrane oxygenation support for ventricular tachycardia ablation: a systematic review. *ASAIO J*. 2020; 66 (9): 980–985. DOI: 10.1097/MAT.0000000000001125. PMID: 31977352.
9. European system for cardiac operative risk evaluation. URL <http://www.euroscore.org/calc.html>
10. Santangeli P., Muser D., Zado E. S., Magnani S., Khetpal S., Hutchinson M. D., Supple G., et al. Acute hemodynamic decompensation during catheter ablation of scar-related ventricular tachycardia: incidence, predictors, and impact on mortality. *Circ Arrhythm Electrophysiol*. 2015; 8 (1): 68–75. DOI: 10.1161/CIRCEP.114.002155. PMID: 25491601.
11. Muser D., Santangeli P., Castro S. A., Pathak R. K., Liang J. J., Hayashi T., Magnani S., et al. Long-term outcome after catheter ablation of ventricular tachycardia in patients with nonischemic dilated cardiomyopathy. *Circ Arrhythm Electrophysiol*. 2016; 9 (10): e004328. DOI: 10.1161/CIRCEP.116.004328. PMID: 27733494.
12. Tung R., Xue Y., Chen M., Jiang C., Shatz D. Y., Besser S. A., Hu H., et al. First-line catheter ablation of monomorphic ventricular tachycardia in cardiomyopathy concurrent with defibrillator implantation: the PAUSE-SCD randomized trial. *Circulation*. 2022; 145 (25): 1839–1849. DOI: 10.1161/CIRCULATIONAHA.122.060039. PMID: 35507499.
13. Napp L. C., Basir M. B. Outcomes of mechanical circulatory support for ventricular tachycardia ablation in severe systolic heart failure. *J Interv Card Electrophysiol*. 2021; 61 (2): 431–433. DOI: 10.1007/s10840-021-00997-x. PMID: 33931793.
14. Garg J., Kewcharoen J., Shah K., Turagam M., Bhardwaj R., Contractor T., Mandapati R., et al. Clinical outcomes of radiofrequency catheter ablation of ventricular tachycardia in patients with hypertrophic cardiomyopathy. *J Cardiovasc Electrophysiol*. 2023; 34 (1): 219–224. DOI: 10.1111/jce.15739. PMID: 36335616.
15. Calcagno T., Cesmat A., Sipko J., Baranowski B., Bhargava M., Callahan T. D., Chung M. K., et al. Prolonged hospitalization after catheter ablation of ventricular tachycardia: predictors and outcomes. *Heart Rhythm*. 2025; 22 (11): 2857–2866. DOI: 10.1016/j.hrthm.2025.05.063. PMID: 40472946.
16. Jentzer J. C., Noseworthy P. A., Kashou A. H., May A. M., Chrispin J., Kabra R., Arps K., et al. Multidisciplinary critical care management of electrical storm: JACC state-of-the-art review. *J Am Coll Cardiol*. 2023; 81 (22): 2189–2206. DOI: 10.1016/j.jacc.2023.03.424. PMID: 37257955.

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