https://doi.org/10.35336/VA-2022-3-05

A CASE OF SUCCESSFUL RADIOFREQUENCY ABLATION OF ECTOPIC VENTRICULAR ACTIVITY WITH PARA-HISIAN ORIGIN BY ACCESS FROM THE RIGHT CORONARY SINUS OF VALSALVA

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A clinical case of successful radiofrequency ablation of ventricular tachycardia with para-Hisian localization of the substrate by access from the right coronary sinus of Valsalva is presented.

Key words: radiofrequency ablation; aortic sinus of Valsalva; ventricular tachycardia; premature ventricular contractions.

Conflict of Interests: nothing to declare
Funding: none
Received: 27.01.2022 **Revision received:** 30.01.2022 **Accepted:** 31.01.2022
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For citation: Matsonashvili GR, Serguladze SYu, Matsonashvili TR, Suladze VG, Kulumbegov GR, Fayzaliev RKh. A case of successful radiofrequency ablation of ectopic ventricular activity with para-Hisian origin by access from the right coronary sinus of Valsalva. *Journal of Arrhythmology.* 2022;29(3): 37-43. https://doi.org/10.35336/VA-2022-3-05.

Premature ventricular contractions (PVCs) are common heart rhythm disorders occurring in patients without any structural heart disease. There are several mechanisms responsible for PVCs development: abnormal automaticity, triggered activity and re-entry. Despite the absence of clinical manifestation in several patients, high PVC burden can lead to the development of PVC-induced cardiomyopathy followed by worsening of systolic and diastolic functions of the left ventricle (LV) and affecting quality of life [1].

Radiofrequency catheter ablation (RFA) is considered an effective method for treating patients with PVCs and ventricular tachycardias (VT). According to Latchamsetty et al. (2015) reports, acute effect of PVC ablation procedures was achieved in 84% of patients, medium-term effectiveness (follow-up time 20.2±21.7 months) was 71% and 85% in combination and without antiarrhythmic drug therapy respectively [2].

The substrate of some arrhythmias may be inaccessible from the endocardial surface of right chambers, and that is precisely why retrograde arterial approach via sinuses of Valsalva is preferred in such cases, especially when the origin of arrhythmia is localized in para-Hisian region [3]. According to different literature, in adults the incidence of PVCs and ventricular tachycardias originating from the aortic sinuses varies between 16.6-18%. Furthermore, ventricular arrhythmias more often originate from the left sinus of Valsalva [4].

The aortic root comprises the sinuses of Valsalva, valvar leaflets and fibrous interleaflet triangles. This region is of particular interest to electrophysiologists, because it takes central position in the heart and anyway contacts atrial and/or ventricular myocardium, this circumstance makes it possible to eliminate some types of arrhythmias by access from the aortic sinuses located at the base of the aortic root. The right sinus of Valsalva (RSV) is commonly located directly posteriorly and downwards from the right ventricular outflow tract (RVOT). From this spatial relationship it follows that the electrogram in the RSV region has a large ventricular component reflecting the activation of the adjacent relatively thick posterior wall of the infundibulum of the RVOT. In the area of the fibrous interleaflet triangle between non-coronary and right sinuses of Valsalva the central fibrous body is located. The penetrating bundle of His is located here, and more distally, the beginning of its left bundle branch. The compact portion of the atrioventricular node is placed posteriorly and downwards from the commissure between non-coronary and right sinuses of Valsalva. Awareness of these anatomical relationships is of significant importance for safe RFA in the area of RSV [5].

Considering possible complications of RFA in this area (coronary vascular or leaflet injury, conduction disturbances, systemic embolisms and transient ischemic attacks), it is necessary to follow certain rules and have a sufficient experience in carrying out such procedures, as well as use available methods of visualization to assure safety of mapping and RFA [5, 6].

This article presents a clinical case of successful catheter ablation of ventricular ectopic activity by access from the RSV.

A 65-year-old patient was admitted with dyspnea during exercise, palpitations and general weakness. The *patient has been observed for arrhythmia for the last four years. From Holter monitoring data, up to 30000 monomorphic PVCs were registered per day, in this connection the patient received antiarrhythmic drug therapy (I and II classes according to Vaughan-Williams classification). On the background of treatment, no significant clinical effect was observed, and the patient was recommended to perform RFA of arrhythmogenic foci in one of the cardiovascular surgical hospitals. According to the patient's operative notes from the medical institution in which the patient previously underwent RFA, the origin of PVCs was in para-Hisian region. RFA was accompanied by the appearance of rapid junctional rhythm with a transient atrioventricular block, and therefore the procedure was discontinued. It was decided to refrain from further ablation due to the high risk of atrioventricular block. With the same complaints, the patient was hospitalized for a repeat catheter ablation.*

Physical examination: heart tones are attenuated, there are no murmurs, heart rate 68 b.p.m., blood pressure 130/85 mmHg. Radial artery pulse is symmetrical, arrhythmic, of satisfactory filling. Height - 177 cm, body weight - 88 kg, body mass index - 28.09 kg/m^2*.*

Coronary angiography data: proximal stenosis of anterior interventricular branch of left coronary artery (CA) (up to 30%), the remaining arteries without angiographically significant stenosis.

According to 12-lead Holter monitor data, 22651 monomorphic PVCs were registered per 24 hours, including couplets and triplets. Preoperative analysis of QRS-morphology on algorithm proposed by K. Park et al. (2012) allowed to suggest the origin of PVC in His bundle [7].

Transthoracic echocardiography data: LV end-diastolic volume 174.2 ml, LV ejection fraction 49.5%, LV end-systolic diameter 4.4 cm, LV end-diastolic diameter 5.9 cm, LV posterior wall hypokinesia; moderate mitral and tricuspid regurgitation. Aorta: ascending part 42 mm, the walls are indurated, the valve at the level of the fibrous ring is 26 mm, regurgitation is minimal. Interventricular septal thickness is 12 mm.

Medication: amiodarone 200 mg/day, aspirin 75 mg/day, indapamide 1.5 mg/day, atorvastatin 20 mg/day, ramipril 10 mg/day.

Based on complaints, anamnesis, objective examination, as well as the results of additional methods of medical examination, the patient was diagnosed with "Cardiac arrhythmia. PVCs, 4B grade (B. Lown). Paroxysmal ventricular tachycardia. RFA of PVCs with para-Hisian origin

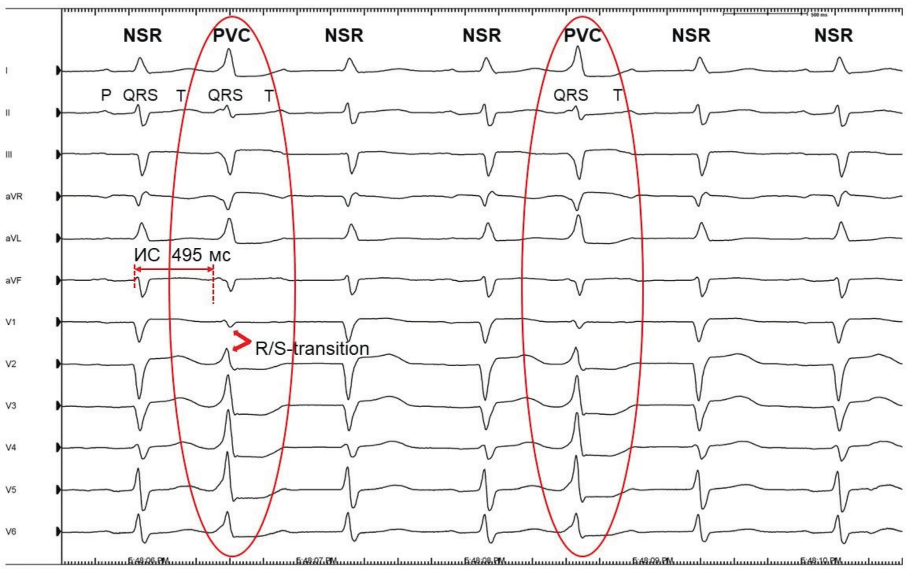

Fig. 1. ECG (50 mm/sec, 10 mm/mV). Sinus rhythm, rate 72-75 bpm, single monomorphic premature ventricular complexes (circled) with coupling interval (CI) 495 ms, left anterior fascicular block, PQ interval extension to 230 ms. From top to bottom: I, II, III - standard limb leads (bipolar), aVR, aVL, aVF - augmented limb leads (unipolar), V1-V6 - precordial leads (unipolar). PVC - premature ventricular complex; NSR - normal sinus rhythm.

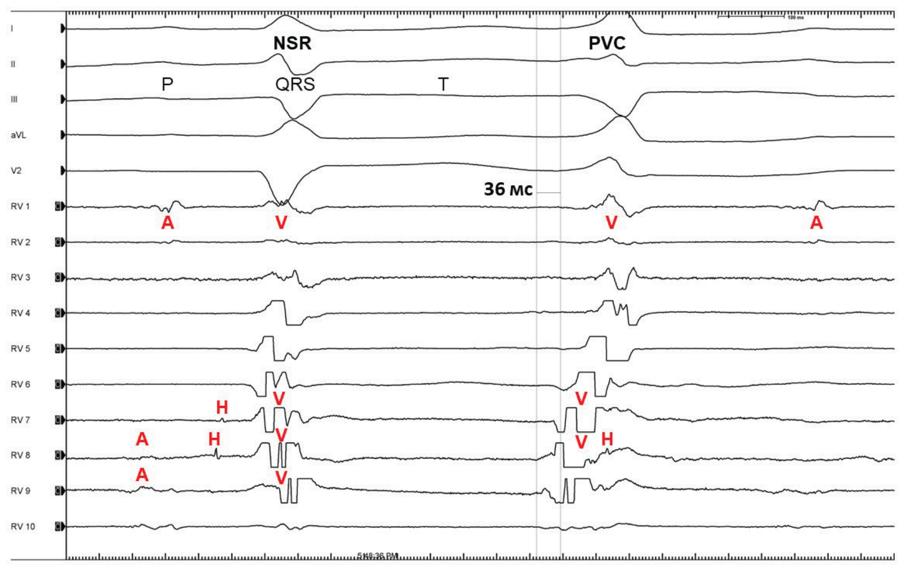

Fig. 2. Bipolar electrograms obtained during right ventricular outflow tract mapping (200 mm/sec). The earliest site of ventricular activation (-36 ms ahead of the referent - R-wave in lead II) is recorded on electrograms from channels RV 8-9; on these and adjacent channels the spike of His-bundle (H) is also noted. From top to bottom: I, II, III, aVL, V2 ECG leads; electrograms recorded from a 20-pole diagnostic electrode placed in right ventricular outflow tract (RV 1-10). NSR - normal sinus rhythm; PVC - premature ventricular complex; A - atrial activation; H - His bundle activation; V - ventricular activation.

in 2017. Arterial hypertension, grade 3, very high cardiovascular risk".

Surgery

The patient was taken to the electrophysiological laboratory in sinus rhythm, heart rate 70-75 bpm, left anterior fascicular block, PQ interval extension to 230 ms, frequent PVCs, presumably from the para-Hisian region (according to the algorithm, proposed by K. Park et al., 2012) (Fig. 1). [7].

The right femoral vein was punctured three times under combined anesthesia. A diagnostic 10-pole catheter was placed in the coronary sinus. A diagnostic 20-pole catheter, as well as an irrigated ablation catheter Celsius Thermocool (Biosense Webster) were positioned in RVOT. The "earliest" activation site is registered close to the His-bundle (Fig. 2). When mapping this area, the earliest site was -37 ms ahead of the referent (R-wave in lead II).

Due to high risks of RFA in the His bundle, it was decided to continue mapping in the aortic root. A puncture of the right femoral artery was performed, heparin was instantly injected (100 I.U. per 1 kg of body weight). An irrigated ablation catheter was delivered to the aortic root. When mapping this region, the "earliest" site (-40 ms ahead of the aforementioned referent) was registered in RSV (Fig. 3). Pace-mapping in this area had not succeeded due to the lack of ventricular myocardium "capture".

A puncture of left femoral artery was performed. A Judkins-type angiographic catheter was delivered to the aortic root. A multi-projection coronary angiography of the left and right CA was performed, a safe position of ablation catheter from the ostia and trunks of the CA was verified (Fig. 4 A, B, C, E). Under continuous angiographic control, irrigated RFA was carried out in this site for 2 minutes at 40-42 ºC and 35 W. The disappearance of PVCs was noted at the 3rd second of the first RFA, in the next 45 minutes of observation a stable sinus rhythm without PVCs had been recorded. During the entire procedure, there were no ST-segment displacements and T-wave morphology abnormal changes. At the end of the procedure, coronary angiography was performed (no signs of thermal damage to the coronary arteries) and, then, echocardiography, decannulation and hemostasis. The patient was transferred to the department with sinus rhythm.

A normal sinus rhythm without PVCs was recorded before patient's discharge. (Fig. 5). In the early postoperative period, a control Holter monitoring was performed: 16 supraventricular extrasystoles, 4 single monomorphic PVCs of another morphology. The patient was discharged with a significant improvement in well-being.

DISCUSSION

In catheter treatment of supraventricular and ventricular arrhythmias retrograde arterial approach is an effective and save alternative to venous access. There are several electrocardiographic indicators in the arsenal of cardiologists and cardiovascular surgeons that allow to assume at the preoperative analysis that one of the sinuses of Valsalva would be the best access for PVC/VT ablation. VT and PVCs from the region of the Valsalva sinuses have similar features on ECG to those from the upper-septal part of RVOT. Nevertheless, the former usually show an early R/S transition in leads V1-V3, whereas for the latter the R/S transition occurs in lead V3 or later [8]. In the presented case report, the R/S transition was determined between leads V1 and V2.

Several quantitative ECG-indexes have also been proposed, which make it possible to distinguish the PVC/VT originating from the sinuses of Valsalva from other idiopathic ventricular arrhythmias. For example, R-wave duration index, which is defined as a ratio of R-wave duration (measured from the onset of the QRS complex to the transition point between the R-wave and the isoelectric line) to the total QRS duration in lead V1. Values ≥50% for PVC/VT with left bundle branch block morphology and an inferior axis suggest the Valsalva sinuses origin [9]. In the presented case report the value of this indicator amounted 53%. (Fig. 4 D)

The benefit of retrograde arterial approach to eliminate PVC/VT is evidenced, first, by the results of activation mapping in the right ventricle: if the "earliest" ventricular activation is detected in the area of His bundle, the access from the Valsalva sinuses may be effective

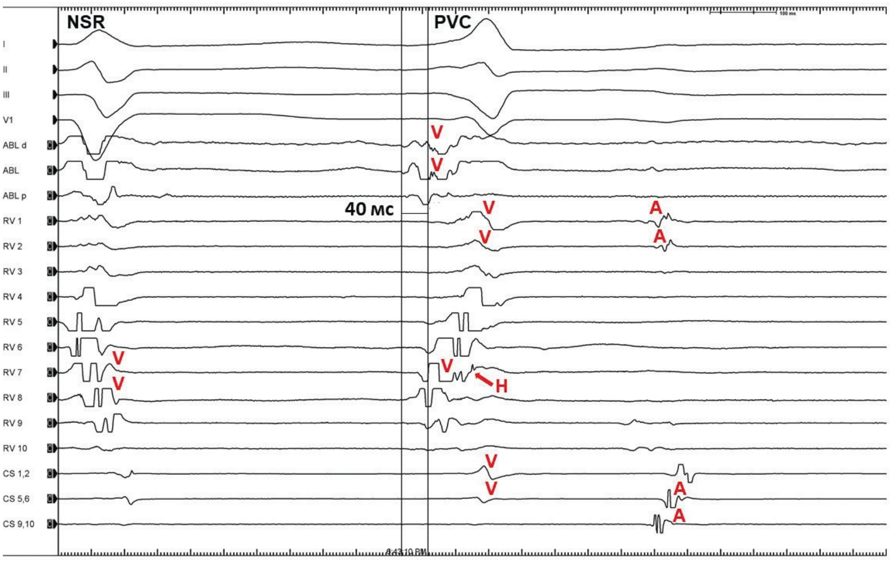

Fig. 3. Activation mapping within right sinus of Valsalva (200 mm/sec). The "earliest" activation is recorded on the ablation electrode (-40 ms ahead of the referent - R-wave in lead II). From top to bottom: I, II, III, V1 ECG leads; electrograms recorded from the ablation catheter (ABL); electrograms recorded from a 20-pole diagnostic electrode placed in right ventricular outflow tract (RV 1-10); electrograms recorded from a diagnostic electrode in coronary sinus. NSR - normal sinus rhythm; PVC - premature ventricular complex; A - atrial activation; H - His bundle activation; V - ventricular activation.

[4]. Additional validity for the arterial access choice in the presented case report was the previous episode of unsuccessful ablation in para-Hisian region by access from the RVOT.

Prior to RFA it's recommended to examine the aortic root to visualize the peculiarities of anatomy, CA ostia localization, as well as to establish anomalies of the CA, if any. Coronary angiography is the gold standard. It should be performed during and after RFA, to exclude possible subclinical injury of CA. In some cases, electroanatomic mapping with non-fluoroscopic navigation is useful, which also allows you to model detailed anatomy of cardiac structures with high accuracy and, as a result, safely perform manipulations in the aortic root. An alternative method of intraoperative diagnostics is intracardiac echocardiography, which allows you to control the distance between the tip of the electrode and the ostia of CA, and also makes it possible to visualize atherosclerotic areas and calcification of the aorta [4]. Besides, the use of intracardiac echocardiography is reasonable if there are any relative contraindications to coronary angiography (contrast-induced nephropathy, etc.). According to Al Ahmar M. et al. (2021) research, in 95% of cases, monitoring of the safety of RFA in the Valsalva sinuses was performed under control of intracardiac echocardiography, only in 5% of cases there was a necessity of coronary angiography to visualize the CA [6].

Conventional, irrigated radiofrequency electrodes or cryoenergy sources can be used for ablation in the sinuses of Valsalva. Each of the listed electrodes has its own advantages and disadvantages. Conventional electrodes are widely available and effective, acceptable for most ablation procedures, but, on the other hand, they promote coagulation at the tip of the electrode. There are observations demonstrating a greater risk of cerebral microembolism associated with RFA using conventional electrode [10]. In this regard, irrigated electrodes have significant advantages: greater lesion depth (compared to conventional and cryoelectrodes), counteraction to coagulum formation and reduction of the risk of thromboembolism. Cryoablation doesn't destroy elastic fibers in the tunica media, this is an obvious advantage in the context of reducing the severity of the inflammatory reaction provided by macrophages [9].

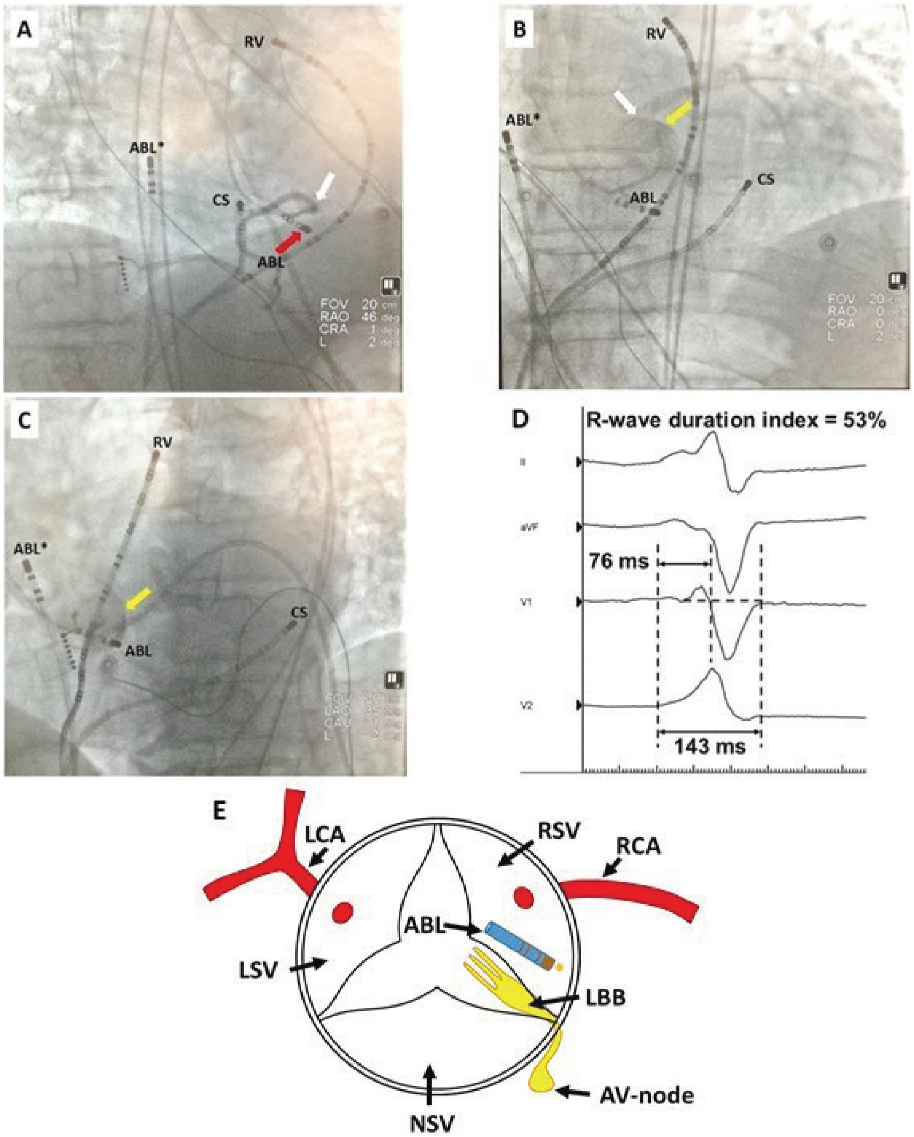

Fig. 4. The position of the ablation catheter at the effective site of ablation on intraoperative radiographs: A - right anterior oblique view (RAO 46 deg.), the white arrow indicates the ostium of the right coronary artery, the red arrow indicates the tip of ablation catheter placed in the "earliest" site of ventricular activation; B - antero-posterior view, the white arrow indicates the ostium of the left coronary artery, the yellow arrow indicates the bottom of the left sinus of Valsalva; C - left anterior oblique view (LAO 35 deg.), the yellow arrow indicates the boundary of the right sinus of Valsalva. D - R-wave duration index, calculated for premature ventricular complex; from top to bottom: II, aVF, V1 u V2 ECG leads. E - schematic representation of the position of the ablation catheter at the effective site of RFA. Indications on radiographs: CS - 10-pole diagnostic electrode placed in coronary sinus; RV - 20-pole diagnostic electrode placed in right ventricular outflow tract; ABL - ablation catheter delivered via retrograde arterial approach; ABL* - ablation catheter passed via the right femoral vein into the "right" cardiac chambers. Indications on the operation diagram: LCA - left coronary artery; RCA - right coronary artery; LSV - left sinus of Valsalva; RSV - right sinus of Valsalva; NSV - non-coronary sinus of Valsalva; LBB - left bundle branch; ABL - the position of the ablation catheter.

The literature highlights the experience of using various parameters of RFA by access from RSV: 1) assessment of paced QRS morphology during pace-mapping: the similarity of paced QRS morphology with the native PVC in 11 of 12 ECG leads is desirable [11]; 2) the number of RFA: 1-3 RFA are sufficient for successful ablation of supraventricular arrhythmias, whereas for PVC/VT there could be more (2-6); 3) duration of exposure: it is generally accepted to stop RFA in the absence of an effect within 10 seconds from the onset [4].RFA in the sinuses of Valsalva often causes anxiety among electrophysiologists due to possible complications. Let's focus on them in more detail.

In some cases, the optimal ablation point is closely adjacent to the ostium of the CA, so ablation in the right and left coronary sinuses is associated with a significant risk of spasm, injury, or occlusion of the CA. Therefore, it is generally accepted among electrophysiologists that these vessels should be visualized before RFA is performed. If it is not possible to ensure a stable position of the electrode, it is proposed to protect the coronary artery by cannulating it with a Judkins catheter (5F) [10]. Most researchers are of the opinion that RFA is safe at a distance of more than 1.0 cm from the ostia of the coronary arteries. If the arrhythmogenic focus is localized too close to the ostium of the CA, then the risk of injury exceeds the benefit of RFA in this area, and alternative approaches should be considered. It is possible to verify the absence of CA stenosis when performing an exercise stress testing after 6 months after RFA [6].

Certain attention is required for cerebral and peripheral thromboembolism during the procedure or in the immediate postoperative period caused by aortic wall damage. Therefore, adequate antithrombotic therapy is necessary during and after RFA [10].

It is important to take into account, that there is a central fibrous body behind the fibrous interleaflet triangle between the right coronary and non-coronary sinuses of Valsalva, through which the penetrating bundle of His passes. For this reason, RFA in the two mentioned sinuses of Valsalva may be complicated by a violation of atrioventricular conduction up to complete block [4]. The appearance of an accelerated junctional rhythm during RFA in these sinuses should be followed by an immediate cessation of energy delivery [4, 11]. ECG monitoring of the integrity of atrioventricular conduction after RFA is necessary before patient's discharge and after 6 months of follow-up. At the same time, the risk of atrioventricular junction injury is much less frequent than if one uses access from the right chambers. So, Wei et al. (2018) report successful RFA of PVC/VT substrate in para-Hisian region in 13 out of 14 patients by access from RSV, only in 1 patient the RFA was accompanied by the appearance of an accelerated junctional rhythm, and therefore energy delivery was discontinued. [11].

The thermal effect of RFA in RSV may be accompanied by a vagal reaction caused by the penetration of energy into the adjacent epicardial fat pad. The fat pad contains autonomous fibers and parasympathetic ganglia, their irritation or injury potentiates Bezold-Jarish response (bradycardia, hypotension, hypopnea) [12].

CONCLUSION

Among all ventricular arrhythmias that have a substrate in the aortic root area, only about 9% originate from the right sinus of Valsalva. Radiofrequency ablation by access from the right sinus of Valsalva shows high efficiency in the treatment of ventricular arrhythmias with para-Hisian localization of the substrate. Fundamentally important for reproducing this access is understanding of cardiac anatomy, especially the structural relationships between the aortic root, ventricular outflow tracts, coronary arteries and conduction system. At the same time, access from the right sinus of Valsalva leaves the question of the commensurability, on the one hand, of greater safety of the cardiac conduction system elements, and, on the other hand, the risk of coronary arteries injury. Currently available visualization methods (angiography, intracardiac echocardiography), as well as navigation systems for electroanatomic mapping, pretty much allow monitoring the safety of lesions in this area.

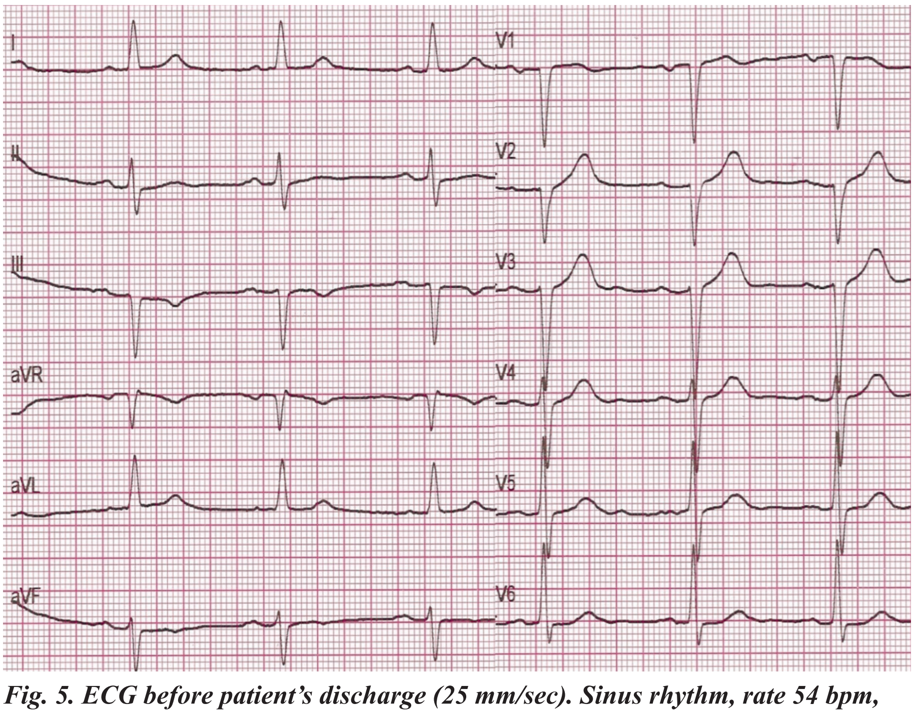

Fig. 5. ECG before patient's discharge (25 mm/sec). Sinus rhythm, rate 54 bpm, left anterior fascicular block, PQ interval extension to 230 ms. I, II, III - standard limb leads (bipolar), aVR, aVL, aVF - augmented limb leads (unipolar), V1-V6 - precordial leads (unipolar).

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