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CASE REPORT

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Heart rate-dependent mitral regurgitation

Dzhem Farandzha | **Irina Lyoskova** | **Petranka Shikerova** | **Dobri Hazarbasanov**

Department of Cardiology, University Hospital Lozenetz, Sofia, Bulgaria

Correspondence
Dzhem Farandzha, Department of Cardiology, University Hospital Lozenetz, Kozyak 1, Sofia 1407, Bulgaria.
Email: cemf@abv.bg

Key Clinical Message

Mitral regurgitation (MR) is a particularly dynamic valvular disorder. Extreme bradycardia can lead to prolonged left ventricular filling time and mitral annular dilatation, hence causing secondary MR in a structurally normal mitral valve.

KEYWORDS

dynamic mitral regurgitation, heart rate-dependent

1 | INTRODUCTION

Quantifying mitral regurgitation (MR) on transthoracic echocardiography (TTE) requires not only command of echocardiographic techniques but also knowledge of patient characteristics and physiology. Unlike aortic regurgitation, insufficiency of the mitral valve is a more dynamic valvular disease, which makes it more challenging to assess and obtain reproducible results. Mitral regurgitation is also more dependent on left ventricular function and preload.[1,2] An inverse relationship between the degree of mitral regurgitation and heart rate has also been described.[3,8] This is most likely due to increased time for left ventricular filling in bradycardia, hence an increased left ventricular end-diastolic volume (LVEDV) and mitral annular dilatation leading to secondary MR in a structurally normal mitral valve.

2 | CASE HISTORY

A 71-year-old woman was admitted to our department with complaints of fatigue, breathlessness, and dizziness. She had a left bundle branch block (LBBB) diagnosed in the past and two coronary angiographies performed with no significant lesions present. Her mitral regurgitation was assessed as mild on both left ventriculography and TTE. The patient's medical records showed that she had paroxysmal atrial fibrillation and had been taking propafenone 150 mg tid for a nonspecified period of time after which she was switched to amiodarone 100 mg/d. Outpatient Holter monitoring 2 years prior to admission recorded SA pauses of up to 1.8–2.1 s and no atrial fibrillation. Amiodarone was then stopped, and beta blockers were not used due to a propensity for bradycardia. On her current admission, the patient did not report syncope, but had been complaining of dizziness, fatigue, and breathlessness in the last few weeks. A resting electrocardiogram (ECG) was obtained (see Figure 1).

3 | INVESTIGATIONS AND TREATMENT

The patient denied having any symptoms of angina, her current ECG did not differ significantly from her previous ECGs, and her high-sensitivity troponin I (hsTrI) was within reference ranges. On transthoracic echocardiography, she was noted to have moderate-to-severe mitral regurgitation with an effective regurgitant orifice area (EROA) of 0.23 cm^2 and MR volume of 49 mL (see Figure 2 and Video S1). Normal left ventricular systolic function with an ejection fraction (EF) of 64% and no potential reversible causes of conduction disturbances were also noted. Her heart rate ranged from 42 to 47 bpm during her echocardiographic exam.

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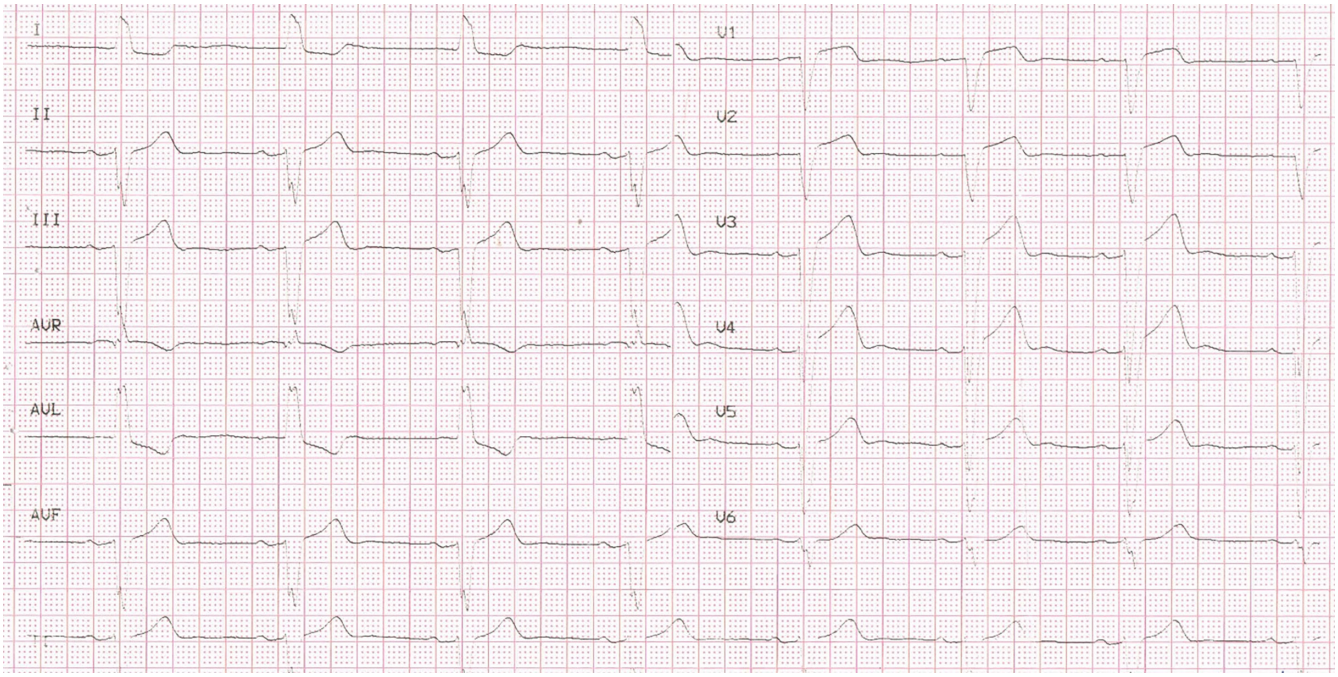

FIGURE 1 ECG obtained on admission with sinus bradycardia and LBBB.

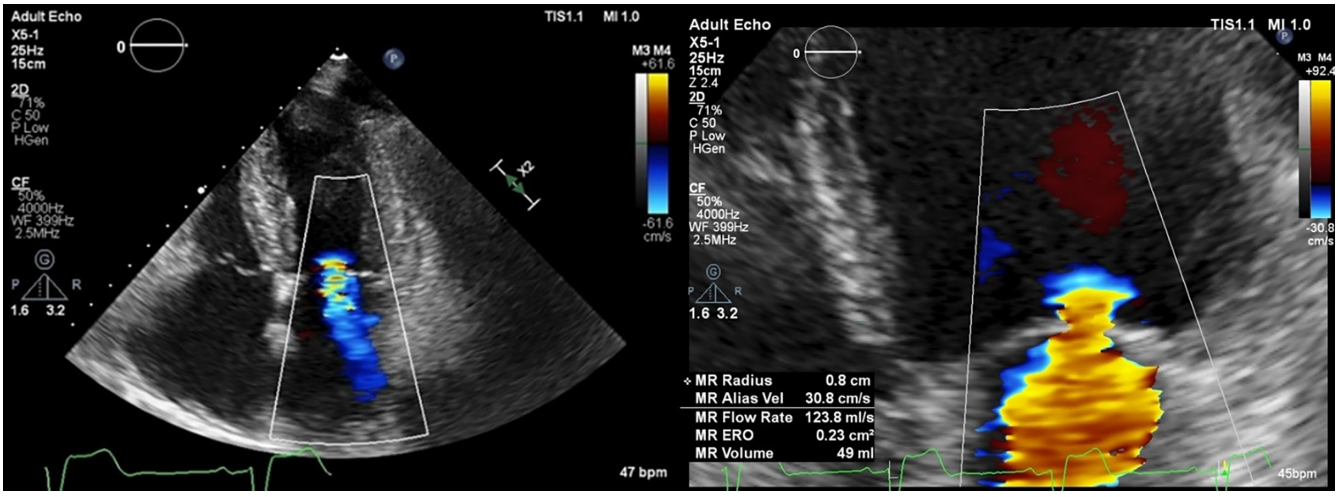

FIGURE 2 TTE obtained on admission with a considerable increase in the severity of mitral regurgitation as compared to patient's past medical records.

It was decided to reassess her mitral regurgitation after further clarification of the bradycardia. A 24-h Holter monitoring was performed, which revealed sinus node dysfunction with inadequate chronotropic response to exercise and atrial ectopy (see Figures 3 and 4). Patient's mean heart rate was 44 bpm (36–71 bpm) during monitoring.

A dual-chamber pacemaker in DDDR mode was implanted. Rate response function was activated due to the underlying chronotropic incompetence. ECG performed after implantation shows normal function of the device with a ventricular rate of 60 bpm (see Figure 5).

4 | OUTCOME AND FOLLOW-UP

The second transthoracic echocardiography performed after pacemaker implantation (2 days after the initial TTE) showed only mild mitral regurgitation with an EROA of 0.13 cm^2 and MR volume of 18 mL (see Figure 6 and Video S2). There was also a significant decrease in the peak mitral inflow E wave velocity as well as the estimated pulmonary artery pressure (see Figure 7). The patient's heart rate during her second echocardiographic exam was 60 bpm. She was discharged home without further investigation.

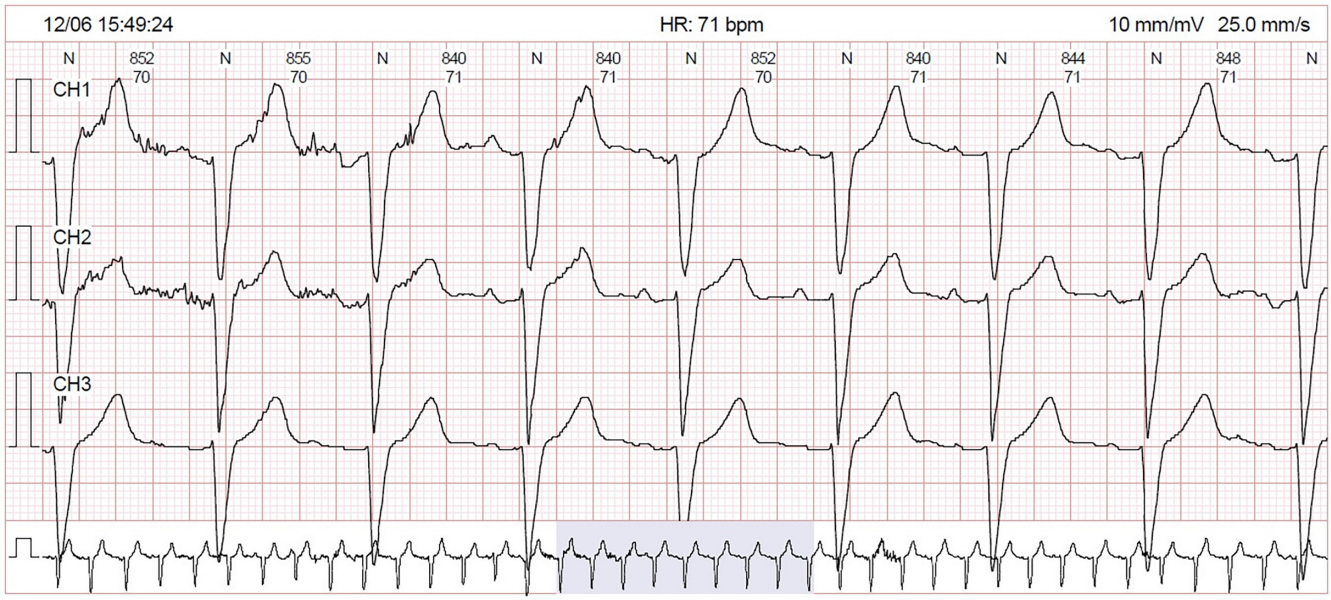

FIGURE 3 Holter monitoring showing chronotropic incompetence during physical exercise with a peak heart rate of 71 bpm.

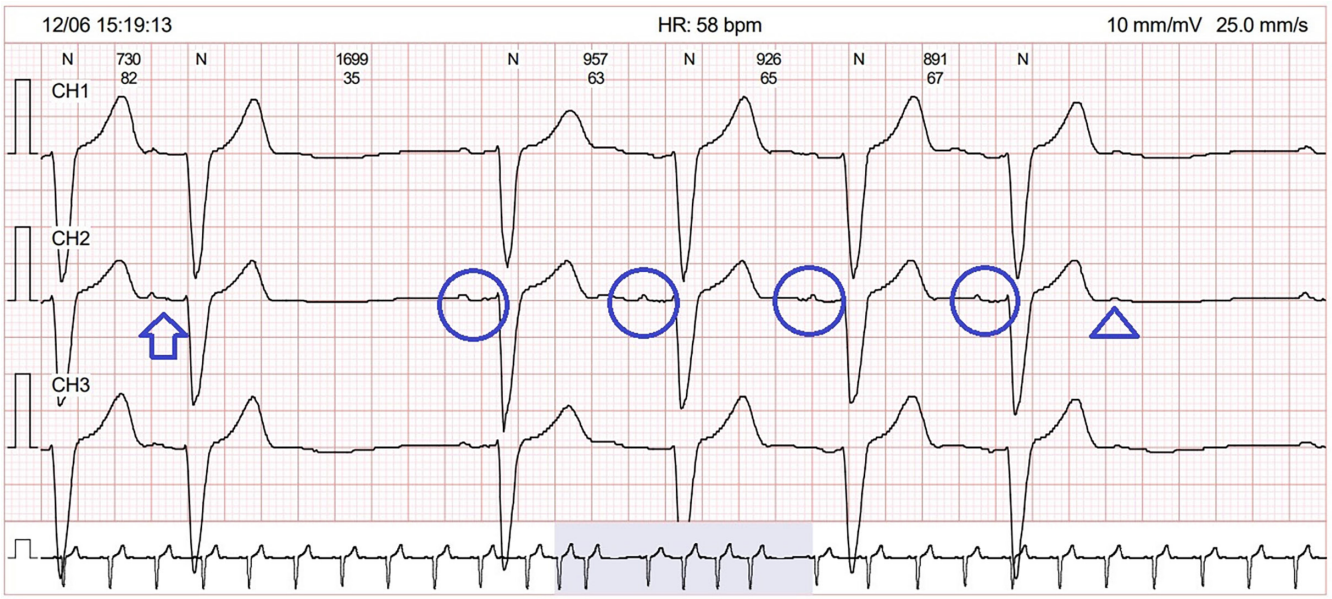

FIGURE 4 Holter monitoring with atrial ectopy (blue circles), blocked premature atrial complex (blue arrowhead), and prolonged atrioventricular conduction (blue arrow).

One year after discharge, the patient is feeling well. She does not report any palpitations, dizziness, or shortness of breath. She is able to perform her regular daily activities without any limitation.

5 | DISCUSSION

Mitral regurgitation is a common valvular disease, which is usually observed during ventricular systole when blood is being ejected through the aortic valve and its backflow from the left ventricle to the left atrium cannot be prevented by the mitral valve. In addition to the more frequently observed systolic mitral regurgitation, cases of diastolic mitral regurgitation have been described, which are usually due to atrioventricular block, severe aortic regurgitation, or dilated cardiomyopathy.[4,5] The underlying mechanism for the insufficiency of the mitral valve in the presented case was not the absence of atrioventricular synchrony, but rather the prolonged left ventricular filling time as a result of extreme bradycardia, and thus, mitral regurgitation was observed during systole. However, considering the patient had left bundle branch block, ventricular dyssynchrony, as opposed

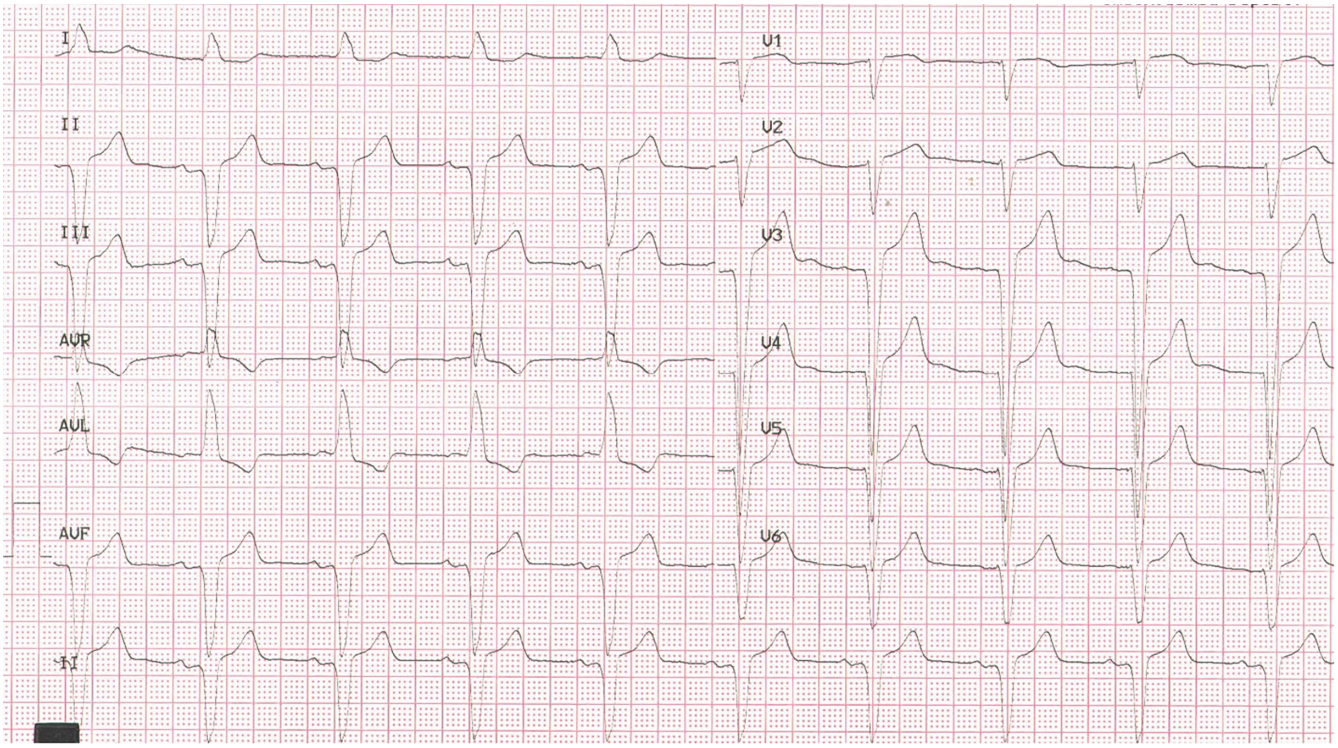

FIGURE 5 ECG performed after pacemaker implantation in DDDR mode.

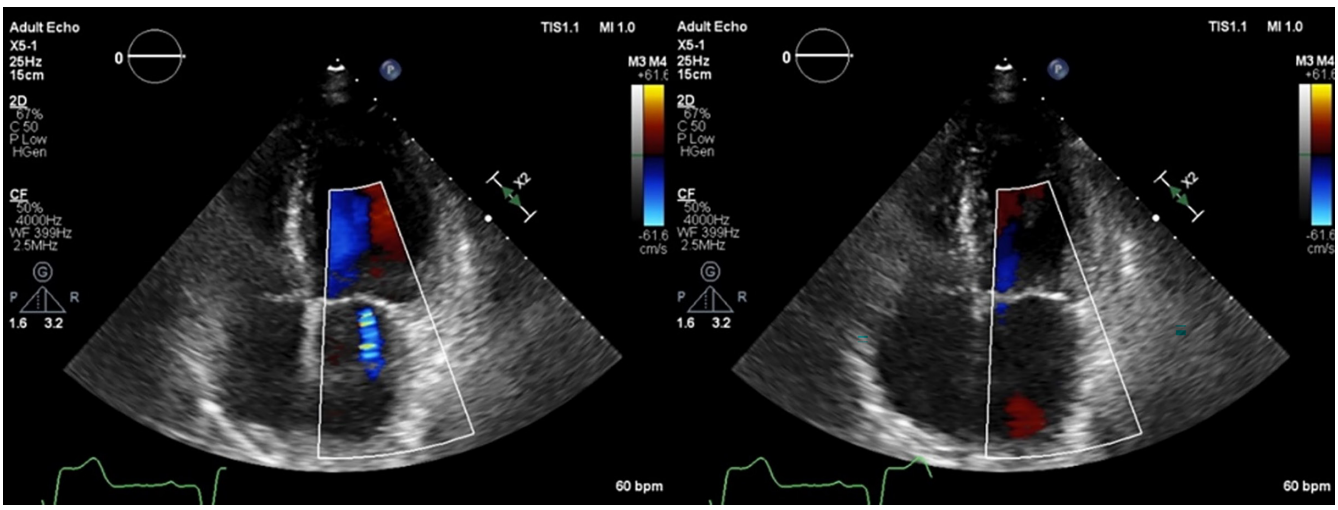

FIGURE 6 TTE performed after pacemaker implantation shows mild mitral regurgitation in early to mid-systole. No mitral regurgitation is visible in late systole as opposed to the pre-pacemaker implantation TTE when most of the regurgitation was observed in late systole.

to atrioventricular dyssynchrony, prior to pacemaker implantation is very likely. LBBB-related papillary muscle dyssynchrony has been described as a possible cause of functional mitral regurgitation even in patients with preserved ejection fraction.[6,7] However, as previously stated, the patient's mitral regurgitation was assessed as mild on both left ventriculography and TTE, which makes LBBB-related dyssynchrony as the main cause of MR unlikely. Thus, it is reasonable to assume that the increase in MR severity was triggered by the prolonged left ventricular filling time and mitral annular dilation as a result of bradycardia, while the LBBB-related dyssynchrony was probably only a contributing factor. In any case, right ventricular septal pacing helped resolve both of these issues. Another evidence supporting our hypothesis was the significant decrease in the peak

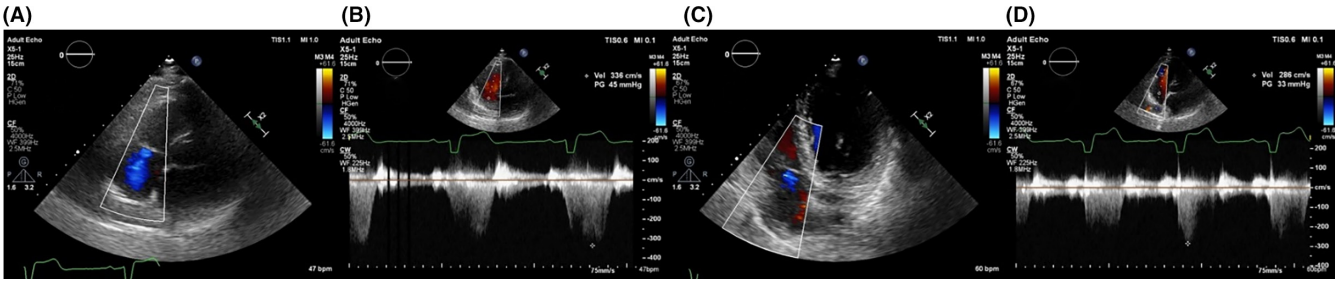

FIGURE 7 Shown sequentially from left to right are tricuspid regurgitation on admission (A), regurgitation jet velocity and pressure gradient (336 cm/s and 45 mmHg) across the tricuspid valve on admission (B), tricuspid regurgitation after pacemaker implantation (C), and regurgitation jet velocity and pressure gradient (286 cm/s and 33 mmHg) across the tricuspid valve after pacemaker implantation (D).

mitral inflow E wave velocity, tricuspid regurgitation, and estimated pulmonary artery pressure on echocardiography along with the severity of mitral regurgitation after pacemaker implantation. These results are also backed up by the findings of an experimental animal study which analyzed the effects of increasing heart rate on mitral regurgitation severity and found that an increase in HR was associated with a significant decrease in regurgitant volume and left ventricular end-diastolic pressure.[8]

6 | CONCLUSION

Mitral regurgitation is a particularly dynamic valvular disorder that may vary significantly with changes in left ventricular volume and filling pressures. Extreme bradycardia can lead to prolonged left ventricular filling time and mitral annular dilatation, hence causing secondary MR in a structurally normal mitral valve. Correctable causes of secondary MR should be treated appropriately before final assessment of MR severity.

AUTHOR CONTRIBUTIONS

Dzhem Farandzha: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; visualization; writing – original draft; writing – review and editing. **Irina Lyoskova:** Conceptualization; data curation; investigation; validation; visualization; writing – review and editing. **Petranka Shikerova:** Conceptualization; formal analysis; investigation; methodology; supervision; validation; visualization; writing – original draft. **Dobri Hazarbasanov:** Conceptualization; methodology; project administration; supervision; validation; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest regarding the publication of this article.

DATA AVAILABILITY STATEMENT

All relevant data used to support the findings of this study are included within the article and supplementary files.

CONSENT

Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

ORCID

Dzhem Farandzha https://orcid.org/0000-0003-2011-354X

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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