

Leadless pacemaker implantation planned with computed tomography–based 3-dimensional modeling in a 51-year man with a functional single left ventricle and pulmonary outflow obstruction

Wojciech Kwaśniewski¹, Wojciech Wróbel¹, Maciej Pyza², Jadwiga Gabor², Katarzyna Mizia-Stec^{1,3}, Andrzej Swinarew^{2,4}

1 First Department of Cardiology, School of Medicine in Katowice, Upper Silesian Medical Centre, Medical University of Silesia, Katowice, Poland

2 Faculty of Science and Technology, University of Silesia in Katowice, Chorzów, Poland

3 Centre of the European Reference Network for Rare, Low Prevalence, or Complex Diseases of the Heart (ERN GUARD Heart), Katowice, Poland

4 Department of Training and Nutrition in Sports, Faculty of Physical Education, Jerzy Kukuczka Academy of Physical Education, Katowice, Poland

A 51-year-old patient with a congenital functional univentricular heart (single dominant left ventricle) has survived into late adulthood without definitive biventricular repair (FIGURE 1A–1E). Long-term survival in unoperated single-ventricle physiology is uncommon; however, selected patients with a “balanced” circulation—frequently involving left ventricular morphology and pulmonary outflow obstruction—may reach late decades of life with preserved functional status.¹

The patient presented with acquired third-degree atrioventricular block requiring permanent pacing. In adult congenital heart disease, conventional transvenous or epicardial pacing is often limited by complex anatomy and vascular access constraints. Therefore, leadless ventricular pacing was considered the most appropriate option in this case.^{2,3}

Due to the highly atypical intracardiac anatomy, standard procedural planning tools, such as the Leadless Pacemaker Implantation Score, could not be applied. A patient-specific 3-dimensional (3D) model based on cardiac computed tomography (CT) imaging was therefore created to support procedural planning (FIGURE 1F and 1G).

Importantly, beyond technical preparation, the model enabled identification of a feasible implantation zone within the dominant left ventricle, most likely along the mid-to-apical septal region, where sufficient myocardial thickness and stability for device fixation could be anticipated, while minimizing the risk of interference with

abnormal inflow structures and avoiding regions of turbulent flow related to the ventricular septal defect.^{4,5}

Based on this planning, the procedure was performed via the femoral venous access, and a leadless pacemaker was successfully implanted. The final device position corresponded well with the preprocedural simulation; it was located in the trabeculated septal portion of the dominant ventricle, providing stable fixation and appropriate electrical parameters.

Immediate postprocedural assessment demonstrated stable device positioning within the trabeculated septal region of the dominant ventricle, with satisfactory electrical parameters and no procedure-related complications (FIGURE 1H). At the time of implantation, pacing threshold was 0.75 V at 0.4 ms, R-wave sensing amplitude was 12 mV, and pacing impedance was 780 Ω.

On the first postimplantation day, device interrogation confirmed stable electrical performance, with preserved pacing threshold of 0.75 V at 0.4 ms, improved sensing amplitude exceeding 18 mV, and impedance of 560 Ω. No device-related abnormalities or alerts were detected during interrogation.

The device was programmed in the VVIR mode with rate-responsive pacing enabled, a lower rate limit of 60 bpm, and a maximum sensor rate of 130 bpm. Short-term follow-up demonstrated effective ventricular pacing without evidence of device dislodgement, thromboembolic

Correspondence to:
Andrzej Swinarew, PhD,
Faculty of Science and Technology,
University of Silesia in Katowice,
ul. 75 Pułku Piechoty 1A,
41-500 Chorzów, Poland,
phone: +48 32 349 75 22,
email: andrzej.swinarew@us.edu.pl
Received: May 14, 2026.
Revision accepted: May 29, 2026.
Published online: June 1, 2026.
Pol Arch Intern Med. 2026; XX: 17316
doi:10.20452/pamw.17316
Copyright by the Author(s), 2026

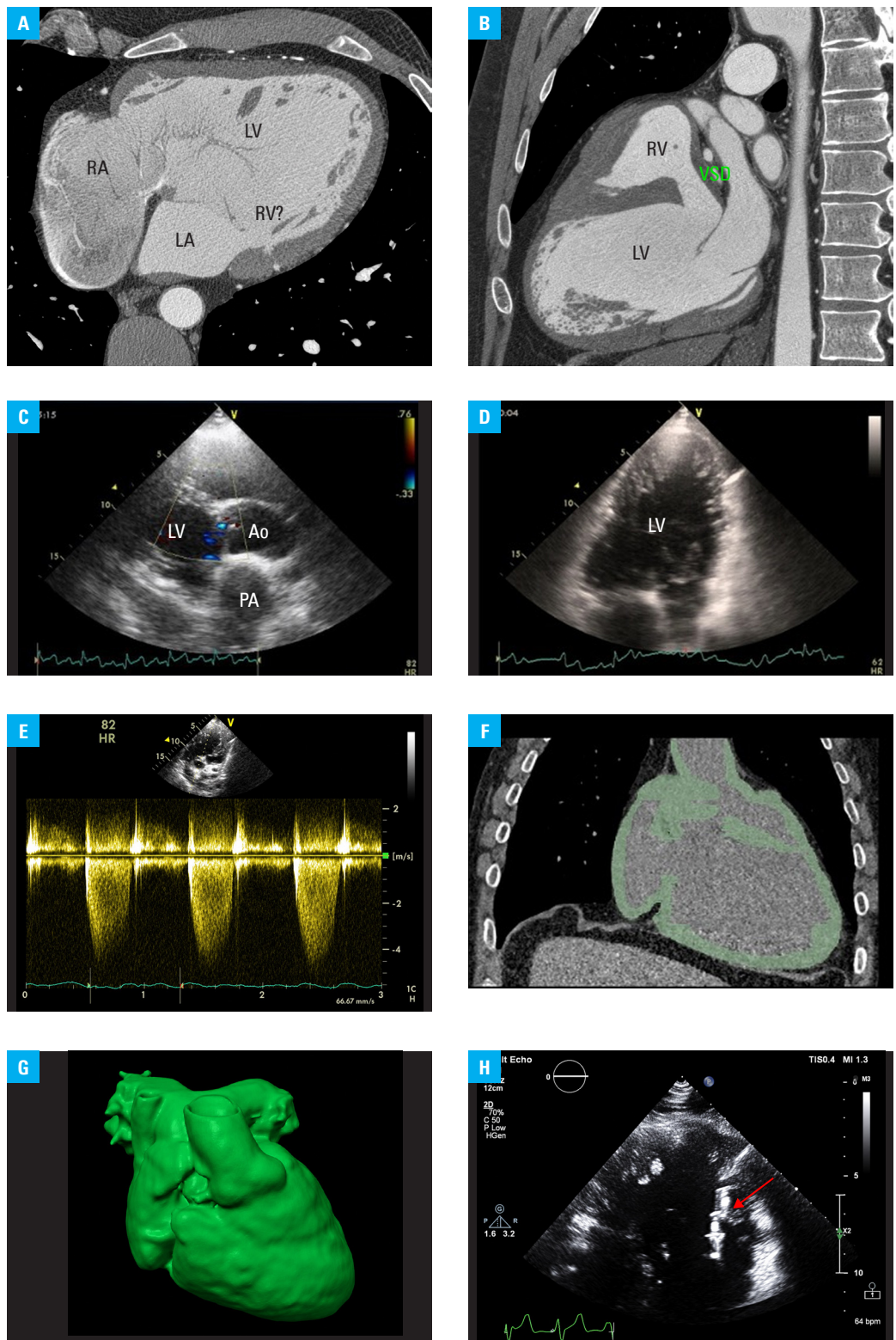


FIGURE 1 **A** – axial cardiac computed tomography (CT) demonstrating a double-inlet left ventricle with discordant atrioventricular connection and unrestrictive ventricular septal defect resulting from an absence of the inlet portion of the interventricular septum; **B** – sagittal CT view showing ventricular septal defect and a hypoplastic right ventricle without a functional outflow tract; **C** – transthoracic echocardiography (parasternal long-axis view) demonstrating parallel orientation of the great arteries and pulmonary outflow obstruction located posterior to the aorta; **D** – apical echocardiographic view demonstrating an absence of the anterior interventricular septum; **E** – continuous-wave Doppler ultrasound demonstrating high-velocity flow across the stenotic pulmonary valve; **F** – coronal CT projection used for 3-dimensional (3D) segmentation and procedural planning; **G** – patient-specific 3D heart model generated in 3D Slicer software for preprocedural planning of leadless pacemaker implantation; **H** – postprocedural transthoracic echocardiography demonstrating stable implantation of the leadless pacemaker within the trabeculated septal region of the dominant systemic ventricle (arrow) in a patient with functionally univentricular physiology
Abbreviations: Ao, aorta; LA, left atrium; LV, left ventricle; PA, pulmonary artery; RA, right atrium; RV, right ventricle; VSD, ventricular septal defect

complications, worsening heart failure symptoms, or an increase in pacing threshold. To our knowledge, reports describing CT-based 3D planning of leadless pacing in long-term survivors with functionally univentricular physiology remain extremely limited.

ARTICLE INFORMATION

ACKNOWLEDGMENTS None.

FUNDING None.

CONFLICT OF INTEREST None declared.

AI STATEMENT Artificial intelligence was not used in the preparation of this manuscript.

OPEN ACCESS This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0), allowing anyone to copy and redistribute the material in any medium or format and to remix, transform, and build upon the material, including commercial purposes, provided the original work is properly cited.

HOW TO CITE Kwaśniewski W, Wróbel W, Pyza M, et al. Leadless pacemaker implantation planned with computed tomography-based 3-dimensional modelling in a 51-year man with a functional single left ventricle and pulmonary outflow obstruction. *Pol Arch Intern Med.* 2026; XX: 17316. doi:10.20452/pamw.17316

REFERENCES

- 1 Poterucha JT, Anavekar NS, Egbe AC, et al. Survival and outcomes of patients with unoperated single ventricle. *Heart.* 2016; 102: 216-222.
- 2 Glikson M, Nielsen JC, Kronborg MB, et al; ESC Scientific Document Group. 2021 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy: developed by the Task Force on cardiac pacing and cardiac resynchronization therapy of the European Society of Cardiology (ESC) with the special contribution of the European Heart Rhythm Association (EHRA). *Eur Heart J.* 2021; 42: 3427-3520.
- 3 Bassareo PP, Walsh KP. Micra pacemaker in adult congenital heart disease patients: a case series. *J Cardiovasc Electrophysiol.* 2022; 33: 2335-2343.
- 4 Olejnik P, Nosal M, Havran T, et al. Utilisation of three-dimensional printed heart models for operative planning of complex congenital heart defects. *Kardiol Pol.* 2017; 75: 495-501.
- 5 Martinez-Sande JL, Gonzalez-Melchor L, Garcia-Seara J, et al. Leadless pacemaker implantation with hybrid image mapping technique in a congenital heart disease case. *HeartRhythm Case Rep.* 2021; 7: 797-800.