

Clinical Cases in Implantable Cardiac Devices

(PPM / ICD / CRT)

**Case-based Review for Electrophysiologists, Cardiologists, Cardiology residents
and Allied healthcare professionals**

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Introduction

It is with deep honor and heartfelt dedication that I present *Clinical Cases in Implantable Cardiac Devices*, a carefully curated collection derived from the educational platform **CardioCase.com**, established in January 2022, this initiative was founded in loving memory of my late beloved wife, **Dr. Maryam Khoshnevis**, a devoted echocardiologist whose kindness, intellect, and passion for cardiology continue to inspire all who knew her.

This book brings together a selection of clinical cases from **CardioCase.com**, thoughtfully compiled by **Dr. Siroos Nasiri**. Designed as a practical reference, it aims to enhance the understanding of implantable cardiac devices for electrophysiology fellows, cardiology residents, and allied cardiac technicians. By presenting real-world scenarios, this work seeks to strengthen the connection between theoretical knowledge and clinical practice, offering valuable insights into the management of device-related challenges. I would like to express my deepest gratitude to the editorial board of CardioCase.com for their invaluable contributions: Dr. Motahare Hatami, Dr. Kaveh Hosseini, Dr. Pooria Ahmadi, Dr. Hamid Khederloo, Dr. Fatemeh Baharvand, Dr. Sarah Taaghi, Dr. Hamidreza Karimi, Dr. Obaida Alothman, Dr. Maryam Aghakouchakzadeh, Dr. Houshang Bavandpour, Dr. Samaneh Mohammadi, Dr. Alireza Farzaii, Dr. Shayan Shahi, Dr. Neda Radfar, Dr. Aghil Zarbini, Dr. Siroos Nasiri, Dr. Samaneh Sardari, Dr. Mohammad Jabalameli, and Dr. Mohammad Sharafi. I also extend special thanks to **Dr. Ehsan Saraii** for his technical expertise in developing and coding the website, which was essential for its smooth operation.

I would like to extend my sincere appreciation to my respected professors and colleagues in the Electrophysiology Department of Tehran Heart Center for their invaluable guidance and collaboration: Dr. Ahmad Yaminisharif, Dr. Saeed Sadeghian, Dr. Ali Kazemisaeed, Dr. Gholamreza Davoudi, Dr. Ali Vasheghani Farahani and Dr. Farzad Masoudkabar.

I would also like to acknowledge the skilled technicians of the Tehran Heart Center EP ward, whose dedication and precision are essential to our daily practice: Ms. S. Abdi, Mr. M. Haddadi, Mr. Gh. Kavand, Mr. A. Senobar, Mrs. S. Shaarbaf, and Mr. A. Nomanipour.

To the readers of this book—whether you are preparing for board examinations or seeking to refine your clinical skills. I hope this resource serves as a useful companion in your professional journey. Should you encounter any errors or have suggestions for improvement, I warmly welcome your feedback, as it will help enhance future editions. Forthcoming Publications from the CardioCase.com Team:

- Clinical Cases in Electrophysiology: A deeper dive into complex arrhythmia management, featuring advanced mapping, ablation techniques, and challenging EP studies.
- Surface ECG: From Basics to Advanced Interpretation: A comprehensive guide designed to build a systematic approach to ECG reading, from fundamental principles to the nuances of complex diagnoses.

It is my sincere hope that this collection honors the educational legacy we strive to build and provides a meaningful contribution to the field of cardiac electrophysiology. With gratitude and best wishes,

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Contents

Case 1	1
Case 2	4
Case 3	7
Case 4	9
Case 5	14
Case 6	15
Case 7	17
Case 8	21
Case 9	23
Case 10	26
Case 11	29
Case 12	31
Case 13	35
Case 14	37
Case 15	39
Case 16	41
Case 17	43
Case 18	44
Case 19	46
Case 20	48
Case 21	50
Case 22	51
Case 23	52
Case 24	55
Case 25	57
Case 26	59
Case 27	61
Case 28	63
Case 29	65
Case 30	68
Case 31	71
Case 32	73
Case 33	74
Case 34	77
Case 35	79
Case 36	81
Case 37	84
Case 38	86

Case 39	88
Case 40	90
Case 41	93
Case 42	95
Case 43	96
References	98

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Case 1

History:

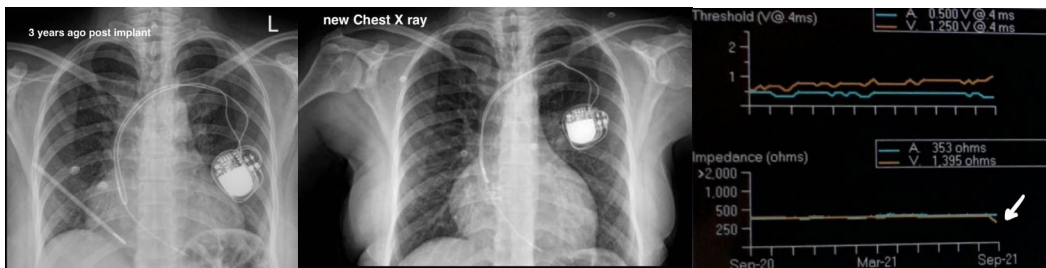
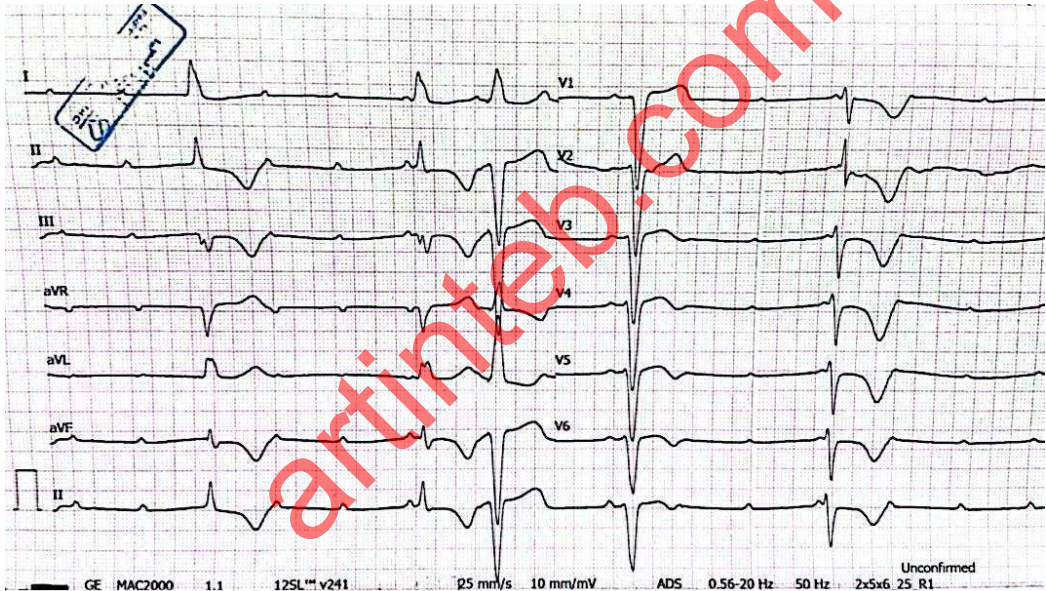
54-year-old lady with a history of dual-chamber pacemaker implantation presented with dizziness and syncope.

Look at ECG, Chest X-ray and device programming:

Question:

 According to findings, what is the best explanation for device malfunction?

- A - Lead dislodgment
- B - Generator depletion
- C - RV lead insulation break
- D - RV lead fracture





Correct answer is D

This patient, with ischemic cardiomyopathy and a LVEF of 20%, underwent CRT-D implantation. Before implantation, the ECG showed LBBB (Left Bundle Branch Block, and after implantation, the ECG displayed shorter QRS duration with an rS pattern in V1 and a q wave in I and aVL, indicative of successful CRT implantation.

ECG Features of Biventricular Pacing:

(van Stipdonk, Antonius et al. "ECG Patterns in Cardiac Resynchronization Therapy." Journal of Atrial Fibrillation, vol. 7, no. 6, 2015, doi:10.4022/jafib.1214)

Three distinct V1-V2 QRS complex patterns during CRT were identified:

Fusion complex with an increased or dominant R wave, independent of QRS duration.

QS pattern with QRS duration normalization.

QS pattern with an increased QRS duration.

While the second pattern (QRS duration normalization) was observed in a relatively smaller group of patients, they experienced the largest benefit in reverse remodeling. The 12-lead ECG provides important information for clinical follow-up in CRT, but it must be carefully evaluated. Understanding the electrophysiology of LBBB, RV pacing, LV pacing, and biventricular pacing (with or without fusion) is crucial for assessing CRT effectiveness in heart failure patients. However, due to the merging wave fronts and the complexity of QRS patterns, careful analysis is necessary.

Key Points:

For CRT non-responders, a simple analysis of the QRS pattern can indicate whether biventricular pacing is being performed adequately.

When the QRS duration does not decrease and there is no contribution from LV pacing, further analysis of the ECG during intrinsic rhythm, RV-only pacing, and LVo nly pacing can reveal inadequate CRT programming or poor LV lead positioning.

LBBB/ RV Pacing	LV Pacing	BV Pacing	QRSdiff ($QRS_{BV} - QRS_{LBBB}$)	QRS Fusion Type*
			(+, 0, -)	1 QRS conformational change
			(-)	2 QRS normalization
			(+)	3 Persistent LBBB

Case 22

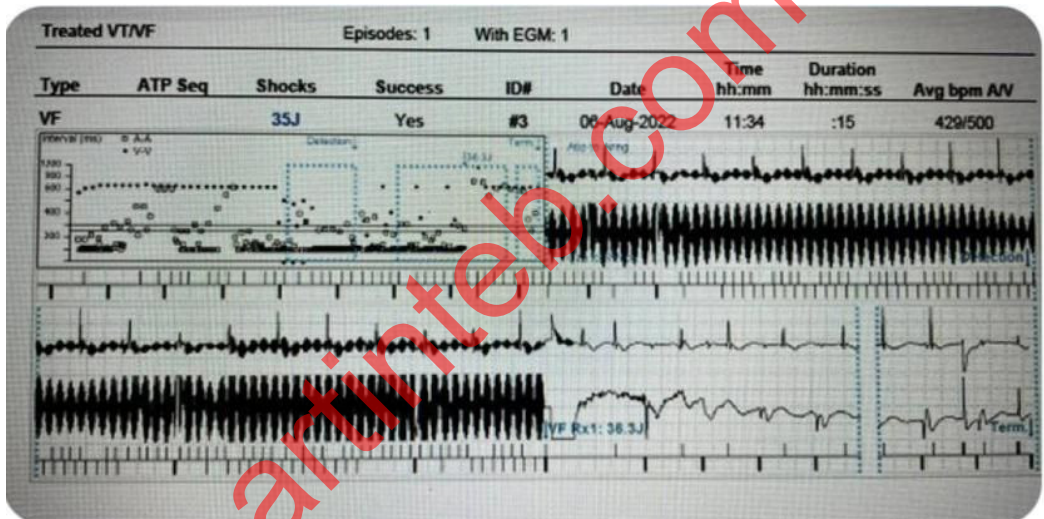
History:

A 45-year-old electrician with a history of ICD implantation experienced an ICD shock. Below you can find the plot diagram and EGM of the event.

Question:

Which statement is **WRONG**?

- A - The implanted device is an ICD DR
- B - Shock delivered with about 38 J energy
- C - The event is caused by electrical current
- D - The device saved his life
- E - All statements are correct



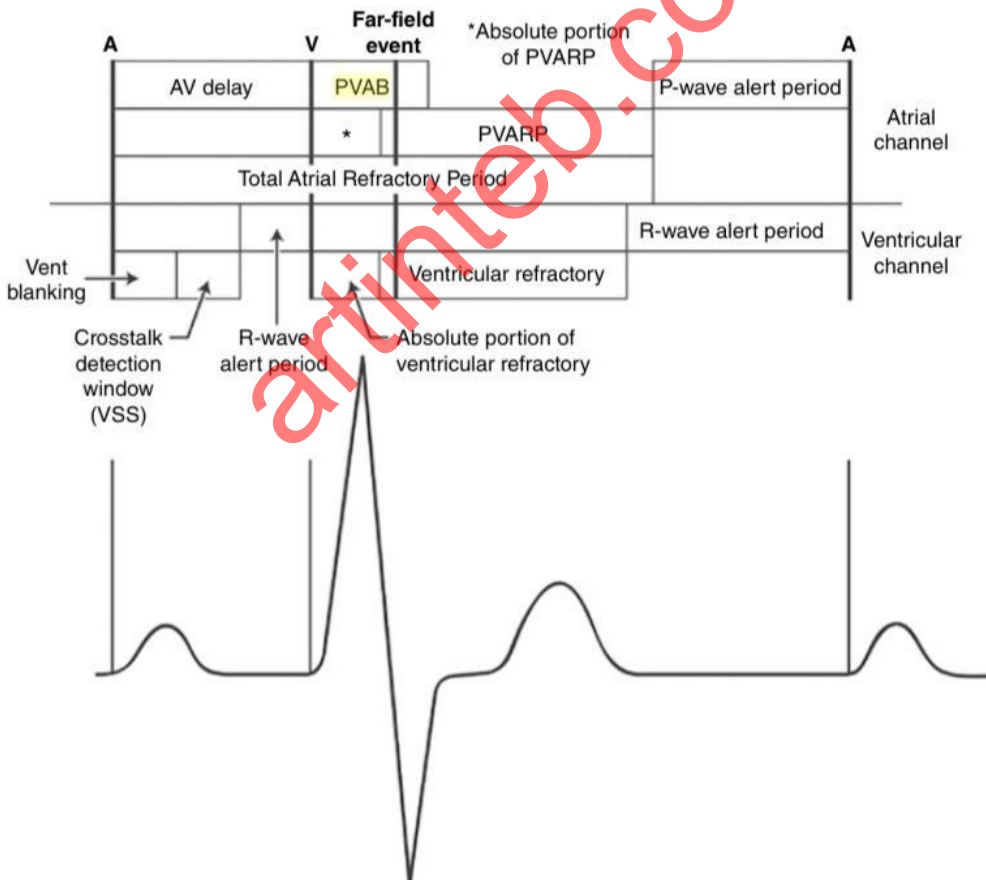
Correct answer is E

This electrician was electrocuted while touching an exposed cable. The electrical current possibly caused VF. The shock was delivered, which also made the patient move away from the electric source. Therefore, the device saved his life.

Upon careful examination of the device analysis image, a discrepancy between atrial EGM and annotation is evident. Notably, every other P wave is not recognized by the device. While this might initially suggest atrial undersensing, it is inconsistent with the fact that the pacemaker is detecting similar P waves.

This discrepancy is related to the pacemaker's basic timings. Following each sensed or paced QRS, a period of atrial blanking, known as PVAB (Post Ventricular Atrial Blanking), begins. During this time, any P wave occurring is not registered by the pacemaker. Subsequently, the atrial refractory period (PVARP) commences, during which the pacemaker observes atrial channel activity without responding.

The observed pattern, where every other P wave coincides with the PVAB, suggests a 2:1 Atrial Flutter based on the rate and morphology of the P waves in the surface ECG. It is essential to emphasize the importance of comparing EGM with annotations, as annotations represent the pacemaker's interpretation of events, which may not necessarily align with the actual occurrences.



Case 42

History:

A 75-year-old man with a history of CABG and recurrent device infection (twice) is currently undergoing a procedure. Fluoroscopy images of the intervention are shown.



Question:

What is the most likely interpretation of these fluoroscopy findings?

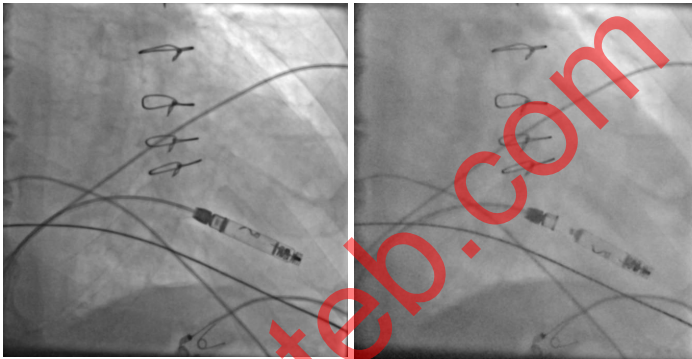
Choices:

A - Implanting TPM

C - Implanting leadless PPM choice

B - Implanted TPM

D - Implanted leadless PPM



Correct answer is C

These fluoroscopy images demonstrate the implantation of a leadless pacemaker (AVEIR VR). As seen in the fluoroscopic sequence, the device is being deployed. Notably, this case represents the first AVEIR VR leadless pacemaker implantation performed at Tehran Heart Center in September 2024. One year post-procedure, the patient remains in good clinical condition. A follow-up chest X-ray is provided below for reference.

