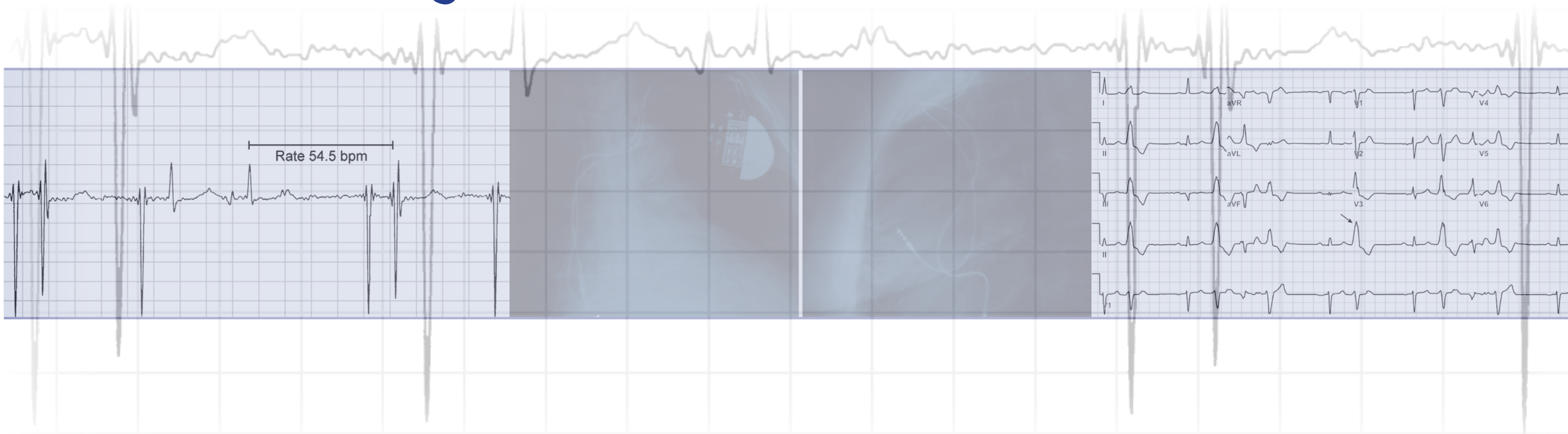
A Case-Based Approach to Pacemakers, ICDs, and Cardiac Resynchronization

Volume 1



Questions for Examination Review and Clinical Practice

Edited by

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Preface

The book that you hold in your hands, *A Case-Based Approach to Pacemakers, ICDs, and Cardiac Resynchronization: Questions for Examination Review and Clinical Practice*, is a compilation of our favorite teaching cases that were seen at or sent to Mayo Clinic. As our device practice has grown, we have found that one of the best ways to remain current and to educate incoming physicians and nurses is the review of interesting "unknown" clinical cases. Consequently, we established a morning conference in 2008 for the purpose of presenting and discussing interesting or uniquely educational cases. Since learners ranged from cardiology fellows who were new to the device practice to experienced nurses and physicians, group discussion brought out facets of interest at all levels. Cases for this book were selected based on clinical relevance and their usefulness for illustrating general principles, practical tips, or interesting findings in device practice. Occasionally, manufacturer-specific features are discussed, but always with a goal of advancing general concepts in device management.

The cases in this book are presented as a case history, an image when pertinent, and a multiple-choice question. The answer and a detailed explanation is presented on subsequent pages. We've adopted this format to encourage the reader to think through the differential diagnosis and approach the clinical problem based on the information presented. In light of the growing use of pacemakers, defibrillators, and resynchronization devices, we are confident that readers will find this practical means of self-assessment and education useful. Although the questions are designed in a multiple-choice format that may be particularly useful for self-assessment for test-takers, they are not formally validated board questions. This book is for any individual who sees patients with implantable devices, or who will be taking an examination related to device management.

How to Use This Book

The cases generally progress from simpler to more complex, understanding that there will be individual variation in what constitutes a difficult case.

There is no table of contents because the case numbers are clearly marked at the top of each page and we specifically did not want to include in the beginning of the book a listing of the "diagnosis" for each case and therefore limit the ability for the reader to approach the cases as unknowns.

For the reader interested in reviewing a specific type of case (such as "T-wave oversensing" or "inappropriate shock"), two resources are offered. An appendix is provided that identifies the major diagnostic dilemma presented by each case, and the index will direct the reader to cases and discussions focusing on specific issues. However, we encourage readers to progress sequentially through cases as unknowns to maximize learning and interest.

This book is one of two volumes. The first volume includes introductory and intermediate cases. The second volume includes additional intermediate cases as well as advanced cases. There are more multipart cases in volume 2, to delve more deeply into important concepts.

In various electronic versions of this book, hypertext links and linked indices have been added to facilitate navigation. Also, a combined index that covers both volumes is available at www.cardiotextpublishing.com/titles/detail/9781935395812.

This text includes a collective wisdom of numerous physicians, nurses, technicians, educators, and practitioners. We are indebted to the entire Heart Rhythm services team at Mayo Clinic for identifying and discussing cases, and educating us with them. We have also benefitted greatly from friends and colleagues at other institutions who have kindly shared interesting cases with us, and permitted us to include them in this work. We are grateful for their generosity. If you come across an interesting case that you would like included in a future edition of this book, we would love to discuss it with you. E-mail addresses are listed below for that purpose. Please enjoy the cases! We look forward to your feedback and future contribution.

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Abbreviations

A	atrial
AF	atrial fibrillation
APC	atrial premature contraction
AS	atrial sensed
ASD	atrial septal defect
AT	atrial tachycardia
ATP	antitachycardia pacing
AV	atrioventricular
AVNRT	atrioventricular nodal reentrant tachycardia
BBB	bundle branch block
CI	confidence interval
CRT	cardiac resynchronization therapy
CT	computed tomographic
ECG	electrocardiogram
EGM	electrogram
EMI	electromagnetic interference
EP	electrophysiological
FFRW	far-field R wave
ICD	implantable cardioverter-defibrillator
IV	intravenous
J	Joules
LAO	left anterior oblique
LBBB	left bundle branch block
LV	left ventricle; left ventricular
LVEF	left ventricular ejection fraction
MRI	magnetic resonance imaging
OR	odds ratio
PA	pulmonary artery
PAC	premature atrial contraction
PMT	pacemaker-mediated tachycardia
PVARB	postventricular atrial blanking period
PVARP	postventricular atrial refractory period
PVC	premature ventricular contraction
RAO	right anterior oblique
RBBB	right bundle branch block
RV	right ventricle; right ventricular
RVOT	right ventricular outflow tract
SVT	supraventricular tachycardia
TARP	total atrial refractory period
TENS	transcutaneous electrical nerve stimulation
V	ventricular
VA	ventriculoatrial
VF	ventricular fibrillation
VRR	ventricular rate regulation
VS	ventricular sensed
VSD	ventricular septal defect
VT	ventricular tachycardia

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Questions for Examination Review and Clinical Practice

Case 1

A 67-year-old male received a dual-chamber ICD for inducible ventricular tachycardia in the presence of ischemic heart disease. Four years later he received his first shock during a visit to his chiropractor. He had sought chiropractic treatment due to chronic shoulder discomfort.

Device settings:

- Mode: DDD
- Mode switch: on
- Pacing rate: 40 bpm (lower rate), 120 bpm (upper rate)
- Amplitude: 2.6 V (right ventricular), 2.0 V (atrial)
- Pulse width: 0.50 ms (right ventricular), 0.40 ms (atrial)
- Sensitivity: 0.18 mV (right ventricular), 0.18 mV (atrial)
- Dynamic AV: off
- Refractory after pace: 250 ms
- Antitachycardia therapies: initial burst ATP followed by 33-J shock

Upon interrogation the tracing in Figure 1.1 was obtained.

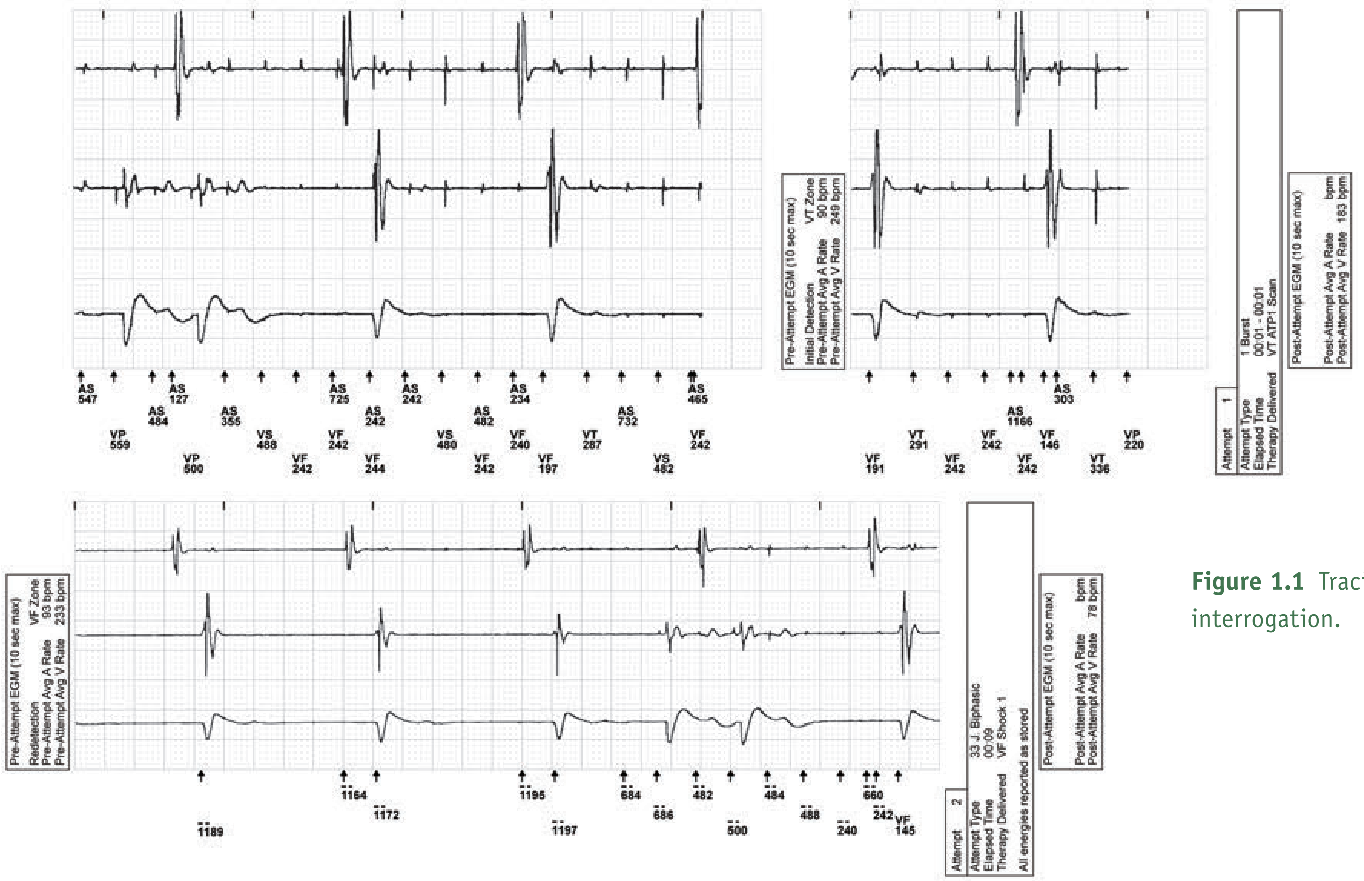

Figure 1.1 Tracing upon interrogation.

Q: As a result of the EGMs and therapies delivered, what would be your next step?

1. Initiate new or additional antiarrhythmic medications
2. Consider ablation of the ventricular ectopic focus
3. Reprogram ventricular sensitivity
4. Look for source of EMI

1

4. Look for source of EMI

The tracing reveals sinus rhythm with a rate of approximately 52 bpm. However, other signals are present on the EGMs, often occurring at a regular cycle length of approximately 220 ms, which, if consistent, would be equivalent to a rate of approximately 272 bpm. These signals are sensed as ventricular events and labeled as VF or VT. Burst ATP therapy is delivered at the end of the first strip and a 33-J shock is delivered after the second tracing. Postshock tracing is shown in Figure 1.2. The signals that were occurring at a cycle length of 220 ms are no longer present. Note that the tracing includes both AS-VP cycles as well as VS events that appear to be premature ventricular contractions.

The appearance of very regular signals without any corresponding intrinsic events on the EGM or surface recording suggests electromagnetic noise or interference. In this example, the patient was receiving a treatment with diathermy. When the shock was delivered the diathermy was stopped and no further noise is noted. Diathermy is a method of physical therapy that involves generating local heat in body tissues by high-frequency electromagnetic currents.

A question could arise as to whether a problem with ventricular lead integrity was responsible for this appearance. When oversensing occurs as a result of loss of lead integrity, the VV intervals would most likely be shorter and more irregular.

Any circumstance in which a device patient is going to be subjected to any equipment with known potential for electromagnetic interference should be carefully assessed prior to initiating therapy.

Answers 1 and 2 are incorrect because the abnormality noted is due to external EMI, not an intrinsic rhythm disturbance. Answer 3 is incorrect because ventricular sensing is fine in the absence of the EMI.

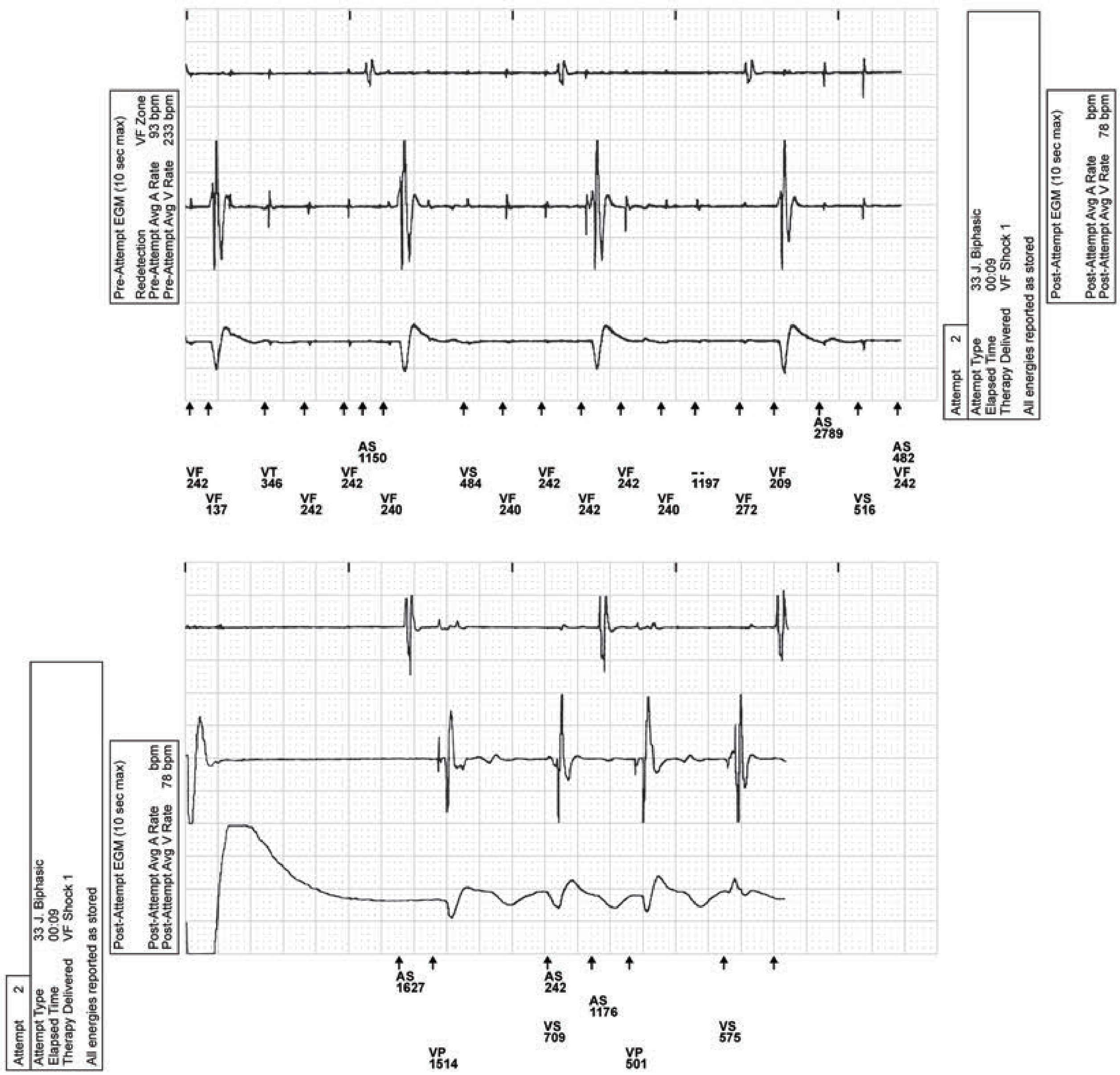

Figure 1.2 Postshock tracing.

Case 17

The same 73-year-old man from case 16, with a history of single-chamber defibrillator implantation, has a RV pace-sense lead added because of T-wave oversensing on his defibrillator lead, which was causing inappropriate shocks. One month later, the patient receives another defibrillator shock and remotely transmits his data. The patient is currently in sinus rhythm. Figure 17.1 shows the shock episode.

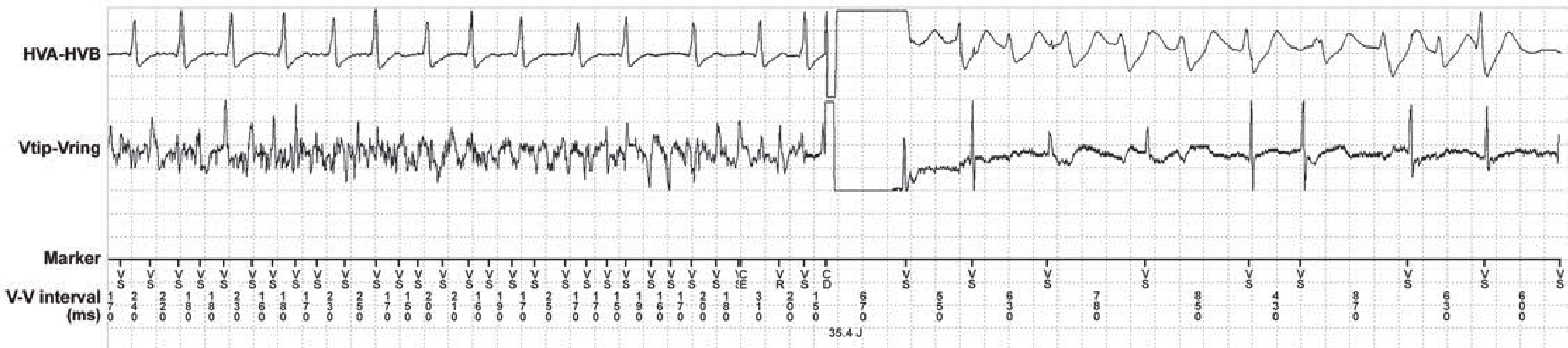

Figure 17.1 Arrhythmia episode. The top row demonstrates far-field signal derived from the high-voltage EGM (shock). The bottom row demonstrates near-field signal derived from a separate RV sense-pace lead.

Q: *What is the most likely cause of the shock episode?*

1. Lead dislodgment
2. Dual atrial and ventricular tachycardias
3. Electromagnetic interference
4. Oversensing of diaphragmatic myopotentials

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1. Lead dislodgment

This case illustrates the problem of inappropriate shocks from ventricular oversensing of atrial signal due to ventricular lead dislodgment.

Comparison of the near-field and far-field channels in Figure 17.2 clarifies the problem. Recall that the far-field signal is derived from the shock circuit (pulse generator can/superior vena cava coil and RV coil) and provides morphology information. The near-field EGM, in this case, is derived from a separately implanted RV pace-sense lead, and is used by the device to identify and count ventricular signals.

The far-field channel shows irregular, but distinct, R-R intervals and no apparent P waves, which is consistent with atrial fibrillation. The near-field signal, in contrast, looks erratic and is also consistent with ventricular oversensing of atrial fibrillation. Administration of a defibrillatory shock clears up much of the high-frequency signal on the near-field, likely terminating the atrial fibrillation. A wide complex rhythm is then seen on the far-field, and irregular complexes (probably atrial in origin) are sensed on the near-field. Most likely, the rhythm is an idioventricular rhythm (as the ventricular rate exceeds the atrial rate), although intermittent ventricular sensing of a slowed atrial dysrhythmia with aberrancy or postshock morphology changes cannot be excluded.

These findings are consistent with dislodgment of the ventricular lead into or near the atrium, resulting in inadvertent misclassification of atrial fibrillation as ventricular fibrillation. Figure 17.3 shows the real-

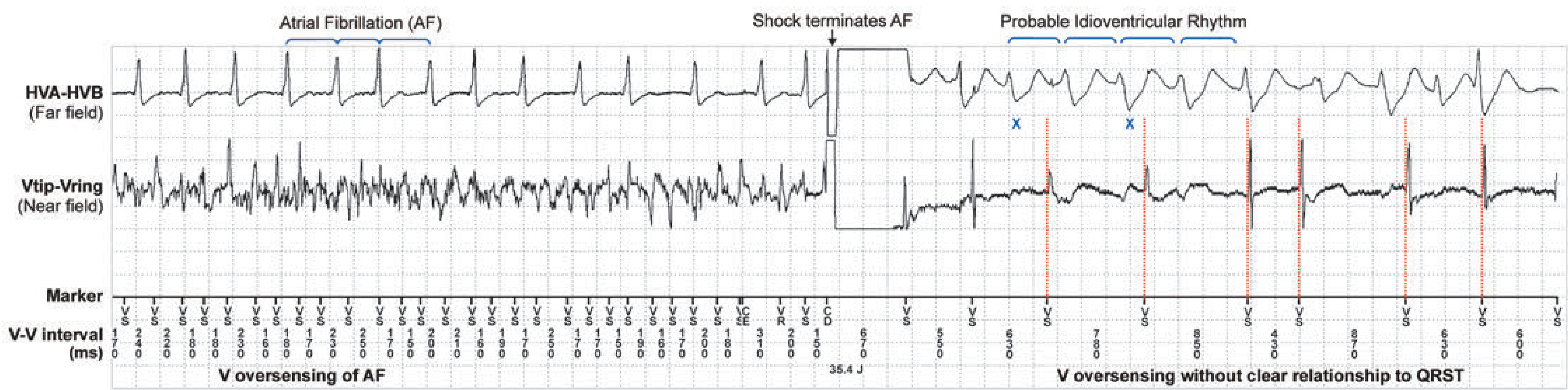

Figure 17.2 Arrhythmia episode, annotated.

time EGM that was transmitted following the shock. The ventricular EGMs on the near-field channel correspond to P waves rather than QRS complexes, indicating that the ventricular pace-sense lead was dislodged to the atrium. The smaller, dedicated pace-sense lead may be more prone to dislodgment into the atrium than a defibrillator's lead.

Oversensing of atrial signals on the ventricular lead can occur with dislodgment of the ventricular lead to the annulus or to the atrium (as in the present case). Integrated bipolar leads, particularly with proximally placed leads or in children, may also lead to oversensing of atrial EGMs since the large distal coil is part of the sensing circuit. If it is placed at or near the level of the tricuspid valve annulus, it may record atrial and ventricular signals. Atrial arrhythmias, in particular, may be sensed incorrectly as ventricular arrhythmias.

There is no ventricular tachycardia present, making answer 2 incorrect. Electromagnetic interference (answer 3) is incorrect because it would be present, and typically larger in amplitude, on the far-field EGM as well as the near-field EGM. Answer 4 is incorrect because diaphragmatic myopotentials, although also near-field, present as bursts of lower-amplitude, high-frequency noise that varies with respiration and occur most commonly after pacing or long diastolic intervals. The pattern should be similar after a shock.

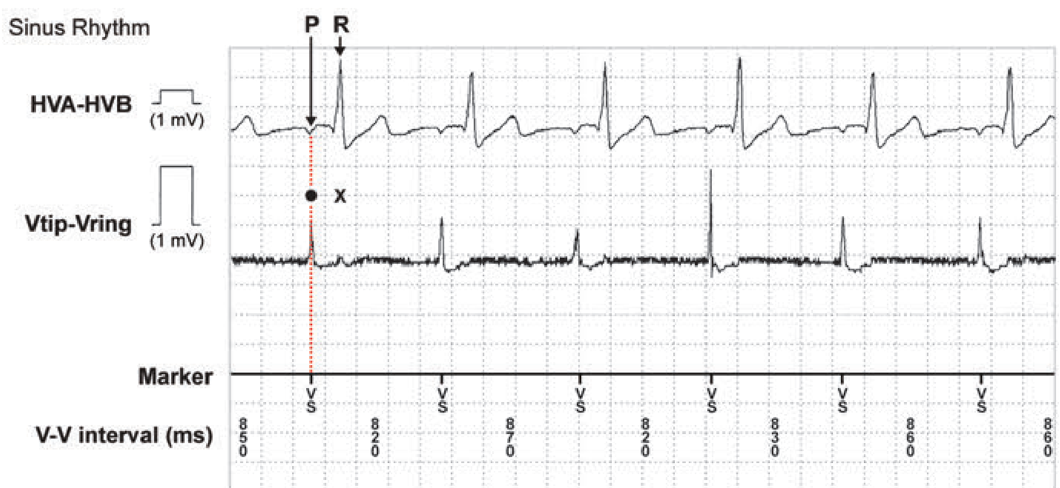

Figure 17.3 Real-time EGM.

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