

Critical Cases in Electrocardiography

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Steven R. Lowenstein
Frontmatter
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Critical Cases in Electrocardiology

An Annotated Atlas of Don't-Miss ECGs for Emergency
Medicine and Critical Care

Steven R. Lowenstein
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Every effort has been made in preparing this book to provide accurate and
up-to-date information that is in accord with accepted standards and
practice at the time of publication. Although case histories are drawn
from actual cases, every effort has been made to disguise the identities of
the individuals involved. Nevertheless, the authors, editors, and
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information provided by the manufacturer of any drugs or equipment
that they plan to use.

All of the cases in this atlas represent real patients who were seen by physicians in various hospitals. In some cases, ages and other details were changed to protect personal health information.

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Foreword

For my entire career as a cardiologist I have worked for organizations that provided time and money each year for me to attend any medical education conference of my choosing. Unlike most of my colleagues, I did not use those resources to attend the annual meetings sponsored by the American College of Cardiology or the European Society of Cardiology. I decided that it would be better for my patients and me if I attended a conference focused on a particular theme. I would choose a meeting on echocardiography, heart failure or another specific topic.

Several years ago I attended a meeting focused on what I thought was the diagnosis and treatment of cardiac dysrhythmias. At the opening of the conference the hosting cardiologist said, “I know we’re all here because of our love of electricity.” Being deeply clinically oriented, I related not at all to what he said. As I looked at the titles of the morning’s lectures, though, it became clear that the meeting was for electrophysiologists rather than general cardiologists like me. The hosting physician then declared that the conference was the first electrophysiology board review in the United States!

For the duration of the course I sat through hour-long lectures discussing physics, electrophysiologic principles and invasive catheter-based treatments of which I would have no part. A small portion of each lecture covered something relevant to a general cardiologist. It was a long week.

This story comes to mind because, having been asked to write the foreword for Dr. Steven Lowenstein’s *Critical Cases in Electrocardiography* – and having the privilege of reading it beforehand – it is gratifyingly clear that Dr. Lowenstein did not write the book because he loves electricity. He wrote it because he loves *electrocardiography* and especially the sharing of it

with clinicians in an effort to have us not only better understand the genesis and identification of various waveforms but, by doing so, arrive at correct diagnoses and treatments in complicated cases.

Dr. Lowenstein’s enthusiasm for teaching is apparent throughout the book. He does us the favor of approaching ECG tracings from the sharing of patient stories – which makes the reading more appealing, easier to remember, sometimes amazing and often fun. Have you seen an image of a suspension bridge in any other medical text? To help us recognize a certain pathologic ST-segment waveform – similar to the curvature of the cables of a suspension bridge – Dr. Lowenstein incorporates one here!

This atlas is also made more interesting because of not only *what* is written but also *how* it is written. Dr. Lowenstein includes insightful and often lyrical historical comments from pioneers in electrocardiography. Both the historical sages and he at times offer philosophical comments about the deeper meanings of what an electrocardiogram can tell us to remind us of why we want to know all we can about a tracing – to perhaps spare suffering or prolong a life.

I have learned more from Dr. Lowenstein and his fascinating book than I did spending that tedious week with electrophysiology – or from any other book on electrocardiography I have read. I suspect that you will learn a lot from his book, too, and will have a good time doing so.

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Preface

There is a need in any worthwhile human endeavor for substantive engagement. In biology, the engagement is with the processes of life; in medicine, with the problems of the sick. In electrocardiography, it is with the electrical outpourings of the heart.

—Horan (1978)

This atlas deals solely with the electrocardiogram (ECG) and its applications in emergency medicine and critical care practice. Despite advances in diagnosis and therapeutics, the ECG remains an indispensable tool in emergency care. The ECG is painless and noninvasive. It is quick. It is reproducible. And it has no known risks.

It is self-evident that the ECG plays a pivotal role in patient care. The information contained in the ECG cannot be duplicated by even the most painstaking patient history nor by palpation, percussion or auscultation. Nor is the same information readily obtainable through blood work, radiographs, sonograms or high-tech body imaging. The electrocardiogram is, according to Horan, “a form of nonverbal communication from the patient’s heart to the physician” (Horan, 1978). The ECG is “where the money is” for a wide variety of chief complaints, including chest pain, dyspnea, syncope, electrolyte abnormalities, shock, cardiac arrest, arrhythmias, poisonings and other critical emergencies. More often than not, the ECG rules in or out one or more life-threatening conditions and changes management. As Sir Zachary Pope wrote in his introduction to *Early Diagnosis of the Acute Abdomen*, “There is little need to labour the truism that earlier diagnosis means better prognosis” (Cope, 1972).

I have prepared this atlas with two simple objectives in mind. The first is to help readers advance beyond the stage of “competent” electrocardiographer, since basic competence is not sufficient. Emergency physicians must be *expert electrocardiographers*. Referring colleagues, consultants, hospital administrators and, most importantly, patients expect that front-line emergency physicians can recognize all the common electrolyte abnormalities, decipher complex tachycardias, distinguish among various causes of “nonspecific ST-T changes” and detect acute myocardial infarctions in their early, subtle stages. It is not enough that the emergency physician is able to recognize an acute inferior wall myocardial infarction when there are 7 mm “tombstone” ST-segment elevations in the inferior leads. Readers of this atlas will learn that ST-segment

straightening in lead III may be the only abnormality that warns of an impending infarction and that isolated depression of the ST-segment in lead aVL may also herald the development of an inferior wall ST-elevation myocardial infarction (STEMI). Therefore, one critical goal of this atlas is to enable emergency physicians to make lifesaving diagnoses before others can. As Zoneraich and Spodick wrote, “Identification of subtle changes in the ECG . . . remains the privilege of the well-informed” (Zoneraich and Spodick, 1995).

My second goal in preparing this atlas is to help emergency physicians develop a sense of excitement about reading ECGs. This is possible, I believe, by emphasizing clinically relevant topics, by presenting examples of obvious and not-so-obvious disease, by integrating electrocardiography with bedside clinical practice and by focusing squarely on situations where interpretation of the ECG contributes to clinical decision-making. I have also included numerous examples of ECG “misses” – cases where the computer or the clinicians (or both) got it wrong.

Interest and excitement in ECG reading are also reinforced by paying close attention to the anatomic and electrophysiologic origins of various ECG abnormalities. Therefore, wherever relevant, each chapter includes a brief “basic sciences” or “coronary anatomy” section, which attempts to explain the surface ECG tracings by describing clearly their anatomic or electrophysiologic correlations. The ECG is a remarkably true reflection of anatomy and electrophysiology, and in most cases we are better served by learning these connections than by relying solely on pattern memorization.

It seems surprising that there are no accepted standards for measuring physician competency in ECG interpretation in the emergency department setting. No one has defined the essential electrocardiographic skills or experience that are necessary for safe practice. In 2003 the majority of emergency medicine residency program directors voiced opposition to establishing a national ECG competency examination or even a national model curriculum (Ginde and Char, 2003). Thus, for emergency medicine trainees and practitioners, self-study remains the only game in town. I will accept at face value the argument that ECG interpretative skills improve with study and practice. They have for me.

Some clinicians have warned that interest and expertise in ECG interpretation are waning as new procedures and

Preface

technologies “compete for the attention of the bright young clinician and clinical investigator” (Fisch, 1989). More than 30 years ago, Wellens lamented that “invasive procedures, with their diagnostic (and financial) rewards, have stolen the interest of the younger generation” (Wellens, 1986). Horan warned, “We may program computers to read electrocardiograms, [but] we must not deprogram doctors” (Horan, 1978). Fye, Fisch and others have also argued that computer-assisted ECGs have led to complacency, are “an obstacle to acquisition of electrocardiographic skills” and have “hastened the decline of clinical electrocardiography” (Fisch, 1989; Fye, 1994). This is debatable. I will grant that computer-assisted electrocardiograms and alternative technologies have captured the attention of cardiologists and other specialists, but I do not sense that interest in electrocardiography is waning in emergency medicine, although systematic instruction has not always kept pace.

In reference to computer-assisted ECG interpretation, we should remember that computer algorithms are notoriously insensitive for the diagnosis of acute STEMIs and many other critical emergencies. As highlighted throughout this atlas, computers often miss subtle STEMIs; early STEMIs; anterior, posterior and lateral STEMIs and STEMIs hiding under the cover of a bundle branch block or left ventricular hypertrophy with “strain” (Massel et al., 2000; Elko et al., 1992; Kudenchuk et al., 1991; Southern and Arnsten, 2009; Kligfield et al., 2007; Ayer and Terkelsen, 2014). Computer algorithms miss all manner of “STEMI equivalents,” such as widespread ST-segment depressions with ST-elevation in lead aVR, which may signify acute left main coronary artery obstruction. Practice and confidence are needed to overrule the computer’s missteps. As Marriott wrote, “Marvelous as the computer is, it has not yet achieved glory in ECG interpretation . . . [and] sometimes the computer is dangerously deficient” (Marriott, 1997).

A final word about the organization of this book: *Critical Cases in Electrocardiography* is an atlas, not a comprehensive textbook. The emphasis is on “don’t-miss” ECG tracings. *Critical Cases in Electrocardiography* emphasizes the subtle and the advanced, if this knowledge is critical to the practice of emergency medicine or critical care. For example, the Brugada syndrome is included in the chapter on nonischemic causes of ST-segment elevation (coronary mimics); Brugada is rare statistically. But in young patients with syncope, its presence is unmistakable to the trained eye. Recognition of the Brugada pattern in syncope patients is an opportunity to prevent sudden cardiac death.

This atlas also differs from other ECG textbooks, which devote more attention to standard ECG criteria for topics such as left ventricular hypertrophy, p-mitrale, right bundle branch block and the like. Some of the chapters in this textbook cover conventional topics, such as inferior, anterior or posterior wall myocardial infarction. But other chapters in *Critical Cases* are quite different from most ECG textbooks because they are organized according to patients’ presenting problems. Thus, there is a chapter on the electrocardiography of shortness of breath, where pulmonary embolism, myocarditis and

pericardial tamponade are covered. Several of the chapters highlight STEMI equivalents, while other chapters focus on deciphering nondiagnostic ST-T changes that can masquerade as myocardial ischemia, such as LVH with strain, early repolarization, electrolyte abnormalities and digitalis effect. For the most part, it is assumed that readers already have a strong understanding of the normal ECG, although the genesis of the normal ECG is reviewed in Chapter 1.

In preparing this atlas, I have been inspired by some of the great textbooks and manuals of electrocardiography, some of which have also focused specifically on the diagnosis of acute myocardial ischemia and infarction (Wagner and Strauss, 2014; Goldberger et al., 2013; Chan et al., 2005; Smith et al., 2002; Surawicz and Knilans, 2008). Perhaps most of all, I have been inspired by Marriott’s *Emergency Electrocardiography*, which the author called “a vademecum for every caretaker of cardiac crises” (Marriott, 1997). Marriott was one of the first to spell out the importance of the ECG changes that routinely “escape the eye of the unwary.” And Marriott’s *Emergency Electrocardiography* is also the book where I was first introduced to his many wonderful words and phrases, such as T-waves that are “humble,” “bulky,” “noble” or “spread eagle,” and also the “wishbone” effect, ST-elevations in “indicative leads,” “milking the QRS complex” and “fishhooks” in the J-point.

A final disclaimer: in this atlas, there is no mention, even in passing, of Einthoven’s triangle, summed action potentials or vectorcardiograms. These concepts may be interesting to some, and they represented fundamental discoveries in the early days of cardiac electrophysiology and electrocardiography. However, they are not necessary for an in-depth understanding of normal and abnormal electrocardiograms. Einthoven’s triangle is seldom mentioned in the emergency department, the catheterization laboratory or the intensive care unit. As Marriott wrote in the preface to the first edition of his classic textbook, *Practical Electrocardiography*, too often, introductory chapters are “so intricate and longwinded that the reader’s interest is easily drowned in a troubled sea of vectors, axes and gradients” (Marriott, 1988).

My goal in this atlas, in the tradition of Marriott and other classic electrocardiographers and teachers, is to emphasize “the concepts required for everyday ECG interpretation” (Wagner and Strauss, 2014). The focus is clinical diagnosis, late at night in the emergency department or critical care unit, in the service of seriously ill patients.

Almost a century ago, cardiologist Calvin Smith cautioned:

The person who undertakes to make a success of electrocardiography . . . must be prepared to devote all his time to acquiring and understanding of [the] art . . . [which] must be practiced regularly, systematically and faithfully, day after day, week after week, before proficiency is obtained. The mere possession of electrocardiographic equipment no more makes a person a cardiologist than the possession of Shakespeare’s volume makes the owner a litterateur.”

(Smith, 1923)

I do not agree, necessarily, that a lifetime of devotion is required to learn to interpret electrocardiograms. No one can practice reading ECGs “systematically and faithfully, day after day.” *Critical Cases in Electrocardiography* was written

so that emergency and critical care physicians can learn to recognize electrocardiographic “life threats” and strengthen their electrocardiographic skills – over a much shorter time.

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In preparing this atlas, I have also been helped by a generation of emergency medicine residents. I am inspired by your intelligence, your dedication to the care of our patients and your humanity. Thank you for everything you have taught me.

I am indebted and grateful to my wife, Elaine, and to our sons, Adam and Chris, most of all. I am certain that ECGs are not the focus of your existence. I am just as certain that you are the focus of mine.