Cardiac Arrhythmia Management
A Practical Guide for Nurses and Allied Professionals
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Dedications

To my husband Boris, my son Feliks, and my parents for their encouragement, love, support, and many sacrifices. To all my teachers for their wisdom and inspiration.

Angela Tsiperfal

To Gary, Lucas, and Briana for their love and willingness to support my professional endeavors. To my Stanford Arrhythmia colleagues for providing daily inspiration to seek new knowledge and challenge ourselves to always provide excellent care to patients.

Linda K. Ottoboni

To my mentors Afaf Meleis, RN, DSC and Andrea Natale, MD who were my inspiration.

Salwa Beheiry

To my wife Rola and my children Maya, Dana, and Mohammad for their patience, love and support. To my parents for their constant guidance. To my teachers and mentors for their inspiration. To the nurses and technicians who I am privileged to work with and learn from every day.

Amin Al-Ahmad

To my family and my staff for the endless patience and the unwavering support.

Andrea Natale

To my loving wife, Gloria, and my wonderful daughters, Margaret and Katie. To the fantastic nurses, technicians, fellows, and colleagues, with whom I feel privileged to work.

Paul J. Wang
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Over the last three decades, we have witnessed a remarkable expansion and maturation of the fields of cardiac electrophysiology, ablation, pacing, and defibrillation. This has resulted in a core of highly skilled nurses, physician assistants, technicians, and industry-employed allied professionals assuming a larger and increasing important role in the clinical care of patients with arrhythmias. Given the considerable progress in the clinical evaluation and management of patients, the need has emerged for a comprehensive educational resource to ensure the highest quality of care. Cardiac Arrhythmia Management: A Practical Guide for Nurses and Allied Professionals merits particular recognition as it uniquely fulfills this need. It represents a timely and novel contribution that should be considered essential for all health care professionals involved in the care of patients with heart rhythm disorders.

Amin Al-Ahmad, MD, Paul J. Wang, MD, Andrea Natale, MD, Angela Tsiperfal, RN, NP, Linda Ottoboni, RN, MS, and Salwa Beheiry, RN, as editors, have masterfully selected topics and authors to produce an essential educational resource. All sections, including those on anatomy, physiology, arrhythmia mechanisms, pacemakers, defibrillators, pediatric arrhythmias, syncope, sudden death, and ethical issues, are superbly written by leading clinical educators. The case-based approach supplements the didactic materials. This allows the practical application of both clinical and technical knowledge to the individual case. As always, this markedly enhances information retention and clinical utility.

The editors and authors are to be congratulated for producing this unique, practical, and comprehensive book. All interested in improving their knowledge and skills related to arrhythmias, ablation, pacing, and defibrillation should consider it an essential resource. With mastery of its content, all health care professionals will meaningfully improve their ability to ensure optimal patient outcomes.

N.A. Mark Estes III, MD, FHRS, FACC, FAHA
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The role of allied professionals in providing care to patients with cardiac rhythm management devices is constant yet dynamic. While this statement may seem paradoxical, its truth is self-evident to all who work in this rapidly growing subspecialty within cardiology.

One has only to look at the history of cardiac electrophysiology to discern the truth of constancy amid innovation. Today’s devices are a testament to the visions of scientists who, working in concert with engineers and medical professionals, have produced devices that are life saving and life enhancing. Innovative catheter-based technologies and cardiac rhythm management devices present new challenges. As visions become reality and theory is applied to clinical practice, new operational features are assessed, evaluated, and integrated to ensure the provision of safe, optimal patient care.

Our goal always has and always shall be providing safe and optimal patient care. Daily, we strive to incorporate how to best assess available evolving therapies and an ever-expanding array of physiologically based device features and device-based diagnostic data as we evaluate patients “in person” and “remotely.” Efforts to contain health care costs impact us and we are expected to be not only proficient but also efficient. We seek to apply scientific principles as we navigate and plumb the depths of devices, their programmers, and remote Web sites to evaluate data and ensure devices are optimally programmed to meet the needs of individual patients. How to assess and address the unique challenges of device-based care permeate this text, which integrates the theoretical and the practical. In this regard, the text for allied professionals espouses and exemplifies the standards of professional practice for allied professionals in pacing and electrophysiology (Gura et al. 2003).

Devices represent only one of the varied therapy options. The challenges to understand and apply technology to the management of life-threatening/life-altering arrhythmias in patients are vast. A thorough understanding of arrhythmia mechanisms provides an essential foundation for identifying the most appropriate technique for patient treatment. Advanced diagnostic testing creates additional patient-specific information that results in an optimal treatment decision. Within the electrophysiological procedure and ablation, innovative technological achievements have simplified
arrhythmia location, improved catheter ablative therapy techniques, and reduced patient complications. All of these are outlined in the text so that caregivers can deliver improved patient care with an understanding of the pathophysiology and biomedical technology. One must also consider the “care” in patient care. We strive to do so while acknowledging the unique human qualities and quirks of our patients, recognizing that the ordinary and mundane to one person may represent the unique, provoking anxiety and distress to others.

The authors and editors of this text provide exemplary material designed to teach us how to utilize technology to enable each of our patients to derive maximum benefit.

Rosemary S. Bubien, RN, MSN, FAHA, FHRS, CCDS

REFERENCE

The field of cardiac arrhythmias has evolved greatly over the past several decades. This field involves direct patient management of patients who have implantable cardiac devices such as pacemakers or implantable cardioverter defibrillators. In addition, the role of catheter ablation in these patients has expanded over the past few years for arrhythmia management. The front line in management of arrhythmia patients is often nursing or allied professional staff that works closely with cardiologists and cardiac electrophysiologists.

This aim of this book is to be a comprehensive reference for allied professionals in a very specialized field. The book is divided into six sections that cover the variety of topics in the field of arrhythmia management, from the most basic to the complex. Each chapter was written and edited by experts in the field and was the collaboration of electrophysiologists and allied professionals.

Our goal is to provide the fundamentals and nuances in management of cardiac arrhythmia devices, as well as arrhythmia management for patients who undergo radiofrequency ablation procedures.

We hope that this book will be used by both experienced and novice nurses and allied professionals. We also hope this book may be useful for those preparing for any examination of competency in the field and will be valuable as a learning guide as well as a useful resource on a day-to-day basis. We hope that this book will contribute to the improvement in care of the arrhythmia patient.

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Cardiac Arrhythmia Management
A Practical Guide for Nurses and Allied Professionals
Section 1
Basics of Cardiac Anatomy and Electrophysiology
Electrical stimulation is the key in initiating the sequence of events that result in cardiac contraction, the ultimate measure of cardiac performance. The inherent pacing properties that are required to generate an electrical impulse, the intrinsic conduction pathways that move depolarization from the initial impulse throughout the entire cardiac muscle, and finally, the patterns of depolarization that create an optimal squeeze of the cardiac muscle are the result of the electrical conduction system and mechanical system functioning synchronously. Impulse generation and dispersion to all areas of the heart muscle via cell-to-cell activation and via electrical pathways must be well understood to comprehend the complexity of electrical conduction and the strategies for treating conduction abnormalities. This chapter will provide an overview of cellular physiology, electrical physiology, the anatomy of the conduction system, and the medications that can be used to treat conduction abnormalities. A thorough understanding of the normal anatomy and physiology of the conduction system will enable the allied professional to understand the rationale for utilizing specific arrhythmia treatment modalities, whether it be medications, ablations, or devices.

ANATOMY OF THE CARDIAC CONDUCTION SYSTEM

The anatomy of the conduction system is composed of electrical tracts within the myocardium. This electrical network is strategically arranged in the nodes, bundles, bundle branches, and branching networks of fascicles. The cells that form these structures lack contractile capability but can generate spontaneous electrical impulses and alter the speed of electrical conduction throughout the heart. The sinoatrial (SA) node, internodal tracts, atrioventricular (AV) node, bundle of His, right
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within the heart and is composed of cells capable of impulse formation or “pacing.” Pacing cells within the SA node independently move to a threshold potential, thereby initiating depolarization. The SA node establishes the intrinsic heart rhythm between 60–100 pulses per minute but is influenced by the autonomic nervous system to meet the changing requirements of the body (Fig. 1.1.2). The region of the sinus node has numerous nerve endings and is predominantly regulated by the parasympathetic system or acetylcholine at rest and the sympathetic tone is mediated with the release of norepinephrine to meet increased energy requirements.

Anatomically, the SA node is subepicardially located in the left upper corner of the right atrium, near its junction with the superior vena cava. The SA node is the native pacemaker site of the heart and is composed of cells capable of impulse formation or “pacing.” Pacing cells within the SA node independently move to a threshold potential, thereby initiating depolarization. The SA node establishes the intrinsic heart rhythm between 60–100 pulses per minute but is influenced by the autonomic nervous system to meet the changing requirements of the body (Fig. 1.1.2). The region of the sinus node has numerous nerve endings and is predominantly regulated by the parasympathetic system or acetylcholine at rest and the sympathetic tone is mediated with the release of norepinephrine to meet increased energy requirements.

Figure 1.1.1 Anatomy of the conduction system.

bundle, left bundle, anterior and posterior fascicles, and the Purkinje fibers are all the necessary conduction routes established throughout the cardiac muscle (Fig. 1.1.1). Normal conduction utilizes this electrical conduction system to expedite transmission of the electrical impulse from the top of the heart to the bottom. Abnormal conduction or arrhythmias are the result of an arrhythmogenic site or region that interferes, alters, or bypasses the normal conduction circuit. Therefore, a comprehensive understanding of normal conduction provides a foundation for better understanding the mechanisms present in abnormal conduction or arrhythmias.
flow (Anderson et al. 1979). The function of the sinus node may be jeopardized if the blood supply is reduced due to coronary artery disease or an increase in fibrous tissue with maturity, resulting in fewer SA cells available for impulse formation within the sinus node (Davies and Pomerance 1972).

Once the impulse is initiated within the SA node, it not only travels cell to cell through the atrium but also utilizes more specialized, expedient pathways known as internodal tracts (Fig. 1.1.1). The Bachmann’s bundle moves away from the SA node anteriorly around the superior vena cava and then bifurcates with one branch leading from the right to the left atrium, while the other branch descends along the interatrial septum into the anterior portion of the AV node (fast pathway). The Wenckebach’s tract transfers the stimulus from the superior region of the SA node, posterior to the superior vena cava, and travels through the atrial septum to the AV node, while the third pathway (Thorel’s) is responsible for moving the impulse inferiorly and posteriorly along the coronary sinus, arriving into the posterior portion of the AV node (slow pathway).

Once atrial depolarization is completed, depolarization moves into the AV node via the internodal tracts previously described or via cell-to-cell conduction. Normally, the structure of the AV node is the only conduction route from the atrium to the ventricle because the chambers are separated by fibrous and fatty tissue that is nonconductive. The primary function of the AV node is to slow electrical conduction adequately to synchronize atrial contribution to ventricular systole. The AV node is also capable of rescue pacing when the SA node fails and will provide a heart rate of 40–60 bpm (Fig. 1.1.2). By contrast, an ectopic
site within the AV node is capable of pacing competitively against the SA node to produce arrhythmias or junctional tachycardias greater than 100 bpm.

The fast and slow pathways of the AV node are anatomical as well as functional structures. Slow pathway physiology is not seen in every individual. The fast pathway conducts more quickly but has a longer refractory period or recovery period. By contrast, the slow pathway conducts more slowly but has a shorter refractory or recovery period. Conducted impulses commonly travel along the fast pathway through the AV node, but with increased heart rates or the presence of a premature stimulus, the fast pathway may be unable to transmit because it is unable to recover fast enough to transmit the stimulus or be “refractory.” Because the slow pathway has a shorter effective recovery time or is able to recover more quickly, it is able to transmit a signal down the slow pathway while the fast pathway is still recovering. The timing of recovery and the ability or inability to transmit a signal can result in a reentrant tachycardia (Fig. 1.1.3). Reentry is the result of a circuit that is initiated by a signal, often early, being blocked and forced to move in the opposite direction. When the electrical signal conducts back toward the area of block, the structure has had time to recover and is now able to transmit the signal in the opposing direction. Hence, the critical timing sequence of the signal being transmitted creates an independent reentrant circuit.

Once the activation through the AV node occurs, depolarization travels to the common bundle of His (also called His bundle or common bundle). The region where the AV node (node of Tawara) and the His bundle join can be termed the triangle of Koch. Anatomically, the triangle of Koch includes the coronary ostium, the tendon of Todaro, and the tricuspid valve annulus along the septal leaflet. The AV node is approximately 5–6 mm long and 2–3 mm wide, and 0.5–1.0 mm thick, although there is some discrepancy in what is included in the AV node (Hecht et al. 1973; Becker and Anderson 1976). The blood supply of the AV node is the AV nodal artery and is usually dual supplied by the right coronary artery in 90% of the patients and the remaining 10% receive blood from the left circumflex coronary artery. Similar

![Figure 1.1.3 Reentry of the fast and slow pathways.](image)