CLINICAL UNIPOLAR

ELECTROCARDIOGRAPHY

CLINICAL UNIPOLAR
Electrocardiography

by

BERNARD S. LIPMAN, A.B., M.D.

Instructor in Medicine, Emory University School of Medicine; Consultant, Cardiac Clinic, Grady Hospital; Cardiac Consultant, Veterans' Administration Regional Office, Atlanta, Georgia

and

EDWARD MASSIE, A.B., M.D., F.A.C.P.

Assistant Professor of Clinical Medicine, Washington University School of Medicine; Director of Heart Stations, Barnes Hospital and Jewish Hospital, St. Louis; Director, Cardiovascular Clinic, Washington University Clinics; Area Consultant in Cardiology to the Veterans' Administration.

200 EAST ILLINOIS STREET . CHICAGO

THE YEAR BOOK PUBLISHERS · INC.

Reprinted, November 1951

Second Edition, 1953

PRINTED IN THE U.S.A.

Dedicated to

LESLIE JOY LIPMAN

and

FELICE MASSIE

and our children

Preface to Second Edition

IN UNDERTAKING this second edition, we have tried to apply the same principles of simplicity and practicality utilized in the first edition, keeping in mind that this manual was intended primarily for those inexperienced in the field of electrocardiography. Various changes have been incorporated and chapters or sections added on cardiac arrhythmias, myocarditis, congenital heart disease, hyperventilation and the two step (Master) exercise test.

Those familiar with the first edition are aware that the subject of the arrhythmias was omitted to keep the presentation uninvolved. Many students, colleagues and friends, however, requested that a chapter on cardiac arrhythmias be written in the same elementary, concise manner in keeping with the rest of the monograph. More than 50 illustrative electrocardiograms of the arrhythmias have also been added.

A chapter on vectorcardiography was contemplated but dismissed for two reasons. First, the topic could not be covered adequately within the limited confines of this monograph, and second, the subject would involve detailed and complex discussions which would tend to confuse the beginner. It is our firm belief, moreover, that at present the orthodox method of learning electrocardiographic interpretations is much easier for the inexperienced to grasp than is the vector method.

Whatever success the first edition attained was achieved, we feel, through the simplified manner of presentation. We have sincerely endeavored to present the material in this edition in the same way.

Again we wish to express our indebtedness to the late Dr. Frank Wilson without whose experiments and contributions to the literature this manual could not have been written. We are very grateful to Dr. Bernard A. Bercu and to our Barnes Hospital Heart Station colleagues who have offered many helpful suggestions. The Heart Station technicians and especially Miss Dorothy Hollander have been extremely co-operative in enabling us to secure the various electrocardiograms. Miss Edna Edwards, our head technician, has been of immeasurable help in mounting the electrocardiograms and deserves our most sincere appreciation. Mrs. Wanda Coburn has been most helpful with her patient and skilful typing of the additions to the manuscript. We are again grateful to Mrs. Carol Deakin Reynolds for her able handling of the sketches, and we wish to express our thanks to the Year Book Publishers for continued co-operation.

—BERNARD S. LIPMAN.
—EDWARD MASSIE.

Preface to First Edition

WE PREPARED a booklet, "Unipolar Electrocardiographic Notes," for the students of Washington University School of Medicine and the staff of the Barnes Hospital, which received such favorable comment that we were persuaded to write a simple, practical, more complete monograph in the form of a manual on the subject, intended primarily for those inexperienced in the field of "V lead" electrocardiography. Keeping in mind this purpose, we endeavored to approach the subject in an elementary, clear and concise, albeit dogmatic, fashion. We did not wish, however, to apply dogmatism to the point that the theories of unipolar electrocardiography would be accepted as established facts. Much of our knowledge of electrocardiography is, after all, still empiric.

The subject of cardiac arrhythmias was not dealt with extensively since numerous treatises on electrocardiography cover this field; furthermore, we wished to keep our presentation uninvolved. No attempt was made to review the subject of unipolar electrocardiography in a comprehensive or exhaustive manner—a task which would involve detailed and complex discussions. Rather, we tried to set forth the more popular current views in a pedagogic approach free from complexity. Written primarily for the beginner, the manual offers these concepts as a practical basis for V lead interpretation. The principles of physics and cardiac physiology essential to this discussion are incorporated in the simplest of terms. Numerous schematic diagrams are interspersed throughout the text for their elucidative value.

We wish to express our gratitude and deep indebtedness to the many investigators in the field of electrocardiography and particularly to Dr. Frank N. Wilson, without whose efforts and contributions this manual could not have been written. We extend our sincere thanks and appreciation to Drs. Maurice Sokolow, Adolph Surtshin, Bernard Bercu and W. Barry Wood, Jr., who reviewed the manuscript and offered many helpful suggestions. We are extremely grateful to our Barnes Hospital colleagues, Drs. William D. Love and Frank B. Norbury, and to the Heart Station technicians, especially Miss Edna Edwards, for their co-operation and assistance. Miss Carol Deakin deserves our most sincere appreciation for her able handling of the sketches which are so important in clarifying the discussions. We also wish to thank Miss Janice Lybyer for her patient and skilful typing of the monograph and Mrs. Alice Marshall for her typing of the legends. Finally, for the considerate and unfailing co-operation of the Year Book Publishers we wish to express our special thanks.

Table of Contents

Chapter ONE

Introduction

HISTORY

IT HAS BEEN known for many years that muscle tissue has the inherent ability to produce and transmit electric current. As early as 1856, Kölliker and Müller demonstrated the presence of action currents associated with the heart beat. They placed a frog's nerve-muscle preparation in contact with a beating heart and were able to demonstrate twitches of the frog's muscle with each contraction of the ventricle. Their observations were followed by those of a number of other investigators. In 1887 Waller and Ludwig, using the capillary electrometer, were the first to demonstrate a measurable amount of current in the human body associated with contraction of the heart. But it was not until 1901 that the current from the human heart beat was registered in an accurate, quantitative manner. This was made possible by the introduction of a new instrument, the string galvanometer, by Willem Einthoven.

The string galvanometer is a precise sensitive instrument. At first it was used to record the heart beats in experimental researches; however, it was not long before this valuable tool was utilized routinely to aid in the clinical evaluation of cardiac disease. The string galvanometer designed by Einthoven was based on the familiar principle that a magnet and a conductor of current will interact. The galvanometer consisted of a powerful electromagnet between the poles of which was stretched a fine, metallic covered quartz filament. When the connections were completed between the resting subject and the galvanometer string, the only significant electrical potentials were those coming from the heart and they were recorded as a deflection of the quartz string. A source of illumination and a system of lenses photographed the string shadow on a moving film. Other types of galvanometric instruments were devised, one of which was the oscillograph. This instrument consisted of a small magnet to which a mirror was attached. The magnet was surrounded by coils of wire and suspended by a fine thread. When current flowed through the coils of wire the magnet was deflected, and a beam of light reflected by the mirror registered this movement. Within recent years other principles have been utilized. Thus the cathode ray oscillograph offers direct visualization of the electric waves as well as a permanent record. The use of vacuum tube amplification instruments permits immediate visualization of the electrocardiogram, a distinct advantage clinically.

The considerable progress made in the field of electrocardiography has been aided and abetted in no small manner by the researches of Sir Thomas Lewis during the first quarter of the twentieth century. In 1933 Frank N. Wilson and his associates devised the unipolar electrocardiogram. The unipolar method of recording electrical activity in the heart was used first for experimental purposes but, like Einthoven's galvanometer, eventually gravitated into the field of clinical medicine. Only recently, however, has the practical value of unipolar leads been emphasized, publicized and finally utilized in the routine armamentarium of the clinical cardiologist.

ELECTRICAL ACTIVITY OF THE HEART

The heart has the innate ability to contract. Each contraction is preceded by excitation waves of electrical activity. It is possible for the heart to be completely separated from its normal environment and to continue to beat for an indefinite period. The frog's heart, for example, may be completely isolated and will continue to beat. William Harvey as early as 1628 demonstrated this phenomenon by cutting an isolated heart into small bits and noting that each portion continued to beat independently. He observed, moreover, that the auricular portions beat more frequently than the ventricular elements. Keith and Flack in 1907 suspected that the cardiac pacemaker was contained in a collection of specialized muscle tissue located in the right auricle. It was Sir Thomas Lewis who directed attention more particularly to the sinoauricular node and to a better understanding of the spread of the excitation wave which precedes every beat of the heart. It is now known that the electric impulse in the normal heart originates in the sinoauricular node situated in the right atrium and travels through both auricles in wavelike fashion to reach the auriculoventricular node, which is another group of specialized muscle tissue located in or near the membranous portion of the interventricular septum. The excitation wave then passes to the bundle of His, proceeding along its main right and

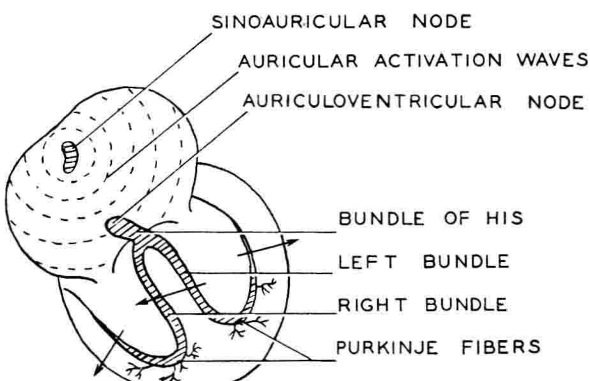

FIG. 1.—The specialized conductive tissues of the heart.

left branches to the Purkinje system. Activation of the ventricular musculature takes place initially in the septum and subsequently in the free walls of both ventricles.

Figure 1 illustrates the specialized conductive tissues of the heart which consist of the sinoauricular node, auriculoventricular node, bundle of His with its right and left branches and the Purkinje fibers. It has been demonstrated fairly conclusively that impulses travel at the apparent rate of 4,000 mm./second in the Purkinje fibers, 200 mm./second in the nodal tissue and 900 mm./second in the auricular muscle and at the rate of 400 mm./ second in the ventricular muscle. It is primarily the electrical activity within the cardiac muscle which is recorded on the electrocardiogram. A lesion which blocks or alters the spread of activity, whether in the specialized tissue or in the remainder of the heart muscle, will alter the recorded electrocardiographic pattern.

In relation to the anatomy of the heart, the conducting system is tiny and comprises a minute portion of the heart mass. The wall of the left ventricle is two and one-half to three times as thick as the right ventricular wall and the interventricular septum is almost as thick as the left ventricle. The major portion of the muscle mass consists of the free walls of the right ventricle, the left ventricle and the septum. Similarly, the major portion of the completed electrocardiogram consists of the electrical activity present in the septum and the two ventricles.

THE ELECTROCARDIOGRAM

What is the electrocardiogram? It is simply a graphic representation of the electrical forces produced by the heart. It is extremely important in electrocardiographic interpretation to realize the limitations of this diagnostic test. An abnormal tracing ordinarily, though not always, implies an abnormally functioning heart. An alteration in the physiologic activity of the heart often, but not necessarily, causes an alteration in the electrical processes. An abnormal electrical pattern may be present but may not be recordable owing to its obscure location. Numerous extrinsic factors not related to the heart per se may also alter the final record. Some of these factors are skin resistance, the heterogeneous conducting tissues of the body, polarization, thickness of the chest wall, distance of the chest wall from the heart, position of the heart within the thoracic cage, skeletal muscle tremors, electrical interference, the technical problems concerned with the proper method of taking electrocardiograms (particularly incorrect standardization) and the proper functioning of the electrocardiographic instrument. Drugs, infections, pulmonary emboli, pain, fear, exercise, shock and blood electrolytes alter the electrocardiogram. Thus it is important to remember that the electrical forces of the heart which are registered are at most an indirect index of the functional and anatomic state of the heart and may be influenced by various extrinsic cardiac factors.

Einthoven, Sir Thomas Lewis and others correlated the electrocardiographic waves with the contracting heart and demonstrated that the P wave was related to the auricular contraction, whereas