AN ELEMENTARY ATLAS OF CARDIOGRAPHY

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An Introduction to Electrocardiography and X-ray Examination of the Heart

BY

H. WALLACE-JONES, M.D., M.Sc., F.R.C.P.
Honorary Consulting Physician, Royal Liverpool United Hospital

AND

E. NOBLE CHAMBERLAIN, M.D., M.Sc., F.R.C.P.
Honorary Physician, Royal Liverpool United Hospital

AND

E. L. RUBIN, M.D., F.F.R., D.M.R.E.
Honorary Radiologist, Royal Liverpool United Hospital

INCORPORATING THE
THIRD EDITION OF "ELECTROCARDIOGRAMS"
WITH 100 ILLUSTRATIONS

BRISTOL: JOHN WRIGHT & SONS LTD.
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1948

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PREFACE

THIS little book, which first appeared in 1939 as an Atlas of Electrocardiography, has now been enlarged to incorporate a section on cardiac radiology. Its elementary character has been retained.

A few modifications have also been made in the electrocardiographic section, notably the addition of records showing Lead CR1 both normal and in abnormal rhythms. The light thrown upon auricular fibrillation by the use of this lead made it necessary to rewrite the section dealing with this abnormal rhythm.

The electrocardiograms and radiograms are presented in separate sections. While the student will probably find this an advantage in an elementary atlas, he must realise that in clinical practice neither electrocardiograms nor radiograms can profitably be considered alone but only as part of the whole clinical picture.

Once again we are indebted to the publishers and especially to Dr. Hunter, the Medical Editor, for their helpful advice in the new production.

H. W. J.
E. N. C.
E. L. R.

July, 1948.

PREFACE TO THE FIRST EDITION OF "ELECTROCARDIOGRAMS"

In presenting this small book we have aimed chiefly at supplying the wants of the medical student, whose career is so overburdened with specialized subjects that we feel electrocardiography should not loom too largely in his general knowledge of medicine.

Yet the subject cannot be wholly neglected, and in the Heart Clinic of the Royal Infirmary we have frequently been asked by students for a set of representative electrocardiograms. Such a set we have endeavoured to give here, fully realizing that our choice has been arbitrary and necessarily limited.

The descriptive text has been reduced to a minimum so as to make the publication more of an atlas than a book, but to make up for this the legends beneath each record are fuller than usual. Most of the records are from our own files.

We consulted Dr. H. R. Hurter on the use of the words electrocardiograph and electrocardiogram, and his authoritative knowledge of the English language enabled us to decide that cardiograph should be applied only to the instrument and cardiogram only to the record. We are grateful for the trouble he took to put this decision on a firm etymological foundation.

We also thank Mr. E. Caldwell for his care in the production of the records; our secretaries, Miss Ebbrell and Miss Wolfenden; and finally the publishers, Messrs. John Wright & Sons, for their well-known courtesy and helpful advice.

H. W. J.
E. N. C.

August, 1939.

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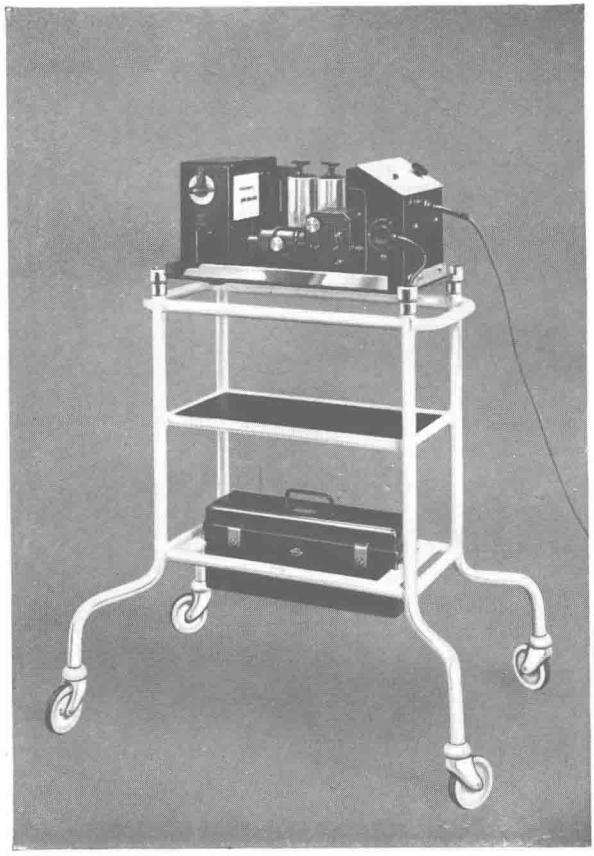

Standard electrocardiograph arranged on a trolley.

[*Courtesy of the Cambridge Instrument Co., Ltd.*]

CHAPTER 1

INTRODUCTION

THE electrocardiograph is an instrument for recording the electrical changes in the heart muscle each time the heart contracts. Most electrocardiographs are based on the principle of the Einthoven string galvanometer, which consists of a fine fibre of silvered quartz stretched between the poles of a powerful electromagnet. When a current passes through this fibre it is deflected from side to side, the degree of deflection depending on the amount of current which flows. This fibre is of very light weight, and therefore as there is no ' over-swing ' an accurate record of quick changes in electrical potential is recorded. The movements of the fibre are projected through an optical system throwing a shadow magnified 450 times on the screen. Behind the screen a frame holding a photographic plate, film, or roll of sensitized paper falls at a uniform speed, so that a permanent record of the movements of the fibre can be obtained. By altering the tension of the fibre its sensitiveness can be varied, and it is usual to arrange the tension of the fibre so that a current of 1 millivolt will move the shadow of the fibre on the screen 1 centimetre. In this way electrocardiograms are standardized and can be compared when taken on different machines.

In addition, the whole field is interrupted periodically by a rotary time-marker, which records thick and thin lines across the record indicating $\frac{1}{5}$ sec. and $\frac{1}{25}$ sec. respectively. In most electrocardiographs the switchboard is so arranged that the skin currents which develop when the patient is connected to the galvanometer can be neutralized by a current flowing in the opposite direction, but in some of the newer types the effect of the skin current is overcome by passing it through a condenser. In the valve type of machine no neutralization of the skin current is necessary.

The patient is connected with the machine either by :—

1. Non-polarizable wet electrodes consisting of (*a*) an outer pot of glazed porcelain containing a saturated solution of zinc sulphate and a zinc plate, to which the lead is attached ; and (*b*) an inner porous pot containing normal saline solution, into which the limbs are placed ; or

2. Metal electrodes which are strapped on the limbs and smeared with conducting jelly.

In the standard electrocardiogram the three leads are :—

Lead I. Right arm and left arm.

Lead II. Right arm and left leg.

Lead III. Left arm and left leg.

Recently it has been shown that many cases of definite coronary thrombosis give normal records with the three standard leads owing to the fact that they are taken only in one plane. To get over this difficulty a fourth lead has been introduced in which one of the electrodes is placed over the apex beat and the other is placed on some distant part of the body, usually the right arm or left leg. It is now customary in order to standardize these Lead IV records to place the electrocardiograph switchboard at Lead I and to place the left-arm electrode on the precordium and the right-arm electrode on either the right arm or the left leg. These leads are called Lead IVR and Lead IVF respectively.

Other chest leads have special values. That known as CR1 (left-arm electrode at 3rd to 4th right costosternal junction and right electrode on right arm) is particularly valuable in the analysis of cardiac arrhythmias (*see Fig.* 4).

In addition to the standard machine (*see Frontispiece*), which is the type found chiefly in hospitals, portable machines are also extensively used. These fall as a rule into three different types :—

1. Those which have the ordinary type of string galvanometer, but use permanent magnets instead of electromagnets for the galvanometer, and by means of a system of mirrors reflect the ray, so that the whole machine is made much lighter and more compact.

2. Those with a much smaller and relatively insensitive galvanometer, either an oscillograph or a string galvanometer, in which the cardiac currents are increased by means of wireless valves arranged as an amplifier.

3. Those making use of the cathode-ray tube. In this system the end of the tube is coated with a fluorescent screen with a delayed action, so that the path of the spot of light remains visible for an appreciable time after it has moved along. In this way the electrocardiogram can be read immediately without the necessity of taking a photographic record.

CHAPTER II

FORMATION OF THE ELECTROCARDIOGRAM

To understand the significance of the various waves which make up the human electrocardiogram the student must remember the mechanism of the heart-beat (*Fig.* 1). The impulse which starts the contractions of the heart originates in the sino-auricular node, a small collection of specialized tissue lying at the junction of the superior vena cava with the right auricle.

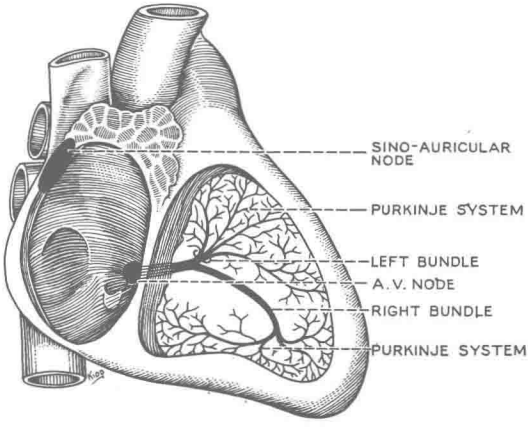

Fig. 1.—Diagram to show the conduction system of the heart. Heart-block may occur at any of the situations indicated (*see* Chapter IV).

A wave of excitation passes from this node through the auricular muscle, taking a path which has not yet been fully defined, but arriving finally at the auriculo-ventricular node which lies in the inter-auricular septum at the junction of the auricles and ventricles. This A.V. node is subsidiary to the S.A. node and under normal circumstances plays a passive part in the cardiac cycle. The impulse which reaches it is immediately transmitted down the trunk of the specialized tissue known as the bundle of His. The greater part of this lies in the inter-ventricular septum and splits into right and left branches which in their turn arborize extensively in the

ventricular muscle. The impulse which has been transmitted from the auricles takes rather less than $\frac{1}{5}$ sec. to pass through the bundle of His. Thereafter it reaches the ventricles at slightly different time intervals in various parts, but the variation in these time intervals is not sufficient to cause asynchronous contraction of the ventricles, though it accounts for the manner in which one part of the ventricle contracts slightly before the others. The arrival of the impulse, however, is so timed that the various parts of the ventricles contract in sequential order.

Electrical variations in the heart are associated with these mechanical changes. It must be emphasized at once, however, that their relationship is more in time than in quantity. For example, it does not follow that a large contraction of one part of the heart is necessarily associated with a large excursion in the fibre of the electrocardiograph ; indeed, the converse is sometimes the case. The electrical variations are due to changes in potential, and they appear to precede slightly the wave of excitation which passes through the heart. Nevertheless, it is possible to correlate very closely the mechanical events of the cardiac cycle which have been described with the various waves of the electrocardiogram. Coinciding with the passage of the stimulus from the S.A. node through the auricular muscle there appears in all leads a small wave known as the P wave. It may be sharp or slightly rounded, and varies in height from a barely susceptible rise to 5 mm., though in a great majority of cases it averages about 2 mm. This P wave is usually well defined in a normal electrocardiogram, especially in Lead II. Following it there is an iso-electric period denoted by the level base line of the record. Then follow the waves, Q, R, and S, associated with the commencement of the ventricular systole.

From the beginning of the P wave until the beginning of the R wave occupies an interval of less than $\frac{1}{5}$ sec., usually from 0·14 to 0·18 sec. This corresponds with the time taken by the excitation wave to pass through the bundle of His. The initial ventricular events, Q, R, and S, vary considerably in normal persons ; Q and S in particular show a great variation. Sometimes they are well defined ; Q may measure as much as 4·5 mm., S as much as 11·5 mm., though the averages are about 1 mm. for Q and 2·3 mm. for S. In other cases these waves are absent or barely appreciable. R, on the other hand, is a tall, well-defined wave averaging from 8 mm. to 15 mm., and is most prominent in Lead II. It is normally upright. The Q R S interval should not occupy more than 0·1 sec.,

averaging from 0·05 to 0·06 sec. S is followed by another iso-electric period and this in its turn gives way to a final wave known as the T wave.

The S–T interval shows considerable variation. Sometimes there is a well-defined iso-electric period of as much as 0·16 sec., but in other cases the T rises up from a steep S wave. The total S–T interval is usually about 0·28 sec., i.e., considerably longer than the P–R interval.

The T wave is usually rounded and upright except in Lead III, where in 30 per cent of cases it is inverted. The T represents the return of the excitatory wave to the base of the heart.

Q, R, S, and T are associated with the mechanical contraction of the ventricles, and they are succeeded by a long iso-electric period corresponding with diastole. Sometimes during this period a small blunt U wave may appear, the significance of which is not very clear, though at present it does not appear to have any special clinical importance.

In the less commonly used leads, chiefly those from the chest, the direction of the waves in health may be different from those in the standard leads, and this must be taken into account in the interpretation of the results.

Measurement of Electrocardiographic Waves (*Figs.* 2, 3).—The amplitude of the P, Q, R, S, and T waves is measured by horizontal lines on the film or plate, the distance between each line being 1 mm. These lines are photographed on the film from a scale marked on the lens of the camera.

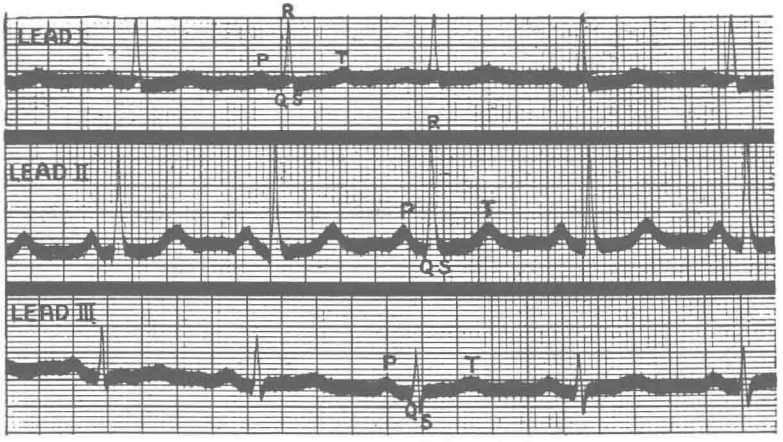

Fig. 2.—Normal electrocardiogram, standard leads. Note the regularity of the cardiac cycle, the upright and well-defined character of the P, R, and T waves, and the normal time relationships.

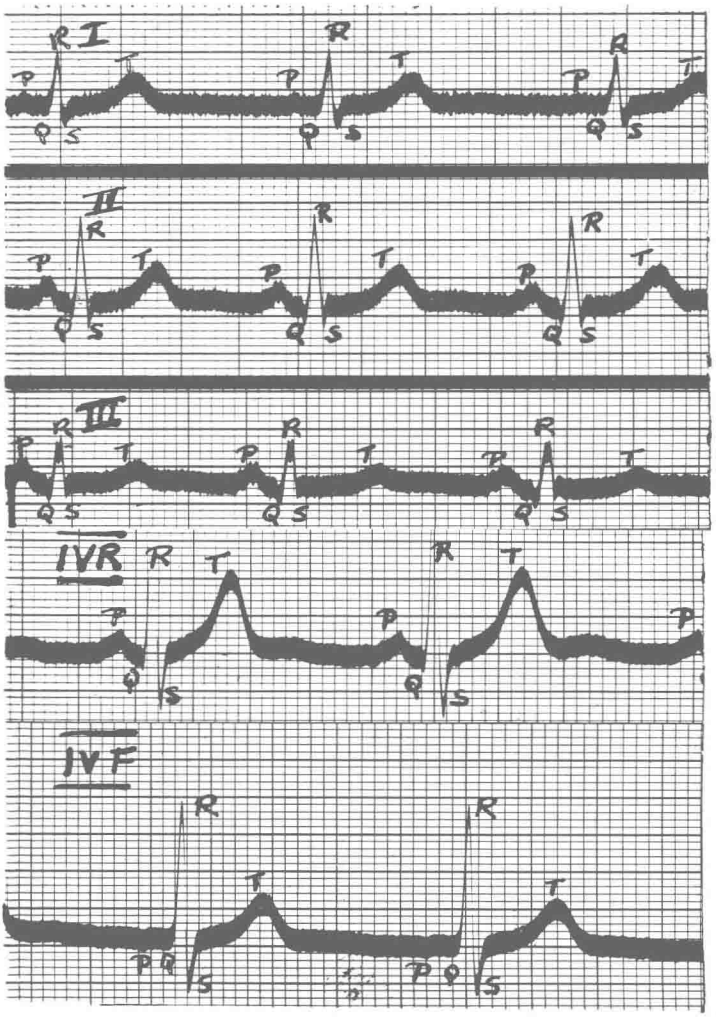

Fig. 3.—Normal electrocardiogram, illustrating Lead IV. The figure shows the conventional three leads, and, in addition, the two common precordial leads (IVR and IVF) recommended by the Cardiac Society of Great Britain and the American Heart Association. The characteristics of the normal Lead IV are as follows: (1) Small P wave—upright in IVR, negative in IVF; (2) Initial positive deflection (R wave); (3) Biphasic R–S complex with big S wave; (4) A large upright T wave; (5) Often notching of Q R S complex; (6) Slight displacement of R–T, i.e., deviation above or below the iso-electric level, not usually exceeding 1 mm. but at the most 2 mm. Lead IVR seldom gives any information not provided by Lead IVF.