REFRESHER COURSE FOR GENERAL PRACTITIONERS

THE CARDIOGRAM IN CLINICAL DIAGNOSIS AND PROGNOSIS

I. THEORETICAL CONSIDERATIONS

BY

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When the muscle fibres of the heart pass from the resting to the active phase of systolic contraction electrical changes take place. These can be recorded by a suitable instrument. Several types have been used. The string galvanometer makes a photographic record of the greatly magnified movements of an almost invisible fibre. The currents from the heart may be intensified by thermionic valves to work a mirror galvanometer which writes on sensitive paper with a beam of light. The cathode-ray oscillograph may illuminate a fluorescent screen; direct records may be made on special paper by heated points, or traced with ink. The result of all these methods is the cardiogram.

I will consider for a moment the unit—the muscle cell. At rest it is polarized, with a negative charge of anions lining its semi-permeable membrane on the inside, balanced against a positive charge of cations on the outside. When the “stimulus” for action reaches this cell it becomes depolarized, the ions change position, and the cell achieves its one purpose in life—contraction. The process of depolarization is associated with a difference of electrical potential at the ends of the cell, and current flows. Contraction over, repolarization sets in, starting where depolarization began, and again there is a difference of electrical potential and a flow of current, but opposite in sense to that of depolarization. Polarization being complete, current ceases to flow, and there is diastolic rest until the next phase of systolic activity. Any type of electrocardiograph will record these currents.

What has been instanced above must be multiplied untold times when we attempt to conceive the total systolic activity of the syncytium of cells which compose the whole heart muscle. One must remember, too, that the impulse for action passes throughout this mass during a definite interval of time, and that, so far as the auricles are concerned, these impulses are merely simple transmissions through the muscle sheet. But in the ventricles there is a special telegraph apparatus—the Purkinje system—which distributes the impulse as rapidly as possible through these chambers, which are indeed muscular cups. It must also be remembered that the general distribution of the spread of the impulse, considered in three dimensions, is opposite on the two sides, right and left.

Normal Cardiogram : Nomenclature

The apparatus is so arranged that a positive potential will produce a deflection from the base-line (which is spoken of as isoelectric) in an upward direction; a negative potential will give a downward deflection. Hence the direction of deflections is usually spoken of as positive or negative (or upward or downward). It is a fundamental fact that so long as an impulse is travelling towards a recording electrode the potential of that electrode is positive. Similarly when an impulse is receding from an electrode its potential is negative (Fig. 1).

Standardization.—It is now the universal practice to standardize the deflections so that a difference of potential of one millivolt causes a movement of one centimetre.

Auricular Activity.—The electrical potentials developed by auricular systole cause a small deflection, which is always labelled P. As a rule it is positive in standard Leads I and II. It may be negative in standard Lead III. It is shown best by standard Lead II, VR, VF, and V₁. (See below for the explanation of these terms.)

Ventricular Activity.—The impulse reaches the ventricles after a short interval occupied by its passage through the conducting tissues. The first indication of electrical change may be a negative or downward deflection

Q. This varies much in size in different leads. Its presence may be physiological merely, or definitely pathological in significance. It is not always seen. It may be followed by a positive deflection R; if Q is wanting this will be the first deflection. It varies much in height for many reasons. After this may come a negative deflection S, again very variable in depth. If the sole deflection recorded be negative there has been some doubt whether it should be called Q or S. It is safest to label it with both letters.

The QRS complex, as it is called, coincides with the process of activation of the ventricles, or the beginning of ventricular systole. Following this phase, for the instant when all the muscle is in a state of activity, there is no difference of potential anywhere, and the recording curve is at the base-line again. Then that part of the myocardium which first became depolarized starts to become repolarized and for the moment, until repolarization is everywhere complete, there is electrical disequilibrium. This causes a further flow of current through the galvanometer, and a flattened curved wave is recorded which is always labelled T. It is usually positive; in fact, in some leads a negative T can always be regarded as of pathological significance, but in others this is not so. The shape of the wave may be very important and indicate the cause of an abnormal appearance. Sometimes the S-T or RS-T phase is not at the base-line, or isoelectric: it is then said that there is S-T (RS-T) deviation—positive or negative. This may be of great pathological importance in indicating myocardial disease.

FIG. 1.—Normal electrocardiogram

It must be remembered that, as in all natural things, the range of the normal cardiogram is wide, and that its limits are by no means clearly defined. Long experience is needed to appreciate these points. The variations in the size and shape of the deflections are considerable, and depend on such causes as the lie of the heart in the chest, the vigour of the heart, the resistance of the skin, and other factors but little understood.

Time Measurements.—All cardiograms show a time scale, usually in 1/5 and 1/25 second. It is convenient to mention here that the interval between the beginning of the wave of auricular systole (P) and the wave of ventricular systole (Q or R) should not normally exceed 0.2 second. The duration of the QRS complex should not normally exceed 0.1 second.

Technique

For many years the standard three bipolar leads from the contacts placed on the arms and the left leg were all that could be offered. Then a fourth lead from the front of the chest in the region of the apex of the heart was added. The potential at the exploring, or precordial, electrode was much higher than that at the distal electrode, which was placed on either the right arm (CR) or left foot (CF), so that the curve was practically derived direct from the region of the heart itself. The next step was to use a variety of precordial contacts, starting with the first position in the fourth intercostal space just to the right of the sternum, the second just to the left of the sternum at the same level, and so on to the sixth in the left mid-axillary line; the fourth position being in the left mid-clavicular line in the fifth interspace. All those were bipolar leads.

The latest development is the introduction of unipolar leads. There are three unipolar limb leads, from the right and left arms and the left leg. It will be appreciated that there is obviously a close relationship between the standard bipolar limb leads and the unipolar limb leads. Lead I records the difference of potential between the right arm and the left arm. The unipolar arm leads record only the electrical potential at each arm.

In the same way standard bipolar limb Lead II records the difference of potential between the right arm and the left leg; and standard bipolar limb Lead III the difference of potential between the left arm and the left leg. The unipolar limb lead from the left leg records only the changes of potential in that limb.

By a similar method unipolar precordial leads have come into use, numbered 1 to 6 (7 and 8 may be added if need be).

The letter V (voltage) has been employed to indicate unipolar contact—VR, VL, VF, for the right and left arms and the left foot, and V₁₋₆ for the precordial contacts.

CR and CF were the initials indicating the bipolar precordial (or chest) leads, with the right arm or left foot as the distal electrode, respectively.

This brief survey of the technical side of the nomenclature is needed, partly because the terms may be unfamiliar to many, and also to show that in the past few years a very considerable development in technique has taken place. At present it may be said that the full electrical exploration of the heart requires at least 12 leads, and possibly some six or more at higher levels on the chest. The additional value of oesophageal leads, or of contacts placed on the back of the thorax or on the epigastrium, is still to be assessed. How far the original bipolar limb leads will be retained remains to be seen, and how many of the new ones will be used in the first stages is still uncertain. The introduction of the direct-writing type of cardiograph is a

great advantage over the older photographic models; much time can be saved and the use of multiple leads greatly facilitated. It may well be that the simplicity of this technique will enable many or all to be used.

Cardiogram and Position of Heart

The general direction of the spread of the current of activation through the ventricles is downwards and forwards and to the left. Roughly, this is at an angle of about 60 degrees to the horizontal. The direction of this electrical change at any given moment is called the electrical axis.

The lie of the heart in the thorax varies much with a patient's build and with the position of the diaphragm. A person with a long narrow chest will have a vertical heart; a person of stocky build, with wide chest and horizontal rib margins, will have a transversely placed heart. Obesity, pregnancy, and the expiratory phase of respiration will raise the diaphragm and make the heart more transverse. These changes in position alter the appearance of the cardiogram in the standard bipolar limb leads and in the unipolar limb leads.

The expression "left axis deviation" was coined to describe an anticlockwise rotation of the heart's axis in a frontal plane, upwards and to the left. The expression "right axis deviation" describes the opposite, a rotation in a clockwise direction, downwards and to the right. These changes may be caused by the build of the patient or by the phase of respiration. But enlargement of either ventricle also causes them and to a far greater degree than other means. Enlargement of the left ventricle is associated with left axis deviation, enlargement of the right ventricle with right axis deviation. The terms "left and right ventricular preponderance or predominance" were also in vogue to describe these curves.

Cardiogram in Cardiac Enlargement

As many of the features of position and enlargement are closely connected it is convenient to discuss enlargement at this stage, though it is in a sense a myocardial abnormality. The extent to which active hypertrophy of either or both ventricles may produce characteristic curves is very variable. Very often recognizable reliable changes are not seen: on the other hand, if they are present they should be capable of interpretation. In order to find out whether there is hypertrophy of the ventricles one should examine the patient clinically and with the fluoroscopic screen rather than the cardiogram. But there are occasions on which the cardiogram may give useful confirmatory evidence concerning which ventricle is enlarged. This hint is particularly useful in congenital defects.

Considerable increase in size of either ventricle may be present without any modification of the curve; for example, there may be obvious enlargement of the left ventricle from hypertension and yet a normal curve may be obtained. The reason for this is not understood. But once a certain degree of hypertrophy has been reached the characteristic cardiograms are usually seen. In many cases it is possible to gauge the degree of change in the heart by the type of curve. What the causes are, and in what proportion they operate in producing the curves of hypertrophy, is still far from clear. The altered position or lie of the heart in the chest and the increase in the thickness of the ventricular wall are probably the important ones. The most recent trend, due to the use of unipolar leads, is to indicate the position of the heart—horizontal, semi-horizontal, vertical, and so on—and also to refer to any suggestion of hypertrophy.

The right ventricle may influence the change in the curve in the same way as the left; but its relatively smaller normal bulk requires gross increase to produce much effect, so it therefore seems relatively late.

For the most part gross cardiac enlargement is due to valvular disease or hypertension, or congenital defects; less commonly to abnormalities in the pulmonary circulation. The cardiogram will then to some extent help to gauge the degree of deviation from the normal, and so help to assess the gravity of the case. The changes associated with hypertrophy of one or other ventricle give a progressively abnormal type of curve, and so may indicate to which stage the disease has reached.

It must be remembered that in some cases of hypertensive heart disease ischaemic lesions may be present as well. These would increase the gravity of the prognosis. The cardiogram may reveal them.

The cardiogram is quite useless in the early diagnosis of valvular disease, or in the direct diagnosis of valvular disease at all; only indirectly, by indicating ventricular hypertrophy, may the curve suggest that a defect in the function of a particular valve may be the cause of it.

Fig. 1 is reproduced from Scherf and Boyd's *Clinical Electrocardiography* by permission of the authors and Messrs. Heinemann Medical Books, Ltd.

UNIVERSITY VENTURES OLD AND NEW*

BY

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All university education, and indeed all education and all activities of universities, could be brought under my title. For, whatever can be said for or against the educational process, it is a constant series of ventures—often over seas which are unknown and therefore uncharted. Which of them shall I choose?

There is first the venture of doing things for the first time. Some of you may well feel that you have a special claim to inclusion here. It is your first year in the school or your first year of a new and different part of your course. I can assure you, however, that these particular types of venture do not stop here. I claim a special place in this category myself—by asserting that few people so often do strange acts for which they feel at best only partly qualified. I should like to warn you of this in case any of you are thinking of becoming vice-chancellors. The things may be different, but the process remains the same.

But it is of collective rather than individual ventures that I want mainly to speak—appropriately enough to a world where emphasis is growing on the importance of collective action or, if you prefer it, combined operations. The use of the last term will in itself be enough to show that collective action is in the last resort the action of individuals. The antithesis is an unreal one. Somewhere in all collective action there is someone who is making a decision. Frederick the Great once said that he disliked councils because they were always timid. One of the problems of the modern world is to secure that this is not true. Individual responsibility and individual initiative are, when it

comes to the point, essential to all organizations, large or small. That cannot need emphasis in a medical school which has, at least in its associated hospitals, so many examples of the individual idiosyncrasies of the members of the human race.

We start, then, with the knowledge that these corporate activities of ours are at heart the activities of individuals. And I am choosing at random. The first I would call the venture of choosing and finding the subjects of academic study. We have been on the whole conservative in this country in our attitude to university education. Some countries have gone further than we have in the direction of including among the courses which could be taken for university degrees a number of forms of training which are training for a particular type of post, and it may well be that there will be further pressure upon us in this country. No one would in fact be prepared to say that subjects should be excluded because they are useful. We are driven to the harder task of defining what we mean in a positive form. What are the characteristics which entitle a subject to be put on the right side of the line? Perhaps the nearest that we can get to it is to say that every subject which should be included contains in it an unlimited possibility of development by research. This on the whole is a good approximation to the truth, for it implies something which I believe to be fundamental to undergraduate study, that what is being studied is something which is constantly changing and which therefore holds out a promise in the future which no undergraduate can hope to reach.

It is true that one of the difficulties of all university education at the present day—and I imagine that this applies to the faculty of medicine just as much as to any other—is that the body of knowledge already obtained is so great that it is necessary to go a very long way before even a glimpse is caught of the knowledge of the future. So far as undergraduates are concerned this situation has obvious drawbacks. We all maintain, those of us who teach in universities, whatever our subjects may be, that we are doing or trying to do something more than impose upon the memories of our students masses of detailed information which indeed is all recorded in numerous textbooks which are available to them. Yet in our candid moments we have all to own that a good memory can carry an undergraduate a very long way.

This brings me to another of the several ventures which are included under my title—the venture which must be of necessity a combined effort on the part of the university teacher and the man or woman who is being taught. This is the venture of seeing beyond the factual information which it is essential to impart or absorb to the as yet unproved or unascertained items of knowledge which lie beyond. It is a venture which requires above all an effort of faith, and I should be prepared to prophesy that a great many of you who are now beginning your university career will find a good many moments, if you take what I have said seriously, when you wonder whether it is anything but moonshine.

If this is a venture of faith and the most constant of all the ventures with which we are concerned, it is nevertheless only one of the many differing things which can be brought under my heading. I should like to refer in the first place to some matters with which I have been concerned.

During the war—and I am not concerned for the moment in dealing with the reason—there was a greatly increased sense of purpose in relation to a totally different aspect of governmental activity: the welfare of colonial peoples. It is difficult to give a date to this development, but roughly speaking it came with the

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