ELECTRO-CARDIOGRAPHY AND ITS IMPORTANCE IN THE CLINICAL EXAMINATION OF HEART AFFECTIONS.

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(Concluded from vol. i, 1912, page 1482.)

PART III.

The Analysis of Cardiac Irregularities.

In the preceding articles I have dealt almost exclusively with illustrations of the value of electro-cardiography in the examination of hearts which beat regularly. In the present article I propose to describe and illustrate the more important forms of heart irregularity as they are portrayed by this method. Formerly it was customary to class all types of cardiac irregularity together, or at the most to distinguish between "intermittence" and so-called "delirium cordis." To-day our knowledge of arrhythmia of the heart forms one of the most complete chapters of clinical medicine. We are largely indebted to electro-cardiography for this knowledge. We now know that there are a number of different causes of disorderly heart action, and that they have widely different effects upon the circulation and upon the life-histories of the patients in whom they occur. We have learnt that the response of a heart, in which the chamber contractions are disorderly, to therapeutic agents is largely controlled by the nature of the disorder which is present. It is no longer sufficient to speak of this or that heart action as irregular; we must know the form of the irregularity, the part which each heart chamber plays in it, and its site of origin. This information is supplied by the galvanometer.

So-called "Intermittence" of the Pulse.

In many patients in whom the radial pulse and heart contract with perfect uniformity for long periods an occasional and isolated disturbance is noticed. The pulse is said to "intermit"—it loses one of the serial beats at intervals. The pause, which interrupts the otherwise perfectly regular pulse, is due to one of three causes:

1. *Whole Heart Silences.*—The pause may be due to a rare phenomenon, the complete loss of a whole heart-beat. During the pause the recorded line runs straight (Fig. 15a); no trace of either auricular or ventricular contraction is visible during it. On account of the rarity of the condition, its prognostic significance is at present imperfectly understood. The irregularity is usually vagal in origin.

2. *Dropped Beats.*—The pause contains no ventricular contraction, but an auricular summit P is seen at the

expected point (Fig. 15b). When I say expected point, I mean that the auricular contraction falls at an equal distance between the preceding and succeeding contractions of the same chamber. The auricular rhythm is undisturbed, but a single response of the ventricle is lost.

This form of heart irregularity is not infrequent, and is especially common in patients who are under the influence of drugs of the digitalis series. It also occurs in acute and chronic rheumatic infections, in pneumonia and other conditions. It is due to a deficiency in the functions of the auriculo-ventricular bundle (heart-block), and is in reality an exaggeration of a condition previously described—namely, prolongation of the P-R interval. Its significance is the same, and has been discussed in a previous article. It is a grave sign.

3. *Premature and Weak Contractions.*—The pause may be occupied by a premature and abnormal contraction of the ventricle.† The premature beat is recognized by its strange shape, and by its falling at a point earlier than might be anticipated. It prevents the response of the

ventricle to the succeeding auricular contraction; and this auricular contraction usually falls with the abnormal ventricular beat (Fig. 15c). The auricular rhythm is undisturbed, and, after the pause, the ventricle again responds to the succeeding beats of the auricle.

It is often possible, from the form of abnormal beat, to identify the region of the ventricle from which it arises. It may be stated that it comes from the right or basal portions of the ventricle, or from the left or apical portions. The illustration (Fig. 15c) is of a beat which has arisen near the right and basal portion of the ventricle.‡

This form of irregularity is extremely common; most adult men of sedentary occupation exhibit it from time to time. It is a disturbance of little consequence. The importance of recognizing it lies chiefly in its possible confusion with the other forms of irregularity.

Coupled and Tripled Beats.

A pulse or apex beat is not infrequently felt, in which the beats appear in groups of two or three. The beats at the apex may be similarly grouped. Such pulses are due to one of two chief causes. If, while the auricle beats regularly, a response of the ventricle to each third auricular contraction is missed, the remaining ventricular contractions necessarily occur in couples. If each fourth beat of the ventricle is missed, the remaining beats occur in groups of three (Fig. 17). Coupled or tripled beating of this kind is the result of heart-block.

Coupling or tripling of beats may be due also to frequent intermittences, resulting from premature contractions. If a premature contraction of the ventricle replaces alternate heart cycles, then a normal beat and a premature beat fall closely together (Fig. 16) and form a couple, separated from

† It may also be occupied by other forms of premature beat, which for the sake of simplicity I shall not consider.

‡ This conclusion is based upon experimental observations.

Figs. 15a, b, and c. Three electro-cardiograms, showing the manners in which intermittence of the pulse may arise.

* Work in the tenure of a Beit Memorial Fellowship.

the next couple by a pause of unusual length. Both normal and premature beats may often be felt and heard at the apex beat, but the premature (or second) beat of the couple may fail to affect the pulse. If the premature beat appears at the wrist the pulse beats are coupled. If it does not, the pulse-rate is half that found at the apex beat. Tripling is produced at the apex when a premature beat replaces each third normal cycle.

The significance of coupled or tripled beating depends upon its causation. If due to heart-block, it is of far more

Fig. 16.—Electro-cardiogram showing one form of coupling of the heart beats. Each normal cycle (P, R, and T) is closely followed by a premature ventricular contraction (P, B), which coincides with an auricular beat. These abnormal beats have arisen in the right and basal portions of the ventricle (see Fig. 15 c). The premature beats failed to reach the pulse, the rate of which was 51 per minute. The auricular or true heart rate was 101.

consequence than if due to premature contractions. The difference between the two forms from this point of view has already been discussed.

Halved Pulse-rate.

If in a patient, whose heart has been beating regularly, the pulse suddenly falls to one half its previous rate, it will be evident from the previous paragraph that the disturbance may be due to the occurrence of premature beats. If such be the cause, the electro-cardiogram will show the weak ventricular contractions. Often they may be discovered by ordinary clinical methods; but not infrequently, when the beats are exceptionally weak, and especially if the heart sounds are indistinct, they cannot be discovered in this manner. However weak they may be they are always fully displayed by the galvanometer (Fig. 16).

If the pulse-rate falls to half its original rate, the ventricular-rate may also fall to the same extent. In such a case the electro-cardiographic examination usually discovers two auricular contractions for each ventricular beat. Alternate auricular contractions have alone awakened ventricular response. Halving of ventricular rate, produced in this way, is one of the types of bradycardia, two of which were described in a previous article.

Gross Irregularity of the Heart: Auricular Fibrillation.

There are many forms of heart irregularity other than those which I have so far described. It would occupy too great a space were I to attempt their description. I shall consequently confine myself to one further illustration.

In most patients who suffer from heart disease and in whom the pulse is irregular the pulse irregularity is of a gross type. In the examples of disordered action previously described the derangement is of relatively simple form, consisting of "intermittences," halving of rate, or groupings of beats which are repeated from minute to minute. But the heart's action may be so disorderly that the confusion is extreme, so that few of its cycles appear to be of the same length and the beats or pulsations are of varying strength. Such an irregularity may be due on

rare occasions to irregular generation of the impulses at the normal site, and the whole heart is then involved in the same irregularity (Fig. 18). Such an irregularity is termed a sinus arrhythmia,* and is of no serious prognostic moment. It may also be due to a complex admixture of premature and normal beats, but this form of disordered action is also rare. In 60 to 70 per cent. of all failing hearts irregularity is the result of a remarkable phenomenon which I described in this JOURNAL three years ago, namely, fibrillation of the auricles.

Auricular fibrillation is a condition in which the co-ordinate contraction of the upper chambers is entirely lost; the muscle fibres no longer move together and perform the act of systole, but the walls of the chambers stand in a position of diastole, while fine flickering movements are visible all over their surfaces.† The muscle mass seems to be subdivided into a number of small foci, each of which is contracting independently of the surrounding tissue. The active emptying of the auricles has ceased; they remain always full of blood. That is the mechanical effect of fibrillation; but there is a further and far more

important effect. As soon as the co-ordinate contraction is replaced by fibrillation, so soon are the slow and rhythmic impulses which normally stimulate the ventricle lost, and they are replaced by a large number of haphazard impulses which issue from the auricular turmoil. The result is a rapid ventricular action of an extremely gross type.

The importance of fully understanding the mechanism of this pathological condition and appreciating its effects upon the circulation can scarcely be over-emphasized. In

Fig. 17.—Electro-cardiogram showing one form of triple heart beats. All the ventricular beats (R, S, and T) are preceded by auricular beats (P); but there is a failure of the response to each fourth auricular contraction. Note that after each long pause, the P-R interval is short, and as the group of beats proceeds it gradually widens—that is to say, a gradually increasing difficulty in conduction occurs, until finally response fails at the end of each group.

rheumatic heart disease it is one, if not the most serious, event in the history of the affection. As a general rule, once it appears it remains until death.‡ The rapid ventricular action which it engenders is immediately felt, and is often the cause of the initial breakdown; for a weakened heart muscle cannot maintain an unduly accelerated rate. Moreover, as a large number of the beats are weak and fail to reach the pulse, a great deal of the excessive work is wasted. The rapid and turbulent action is speedily followed by venous engorgement, and signs of pulmonary and abdominal stasis may soon appear as an immediate result.§ Thus the irregularity is the cause of serious

Fig. 18.—An electro-cardiogram from a patient who exhibited gross irregularity of the heart. It shows that the irregularity is of sinus origin—that is to say, the heart beats are generated irregularly. All the heart chambers are affected in the same manner; each ventricular beat (R, T) is preceded by an auricular summit (P).

circulatory embarrassment, and is not, as was formerly

* Sinus irregularities also include the respiratory irregularities of children, where there is a waxing and waning of rate with each act of breathing.

† Our knowledge of these appearances has resulted from experiment. ‡ In a limited percentage of the cases it occurs in paroxysms, giving rise to a type of paroxysmal tachycardia, which is characterized by periods of gross pulse irregularity.

§ The diastolic position of the auricles and consequent stagnation of blood in them might be supposed to predispose to infarction of the lungs; but so far I have been unable to find clear evidence of it. It may be that clots formed in the auricles while fibrillation is present are less readily detached.

taught, the result of such embarrassment. That such is the case is known, for the irregularity appears first; it serves as a warning of future events. Moreover, the circulatory failure is not always immediate; when the heart muscle is stronger it may not show signs of failure until months or years after the onset of the disturbance.

The recognition of the disorder when it is seen—and it is frequently seen by all who practise medicine—is of consequence from several points of view. When, as is so often

Fig. 19.—An electro-cardiogram taken from a case of mitral stenosis; the heart contracted in a grossly irregular fashion. The curve shows that the irregularity was due to auricular fibrillation. The ventricular beats are of the usual form (R and T); the impulses have consequently come down from a point above the ventricle. The whole curve shows continuous oscillations of large amplitude (the conspicuousness of the oscillations is an indication of auricular hypertrophy), oscillations which, as I have shown, result from the fibrillation of the auricles. There are no P summits, representing co-ordinate auricular contraction.

the case, it develops in a case of mitral stenosis, a murmur limited to presystole is no longer audible, for this murmur is dependent upon co-ordinate contraction of the auricle. So it often happens that patients who have exhibited either no diastolic murmur, or only an early diastolic murmur at the apex during life,* are found to have mitral constriction after death.

But its recognition is of chief importance on account of the indications it gives for treatment. These are the cases in which digitalis may be looked to to give its conspicuous reaction. Administered in suitable doses, a great reduction of heart rate and a rapid improvement of the circulatory conditions may be anticipated in a large number of the cases, especially in young subjects. The fibrillation is not abolished, but a check is placed, and may be maintained, upon the number of impulses which reach and stimulate the ventricle. In such cases digitalis brings one of the most successful changes which modern therapeutics can record. Not only does it bring the moribund back to life, but it staves off disaster in those in whom the approach of failure is threatened.

While the disorder may be recognized in a large percentage of cases by ordinary clinical means, its certain and invariable demonstration can only be accomplished electro-cardiographically. The type of curve which it yields is illustrated by the last figure (Fig. 19). The curve was taken from a patient already under the action of digitalis; the ventricular action (R, T) is consequently relatively slow (the actual rate is 70 per minute; it had been 150). The shape of the ventricular curves (R, T) indicates the usual spread of the ventricular contraction, the impulses have come from the auricle. True P summits are absent, for the auricles are no longer contracting co-ordinately. The P summits are replaced by a series of irregular oscillations (f, f) which may be traced continuously throughout the whole curve. These little oscillations are the result of the perpetual and tumultuous activity in the walls of the auricles. They are the result of "fibrillation" in these chambers.

SUMMARY.

To sum up, galvanometric examination of the heart is important from many points of view. It may give indications of enlargement of the walls of one or other cardiac chamber; it may accurately locate small lesions in the musculature. It informs us when the heart beat starts at the normal impulse centre or away from it; in the last named condition it tells us that the rhythm is no longer under the normal nervous control—a fact which is of fundamental importance in the management of our case; it tells us within certain limits where the new beats have their origin. It gives us a separate record of contraction in auricle and in ventricle, and accurately defines the time relation of contraction in one chamber and the other; thereby it frequently elucidates physical signs which otherwise remain obscure. It provides us with a perfect means of ascertaining the functional efficiency of the

auriculo-ventricular bundle, the sole conducting tract upon which the ventricle depends for the reception of impulses which start its contractions. It allows us to differentiate between separate forms of slow and rapid heart action, which are of totally different significance. It provides us with an analysis of every form of cardiac irregularity, an analysis which is unrivalled in its precision by any other method. While the information derived from it relates essentially to the condition of the muscle, the method is

often helpful in the diagnosis of lesions of the valves. It brings us into nearer contact with the functions of the heart muscle than does any other clinical method; it is a precise means of studying the heart as a living and moving organ.

The information obtained by electro-cardiography is not, as commonly thought, of purely scientific interest in the analysis of disordered heart action. It has a great and growing value in the practical management of patients. There are few heart cases in which our knowledge is not added to by its employment, and in a steadily increasing percentage facts which are essential if sound prognosis and treatment are to be attempted are elicited. The time is at hand, if it has not already come, when an examination of the heart is incomplete if this new method is neglected.

SUBPERIOSTEAL HAEMATOMA.

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THE two following cases are recorded because they seem to throw some light on the pathology of cases in which formation of new bone is associated with injury to the periosteum.

CASE I.

A. P., male, aged 16, came under my care at the West Ham Hospital in January, 1911. He complained of pain in the knee and front of the thigh, which began after a fall on to a rail in November, 1910. The pain was constant, of a dull aching character; it was made worse by exercise, and was relieved by lying down. On the front of the thigh, just below its middle, could be felt a hard irregular swelling. This was fixed to the bone, and was less evident when the knee was forcibly and voluntarily extended. The movements of the knee-joint were not interfered with, and the skin over the swelling was normal. An x-ray photograph which was taken showed a deposit of new bone, lamellar in character, and lying for the most part parallel to the shaft of the femur.

An exploratory operation was performed, and an irregular plaque-like mass of rough cancellous bone was found. This was deep to the periosteum and in close contact with the shaft of the femur. The wound was closed, and the limb kept at rest on a splint for three weeks. At the end of that time the mass was considerably smaller, and all pain had ceased. Seven weeks after the operation the mass was scarcely palpable, and a skiagram taken showed nothing but a slight smooth swelling.

CASE II.

L. D., female, aged 23, was admitted to the Cancer Hospital under the care of Mr. Jocelyn Swan, to whom I am indebted for permission to publish this case. Her history was as follows:

Seven weeks ago she fell off a counter and severely bruised her left thigh. She was unable to walk for an hour or two, but afterwards resumed work. She began to feel pain directly after the accident, and this drew her attention to a swelling in the thigh. A fortnight after she attended another hospital where an x-ray photograph was taken, a diagnosis of sarcoma made, and she was advised to submit to amputation. She was able to walk, but had severe aching pain after prolonged standing. On admission she stated that no increase in the size of the swelling

* Such patients are not infrequently mistaken for aortic cases.