Texts and Documents

AUGUSTUS DESIRÉ WALLER (1856–1922)

The electrocardiograph is one of the most important instruments with which to examine the human heart and is in constant use all over the world, yet we doubt whether many physicians know who was the first man to demonstrate that the electrical response accompanying the movement of the human heart could easily be shown by a clinical application of a relatively simple instrument. In the early part of the nineteenth century it was known that electrical phenomena accompanied the action of the muscular heart of the lower animals. But no one had demonstrated whether this was the case in the human being since cardiac surgery had not yet begun, and the clinical method demanded a simple technique which could be applied to any patient. The name of the man who first demonstrated the electrical changes that accompanied the movement of the human heart was Augustus Desiré Waller.

Waller's father was a practitioner who took up physiology and was the discoverer of the method of degeneration of nerves, so that every student of medicine knows about 'Wallerian degeneration of the nerves'. His name was Augustus Volney Waller and he went to live in Paris where his son Augustus Desiré Waller (born on 12 July 1856) spent his childhood and went to the Collège de Génève for a time. The father died in 1870 and the mother, probably for financial reasons, took her son to Aberdeen where he was educated as a medical student, qualified in 1878 and obtained his M.D. in 1881. He also studied at Edinburgh. Like his father he was interested in physiology and took this up as his speciality. In 1883 his first appointment was as lecturer on physiology at the School of Medicine for Women in London, where he fell in love with one of the students, the daughter of Sir George Palmer (of Huntley and Palmer Ltd.). They were soon married and lived a very happy life, for the wife helped her husband in his work and her name appears with his in some of his published work. In 1884 he was appointed lecturer in physiology also to St. Mary's Hospital, Paddington, where he lectured until 1903 when he was appointed honorary professor of physiology at a new department of physiology at London University. At St. Mary's he had quite a good lecture theatre and adjoining it was a large room where he carried out his researches. He was intensely interested especially in the physiology of nerves and of muscle and he did many operations on many kinds of the lower animals to show the electrical responses which the cardiac muscular action produced. Then in 1887 he suddenly thought that there might be a way of recording the electrical phenomena of the human heart by a simple experiment which gave no inconvenience whatever to the person whose heart was being tested. The result was successful and as soon as possible he demonstrated his findings before a meeting of the Physiological Society. (*Proc. physiol. Soc.*, **8**, 1887). The next year, 1888, he was asked to deliver the opening address at St. Mary's Hospital Medical School and to the lay audience in simple language, he devoted a large part of his address to a simple explanation of the discovery he had made.

This was recorded in the *British Medical Journal*, 1888, **ii**, 751–54, as follows:

> . . . The St. Mary's Hospital Medical School is at present rapidly growing, not merely in size, but in complexity; and she has within the last few years developed two entirely new organs, a

physiological and a pathological laboratory. It is not unnatural that those who are most responsible for the development should be glad to hear something about the functions of these organs, and should expect from me as the person responsible for the physiological laboratory some report of progress during the last four years. . . . Our new bit of knowledge is about the human heart, not in a metaphysical or figurative sense, not its motives, but only its action, not its power, but its electrical potential. Put into a single sentence, I am going to describe how the heart of man can be shown to act as an electrical organ, and what we learn from such action. It is a well-known fact that every beat of the heart is accompanied by an electrical disturbance; the nature of this disturbance has, moreover, been studied and understood with the assistance of cold-blooded animals, and in this laboratory in particular an investigation was carried out to learn whether or no warm-blooded animals manifest similar electrical disturbances. These I will not now enter upon, and will only make the passing remark that, while to all appearances the electrical disturbances are similar in the two classes of animals, they are not identically so; these seem to indicate that the contraction, which at each beat of the cold-blooded heart runs down from the base to the apex, runs in the opposite direction in the warm-blooded heart. But this is only by the way, and I make no attempt to explain. It is to the next step that I invite your attention today, namely to the human heart.

Led on from thought to thought it occurred to me that it should be possible to get evidence of electrical action on man by connecting not the heart itself, which is obviously impossible, but parts of the surface of the body near the heart with a suitable instrument; having verified this supposition, the next step was to see whether or no the same evidence can be obtained by connecting the instrument with parts of the body at a distance from the heart, with the hands or feet. The answer was, as you will see, satisfactory. Finally, I tried whether two people holding hands and connected with the instrument, gave evidence of electrical shocks through each other, and I found they did.

The only portion which I wish to explain in any detail is the second step in these experiments, namely, the analysis of the results which are obtained when a single individual, whether man, horse, or dog, is connected with the electrical indicator.

Let me briefly explain the principle of action of an electrical indicator by referring to this diagram [see fig. 1], in which the effects of water-pressure are compared with those of what I may call electrical pressure (potential is the correct term, but I take it to be part of my task today to avoid technical terms).

A and B are two bottles of water, each connected by flexible pipes with a bent tube half full of mercury. If the two bottles are at the same level, the mercury in the bent tube remains at zero, and it is evident that this is still the case if both bottles be raised together or lowered together. But if the bottles are moved unequally, either up or down, the level of the mercury will alter. It is obvious that if A is lower than B, the mercury in this limb of the tube will move upwards, whereas if B is lower than A it will move downwards. And if we imagine everything hidden from us by a screen with the exception of this portion of the tube which we can view through a circular opening, while the two bottles are being moved by unseen hands, it is obvious that we shall be able to tell by the movements of the index, whether A is below B or B below A. If the mercury goes up A is below B, if it goes down B is below A.

Now this is precisely what happens when the two ends of an electrical indicator are in connection with any two points A and B of a living body. If A and B are at the same level the index stands at zero, and it does not move if the two points are raised or lowered together to an equal amount. If the index moves up we know that A is lower than B, if down that B is lower than A.

Let us now apply our instrument to the heart. This, which seems rather a bold proposition, is really a very simple and easy matter. We need simply dip the two hands into two basins of water which are in connection with our indicator, when we shall see that the mercury beats up and down with the pulse [see fig. 2]. These movements of the mercury are due to the electrical changes which occur with every beat of the heart; or we may dip a hand and a foot each into a basin of water with a similar result, only it must be the right hand, the left will not do. This difference, apparently so curious and puzzling at first sight, which seemed unsymmetrical and irrational, is in reality most reasonable, and proved to be the master key which threw open the meaning of subsequent experiment. The difference depends upon the unsymmetrical position of the human heart, which is tilted to the left side somewhat, as shown in this diagram.

Allow me to return for one moment to the physical ABC of the subject. The points A and B are respectively applied to the apex and base of the heart; and if with the contraction of the organ these two portions undergo any electrical change, the change will spread over the whole body in accordance with known laws. I will say no more than that. The form of the change is represented

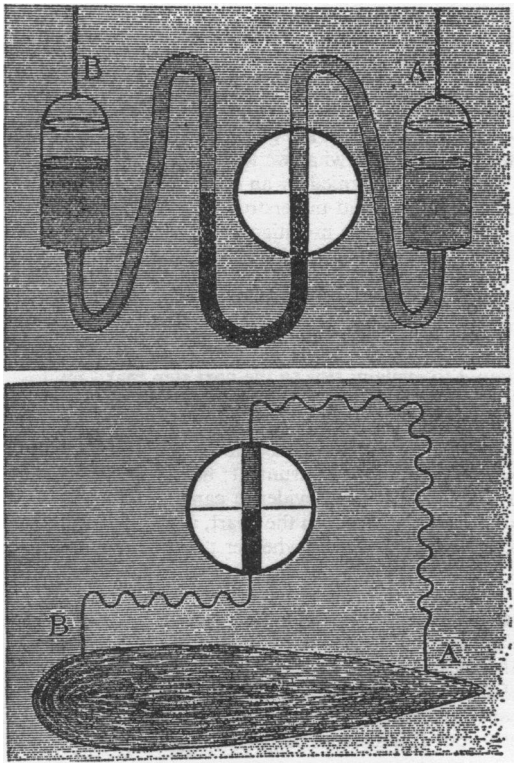

Figure 1

Figure 2

by these oval lines; if the electrical level falls at A it falls over the red area which, as you see, includes the left hand and foot and the right foot. If the electrical level falls at B it falls over this blue area, which includes the right arm and the head.

Now it is obvious that the two ends of the indicator must be connected with A and with B before it will indicate any difference between A and B. If both ends are connected with B, nothing will be seen. This is precisely what we got when the left hand and a foot were connected with the instrument, which begins to pulsate as soon as the right is substituted for the left hand. I might multiply instances, but will only just mention one. You must connect up a blue and a red point; two blue points or two red points are ineffectual.

But this evidence does not stand alone. Cases every now and then present themselves with a transposition of the viscera, which are in such people situated just like those of a normal person as they would be viewed in a mirror. The heart, among other organs, is reversed, and, instead of pointing to the left, points to the right. As regards the electrical relations which I was following out, they are precisely as expected. The left arm was in this case the exceptional limb, and formed an effectual couple with any one of the three other limbs, but was ineffective in combination with the mouth. To make a long story short, the results were throughout as indicated in the diagram; any two blue points in connection with the indicator were silent, but as soon as connection was made with a red point and a blue point then the index moved with each pulsation of the heart.

Let us hear one more witness. The heart of a quadruped (dog, or cat, or rabbit, or horse) is placed far more symmetrically than in man; it is very nearly in the middle line, so that the changes of electrical level whose foci are at A and B spread straight up and down the body, not obliquely as in man [see fig. 3]. The upper half of the body is under the influence emanating from B; the lower half that emanating under A. Unlike what occurs in man, the two front paws coupled with an indicator are silent, while either front paw taken with either hind foot gives us the now familiar answer. These are the principal facts. What can we learn from them with regard

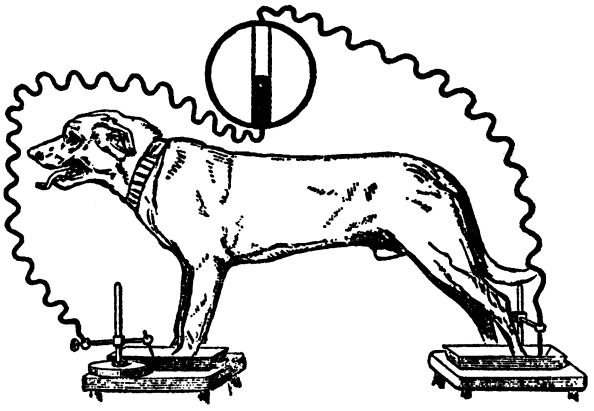

Figure 3

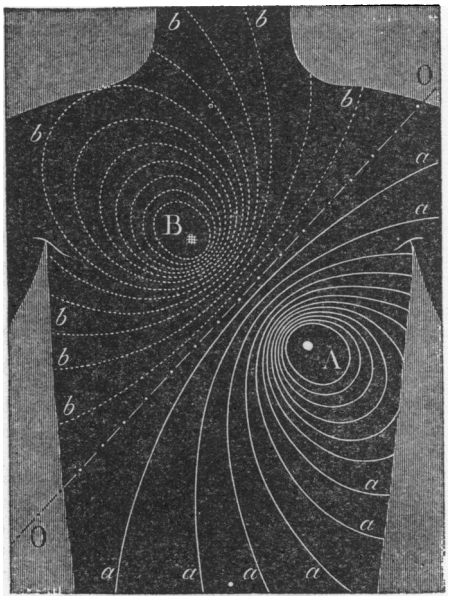

Figure 4

to the normal action of the heart? I must be content with simply stating the answers.
The fact that each beat of the heart gives an electrical change beginning at one end of the organ and ending at the other, proves that the contraction does not occur throughout the mass of the heart at one and the same instant of time; if the two points A and B rose and fell together, there would be no alteration of the index [see fig. 4]. The movements of the index show that there is a fall of A at the beginning of the contraction, and a fall of B at the end of the contraction. One of the most certain and fundamental facts in physiology is that the active state of a living tissue is marked by a fall of electrical level; in other words, an electrical depression is the best, most certain, and most delicate physical sign of physiological action; it proves the fact that living tissue is in excitement just as certainly as a dog's bark proves that a living dog is in excitement; A barks first, B barks last. In the contraction of the human heart the beat begins at the apex and ends at the base.
We have here the answer, and more than the answer, to a question which has often been asked but never settled, namely, does the heart (that is the ventricles) beat simultaneously in every portion, or does the contraction take place progressively, as a state of action traversing the whole mass from a beginning to an end? The answer is a distinct affirmation of the second alternative to the exclusion of the first, with the additional and unexpected rider that the contraction begins at the apex and terminates at the base.

(Waller was using the old Lippmann's capillary mercury galvanometer.)

In the following year Waller demonstrated his discovery before the Royal Society and a few years later, when he was only thirty-six years old, he was elected a Fellow of that distinguished society.

In 1903 Waller left St. Mary's Medical School to take charge of physiological research as a professor in London University. One of his first researches was an investigation as to the best means of safely administering chloroform. Vernon Harcourt was called in to assist and the result was the devising of a method of administration

which, if the instructions were carefully carried out, provided a very safe method of giving chloroform.

At first Waller did not think that his discovery of the electrical reactions of the human heart was likely to be of great clinical value. But the work of Sir Thomas Lewis convinced him that electrocardiography might be of great importance. Waller was attached to the Westmorland Street Heart Hospital and took a great interest in the further development of electrocardiography and in 1921 published an account of an examination of three thousand electrocardiograms. The great development of this subject was largely due to the invention of the string galvanometer by Einthoven, who had seen Waller's earlier attempts and may possibly have been stimulated to seek a method of easier clinical application. There is no doubt that Sir Thomas Lewis popularized clinical electrocardiography and it is relevant here to quote the words of appreciation of Waller's discovery made by Lewis which ran as follows:

> May I add a few words of tribute to the memory of Prof. Waller whose death will be much regretted by both physiologists and physicians in this country and in many other lands. He was a man of unusually keen intellect, and had been for many years a notable figure in British physiology. His brilliant powers of exposition will long render his demonstrations at the Physiological Society memorable. His early work on electro-physiology was extensive, thorough, and is well known. He was the first to show that the currents set up by the beating of the human heart can be recorded; he was the first to obtain a human electro-cardiogram, this has been the main though by no means his sole contribution to the science of experimental medicine. The discovery long preceded the introduction of the string galvonometer and, was the more remarkable in that it was accomplished in the eighties.

This quotation is taken from the obituary of Professor Waller written for the Royal Society by Professor W. D. Halliburton.

DR. AUGUSTUS DESIRÉ WALLER'S CHARACTER

Augustus Desiré Waller was rather short in stature. He had an 'intelligent' face which was made a little longer by a small pointed yellow beard. His voice was clear and rather slow.

During the time I was his pupil (1900–1901) he lectured only from October to December at twelve noon on four or five days a week. He never lectured on any subject other than muscle and nerve, and his textbook on physiology laid special emphasis on those subjects. (The rest of physiology was taken by Legge Symes.)

I well remember the first lecture I heard by Waller. He stood up on the platform and said 'Gentlemen I do not know what to lecture on but I will leave it to chance. There is my note book. I will let it open wherever it may'. Then, placing it on the table, he let the book fall open. 'It has opened at Muscle', he exclaimed, 'so I will lecture on that'. He kept the students in good order, and they were silent and attentive. If ever they were not he soon showed his mettle. On one occasion a student in the front row lay back in his seat, stretched out his legs and opened his mouth wide to give a yawn without his hand in front of his mouth. Waller stopped his lecture, slowly but quietly walked from the platform, and stopped exactly in front of the blushing and confused student and said 'Sir, I . . . do . . . not . . . want . . . to . . . look . . . down . . . your . . . th . . r . . o . . a . . t.' He then returned slowly to the platform and continued his lecture. That was over seventy years ago but I can still picture the scene and hear that devastating voice.

The class remained perfectly silent.

Waller could enjoy a joke. When he came to lecture after his marriage to Miss Palmer he took it in good part when he saw written on the blackboard 'Waller takes the Biscuit'.

Waller's experiments always 'came off'. He was very careful about that and I can still recall the gentle and delicate way in which he fitted the unpolarized electrodes. In the practical exercises he was very helpful.

He has a son who held a physiological post in Manchester and one of his daughters was for many years lecturer on physics at the School of Medicine for Women. Dr. Waller died on 11 March 1922 after two apopleptic strokes. He was recovering well from the first but the second proved fatal.

The omission of his name from the *Dictionary of National Biography* is inexplicable and very sad. I hope that someone will in due time write a more detailed biography.

ZACHARY COPE