CLINICAL LECTURES

ON NERVOUS DISEASES.

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LECTURE III.

ELECTRICITY AS A METHOD OF PHYSICAL DIAGNOSIS IN DISEASES OF THE NERVOUS SYSTEM.

THE uses of electricity as a method of physical diagnosis in diseases of the nervous system has not yet occupied that place in the ordinary systematic course of practice of physic to which it is perhaps entitled. In electricity, we possess a powerful force which can be demonstrated to produce definite and characteristic phenomena on healthy tissues, which conditions are suspended or altered when those structures are injured or diseased. The study of such varied modifications must, if properly applied, give us assistance in the detection of abnormal states; and any exact method of research which will enable us to investigate with greater accuracy so difficult and so obscure a class of diseases as those of the nervous system will constitute a great advance in scientific medical diagnosis.

Like every other science applied in a new direction, the virtues of electricity have, on the one hand, been grossly overrated and abused; and, on the other, decried as absolutely useless or positively injurious. With neither of these extremes have we to do; but we venture to join the ranks of those who, neither dazzled by the promises of the former, nor discouraged by the scepticism of the latter, endeavour, with judicious impartiality, to weigh the evidence before them, to throw aside vague assertions and hypotheses, and to elicit what definite facts they actually possess on the subject, and how these truths may be applied to the practical uses of their profession.

For a long time, various forms of electricity have been employed as therapeutic agents, but on such empirical and unscientific principles as to have failed to convince the profession generally of their utility; indeed, owing to the somewhat attractive nature of the supposed remedy, and the opportunity it affords to unscrupulous persons of benefiting themselves at the expense of the patient, its employment has often been looked upon with distrust and suspicion.

It is only comparatively recently that electricity has been employed as an agent for physical diagnosis, owing chiefly to the researches of Du Bois Reymond, Pflüger, Matteucci, and others, whose discoveries have indicated a more rational and scientific application of this powerful force; and their labours on its physiological actions on the healthy tissues have greatly revolutionised our knowledge of the subject, and assisted us in applying that agent for the detection of disease.

In the limits of a lecture, it would be impossible to enter upon a consideration of the physics of electricity, the different forms of batteries employed for clinical purposes, the various methods of employing them, and the many uses to which they are applied. At present, an attempt will be made to lay before you the general principles on which electricity is employed in the diagnosis of diseases of the nervous system; and such elementary discussions will only be introduced as will enable you to follow the general argument.

For practical purposes, two forms of electricity are employed; namely, the induced or faradic, and the continuous or galvanic currents. The sources from which these are derived, as well as their physical and chemical properties, entirely differ from one another; but with these and other general considerations it must at present be assumed that you are acquainted, and we must devote our attention to their physiological and pathological actions.

In order that electrical reactions in disease may be thoroughly appreciated, a preliminary knowledge of their behaviour in health is essential. We shall therefore discuss the subject under the following heads: 1. The actions of the faradic and galvanic currents upon healthy living tissues; 2. Their actions on injured or diseased living tissues; and 3. The utilisation of our knowledge on these questions for the purposes of diagnosis.

1. *The Actions of Faradism and Galvanism upon Healthy Living Tissues.*—In all the tissues of a living animal where active nutrition is being carried on, there are natural currents of electricity constantly flowing, the character and direction of which can be determined by a delicate galvanometer. In nerve and muscle, this electro-motive force is the greatest; and in them, in common with the other tissues, their interior and exterior aspects are inversely electrified, the current flowing from the latter to the former, from longitudinal to transverse surfaces, and, in the human subject, from the feet to the head. This is a matter of some importance; for, when a current of electricity from a battery is sent in the same direction as the natural animal current, the functional irritability of the tissues is augmented, but if in an opposite direction it is diminished.

The physiological effects of electricity depend upon the form, intensity, mode and length of application, and to the organ and vitality of tissue which come under its influence. The *faradic* current is a powerful nerve-stimulant, and, like all other stimulants if used in excess, it paralyses in large, what it stimulates in small, doses. Consisting, as it does, of a series of rapidly repeated shocks, it has little or no chemical or other effects. The *galvanic* current, on the other hand, has much more extensive properties. In addition to being a nerve-stimulant, it causes contraction of muscular fibre. In small doses, it dilates the blood-vessels, increases the circulation, and raises the temperature. In large doses, it paralyses the vessels, arrests the circulation, and causes destruction of the tissues. It profoundly modifies nutrition, and thereby stimulates into action all the organs. It chemically decomposes all the fluids and solids of the body, and may thus be used as a caustic, and it physically produces such heat as to be efficacious as a cauterising agent.

We shall now consider in detail the effects of each current as applied individually to the different organs and tissues, confining ourselves to those which bear on the present subject of inquiry, namely, the diagnosis of diseases of the nervous system.

The Brain.—The experiments of Hitzig, Ferrier, and others upon animals have shown that faradism, when applied to the surface of the cerebral hemispheres, stimulates the various centres into action which are supposed to originate special functions. Irritation at definite points on the surface of the convolutions, especially round the fissure of Rolando, gives rise to definite movements on the opposite side of the body; whereas in other situations, which have been ascertained not to be motor, the stimulus is not followed by any result. These centres of voluntary motion can, in fact, be stimulated by a weak faradic current into activity, and each thereby performs its own function in the form of special muscular contractions. Faradic irritation of all the motor basal ganglia and motor tracts in the brain cause unilateral movements of all the muscles on the opposite side of the body. Galvanic excitation of similar parts also causes the same muscular contractions, but only at the opening and closing of the current. Although by analogy we may fairly assume that similar phenomena would ensue in the human subject, I am not aware of this having actually been demonstrated. There is no evidence to show that faradism applied to the exterior of the scalp produces any physiological effects on the brain; but, if a strong current of galvanism be made to pass through the head of an animal, Matteucci found that contractions of all the muscles of the body could be produced; and in man, if a weak current be employed in the same way, definite cerebral symptoms will ensue, such as vertigo, sickness, fainting, convulsions, etc., which, although most marked at the opening and closing of the current, continue all the time it is passing. If the galvanic giddiness be produced by the cathode, or negative pole, being placed on the right side of the head, and the anode, or positive pole, on the left, surrounding objects seem to go from right to left. On opening the current, the body has a tendency to fall towards the anode, and, on closing, towards the cathode. It has been shown by experiment that, when the electrodes are placed on each side of the head, the current of electricity actually passes through the brain. The channel through which this takes place is, according to Erb, directly through the medium of the tissues. Dr. Althaus believes it to occur by reflex action through the fifth pair of nerves, and adduces a case to show that, when those nerves are paralysed, no physiological effects could be produced on the brain by application of electricity to the scalp.

The Spinal Cord.—In animals, a faradic current of sufficient strength applied directly to any part of the cord induces tetanic spasms of all the muscles of the trunk and limbs. This continues during its whole course, which, if continued long enough, will cause gradual diminution of these movements, and ultimate paralysis. If a weak current, sufficiently limited, be applied to the motor tract on one side of the cord, it would produce unilateral contractions; on the opposite side of the body if applied above the medulla, and on the same side if below that centre.

Galvanism, in the same way, if applied to any portion of the cord, results in general muscular contractions, but only on opening and closing the current. While the current is passing, there are no apparent movements, but a so-called inhibitory effect is produced, in so far that the cord is rendered insensible to ordinary stimuli; and, while in this condition, if faradism be applied, it will not induce movements of the muscles. This phenomenon is confined to the spinal cord, and does not extend to the nerves; for if, while the current is passing through the former, the latter be stimulated, the muscles readily contract. According to Onimus, a descending current diminishes, and an ascending one augments, the reflex irritation. Faradisation of the cilio-spinal region, or that portion of the cord between the seventh cervical and the sixth dorsal vertebrae, induces dilatation of the pupil through the influence of the sympathetic nerve, which here takes its origin. Irritation of the genito-spinal ganglion at the level of the fourth and fifth lumbar vertebrae causes contraction of the vasa deferentia, the bladder, and the lower portion of the rectum. There is no evidence that faradism has any influence on the cord of man; but both experiment and observation have demonstrated that distinct physiological effects are induced on that centre by the galvanic current; and this is proved, as pointed out by Erb, by the muscular contractions of the parts supplied from the region of the cord irritated.

Motor Nerves.—On irritating a motor nerve with electricity, the only visible phenomenon which follows is contraction of all the muscles which it supplies. Each shock of the faradic current produces a contraction. This also increases the excitability of the nerve, so that a second shock succeeding the first produces more marked muscular movements. This irritability continues to increase with each shock, and at last reaches a maximum which remains stationary for a time, and then gradually diminishes. If these shocks follow one another in rapid succession, there are no apparent intermissions, one contraction not having relaxed before another has taken place; hence there is tetanus, and this continues all the time the interrupted current is passing. If the application be protracted sufficiently long, the tetanus gradually becomes less marked, and ultimately disappears, the nerve having then lost its power of irritability and excitability. Thus the faradic current in moderate and limited doses stimulates the natural function of nerve, in large or long-continued doses it paralyzes it.

The action of the galvanic current on nerve is very different, and much more complicated. When this is applied with moderate power to a nerve, muscular contractions ensue; but these take place only at the moment of making and breaking the current. These are not of a tetanic nature, but short and sudden; and, while the current is passing continuously along the nerve, there are no muscular contractions. These phenomena are influenced by the intensity of the current; the stronger it is, the more energetic the contractions; and, if it be very powerful, there may be tetanic spasms not only on making and breaking, but during its passage along the nerve. The muscular movements vary according to the direction of the current, so that there are four different contractions: (1) the descending closure contraction, (2) the descending opening contraction, (3) the ascending closure contraction, and (4) the ascending opening contraction. These are further modified in strength by the intensity of the current; and the systematic arrangement of which has given rise to what is termed Pflüger's law of contraction, which is as follows.

	Descending.				Ascending.			
	Make.	Break.			Make.	Break.		
Very weak ..	..	..	c	—	..	..	—	—
Weak ..	..	..	c	—	..	..	c	—
Moderate ..	..	..	c	c	..	..	c	c
Strong ..	..	..	c	—	..	..	—	c

It must, however, be observed that this law has been compiled from observation on the lower animals from direct experiment on the dissected-out nerves, to which were applied both poles of the current in different situations. It will subsequently be seen how this table is explained by what has been termed electrotonus, and also that the phenomena are modified when only one pole of the battery is applied to the nerve. Electricity does not cause muscular contractions merely by the power the nerve possesses of carrying its influence to the muscles, but by its specific action in stimulating the nervous elements into functional energy. This is evidenced by the fact that, if a nerve be injured or diseased, no contractions are produced on irritation, although its power of conduction is in no way interfered with. It is also shown by the fact that, the further from the muscle the nerve is irritated, the greater the effect produced; and this is still more increased if a portion of the nerve-centre be included in the circuit.

In man, although there are not the same facilities for applying galvanism directly to the nerves, the same general law of contraction holds good. Here, however, instead of both poles of the battery being placed on any individual nerve, as in the experiments above cited, which give

the united effects of the two, a different system is adopted, termed the polar method of investigation. This consists of eliminating the effects of one electrode by placing it on a distant or indifferent part of the body, such as the back or sternum, and applying the other pole to the nerve, and observing its uncomplicated effects. In this way, also, four contractions are produced, namely, (1) C. C. C., or cathodal closure contraction; (2) C. O. C., or cathodal opening contraction; (3) A. C. C., or anodal closure contraction; and (4) A. O. C., or anodal opening contraction. Following this method, it will be found that different degrees of muscular contraction result according to the pole applied to the nerve, as well as to the intensity of the galvanism employed. The cathode always predominates over the anode in its power of inducing functional activity. If a very weak current be used, and both poles in succession be placed upon a nerve, and alternately opened and closed, as the current is gradually increased, the first contraction to appear is the C. C. C. As the intensity is gradually increased, the C. C. C. augments in force, and, in addition, the A. O. C. is developed. Further increase more fully demonstrates the C. C. C. and A. O. C., and next appears the A. C. C. Finally, a powerful current induces not only C. C. C., A. O. C., and A. C. C., each more powerful than the other according to its order, but ultimately C. O. C. The normal polar reactions of nerve, therefore, occur in the following order: (1) C. C. C., (2) A. O. C., (3) A. C. C., and (4) C. O. C. It must be, however, noted that, in the living human subject, the A. O. C. and A. C. C. are frequently of the same strength, and occur about the same time; and in some cases, even in perfect health, the A. C. C. is more marked than the A. O. C. Under all circumstances, both the A. O. C. and A. C. C. are much inferior in vigour to the C. C. C.

All the phenomena just described take place only when the galvanic current applied to the nerve is closed or opened; that is, when there is any sudden variation in its density. So long as the current is uniform, it may be increased to considerable strength without causing contractions. When galvanism is continuously passing through a nerve, although no muscular movements take place, the condition of the nerve itself is thrown into a peculiar state, termed electrotonus. This electrotonic condition is evidenced by a change in the physiological state of that portion of nerve through which the current passes; and, if this be in the natural direction—that is, upwards—electrotonus is augmented; but if in a contrary direction—namely, downwards—it is diminished. Under these circumstances, the nerve is altered in its power of evolving electricity, in its conductivity, and in its excitability. If a constant current be passing through a portion of nerve, there is a neutral point between the poles which divides it into two areas—namely, one in the neighbourhood of the anode, which is the anelectrotonic area; and the other near the cathode, or the catelectrotonic area. The extent of these two divisions depends on the strength of the current. With one of moderate power, the neutral point is midway between the two poles; with a weak current, it is near the anode, in which case the greater part of the nerve is in a catelectrotonic condition; and, with a strong one, the position is reversed, the neutral point being near the cathode, thus throwing the larger portion of the nerve into anelectrotonus. Now, the excitability and conductivity of a nerve is diminished in the neighbourhood of the anode, and augmented at the cathode; hence, when it is in a catelectrotonic condition, muscular contractions are more readily induced than when it is in a state of anelectrotonus. These changes are most marked at the poles, but extend for some distance on either side. The nerve is excited, and consequently there are muscular contractions when it passes from a lower to a higher state of irritability, as by the appearance of catelectrotonus, and by the disappearance of anelectrotonus. When the reverse takes place, there are no results. A large catelectrotonic area has the power of overcoming the effects of a small anelectrotonic condition; but, on the other hand, a small amount of the former may have no effect in the presence of a large area of the latter. A careful consideration of all these facts on the dissected-out living nerves of animals, and where the poles were directly applied, has given rise to Pflüger's law of contraction already cited.

In man, the same general rules apply, so far as they can be practically demonstrated. Following the polar method, it may be stated generally that the cathode placed over the nerve excites its irritability in the neighbourhood, and that the anode has exactly the opposite effect; while, after what has been already stated, it will be understood that a feeble galvanic current is more stimulating than a powerful one, as the former induces a larger area of catelectrotonus.

It has been already seen that, when faradism is applied to a motor nerve, tetanic contractions take place in the muscles, and remain so long as the current passes. On the other hand, when moderate galvanism is employed, contractions only ensue on opening and closing. This is due to the fact that motor nerves are excited, not so much by the amount of density of the current, as by the suddenness of its variations. With the induced current, these take place rapidly; hence a series of

quickly succeeding contractions, resulting in tetanic spasm; while, with the continuous, these changes only occur at opening and closing. If the galvanic current be rapidly interrupted, it has the same effect on the faradic battery in causing tetanus. Galvanism resembles faradism in this respect, that in moderate and limited doses it stimulates, and in large and prolonged doses it paralyzes, nerve-function.

Voluntary Muscle.—The faradic and galvanic currents directly applied to a healthy muscle produce precisely the same phenomena as when its nerve is similarly treated. This is due to their effect as the terminal intramuscular branches of the nerves. When these are destroyed by poison or otherwise, leaving the muscular structure healthy, the reactions are very different. The faradic current then applied to the fibres alone produces no contraction, neither does rapidly interrupted galvanism. But, if a continuous current slowly opened and closed be employed, there are muscular movements, and, while the current is passing, there is usually slight tetanic spasm. This demonstrates that the fibre is contractile without nervous influence, although in a different manner. There is another distinction; for, as we have already seen, when the nerves are intact, the muscular contractions under galvanic irritation are short, sudden, and complete. When nerve-influence is removed, they are more prolonged, more tardy in appearance, and less vigorous in degree. For this reason, if the variations of the electrical current be quickly recurring, the muscles do not contract at all, and this explains the failure in acting to the faradic and rapidly interrupted galvanic influences. To induce contractions, a longer duration of current is necessary, hence their response to the slowly performed opening and closing. Again, a stronger stimulus is necessary to produce the same effect when muscle is directly irritated as compared with nerve. The order of polar reactions is, however, precisely the same as in healthy nerve. To sum up, muscle, when deprived of nerve-influence, differs from the normal condition: 1. In the contractions being slower in appearing, longer in duration, and less vigorous in degree; 2. In requiring a prolonged application of electricity to produce contraction, hence the failure of action under faradism; 3. In requiring a stronger current to produce the same effect; and 4. With galvanism, there are contractions; with faradism, there are none; whereas in a muscle with the nerve intact, there are stronger contractions with the latter than with the former.

Sensory Nerves.—The effects of the faradic current on sensory nerves depend on its strength, the rapidity of the interruptions, and the nature of the electrodes. If of weak intensity, a slight pricking sensation is felt; if powerful, there is intense pain. A rapidly interrupted current has much more effect than a slowly interrupted one, the feeling from a single faradic shock being trifling; but, if rapidly succeeding one another, each is more powerful than its predecessor, from increasing irritation of the nerve, and hence there is greater pain. After a time, a maximum is reached, which remains stationary, after which sensibility diminishes. Gradually a feeling of numbness is produced; and then, although the current is augmented in strength, there is no increase of pain, and ultimately complete anæsthesia may be induced. A moist conductor, by enabling the current to pass through the skin, causes much less pain than a dry one, which encounters great resistance at the more sensitive part of the integument.

The galvanic current causes a sensation of stinging and heat, which continues while the current is passing. If the current be feeble, this is not unpleasant, but, if strong, there is intense burning pain. This is most marked with the cathode, and with a dry electrode. The effects increase the longer the current is applied, because not only does the nerve become more irritable, but the skin becomes a better conductor, owing to its increasing vascularity. If the current be sufficiently prolonged, the pain diminishes, and numbness, or even anæsthesia, supervenes.

At different parts of the body, the sensibility to the electric stimulus varies greatly; a current, for example, which is unbearable on the face, might not be felt on the sole of the foot. MM. de Watteville and Tschiriew have recently ascertained that "the electrical excitability of the skin, or, rather, of the nerves of the skin, is the same at every part of the body". Hence the actual differences of sensibility in various localities must be due to the variety of conducting media which surround the terminal peripheral nerves of the skin, such as thickness and dryness of epidermis, etc.

Both currents produce a peculiar sensation when applied to muscle called electro-muscular sensibility. This is due to contraction, and is proportionate to the strength of the electricity.

To sensory as to motor nerves, both faradism and galvanism act in small and limited doses as stimulants, and in strong and protracted doses as paralyzing agents.

[To be continued.]

THE MEDICINE AND SURGERY OF HOMER.

By HENRY DUNBAR, M.D.

It cannot but be remarked by those interested in the subject, and conversant with the poems of Homer, how that, in the *Iliad* more particularly, which is altogether taken up with the exploits of heroes, combats, wounds given and received, and death, very little allusion is made by the poet to the medical and surgical treatment of his disabled warriors.

That Homer, however, must have had a very considerable knowledge of the internal economy of the human frame, is abundantly made clear by his nomenclature of the different parts of the body, wounded, met with in various places throughout the *Iliad*, a nomenclature still, in many respects, in vogue with us at the present day; but how the great epic poet acquired his knowledge we have no means of determining. Did he acquire his knowledge of the internal structure of man's frame by ever having seen a dead body examined? To this there must be but one answer; the strongest impossibility that he ever did, for the touch, or examination, of the dead body was interdicted as a profanation by both Jew and Greek, and it was only after the death of Alexander the Great, when learning centred at Alexandria, under the fostering care of Ptolemy Soter, who made Alexandria the capital of his kingdom in 313 B.C., when literature was encouraged, and four schools of science founded—viz., criticism, mathematics, astronomy, and physic—that the examination of dead bodies was permitted. (This period was called the golden age of the Ptolemies.)

The most probable period of time in which Homer lived is considered by most men of learning to have been about 850 B.C. Troy was taken by the Greeks, according to our chronology, in the year 1184 before the Christian era; so that, by computation, Homer flourished about three hundred years after the fall of Troy, and about five hundred years before the reign of Ptolemy Soter; therefore, it was five hundred years after Homer's time that the examination or dissection of dead bodies was sanctioned. Although Homer may never have even seen the body of a deceased person opened for the purpose of being embalmed, yet he must have been aware of such a custom prevailing among the Egyptians; for, in *Iliad*, Book xix, 38, 39, he makes Thetis "instill into Patroclus (dead), through the nostrils, ambrosia and ruby nectar, that his body might be uncorrupted".

"Whole years untouched, uninjured shall remain,
Fresh as in life, the carcase of the slain."

Nectar was supposed to preserve from decay, and to confer immortality; while ambrosia is mentioned by Virgil, *Æneid*, Book xii, line 616, as possessing the power of healing wounds.

I would ask again, Did Homer ever see a human skeleton? That is possible. Did *Æsculapius*? Did his two sons Podalirius and Machaon? Were they acquainted with the anatomy and surgery of the human frame? History is silent on this subject; but that they all must have had some knowledge of the internal economy of man's material substance cannot but be conceded by every one. That the knowledge of medicine and surgery in Homer's time must have been in a very infantile and rude state does not admit of doubt. No mention is made of amputation (*ἀπόκοψις*); no setting of fractures, though broken bones were plentiful; no tying of arteries, which vessels were not known to exist in Homer's time, though *φλέψ* (phlebs), a vein, occurs in *Iliad*, Book xiii, 546; more probably, however, according to the scholiast's interpretation, who calls it a "hollow or empty vein", *κοιλὴν φλέβα* (*koiilên phleba*), it is either the trachea or the thoracic duct of our nomenclature that is meant by Homer; no mention of gout, *ποδάγρα* (*podagra*), or headache, *κεφαλαλγία* (*cephalalgia*), brought on by a disordered liver, or from being *Bacchi plenus*, occurs in Homer's poems, though his heroes, and the immortal gods themselves, "who inhabit wide Olympus", quaffed the wine-cup without stint, as we read of in the last lines of the first book of the *Iliad*, where "Ἥφαιστος (Vulcan) is pouring out, from left to right (of the seated gods), nectar from a goblet, and when inextinguishable laughter arose among his immortal *confrères*, when they saw him, the lame (*ἀμφιγυνής*) Hephaistos, hobbling about, wine-cup in hand. These Dii Majores feasted and drank the entire day till the sun set, when the Olympian Thunderer Jove arose, went to his couch and lay down to sleep, and

—"παρὰ δὲ χρυσόθρονος Ἥρη."

None of the ills to which flesh is heir troubled Homer's heroes; they came to the Troad, and sat down before Troy, sound in wind and limb; no asking to go home "on sick leave" or "on private affairs" ever came into their heads, though Agamemnon himself (*ἀναξ ἀνδρῶν*), when matters were looking black for the Greeks, once or twice counselled a going home to Argos.

Medicine and surgery, such as they were in Homer's time, were con-