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26.

ON THE
APPLICATION OF ELECTRICITY

DIRECTLY

TO THE NERVES AND MUSCLES

BY MEANS OF ACUPUNCTURE.

BY

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By JOHN E. MORGAN, M.A., M.D. (OXON.), F.R.C.P.

ALL who have had much experience in electro-therapeutics must feel that there are many cases, both of motor and of sensory paralysis, where the application of electricity to the epidermis, by means of the various electrodes at present in use, neither affords that exact diagnostic information, nor is attended by such favourable curative results, as we are justified in anticipating from our knowledge of its varied physiological effects.

The different organs and tissues of which the body is built up permit the continuous and induced currents to traverse their structures with considerable facility. Some, it is true, are very much better conductors than others. Indeed, the conductivity of the animal tissues seems to bear a very close relation to the amount of moisture they contain; muscles conducting far more readily than bones, and more readily likewise than cartilages, tendons, or nerves; while the resistance offered by the epidermis to the electric current is very great—so great, indeed, that in numerous instances I believe it materially interferes with the success of our treatment.

In discussing this question it is important to remember that the epidermis itself may almost be looked upon as an insulator. It is probable that the electric current makes its way to the parts which underlie it, chiefly, at any rate, by the sudoriferous ducts. In many cases, however, these paths are more or less closed. Often where this method might be expected to prove most beneficial the skin itself is found to have undergone important changes. In limbs long wasted the perspiration sometimes ceases to be poured out, and the sweat-ducts become gradually occluded; while in other cases the skin itself is in an hypertrophied condition, and thus opposes to the continuous and induced current a greater resistance than when it is healthy. It is said, indeed, that if the epidermis be thoroughly moistened with hot salt and water, it is itself converted into a good conductor. No doubt in this manner its conductivity may be greatly increased. Still, as I shall endeavour to show, its resistance to the different electrical currents is immense. In using electricity at the bedside I have long satisfied myself that there are certain cases where this resistance is so considerable that while the epidermis remains intact it is

impossible to act on the underlying structures. When, however, this obstacle to the electric current is overcome, marked results are immediately obtained. The question, then, which for some years has presented itself to my mind is this, how can we with most effect act directly upon the nerves and muscles? How can we bring electricity to bear on the deeper tissues without its encountering the resistance offered to the current by the epidermis? I first attempted to do this by the application of blisters to those parts of the body which I desired to galvanise. After the removal of the cuticle, the sponges were brought in contact with the denuded surface. But although these experiments convinced me that both galvanism and faradism act very much more energetically when applied directly to the muscles than when the epidermis intervenes, still the irritation set up by the blisters was so great, and the exhausting effects of this mode of treatment so marked, that I was reluctantly compelled to give up the procedure. I next tried to obtain the same results by inserting needles under the epidermis, and for some time confined myself to thrusting them subcutaneously into the connective tissue beneath the skin, much in the same manner as we are accustomed to do in injecting morphia by means of a syringe. Along these needles the electric currents gained access to the parts beneath the skin. In this manner I found that muscular contractions were far more readily induced than when electricity was applied to the outer side of the epidermis. Still the effects thus produced on the muscles and nerves were not so satisfactory or energetic as when the needles were thrust direct into the more fleshy portions of the muscles, and it is to this application of electricity that I desire more especially to direct attention on the present occasion.

It is now about twelve months since I first had recourse to this mode of treatment. I was not then aware that electric acupuncture had ever been practised as a curative measure. In this opinion, however, I find that I am mistaken. It appears that Sarlandière thrust insulated needles through the skin into the muscles in the year 1825—fifty-four years ago. He did not, however, use galvanism, but frictional electricity. Six or eight years later Magendie seems to have practised electric acupuncture, but in his time the batteries in use were far less perfect and effective than those we now possess. So far as I can discover, however, no electro-therapeutist in this country has applied this remedy, either in the manner which I have found most beneficial, or in the class of cases which, in my experience, have proved peculiarly adapted for its use. To illustrate my meaning I propose detailing the symptoms observed in two cases of paralysis which have come under my care in the Manchester Infirmary—the first a case of spinal meningitis, the second of myelitis, both induced by cold.

William B——, aged twenty-five, was admitted under my care on October 1st, 1877. This patient was a navvy, employed in a railway tunnel. For many weeks he was compelled to work in a cold, dank

atmosphere, up to his knees in wet sand. Two months before he entered the hospital he observed that his right leg would occasionally, from no apparent cause, suddenly give way, or jerk out spasmodically from his body. A week later his left leg comported itself in the same manner. Symptoms such as these, indicative of motor disturbance and reflex irritation, rapidly increased; and in the course of two or three weeks he was compelled, most reluctantly, to give up his work. Like many industrious men of his class, he continued to labour when he should have been in bed, and the pain in his back was frequently so severe that he could not refrain from screaming out when the agonising paroxysms seemed to shoot through his body. These paroxysms came on with marked intensity soon after he was admitted into the infirmary. At this time the chief symptoms were, high fever, muscular spasms, hyperæsthesia of the skin, and partial retention of the fæces and urine. There was also marked stiffness of the back and neck, and pain of a rending character in the extremities. These manifestations of irritation of the nervous system lasted for two or three weeks after his admission, and then gradually subsided, hyperæsthesia and muscular spasms being succeeded by anæsthesia and paralysis, which increased until they became complete—motor and sensory paralysis invading every portion of the lower extremities.

During the early stages of the disease various antiphlogistic remedies were tried, and as soon as the more acute symptoms had subsided, electricity was applied percutaneously to the outer surface of the skin. The results, however, were not encouraging. Faradism was first tried, both directly and indirectly. No response was, however, obtained; no trace of muscular contractility could be evoked by this form of electricity, not even when small, well-moistened electrodes were applied to the motor points. Galvanism was next employed, but the results were equally unsatisfactory. Neither cathodal nor anodal closure or opening were attended by any well-marked contractions of the muscles. The stimulus of the will likewise could not be exerted on the conductivity of the nerves. Here, then, was a patient who, in so far as his face, chest, and arms were concerned, looked the picture of robust health, while his lower extremities were in all respects cold, motionless, and devoid of feeling, the feet and ankles perpetually bathed in a clammy perspiration, and the muscles of the thighs and legs atrophied in an extreme degree. While the patient was under treatment, in the more early stages of his disease, the usual internal remedies were systematically tried. Friction also was daily applied to the lower extremities, while passive movements of the limbs were sedulously practised. At the same time galvanism and faradism were assiduously persevered with, rheophores moistened with warm salt and water being brought in contact with various portions of the outer surface of the skin. In spite of these measures, however, the patient steadily lost ground. At one time, indeed, when the negative pole of the galvanic battery was applied over the lower portion of the extensor longus digitorum

of the left leg, very slight contraction might occasionally be induced on cathodal closure, but these effects were not constant, and after a time entirely disappeared. The feet and the legs also became œdematous, and the paralysis of motion and sensation extended upwards with steady strides. At the time to which I allude he had been confined to the infirmary for about seven months, from the 1st October, 1877, till the beginning of June, 1878, and galvanism, faradism, friction, and passive movements had been persistently practised for upwards of four months. Still, in the lower extremities, motion and sensation were completely lost. In addition to atrophy of the muscles, the tendons and ligaments were unnaturally lax and yielding, for when the patient was lifted out of bed and attempts were made to set his legs under him in a vertical position, so that they might, at all events when themselves propped up, support a portion of his weight, they gave way in all directions, being sometimes shot forwards, while at other times they doubled over from side to side. The partial retention also of the evacuations and urine still continued as obstinate as ever.

Such, then, was his state in the early part of June, 1878, when I commenced to treat the case by electric acupuncture. In my earlier experiments I made use of insulated needles similar to those we are in the habit of inserting in the treatment of aneurisms by galvanism. These, however, I soon discarded, and rarely now employ. I found them more difficult to introduce through the skin than needles which are not insulated; and, at the same time, the effect on the deeper tissues seemed more caustic than stimulating and catalytical (to use a term employed by Remak). The needles I now use are as fine as they can be manufactured; they vary in length from two to four inches, and have a metallic knob the size of a small pea attached to one end. On the first occasion on which I practised acupuncture, I cautiously inserted one needle into the upper portion of the left thigh, thrusting it into the semi-membranosus muscle. I then applied the positive pole of a galvanic battery to the dorsal portion of the spine, and touched the protruding extremity of the needle with the negative pole. On turning on ten, twenty, and even thirty Leclanché cells, there was no reaction; but when the electromotor force of the battery was increased to forty cells distinct muscular irritability was apparent, both on cathodal and on anodal closure. But, though the muscles contracted, no pain, nor indeed sensation of any kind, was experienced, even when a current generated by fifty cells was passed directly into the tissues. As this experiment was attended by no untoward results, I carefully felt my way, and, after a few trials, used the needles with very much more freedom; inserting on each occasion from five to seven or eight; three needles being usually thrust into the more fleshy portion of the muscles of the calf, and three or four more into various parts of the muscles of the thigh. The needles were introduced in different directions. Sometimes they were passed from behind forwards;

sometimes the calf of the leg was nearly completely transfixed from side to side; and in other cases, again, the needles traversed the belly of the muscle obliquely, either in an upward or downward direction. The object aimed at was to act on as great a number of muscular fibres as possible, and at the same time to bring the battery to bear on different muscles at the various sittings. I have not, in this case, had recourse to the needles more than twice, or at most three times, in any one week. In using electric acupuncture, one electrode was usually applied to the surface of the skin in some indifferent part of the body, while the other was successively brought in contact with the various needles thrust into the muscles.

Very soon after this mode of treatment was adopted, marked improvement became apparent. Almost each succeeding week the muscles contracted with increasing facility to a weaker current, generated by fewer cells. At the same time, coincidentally with motor improvement, sensibility likewise gradually returned. Indeed, it was with no small feelings of delight that the patient found he was beginning to experience a certain sense of pain and discomfort as the needles were driven into his flesh and the electric current passed along them. On each occasion that galvanism was employed, it was my invariable practice not to omit to touch the extremities of the needles with an electrode connected with a faradaic battery likewise. In doing so I usually employed the direct method, sometimes connecting the two poles to any two of the needles I desired to influence; while at other times one rheophore was held in contact with the outer side of the skin over the longitudinal surface of the muscle, while the other touched a needle passing through its fibres in a transverse direction. Faradism, however, in this case gave far less satisfactory results than galvanism. Indeed, it was very apparent that the reaction of degeneration had proceeded far. For a long time it seemed wellnigh impossible to excite the muscles through their nerves by means of the induced current. Still the case was not desperate. After repeated attempts, continued for about four months, the projecting extremities of the needles were observed to move slightly as the faradaic current passed along them. This phenomenon first occurred in the muscles of the left thigh, and slowly extended to those of the calf and of the foot. I have already stated that the treatment by electric acupuncture was commenced in the early part of June, 1878; it has been continued up to the present time, and during these thirteen months the patient has steadily, though slowly, improved. Some two months after the introduction of the needles he discovered that, by a strong effort of the will, he was able to influence some of the muscles of the foot and of the leg. This response to the stimulus of the will has now extended to the whole of the muscles of the left leg and to the greater portion of those of the right. As the case progressed favourably, the ligaments and tendons round the joints grew more tense, and the atrophy of the muscles far less pronounced. I found also that when he was assisted on to his legs they were able to afford him

a certain amount of support. Soon he could maintain an upright position on crutches; at first making his way about the ward on two crutches, then on one crutch and a stick, and during the last two or three months he has felt himself sufficiently firm on his legs to dispense with his crutches and rely solely on two sticks.

How much further improvement will proceed it is difficult to say. Locomotion is still performed with considerable hesitation. The patient finds a difficulty in starting upon his peregrinations round the wards. When conscious of being watched, also, he moves about far less nimbly than when under the impression that he is unobserved. At the present time the left leg, though weak, has for all practical purposes recovered. Here acupuncture has been given up for the last four or five months. Indeed, in all cases in which the nerves and muscles respond to the induced and continuous current applied percutaneously, there, for the most part, I omit the use of the needles. But although the left leg has now wellnigh regained its functions, the right does not yet answer to the induced current so readily as could be wished. In the thigh, faradaic acupuncture can elicit from the nerves a tolerably energetic response; but the calf of the leg is still very sluggish in awaking to the stimulus. As, however, in these cases reparative changes usually proceed from the central parts towards the peripheral, it may be hoped that, with time, some yet further improvement will be apparent in his state.

I have entered somewhat fully into the symptoms and treatment of this case, because I believe it is one in which the partial recovery at present observed is largely due to the special remedial measures adopted. In the opinion of men looked upon as authorities in these diseases, I should have been perfectly justified in discharging this patient four or five months after he entered the infirmary as incurable. He had been galvanised and faradaised for upwards of four months; the nerves and muscles acted upon from the outer side of the skin could not be persuaded to give any response. The stimulus of the will also was powerless. The muscles, ligaments, tendons, and apparently the bones likewise, were undergoing atrophic changes, while the feet and legs were cold, clammy, and œdematous. The case, I believe, was one of spinal meningitis; but the grey matter of the cord, more especially the anterior cornu, was also affected, for the muscles were atrophied and sensibility lost. Moreover there was partial retention both of the urine and fæces. Can we suppose that in such a case nature, if dependent on her own unassisted efforts, could have brought about the improvement we now observe. It may certainly be urged that the man had youth on his side (he was twenty-five years of age), and that he had, when attacked by illness, an unimpaired constitution. Still, though age and natural vigour are very important factors in calculating the chances of recovery, I scarcely think that they would, without extraneous aid, have availed my patient in successfully battling with his malady. For at the time electric acupuncture was commenced he was steadily retrograding,

while the beneficial effects of the treatment were immediately apparent. These effects also were not merely momentary and transient, but lasted a considerable time. Indeed, he constantly asserted that after the galvanic acupuncture he was conscious of certain definite and abiding sensations, and that these sensations did not occur on the application of the electrodes to the outer side of the skin. The impression first experienced was one of warmth in his feet and in his legs; this feeling of warmth was not confined to the parts immediately acted upon by the needles, but extended downwards to the extremities of his toes; the whole limb felt in a glow. He further noticed that as the parts became warm, the clammy perspiration which stood out in drops upon his feet entirely disappeared, and did not again trouble him for about twenty-four hours.

I may observe that in this case I must have inserted the needles some five or six hundred times during the last thirteen months, but have never, on any single occasion, observed any ill effects attend their application. I usually, as far as practicable, endeavoured to avoid transfixing the larger arteries and veins; still, even if a vessel of considerable size be wounded, only a drop or two of blood is found to escape; as a rule, when the needles are withdrawn, no particle of blood is visible at the spot where the insertion was made. Indeed, the electric current seems to exercise certain well-marked hæmostatic properties.

Before discussing more fully the manner in which electricity thus exerts its recuperative effects, I propose referring to another case in which a similar method of treatment has been adopted, though for a far shorter time. This patient also is at present under my care in the Manchester Infirmary. By occupation he is a labourer, named Thomas K——, aged twenty-five. In following his employment he was exposed to intense cold on the 24th of last December, Christmas-eve—a terrible day, which many of my readers will not readily forget. In various parts of the country the thermometer, in the early part of that day, fell nearly to zero. My patient, while working in the snow, became thoroughly chilled. His feet seemed dead; he could not feel them. He was able to walk home, and, when once there, kept his feet close to the fire. But they remained obstinately torpid; even in bed they were as cold as two stones. This benumbed condition of the feet and legs lasted for upwards of a fortnight. It was attended by severe darting pains in the stomach and abdomen; still, in spite of his sufferings, he regularly followed his employment till the 14th of January. He was able to walk, but he went along like a drunken man; he could not proceed in a straight line. As he passed through the streets the boys laughed at him and pelted him with snow-balls, but he could not run after them nor could he get out of their way, his legs would not allow him. If he tripped against a stone he was sure to fall; and when down, he could not regain his legs: Though he went to his work on the morning of the 14th of January, he was compelled to return home early, and has been laid

up ever since. Every day he remained at home he became worse. Though he tried to sit up, his legs kept giving way until they became utterly powerless. On the 27th of January he was admitted under my care into the Manchester Infirmary. At that time there was complete paraplegia extending as high as the upper part of both thighs. Sensation also was perverted. Pinching and pricking conveyed to his mind no feeling of pain. The sense of touch, however, even in the lower extremities, was not lost, tactile as distinguished from pathetic impressions being readily felt. There was, in fact, an analgesia, but not true anæsthesia. Reflex irritation was augmented. It was most easily excited by the application of heat. If a test-tube containing boiling water was brought in contact with any portion of one of the lower extremities, violent spasmodic movements at once occurred. There was also partial retention both of the urine and fæces. As, however, the paralysis extended upwards and invaded the abdominal and a portion of the thoracic muscles, the contents of the bladder and of the rectum were passed involuntarily. At the same time the abdomen was greatly distended with flatus, and, as the diaphragm was partially paralysed, violent suffocating paroxysms at times came on, due to the upward pressure of the dilated bowels upon the heart and lungs. In the anterior portion of the body insensibility to all painful impressions extended upwards on either side as far as the nipple, and in the back reached as high as the eighth dorsal vertebra. A sloughing bed sore also, nearly four inches in diameter (situated over the sacrum), ate its way into the deeper tissues. So long as the more acute attack continued and the temperature was high, the patient was treated antiphlogistically; but when symptoms of irritation were succeeded by those of paralysis, electricity was cautiously tried percutaneously. It was first applied about two months after the commencement of the seizure. At this time the effects produced were entirely due to reflex irritation. So soon as either electrode was brought in contact with any portion of the integuments, violent spasmodic movements were at once excited. These movements were not limited to the leg galvanised, but extended to the opposite limb and to the majority of the muscles affected by paralysis. The patient likewise expressed himself as "feeling worse" after the electric treatment. He felt much exhausted, and thought the disease was passing higher up his spine. Three weeks later I again resorted to percutaneous electricity, but the results were equally unsatisfactory. I therefore waited for another month, and then determined to try the effects of electric acupuncture. But the case seemed wellnigh desperate. The bedsores had increased in depth and in circumference. Complete anæsthesia had succeeded analgesia. The abdomen was still more distended. The lower extremities looked tense and glossy, and pitted on pressure, the subcutaneous tissues being loaded with serous exudation. At this time, when the patient was placed on his side, he involuntarily rolled on to his back again, being so helpless that he could not maintain the unwonted

position. On the 26th of April I commenced this mode of treatment. The patient was placed on his face. Ten needles were inserted into the muscles of his back and the lower extremities, two needles being thrust into the dorsal muscles, two into those in the gluteal region in the immediate neighbourhood of the bedsores, two into the upper portion of the thighs, two into the lower, and two into the calves of the legs. All these muscles readily contracted to the galvanic current when subcutaneously applied; they contracted both on anodal closure and on cathodal closure. At first the anode was placed over the upper portion of the spine, where sensibility was intact, while the different needles were successively touched, each for a few seconds, by the cathode. Some muscles, it appeared, reacted more readily than others. Indeed, a current from ten Leclanché cells was sufficient to awaken the irritability of some, while others required a current generated by from twenty-five to thirty cells. It was noteworthy also that certain muscles contracted most easily on cathodal closure, others on anodal; while in others, again, reaction occurred with especial facility on cathodal opening. On each occasion that the galvanic battery was used in this case the faradaic was also employed—sometimes in the direct method, sometimes in the indirect; and to this current both nerves and muscles were found to respond. Such, then, was the state of this patient when subjected to electric acupuncture some four months ago; no other remedial measures, such as friction or passive movements, were adopted. Ten to fourteen needles have been inserted always twice, sometimes three times, in the week in the manner I have detailed. After the second application of the needles the patient stated that the sense of uneasiness and discomfort which he had experienced in the trunk had very much disappeared. He further remarked that without assistance he could now turn himself over from the supine to the prone position, which ten days previously he could not even attempt. When first acupuncture was employed I observed serum pervaded the subcutaneous cellular tissue to such an extent that it oozed out for a short time after the needles were withdrawn from the calves of the legs. Two or three weeks later, after five several applications of the needles, this dropsical effusion was completely absorbed. The tense, glossy appearance of the lower extremities totally disappeared. It was now possible to make out the atrophied condition of the muscles, which could not easily be effected so long as the anasarca was present. Soon afterwards a marked improvement was observed in the large bedsores situated over the sacrum, in which healthy granulations might now be seen. At the same time, when the needles were acted upon by the electric current, the patient expressed himself as sensible of the contractions induced in his legs; whereas, when the current was first used, he was altogether unconscious of the movements wrought in his muscles. He further observed that, though formerly he had completely forgotten the very existence of his legs, he is now not only aware of their presence, but can discover

in them a certain feeling of warmth and vitality. He also tells me that, although he is unable by any effort of his will to move his lower limbs, he can now "try to work them," which formerly he was unable to do. The stimulus of the will, directed in this manner to his legs, seemed to him to impart to them a certain feeling of warmth. I should mention that in this case there was complete palsy of the abdominal muscles; they did not respond to either current applied percutaneously. According to Onimus these are the last muscles to become paralysed. Even here, however, I was able to induce muscular contractility by inserting needles obliquely among the fibres of the external and internal oblique. Since this was done the patient tells me that the distension of the abdomen (which at one time proved so distressing) has now nearly ceased. I should further observe that in front sensation has to some extent been regained, for the anæsthesia, which formerly extended as high as the nipple, does not now reach beyond the umbilicus, and in the back sensibility has been regained in the region that lies between the eighth and the twelfth dorsal vertebræ.

There can, I think, be no doubt but that here we have had to deal with a case of spinal myelitis, and that the general symptoms were, and indeed still are, of a very unfavourable character—so unfavourable, that I much fear there is very great danger of a fatal termination. Still, it must be admitted that, even though improvement proceeds no further than it has done during the last four months (since electric acupuncture has been employed), that improvement is very remarkable. Moreover, it must, I believe, be set down to the treatment. Certain definite results followed the application of the needles, and the amelioration observed in the symptoms seemed directly traceable to them.

I shall next proceed to consider what are the particular cases for which this mode of treatment is more especially adapted. The examples I have adduced may be looked upon as typical. Wherever there are marked symptoms of motor and sensory paralysis, and when those symptoms are accompanied by changes in the electric irritability of the muscles or of the nerves, whether those changes be quantitative or qualitative, there acupuncture should always be tried. Hence it is peculiarly suited to the more chronic forms of paraplegia, the sequelæ of spinal myelitis or of spinal meningitis, also to the various forms of paralysis which follow injuries of the spine, whether due to wounds, to deformities, to malformation, to tumours, or to concussions. It would also seem specially applicable to certain forms of syphilis, where it is of the utmost importance to maintain, as far as possible, the nutrition and functional activity of the paralysed tissues, until peradventure antisyphilitic remedies shall have had time to work out in the system their specific effects. I believe, also that this treatment may be usefully employed in many cases of lead palsy. Indeed, in one example of this disease I inserted needles into the arm with beneficial results. In progressive muscular atrophy it

may likewise be employed. My friend and colleague, Dr. Dreschfeld, has described to me a very advanced case of this disorder, accompanied by complete anæsthesia. No response, either to the induced or continuous current, could be elicited, so long as the rheophores were used over the outer side of the integuments; but decided contractions to both currents manifested themselves so soon as the muscles of the hand and thumb were penetrated by the needles. Dr. Dreschfeld believes that this patient experienced decided benefit from electric acupuncture, and that the partial restoration of feeling and of motion was, in a great measure, to be attributed to this method of employing electricity. In certain forms of sclerosis I should be disposed also to believe it might prove beneficial. But in infantile spinal paralysis I scarcely think it could ever be extensively practised. Here sensibility usually is but little affected; consequently the operation is likely to be accompanied by more pain than we should be justified in inflicting on the youthful sufferers. Still we might derive useful information regarding the particular muscles, and portions of muscles, smitten by the paralyzing lesion, by placing the child at times under the influence of an anæsthetic, and then interrogating the muscular fibres by electric acupuncture. In a word, the remedial procedure I am advocating may be legitimately practised in all disorders of the nervous system, more especially in those accompanied by the so-called reaction of degeneration, in which sensory and motor disturbances have proceeded so far that electricity applied percutaneously gives no results but such as are either negative or dubious. Hence it comes to our aid in numerous forms of paralysis which have hitherto been looked upon as desperate; enabling us to make one last additional effort in grappling with a terrible disorder before we finally consign the afflicted to the hopeless ranks of the incurable.

But, it may be asked, have we any valid grounds for believing that when nerves have undergone extensive degenerative changes, when their medullary substance has become affected by fatty metamorphosis, and the neurilemma also is thickened and hypertrophied, any process of regeneration is still possible? This question must be answered in the affirmative. Carefully-conducted experiments, carried out by numerous competent observers, such as Erb, Neumann, Remak, and others, have satisfactorily shown that even when nerves are divided, and the two ends separated from one another by a longer or shorter interval, the gap may be bridged over by fibres of new formation. It is generally admitted that these regenerative fibres commence in the central segment, but others destined to join them occur also at the peripheral segment. Erb observes, in reference to this subject:—“It is certain, and of the greatest importance for the pathology of these affections, that regeneration of the nerve-fibres does take place; that a reunion of divided fibres is effected by nervous tissue, and that thus the means of recovery from paralysis is afforded.” It has further been proved to demonstration that, in cases of paralysis, muscular fibres are liable to undergo certain definite changes. They become

atrophied. They are affected by what is termed waxy degeneration and hypertrophy of the interstitial connective tissue. This induces in them extensive cirrhotic changes; but even here, so soon as regeneration of the nerves takes place, reparative processes also occur in the muscles, which usually follow a retrograde course. When the hypertrophy of the connective tissue is far advanced, it may readily be believed that recovery will necessarily be slow and protracted; still, even after a true cirrhosis of the muscles, a restoration of the fibres to their normal size and state is possible. In dealing with cases of paralysis we must constantly bear in mind these extraordinary reparative changes, which, under favourable conditions, nature herself seems capable of effecting when the powers of the system are in a great measure suspended. When the nutritive processes in certain parts of the body are dormant and cannot fulfil their functions in a healthy manner, some power capable of arousing them into renewed activity is urgently needed. No extraneous influence is so well able to impart fresh impetus to the latent powers of nature as electricity introduced immediately into the tissues by means of acupuncture.

Duchenne in his writings strongly insists that in the electric treatment of paralytic diseases the rheophores should be approximated to each other as closely as possible. In this manner are obtained currents of the greatest density, capable of stimulating the parts to which they are applied to the utmost extent. If, however, a current thus localised is, according to this high authority, so peculiarly valuable, surely that current may be rendered still more concentrated and energetic when needles are thrust subcutaneously into the muscular fibres themselves. This is a still more direct method of applying electricity. It can thus penetrate any portion of the muscles, whether voluntary or involuntary; it can thus directly influence the several nerves, whether motor, sensory, vaso-motor, or trophic; both those structures which lie deep and those which lie nearer the integuments. Duchenne himself remarks, "the thicker the muscle the stronger must be the current, for if the current be feeble, the excitation of the muscles only takes place in the superficial layers." If this be so, there is a manifest danger of the more external fibres being over-stimulated ere a sufficiently strong current is employed to influence those which lie further from the surface, for the effect of the current on the underlying muscles is necessarily weakened by its passage through those which are superimposed. Whenever two rheophores are placed over different parts of the body, the current penetrates the epidermis by one of them, diffuses itself through the tissues for a certain distance, and then gradually converges in the direction of the other. By such ramifications much of its density must be dissipated. Nor is this all. Du Bois Raymond and others have shown that there are, both in nerves and muscles, certain definite electric currents. These currents vary in their intensity and direction. From experiments made on the muscles of animals recently killed, it appears that the direction of this current is from

what has been termed the natural longitudinal section to the natural transverse section. It is further found that the greatest amount of electrical reaction is obtained when the natural longitudinal section is placed upon one electrode of a galvanometer, and the artificial transverse section upon the other. Now, it will be seen that when one electrode is applied to the surface of the muscle, and the other is attached to a needle thrust transversely into the very fibres of that muscle, the current passes in that direction in which the greatest amount of electrical reaction is found to be elicited. In endeavouring to understand the striking effects attributable to electricity in such cases as those I have described, we must remember that those effects are partly mechanical, partly chemical and partly, also, physical. It is a well-known fact that osmotic currents naturally travel in a certain direction, passing from the lighter to the denser liquid. Such, however, is the power of the electric current, that it is able to neutralise this phenomenon, reversing the order of its occurrence, and making the denser fluid flow in the direction of the lighter. If this be possible, we can readily conceive that when the current is sent into the tissues of the body it should arouse the dormant energy of the cells, and, even in cases of extreme serous effusion, should promote absorption. Nor is this all; the continuous current possesses also well-marked electrolytic effects. When, for example, it is passed through a compound liquid, the component substances are separated, and decomposition takes place. In the electrolysis of water hydrogen is evolved at the negative pole, oxygen at the positive. In the decomposition of a salt the bases appear at the negative, the acids at the positive pole. Surely such influences as these exerted upon the various structures of the body, when traversed by the galvanic current, must be very potent. Then, again, when the circulation is languid, the physical effects may be expected to operate beneficially. For, whether the current be employed directly or indirectly, it will stimulate the vaso-motor nerves and lymphatics; hence the circulation is quickened, the vessels are dilated, while warmth and vitality are communicated to the tissues. It will be remembered that both the patients whose cases I have detailed expressed themselves in strong terms regarding the feeling of warmth which succeeded the application of the needles; in one of the two usually lasting for about twenty-four hours; in the other I invariably find, after the needles have for some little time been inserted into the muscles, and the continuous current passed along them, that distinct erythematous patches can be observed around each one of them, where the skin is appreciably hotter than over the surrounding parts. These are some of the more striking effects which follow the application of galvanism. It is important to bear them fixedly in mind in dealing with cases of paralysis. These effects can, I believe, be evoked in a far more marked manner by electric acupuncture than when the current is employed percutaneously. In one of my cases the amount of serum diffused through the subcutaneous connective tissue was so great

that it materially interfered with the passage of the galvanic current. It was found impossible to influence the deeper tissues so long as the epidermis remained intact. When, however, the electric current gained access to these tissues along the needles, not only were the muscles induced to contract, but the œdema itself was very quickly absorbed.

The above remarks refer chiefly to the galvanic current, still in electric acupuncture I always associate with its use faradaic electricity. Schiff believes (and in this opinion he is supported by Onimus) that induced currents only give rise to muscular contractions when they act on the muscles through the medium of the nerves. Where, therefore, the nerves have undergone extensive degenerative changes, muscular contractility cannot be induced by any stimulus acting on them. Here, however, where farado-muscular contractility is abolished, we may, provided the muscles be not utterly destroyed, induce contractions in their fibres by stimulating them with the galvanic current. Hence, in many forms of paralysis, we use galvanism, in order that it may exert its specific effects on the nutrition of the muscles; faradisation that we may stimulate the nerves, and at the same time direct the patient to endeavour to bring his will to bear on the paralysed limbs—in fact, to exercise his will in trying to make his muscles contract, even though no objective results attend the effort. Erb has expressed the opinion that the axis-cylinder of the nerve is subservient to conduction, and the medullary sheath to the reception of excitations. If this be so, the exercise of the will assists in opening out the path traversed by the mental stimulus, the faradaic current will exert its influence more especially on the medullary sheath, and the galvanic on the various processes which minister to nutrition.

There are various other questions connected with this subject which the limits of this paper will only allow me to touch upon very briefly. What should be the direction of the current? Is the direct or the inverse, the descending, or ascending current the more effective in these cases? The reply to such an inquiry must, I think, be somewhat general. No fixed rules can be laid down. Pflüger has shown that when a galvanic current traverses a nerve the excitability of that nerve is increased in the neighbourhood of the cathode; diminished in the neighbourhood of the anode. It may, therefore, be reasonably assumed that in cases of paralysis and anæsthesia, where there is depression of energy, catelectrotonus should, if possible, be induced. On the other hand, when irritability forms a more prominent symptom, the sedative effects of anelectrotonus should be tried. In practice, however, we must not allow ourselves to be too much influenced by these principles. I am myself disposed to believe that very much more depends upon the strength of the current than on the direction. This can be regulated with far greater precision when the current is permitted to pass into the tissues than when electrodes are applied to the outer surface of the epidermis. I believe that in some cases

the beneficial effects likely to accrue from electricity are counteracted by the violent spasmodic movements excited so soon as either of the rheophores, or, indeed, any mechanical source of irritation, comes in contact with the integuments. Here I have found percutaneous electricity decidedly prejudicial. The reflex arcs in the spinal cord are liable to be over-stimulated. In this manner inflammatory processes may be aggravated. On the other hand, if needles are inserted into the muscles (and here insulated needles prove peculiarly valuable), electricity can be passed into the deeper tissues without irritating the cutaneous nerves, and so setting up reflex irritation. I have found also that certain well-marked inhibitory effects accompany the passage of the galvanic current along the spinal cord. These effects themselves exercise a restraining influence on reflex action. They lead us to believe that in electric acupuncture we possess a remedy likely to prove valuable in certain forms of abnormal irritability of the spinal cord and medulla oblongata. I would especially insist that much of our success in the treatment of these cases will depend upon the strength of the current which we use. Much harm is done by over-stimulating the affected tissues. We may be beguiled into doing so by observing the satisfaction our patients experience as they watch the spasmodic contractions of their long-paralysed limbs. Too often this is a seductive manifestation of energy. It exhausts far more than it refreshes. The conservation of vital force rather than the stimulation of vital action should be our main object.

Some persons may be disposed to look on this mode of treatment as formidable and even cruel; so far, however, as my experience goes, the generality of my patients do not look upon the procedure as in any way alarming. They watch with interest the insertion of the needles into their muscles and the transfixing of their limbs; welcoming the return of sensibility, even in the shape of pain, as a longed-for boon.

In conclusion, I would remind my readers that the diseases in which electric acupuncture is likely to prove beneficial require, on the part of the medical attendant, a very large share of perseverance and hopefulness. He must never forget that those reparative changes which alone lead to the restoration of healthy structural and functional activity can only be the slow work of time. No heroic measures must be attempted. Nature may be assisted; she will not permit herself to be forced. He who approaches her in this spirit will be the most successful in his treatment, and will obtain the largest share of her favours.