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The Scientific Rationale of Electro-therapy.*

A REVISED PAPER ON THE THERAPEUTIC APPLICATIONS OF ELECTRICITY.

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EVER since Thales of Miletus, six hundred years before the Christian era, discovered the power of *electron* (amber) after friction to attract light bodies, electricity has been a subject of general wonder, whether displayed in the electric eel, in instruments of man's construction, or in the batteries of the great Omnipotent, when the electric currents of the clouds are seen or heard in lightnings and thunder.

And since Swammerdam, toward the close of the seventeenth century, saw a frog's leg contract through its influence, and Galvani, a century later proved it, this wonderful force has presented a peculiar and increasing attraction to scientists; and ever since our own Franklin, who, with lightning hand, grasped God's hand in nature and brought the convulsive force of the clouds to earth, it has been a subject of therapeutic study in this country. For in 1758 he applied it to disease, and caused a

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NOTE.—For many years we have endeavored to study electricity with that rational and scrutinizing credulity and reasonable confidence in the powers of nature which should ever characterize the true physician. We have sought for the facts upon which the power of this agent to modify organic conditions and processes are based. Such as they have appeared to us, we here record them, in justification of the therapeutic faith that is in us. It is hardly necessary to add that this paper does not claim to be an exhaustive showing of the therapeutic capabilities of electricity, but only a cursory exhibit of its principal therapeutic powers as a working basis for the practical physician. It will serve to show why we employ it in the treatment of disease though it does not give every valid reason for its employment, and it is intended rather for the general practitioner of medicine to read in his office, than for the expert electrician in his laboratory.

paralytic hand to regain, in great measure, its cunning; and before him, in Geneva and the metropolitan centers of all Europe and Great Britain, its powers over disease had begun to be a subject of investigation. Its promiscuous, purely empirical employment by the unprofessional, among them the renowned and Reverend John Wesley, and the exalted claims put forth for it by its hopeful votaries, raised public expectation so high that a reactionary incredulity concerning its powers took the place of previous faith, when its many failures became as well known as its published miraculous cures. For though Watson by it cured a child of chronic congenital muscular spasm (something akin to the later discovered Thomsen's disease) and Brydone, Nilson and DeHaen, cases of long standing deafness, and it had been successfully used by a surgeon of Leeds in amaurosis, and others had relieved neuralgia, headache, rheumatism and chorea, the disappointments and accidents which followed its incautious and unskillful employment counteracted the good impression made by these physicians.

Quacks and mountebanks seized upon it because of its astonishing power, and being reckless and indifferent to its dangers, as they are to this day, employed it without caution, and promised cures it could not, in their hands at least, perform. Out of this ill usage of a truly good remedial agent, the false hopes raised, and unfulfilled promises made, grew distrust in the professional mind, which, to some extent, still abides, but which is destined, under the more certain and definite light now being thrown upon this subject, to give way to its confident and satisfactory employment in therapeutics.

Neurotherapy has taken the lead, but general therapy must and will invoke its certain aid in all those morbid conditions in which its therapeutical utility can be demonstrated.

It is one of the greatest forces of nature and destined, in my judgment, to play as important a part in influencing, and controlling morbid conditions in the human organism,

as it exerts upon inanimate nature, as displayed in its employment in physics, the arts and the natural sciences.

To employ it aright in therapeutics we should study well its precise powers over the physiological and chemical actions of the organism, and to an inquiry into these powers we first address ourselves. These are its physical effects on the system, and to understand them thoroughly is to find out a rational basis for its successful therapeutic employment.

With this enlightenment the stone which the earlier therapeutic builders rejected, is destined to become the head of the corner in the new remedial foundations in the temple of therapy.

Chemical and Physical Changes in the System, Induced by Dynamic Electricity.

Absorption and Endosmosis.—While strong galvanic currents can arrest endosmosis, mild induction currents have a contrary effect. Remak promoted this physiological phenomenon by placing the positive pole on edematous parts, and the negative pole between the swelling and the cerobro-spinal axis.

If two small blisters are made upon the skin, and the positive pole be placed on one and the negative pole on the other, and a strong current be passed between them, the blister under the positive pole will become dry within a quarter of an hour after the electricity has passed, and under the negative pole a new blister will be found.

This law of electrical promotion of endosmosis can be proven out of the body:

If two platinum electrodes should be connected with a constant galvanic current from ten or twelve cells, and then be immersed in pure water, the negative or zinc terminal within a porous vessel, and the positive or carbon terminal outside of this porous medium, the water in the inner vessel will accumulate in two hours to a level about one-sixth higher than that in the outside (Amory,

p. 291). There is a flow of the fluid through a porous septum from the positive towards the negative pole.

Likewise in pure electro-cautery the eschar under positive pole is paler, dryer and harder than that under the negative pole which is soft and moist.

Remak was the first to observe this, and Legros and Onimus first explained the phenomenon upon the hypothesis of vascular contractions, a physiological fact, since abundantly confirmed, but the power of electricity over endosmosis was known to Detrouchet.

Effects on Nerves and Fluids.—The nerves and fluids of the body are good conductors, and it is through nerves and channels of moisture that with galvanism or Faradism we can get into the interior of the body in certain direct lines from pole to pole, in certain parts.

Schiff asserted that the passage of an induction current through a nerve produced appreciable elevation of temperature, and very strong currents must, undoubtedly, heat and destroy nerves, as the galvano-causty current heats the wire, but heat is mostly developed in a part by increase of vascular supply through muscular contraction and reactionary influx of blood after brief vasomotor stimulation and arteriole contraction. The opposite state of heat-depression through electrically-induced anæmia, would likewise occur if applications were not too prolonged.

Nerves may be damaged by crossed currents, but they cannot be excited to physiological action by electricity applied in this way.

Galvanic, Faradic and static currents may be made to penetrate the cavities of the body, the two former only through connecting the body with both poles, the latter in this way and also by electrical discharge. Faradic electricity is, however, more a surface current than galvanic. The Faradic and static forms of electricity exert greater power over the voluntary muscular contractions than the galvanic. The galvanic exerts its most beneficial influence on the non-striated muscular fibers through the vasomotor mechanism.

It may be sent to remote interior parts with more certainty and accuracy and less harm than other currents. It can be passed through the brain, and is the only current which, as a rule, in the present state of our knowledge, can be safely employed, to any considerable extent, upon the interior of the head.

A Faradic current, from center to periphery, causes stronger muscular contractions than from periphery to center.

Chemical Effects—Electrolysis.—Electrolytic decomposition is the chief chemical effect of electricity, acids being formed and liberated at the positive electrode, and alkalies at the negative. When muscles, severed from the living organism, are subjected long enough to electric currents, the mineral acids, sulphuric, nitric, muriatic and phosphoric, are formed at the positive pole, and potassa, soda and ammonia at the negative electrode.

This decomposition at the poles is due to the acids and alkalies formed at the respective poles; for if alkalies be placed at the positive pole to neutralize the acids, and acids at the negative pole to neutralize the liberated alkalies, no blister results.

It can be shown that any internal decompositions take place in electrolysis when the ordinary currents are used. The decomposed elements of the organism appear only at the electrodes.

This is an important point with reference to constitutional electrization, and also shows the probable fallaciousness of the claims of certain quacks that they have been able to extract the mercury and other poisonous minerals put into the system by the regular profession.

Its Power to Coagulate the Blood.—Electrical currents passed through the blood in sufficient strength cause it to coagulate at both poles, but chiefly at the positive pole.

Heidenriech found the coagula at the positive pole to

be composed mainly of albumin, fibrin, fat and acids; chlorine also appeared at this pole. The coagula at the negative pole were made up mainly of iron and the alkaline and earthy bases. The watery and alcoholic extracts and coloring matter also appeared at the negative pole.

The contractile power of electricity over surrounding muscles and its influence over the ganglionic system added to the coagulating power, contribute to the cure of aneurism, by toning and contracting arterial walls, especially of the small arterioles in miliary aneurisms, and strengthening the vessels by artificial walls of fibrin, etc., when electrodes can be inserted.

In 1869, Cliniselli reported out of twenty-one aneurisms treated by voltaic electricity, fourteen successes and seven failures. Inflammation and gangrene set in in five of the failures, probably because too strong a current was used. He used a current of sixty to eighty piles of large surface elements. The current emitted bright sparks and its tension was greater than necessary for mere coagulation of blood. Out of nineteen aneurisms treated by the batteries of Wollaston, Daniel, Bunsen and Senée, there were eight cures and eleven failures. Of the eleven failures four failed because the operation failed, five died and two were made worse. Grave accidents followed in all the eleven. This was in the earlier days of galvano-puncture for aneurism. Since then numerous successes have been reported by different surgeons, and likewise many failures.

I do not think the coagulation should be so much aimed at, especially in the aorta, as tonicity to the weakened arterial walls; and I believe it would be better to apply the current along the arterial walls and to affect the vasomotor ganglion supplying the affected artery, where practicable, by a number of preliminary mild treatments, say fifteen or twenty daily séances, if that much delay were admissible before resorting to the puncture.

Hamilton has reported one hundred and twenty-six cases, out of which there were forty-six recoveries.

He might have had more recoveries had he treated his

cases earlier and endeavored to affect the tonicity and improve the strength of the arterial walls by electrization, preliminary to galvano-puncture. In all such cases I would insulate the patient daily and give him a quiet charge of positive static electricity.

Some put the positive pole in the sac. This pole makes the firm clot, the negative makes the soft one. Althaus and Pepper employ both. I believe it is best to put in only the positive pole. It is said that clots formed by electrolysis have not been known to dislodge and cause embolic closure of distant vessels. This statement is not proven.

This coagulable power of electricity suggests its value in purpura hemorrhagia, varicose veins and hemophilia.

I have employed it to some extent in these states, but not alone because of its power of coagulating the blood, and not without the aid of static electricity.

Static currents of a certain strength not only produce decomposition of blood, but they exert a physiological action over the vessels, as already intimated, which will claim our attention later.

We are now considering the locally disintegrating power of electricity. The blood is here disorganized, and its component elements are separated by chemical action.

In it the scientific therapeutist has the control of a great power for good or ill, just as the machinist and the engineer have in steam a great power evolved from the disintegration of inanimate matter, and either, according as they are used, may benefit or destroy. The judicious physician will not ignore this power because of its strength for evil any more than he rejects a potent drug because in improper hands it may do harm.

Galvano-Cautery.—Next to the electrolytic power of this agent is the galvano-cautery which is direct disintegration by heat destruction. The heat is developed by the quantity of electricity and the degree of resistance in the conductor. It is the most perfect form of actual cautery because it is a fire without blaze or smoke, which

may be lit and extinguished at pleasure, and definitely circumscribed. It stops hemorrhages as the ancients did (with boiling oil) but in a more refined, less formidable and less painful manner. Ends of nerves may be instantaneously destroyed by it in a part, and after that there need be no pain. It may be made to cut with the precision of the knife in certain otherwise inaccessible parts, and it leaves an eschar that protects against hemorrhage and infection. (There are obstacles in the way of successful galvano-cautery in certain regions and tissues, which it is not germane to our present purpose to discuss.) It requires a skilled hand in its use, just as the surgeon's knife does, and may kill or cure; but the surgeon does not hesitate to resort to a daring amputation, because, perchance, the only knife at hand may be an assassin's dirk.

Action on the Nervous System.—Electricity has the power to contract muscular fiber, both striated and non-striated, and in non-striated muscles the temperature rises very sensibly, often as high sometimes as four or five degrees Fahrenheit. The temperature change is due mainly to the muscular contractions and circulatory changes. In the beginning of electro-muscular contractions there is, according to Ziemssen and others, a slight lowering of temperature, but Ziemssen found, after Faradic contraction had been continued for a few minutes, the temperature began to rise, and continued rising till it reached an increase above normal of one to two degrees centigrade. The maximum temperature was reached after cessation of contractions. Here are two other therapeutic powers—muscle-contraction and heat-production in a part.

Faradic or induced currents contract the voluntary muscles more powerfully than galvanic or voltaic.

The real cause of this difference is not certainly known. Ziemssen thought it was due to the difference in rapidity of the two currents, but this is not known.

The contractile effect of galvanic currents, even when

interrupted, is markedly less on voluntary muscle than those of Faradic electricity.

When nerves or muscles undergo alteration, their impressibility to electric stimuli generally diminishes, and a longer and stronger current is necessary to promote contraction, but there is an exception to this law in certain states of muscular degeneration.

When from any cause striated muscles undergo a certain kind of generation through central nerve conditions, and they lose their striated character, they contract more readily to the constant current—this is the reaction of degeneration.

Electrical currents have the following effects on the muscular system in disease:

1. There are cases of peripheral paralysis, when the muscles do not contract either under influence of the will or of voltaic or Faradic currents, and I have found some cases will not respond to static shock.

2. In some cases motility is in part preserved, but neither the affected muscles nor their motor nerves are excitable by induced or voltaic currents. Eulenberg found this the case in rheumatic and facial paralysis.

3. Motility may be entirely extinct, while muscular excitability for both kinds of currents is equal and weakened.

4. The muscles and their motor nerves have lost all contractility under influence of the will and of induced currents, while it is *increased* for *voltaic* currents. Observations give the following phenomena in such cases:

A—during absence of motility.—1. The contractility of voltaic currents is increased; a very feeble current, which would cause no sign of contraction in healthy muscles, produces energetic contractions in the paralyzed muscles.

2. Voltaic excitability increases during the course of treatment, rapidly reaches its maximum, and then diminishes.

3. Voltaic excitability is not always increased at the same time in all the branches of the paralyzed nerve. In the least excitable muscles and nerve branches it increases and diminishes more slowly than in those which are more so.

4. The contractility produced by voltaic current is less rapid for the paralyzed muscles than for the healthy ones.

5. The contraction often occurs only by direct irritation of the muscles, and not by irritation of the corresponding motor nerve.

6. The voltaic excitability is gradually lost with the return of voluntary movements, whilst the Faradic excitability gradually returns (Schulz and Ziemssen).

7. The voltaic excitability is gradually lost with the return of motility, but Faradic excitability remains extinct despite restoration of motility. The excitability for all kinds of currents becomes normal slowly, and in like proportion, after several months or years.

8. Faradic excitability, although reappearing, remains more feeble than for corresponding muscles of healthy side.

9. Voltaic excitability remains the same, and Faradic excitability never returns.

These conclusions are true for rheumatic and traumatic paralysis, and also for diphtheritic and cerebro-spinal fever and some other post-febrile paralytic states.

The same differences between voltaic and Faradic currents has been observed by innumerable observers since Ziemssen, Eulenberg, Legros and Onimus first noted them in cases of muscular degeneration, and in lead palsy, where the voltaic current (fifteen elements) caused no contraction of the healthy muscles, but only of the common extensors of the fingers, extensor proprius of index finger and the extensors of the throat, that is to say, those muscles in which Faradic currents caused no contraction.

After even this incomplete review of what we know to be the power of electric currents ought not pessimism to stand aside and skepticism to be abashed. For one, we confess ourselves to belong to that class of "happy therapeutists" at which Möbius sneers and other German physicians smile. Despite all incredulity and the opposition of the faithless this great and wondrous force is destined to become as indispensable and powerful in the cure of

disease as it is indispensable and powerful in the arts and in the economy of nature. But this is only a part of what we positively know of its powers. In the next number this review of its powers will be extended into a domain still more interesting to the neurotherapeutist.

NOTE.—The reader will perceive how rational the basis for the employment of electricity on the foregoing facts and those to follow in the next paper as compared with such reasoning as appears in the following, which may be found in two works by irregular practitioners, whose authors it is needless here to mention. These writers substitute an unproved and improbable theory for proven fact, and like the blind leading the blind, they go into the ditch together. The theory fixes the nature of the supposed disease and the disease confirms the theory, and thus the vicious circle of their reasoning is complete. The electricity of these fellows is generally of a most positive and shocking kind, and their ignorance and assurance are as positive as their electricity. Muller's idea of weak currents, with which he has done so much, finds no place in such positive and sensational minds. Indeed they have evidently not carefully studied any scientific treatise on the real powers and uses of the electric currents:

"The reader will bear in mind that all acutely inflammatory or hypersthenic affections are electrically *positive* in excess—having too much vital action—being *overcharged* with the electro-vital fluid; and that all paralytic diseases, or those of sluggish, azoodynamic character, or electrically negative, having too little electro-vital fluid, too little vital action. It is a universal law of electricity that positives repel each other, and that negatives repel each other; but that positives and negatives attract each other. This is a principle of electric action everywhere known where anything is known on the subject. *We appropriate it practically to therapeutic purposes.* Therefore, when I wish to repress or repel inflammation, which is electrically positive in excess, I put the positive pole to it; or, at least, I bring it under that half of the circuit with which the positive pole is connected, and as near to the pole or electrode as possible. And because two positives repel each other, and also because the direction of the current is always from the positive to the negative pole, carrying the electro-vital fluid with it, either I must withdraw my positive electrode, or that excess of electro-vitality in the diseased part which makes it morbidly positive, and thus produces inflammation, must give way. I *will not* withdraw my positive pole, and therefore the positive inflammation *must* retreat and be dispersed. In treating this case, I will place my *negative* electrode either on some healthy part, or, if there be perceptible anywhere in the system a morbidly negative part, as is often the case, I will place my negative pole there. For example: if I am treating for *nephritis*—inflammation of the kidneys—when I do not perceive any part to be abnormally negative, I manipulate with my positive electrode over the inflamed kidney, having the negative electrode placed at the coccyx, the lowest part of the spine. My positive pole repels the positive inflammation from the kidney; or, rather, repels from it that excess of electro-vital fluid which makes it morbidly positive and induces the inflammation, while the negative pole attracts the same towards the coccyx. On its way it becomes more or less diverted to adjacent nerves; or, if gathered in the healthy part, under the negative pole, it is immediately dispersed by the normal circulation as soon as the electrode is removed. But if I find *a spinal irritation*, say in one or more of the cervical or dorsal vertebræ, and, at the same time, a stomach affected with *chronic dyspepsia*, accompanied with *constipation of the bowels*, I will work over the inflamed or irritated spine with my positive pole, because I know from the irritation that there is an excess of electro-vital fluid in the part, making it improperly positive; and, with my negative electrode, I will at the same time, treat over the stomach, bowels and liver; because I know, from the *inaction* of these organs, that there is a lack of vital force, a deficiency of the electro-vital fluid, there, and that, consequently, they are too negative."