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Mitchell. Introduction of reflex apparatus with papyrus

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ON THE

PRODUCTION OF REFLEX SPASMS AND PARALYSIS IN BIRDS, BY THE
APPLICATION OF COLD TO DEFINITE REGIONS OF THE SKIN.

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IN the January number of this Journal for 1867, I placed upon record a series of novel researches concerning the influence of extreme cold upon the various central nervous organs. I considered my results as having a double value, first, because they introduced to physiology a new method of examining the nervous system; and, second, because I was enabled, through this means, to discover and investigate certain remarkable phenomena produced by chilling the spinal centres of birds. To these latter facts I desire again to call attention.

On the 11th of May, 1866, Dr. B. W. Richardson, of London, who it seems had been occupied with precisely the same line of investigation as myself, published the first of a series of lectures, in which he repeated and thoroughly confirmed the results I had obtained, while, at the same time, he added very valuable details, and a clear and careful examination of the influence of extreme cold upon nerve trunks—a subject on which I had not touched. While differing from this gentleman as to some of the conclusions at which he arrives, especially concerning the function of the cerebellum,¹ I find

¹ The chief point on which I differ from my friend, Dr. Richardson, is in regard to the inferences he makes from his experiments and my own, as to the physiological balance of control between the cerebellum and the anterior ganglia of the brain. Accepting Magendie's views that the corpus striatum is endowed with a constant backward-propelling energy, while in the cerebellum resides an opponent influence, he states that freezing the cerebellum gives over the pigeon to the governance of the corpus striatum, and so occasions retrogression; the reverse occurrence following the abeyance of function in the anterior centre. I have always believed that these various phenomena of retrogression—lateral motion, *mouvement de manège*, &c., were due to excitation of parts, and not to annihilation of function; and this view is sustained by the fact that mere punctures, which do not destroy the centres, are competent to occasion the enforced motions. In freezing, Dr. R. observed that the first chilling (stage of preaction) of the cerebellum often gave rise to forward motions. The reaction, after deeper freezing, to backward activity. Now Flourens has shown that irritation of the superficial

between his results and my own scarcely any discrepancies which may not be justly considered as due to the fact that we employed different agents to bring about the desired end. As to these differences I shall presently have to say a few words before attacking the subject of this present essay; but I should be ungracious were I not to seize the first occasion to thank Dr. Richardson for the courtesy with which he has seen fit to speak of my experiments, and for the generous care with which he has brought my results before an English audience. I may add, that without the aid of his own brilliant and useful method of causing local anæsthesia, I should have been unable to pursue this line of study at all.

Dr. Richardson describes local anæsthesia where ether is used as presenting the following phenomena:—

First stage: Temperature 96° F.; sensibility perfect.

Second stage: Preaction; removal of nerve-force; increase of temperature and of vascularity; exalted sensibility.

Third stage: Inertia; no nerve-force; temperature 16° F.; perfect insensibility; solidification of fluids of tissues; no blood.

Fourth stage: Reaction; return of vascularity of paralyzed vessels; increased vascularity and temperature; exalted sensibility; re-resolution of fluids of tissue; innervation continued.

Fifth stage: Return to natural state.

All of these stages probably exist in every case of freezing of the tissues in warm-blooded animals; but when rhigolene is employed, the stage of preaction is so brief as almost to defy observation, owing to the great rapidity with which that fluid congeals the part. It differs also from ether in that it freezes less deeply. The former liquid chills so large and deep a

layer of the cerebellum causes motion forward, and that deeper irritation produces retrogression. Is it not probable that the first slight chilling only reached the outer layers, and so gave rise to the forward motion, whilst the reaction after deep freezing, affecting a larger and less superficial mass of the organ, caused retrogression.

In another place Dr. R. seems to consider that retrogression, as I have mentioned above, is due to temporary suspension of the cerebellar function. I myself have not seen this occurrence while the part was really frozen; indeed, so sudden is the reaction, that you can scarcely be sure, a moment after releasing the bird, that reaction has not begun. On the other hand, it was clear to me that the time of greatest retrogressive movement was coincident with the period of profoundest reaction; so that, whatever view we take, must accept a condition of cerebellar irritation as a part of the explanation of the backward tendencies. In corroboration of these very hastily stated views, I may add, that ablation of the cerebellum does not produce those backward movements which can be obtained by irritation of limited regions of this ganglion; and that the experiments of this present paper seem also to favour the view that, in enforced retrogression, forward motion or lateral movement, the principal element of their production is an irritation which affects some mass or masses of ganglionic matter so as to cause convulsive efforts which are vertiginous in character.

portion of tissue, that when freezing begins, there is little obstacle to the process; whilst, with rhigolene, the suddenly congealed layer of skin acts at once as a bad conductor, and interferes with the deeper action which we desire to obtain during the latter stages of the process. Dr. Richardson noticed certain phenomena during the stage of preaction, whilst chilling the spine or brain, which I myself did not observe—possibly because of the speed with which rhigolene acts.

After reading his very interesting lectures, I repeated my experiments, with the view of obtaining the very symptoms of this preactive stage to which he refers; and in this series of observations I was led to notice facts which in themselves are valuable, and which cast a curious light upon some of the most obscure pathological and therapeutical questions of the present day.

If, as I first stated in my former paper, we throw a spray of ether or rhigolene anywhere upon the cervical spine from the skull to the fourteenth vertebra, the bird, on being released, runs forward as if confused and alarmed; then assumes his natural motions; and, after a varying interval, begins to have spells of backward movement, and even of somersaults, alternating with fits of stupor.

Below the fourteenth vertebra, this treatment gives rise, in the same way and time, to attacks of uncertainty of movement, loss of equilibrium, singular stamping motions of the feet, and partial palsy of the legs. All of these symptoms appear to me to belong to the stage of reaction, in which there is excess of blood in the spine, and consequent irritation of this organ. I was, indeed, fortunate enough to get like results by placing on the bare cord a drop of tincture of capsicum, but the congestion and motor phenomena which resulted did not appear for a much longer period of time than under the former process. With these facts as a basis, I began to study the symptoms of Richardson's stage of preaction. In it, as he states when speaking of freezing the cerebrum, the pigeon becomes excited, and attempts to fly forwards or backwards, the stage of reaction being marked by like phenomena. The point which chiefly attracted my notice in Dr. Richardson's statement was this production of constrained movements so soon after the jet struck the skin. I felt doubtful, on reflection, as to the possibility of the centres being thus early affected by any direct influence of the cold. With this uncertainty in my mind, I sought a decision by the aid of the following experiments, and these led me out upon a more interesting track than that upon which I had at first entered.

Expt. 1.—I threw a jet of rhigolene, for a few seconds, on the cervical region of a well-grown pigeon, long enough to freeze the skin very slightly. The sole effect, at first, was to cause deep and frequent respiration. On releasing the bird it ran about uneasily, and in twenty-five seconds had backward movements. Of course, this was due to reaction only, but I was surprised that the spine should have been chilled enough to occasion a result so well marked.

Expt. 2.—I chilled the skin with rhigolene in the same place without freezing, again producing laboured breathing. Within half a minute the bird began to move backwards. As I now felt sure that the spinal centres could not have been reached by the cold, I secured them from all possible chance of this in the following way:—

Expt. 3.—A fresh pigeon was held by an assistant, Dr. Wilson, while I picked up and held between my thumb and finger a portion of the loose cervical skin. The part which projected above my hold was thus removed at least three-quarters of an inch from the spine, while I lightly froze it with the rhigolene jet. Before releasing the bird, I carefully held the skin until it regained its natural warmth, when I set the pigeon at liberty. To my surprise, it showed, in two or three minutes, the utmost confusion of movement, with finally very perfect backward motions.

In another experiment, like the last in all other respects, I warmed the frozen skin before I let the bird go, but the result was nevertheless identical. I now perceived that the phenomena which could be caused by directly chilling the spine, were to be obtained in a less striking manner, but still very remarkably, by merely chilling or freezing the skin of the back of the neck, and that I had before me one of the most beautiful illustrations of reflex pathological movements which had as yet been discovered.

The next experiments it is needless to relate in full. They were directed towards ascertaining the amount of cold which it was requisite to produce in order to occasion the retrograde actions. I found that while for their best display it was well to freeze the skin, in many cases it was only necessary to chill the surface very lightly to get the effect in a form quite sufficiently clear. The extent to which it is desirable to chill or freeze seemed to be determined solely by the individuality of the pigeon itself, since in some a single flash, so to speak, of the rhigolene would answer, while in others I obtained the retrogressive actions only by intensely freezing the skin, or even, in rare cases, not at all. It was also well worthy of note that in pigeons which did not at first yield the usual movements, several repetitions would occasion them, and that afterwards they became easy of production. Moreover, as a rule, each successive exhibition appeared to make the pigeon more readily liable to the motions referred to, so that in some cases, which at first required firm freezing to cause the spasms, even the slightest chilling would suffice.

When fully satisfied that the curious enforced movements above described were due merely to reflex effects, and not to any direct chilling of the spine, I proceeded with care to determine the relation between the region of skin frozen or cooled and the form of the resultant phenomena.

Head.—When the skin of the head over the cerebrum is seized between the fingers, and frozen and thawed before releasing it, there are sometimes seen, at the start, irregular and confused movements. These, as a rule, result in stupor so deep that the bird, if carefully handled, may be laid on its back and left without stirring for many minutes. In general, it starts

off after the freezing, as though quite well, and in a few minutes falls forward in the stupor described, without other motor symptoms of any remarkable character.

Back and Sides of Neck.—I have already pointed out that chilling or freezing the skin of the posterior neck occasions retrogressive acts. In no case did it give rise to the violent somersaults¹ which follow deep freezing. When the sides of the neck are chilled, the bird, as usual in all cases, exhibits some disorder of the respiratory movements. When released, it is apt to move about uneasily for a time, with much confusion in its motions. In other instances no such symptoms appear, but in all, soon or late, the pigeon is attacked at intervals with fits of enforced lateral walking, occasionally ending in a fall upon the side towards which it moves. Nothing more strange or abrupt than these paroxysms can be conceived of. The bird walks about, plumes his feathers, or eats, and on a sudden, under the overwhelming sway of these morbid impulses, it walks staggering to left or right, as the case may be. Stupor was far more rare than in the freezing of other regions.

Anterior Neck, and Skin over the Crop.—Freezing of the former region in the middle line occasioned retrograde motions. The latter proved to be excessively sensitive, and, owing to the stretching of the thin tissues over the full crop, was at times easily frozen by a single breath of rhigolene-vapour. Freezing the middle line of the crop means, of course, portions of skin on both sides of this line. It gave rise, as in other cases, either to no phenomena for a time, or else to sudden forward motions, and to great confusion in the action of both the legs and the wings. Always, however, the final result was sudden and violent retrogression, and even, in rare instances, backward somersaults. I presume that as freezing in the middle line means, practically, freezing both sides at once, it is fair to consider that we have here a balancing of the two lateral tendencies; but also there must be the third element of backward tendency, and this must be due to the effect on parts near to the middle line of the body, because this latter movement—that is to say, retrogression—does not follow, as a rule, the chilling of one side of the crop. Lateral freezing of this part occasions, usually, the most remarkable lateral motion towards the unfrozen side. In rare instances, especially when I froze very far from the central line, and low down on the crop, I obtained with motion to the opposite side a marked weakness and dragging of both the wing and the leg on the frozen side.

Breast and Belly.—Freezing of the breast occasioned some irregular, confused motions, and gave rise, a little later, to great general feebleness, staggering forward, and spells of slight stupor. Freezing of the legs caused a singular dancing movement alone. When the skin of the belly

¹ Dr. Richardson did not succeed in causing this effect.

was chilled, the phenomena of partial paralysis and forward falling were most conspicuous.

Spine below Cervical Region.—Here the phenomena were just such as follow deep freezing of the dorsal or lumbar spine; that is to say, at first little or no result, but finally singular feebleness of movement, with irregular locomotion, stamping of the feet, and forward falls, but no retrogression in any case.

The general law observed in these various cases of freezing of different parts of the surface is capable of very simple statement. If we make allowance for slight discrepancies, and consider the difficulty of exactly localizing the cold, we shall observe that *in pigeons the chilling of any region of skin occasions just such symptoms as follow the application of deep cold to the spinal region which lies below it.* To this there is the exception of the lateral motions, which I have never caused by chilling the spine, but which perhaps I might produce, could we limit the cold to the sides of the bare spine.

In observing these wonderful instances of reflex spasms, and in noticing the alternate or consequent stupors, I have been led to suspect that the whole group of symptoms might be in their nature epileptiform. In fact, they strikingly recalled to me cases of epilepsy in which it was always possible, during a series of fits, to determine instantly a fresh attack by pinching certain regions of the skin, or, as Brown-Séquard states, by galvanizing portions of the integument. Upon reflection, I remembered that in quadrupeds the best type of epilepsy we can artificially induce is to be occasioned by cutting off the supply of blood to the brain. By this means I hoped in the pigeon to produce, for study, the form of epilepsy to which the bird is liable, and so to be able to compare it with the most violent of the convulsive motions caused by cold.

Expt.—I tied successively the vessels of the neck in a pigeon until I brought on sudden and violent convulsions. These consisted first in wild, irregular movements, and finally in backward somersaults, which ceased when I relaxed the ligatures, and began again when I tightened them anew.

By repeated experiments of this nature I satisfied myself that the tendency of the pigeon during epilepsy from anæmia is towards violent backward motion, so that, as far as this may be looked upon as evidence, there is at once made out a conspicuous resemblance between the spasms from cold and those just described.

As I have utterly failed to evolve like phenomena in quadrupeds, I am not prepared to dwell upon some of the tempting analogies between the facts above described and those with which human pathology furnishes us. The most remarkable would be the production of paraplegia or of tetanus in man by the application of cold to the surface. Both here and in the bird it is probable that a congestion of the spinal centres has to do with the result, but in the bird there are always, with the feebleness, larger evidences

of irritation of these ganglia than in the cases of human paraplegia from chill of surface. I have great hopes that further research may determine the possibility of producing in quadrupeds like phenomena, and until then it were perhaps wiser to refrain from further speculation.

There yet remains one very puzzling question. I have been totally unable to occasion any of the phenomena which I have dwelt upon by chilling or freezing the skin with ether. Why this should be, I cannot say. Both Dr. Richardson and myself have obtained perfectly satisfactory backward motions by chilling the spine itself with this agent, but by no variation of treatment has it been made to occasion like effects when used on the skin alone. I trust that others may be more fortunate. I should add that blistering the skin, the use of rhigolene kept from evaporating by ciled silk placed over it, as well as numerous other methods of irritation, have one and all failed to reproduce the results which are given by the rhigolene jet. I do not think that any of the others to be obtained here have so low a boiling point as those used by Dr. Richardson, and since it is the peculiarity of rhigolene to freeze or chill very abruptly, owing to its low boiling point, it may happen that transatlantic observers will be able to repeat my experiments with ethers, which in this respect approach it in their mode of action. I am not aware that rhigolene has been used abroad, and on this very account I have been careful to exhibit my experiments to numerous physicians, among whom were Mr. Spenceer Wells and Drs. Nicolayson, Loring, Keen, Mears, and Parry. I was ably assisted throughout these researches by Dr. John T. Wilson, of Maryland.



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