MEMOIRS
ON SOME
PRINCIPLES OF PATHOLOGY
IN THE
NERVOUS SYSTEM.

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READ APRIL 9TH, 1839.

MEMOIR I.

*On the Condition of the Muscular Irritability in
Paralytic Limbs.*

FROM numerous subjects of investigation in reference to the Pathology of the Nervous System, I have selected, for the present communication, that of the condition of the muscular irritability in paralytic limbs.

The utmost discrepancy of opinion prevails amongst physiologists and medical writers upon this subject. Prochaska, Nysten, and Legallois state, that the irritability of the muscular fibre remains in paralytic limbs; whilst Professor Müller and Dr. Sticker assert the contrary. No attempt has been made to reconcile a contradiction not very honour-

able to our science. To explain this discrepancy of opinion is one of the objects of this communication.

The authors to whom I have referred, misled by the generic term and idea of paralysis, have not sufficiently distinguished between its different species. Yet it will be found, as we proceed, that this distinction is of the utmost importance in the explanation of the phenomena. In fact, cerebral paralysis, or that which removes the influence of the brain, and spinal paralysis, or that which removes the influence of the spinal marrow, are in totally opposite conditions in reference to the irritability of the muscular fibre in the limbs severally affected; facts equally obvious in experiments and in clinical observations. I must begin this paper by quotations of some length, for these are necessary to show the present state of the science. I shall then proceed to the detail of my own investigations.

The first distinct notice of this subject which I think it necessary to adduce, is contained in the following extract from the *Opera Minora* of Prochaska: * “ *Vis nervosa quæ in nervis a commercio cum cerebro separatis superest, non unâ alterâve musculi contractione, quam irritati cient, exhauritur, sed millenis plane convulsionibus excitandis par est; quod expertus sum in ranâ, cui medullam spinalem in dorso abscidi. Supervixit huic vulneri aliquot diebus; interim irritando medullæ spinalis partem eam, quæ erat infra sectionem, convulsiones in artubus inferioribus excitavi toto tempore, quo super-*

* Ed. 1800, p. 84.

vixit, planè innumeras ; neque extremitates inferiores prius mortuæ sunt, quam tota rana ; Dein quod vis nervosa in nervis diu persistere possit citra cerebri auxilium probare videntur musculi paralytici, in quorum nervis ob compressionem aliquam præternaturalem totum commercium cum cerebro sublatum est, nihilominus tamen à stimulo electricæ scintillæ longo jam tempore paralytici musculi convelluntur.”

More detailed remarks were made by Nysten, and these, from being founded upon very distinct post-mortem experiments on the human subject, have excited more attention. This celebrated physiologist observes, “ Chez deux apoplectiques qui avaient succombé au bout de quelques jours, l’un à la première attaque et l’autre à la seconde, le galvanisme a déterminé des contractions aussi fortes dans les muscles du côté sain que dans ceux du côté paralysé : les iris des deux côtés sont également contractées.” “ Cette propriété n’a été complètement anéantie dans les organes musculaires des deux sujets qu’environ 12 heures après la mort ; et on n’a observé aucune différence dans les muscles paralysés.”*

Legallois makes similar remarks, founded upon experiments made upon animals. He observes, “ M. Nysten a montré que dans les paralysies les plus complètes, l’irritabilité se conserve dans les membres paralysés tout aussi bien que dans ceux

* Recherches Physiologiques, 1811, p. 369 ; compare p. 377 and 419 ; and Cuvier, Histoire des Sciences Naturelles, tome i. p. 213.

qui ne le sont pas. J'ai obtenu un résultat semblable d'une expérience que j'ai souvent répétée. Elle consiste à détruire la moëlle lombaire dans un lapin âgé de moins de dix jours ; il faut le choisir de cet âge, pour que la circulation ne soit pas arrêtée, et qu'il puisse continuer de vivre. Quoique dans cette expérience, le train de derrière soit frappe de mort, et que ses nerfs ne puissent plus recevoir aucune influence de la moëlle épinière, l'irritabilité s'y conserve, et l'on peut, pendant fort long-temps, faire contracter les cuisses, en irritant les nerfs sciatiques. Il paraît donc qu'il se fait dans toute l'étendue des nerfs une sécrétion d'un principe particulier." *

From these quotations from Nysten and Legallois we should be led to the conclusion that the muscles of paralytic limbs, in all cases of hemiplegia and of paraplegia simply retain their irritability. From another series of observations, made by philosophers equally worthy of our confidence, we should be led to an opposite conclusion.

Some interesting experiments on this point have been recently performed by Professor Müller and Dr. Sticker. The former† celebrated physiologist observes, " It was known that, after the division of a nerve, the portion cut off from communication with the brain retains, for a certain time, its excita-

* Œuvres de Legallois, éd. 1824, p. 23 and 24.

† See the excellent translation of the " Handbuch der Physiologie," by William Baly, M.D., vol. i., p. 631—633 ; and compare p. 663, 724, 727, 898, &c., and Grainger on the Spinal Cord, p. 96, 97.

bility ; but the question, how far the continuance of the connection with the brain and spinal marrow is necessary for the longer preservation of the irritability of the nerves, and whether the muscles retain their irritability when their nerves no longer communicate with the central parts of the nervous system, could not hitherto be answered with certainty, and had indeed been seldom mooted. Nysten had asserted that the muscles of patients who died a short time after an apoplectic seizure preserved their irritability, and contracted under the influence of the galvanic stimulus, although the functions of the brain had been paralyzed.

“ I had good reasons, however, for believing that, in such cases, the nerves retain their power only for a short time, losing it entirely after a longer interval ; for, in experiments on the reproduction of the nervous tissue in a rabbit, I had once observed, that the lower portion of the nervus ischiadicus, which I had divided some months previously, had lost all its excitability ; and a similar fact had been before observed by Fowler. I have since performed, in conjunction with Dr. Sticker, new experiments, which have completely confirmed that supposition. To prevent the regeneration of the nerves, and to withdraw more effectually the lower portion from the influence of the brain and spinal cord, a portion of the nerve (the ischiadic) was entirely removed. The experiments were made only on two rabbits and a dog ; yet the results were so constant, that they are quite worthy of dependence.

“Eleven weeks after the division of the nerve in the first rabbit, it was laid bare in its course between the biceps and semitendinosus muscles. Contrary to expectation, and to our mortification, the continuity of the nerve was found to be restored. It was divided anew below the cicatrix; and it is remarkable that, although the animal uttered a loud cry, the section excited no contraction of the muscles. The lower portion of the nerve was now exposed to the galvanic stimulus of a single pair of plates, was cut and pulled in every possible way, but not the slightest muscular contraction was excited.

“For the sake of comparison, the nerve of the opposite side was divided, when the animal showed signs of suffering the most severe pain, and violent muscular spasms took place; and, after the division, very slight irritation of the nerve itself, that is to say, of the lower portion of it, or merely of the muscles, excited strong twitchings, even after death.

“Ten weeks after the division of the nerve in the dog, the ends were found to be reunited. The experiment was performed exactly as in the rabbit, and the result, as to the effect on the nerve, was entirely similar: it had lost all its excitability; but the muscles still contracted slightly when stimuli were applied directly to them immediately after death: however, this remaining irritability was gone, while, in the muscles of the opposite leg, the strongest contractions could be excited.

“Five weeks after the nerve had been divided in the second rabbit, we proceeded to examine its state,

and were the more interested on account of the short time that had elapsed since its division. The ends were not united ; they were somewhat swollen, and connected with the surrounding cellular tissue. In the other instances, the portion of nerve removed measured about four lines only ; here its length was eight lines. No contraction of the muscles could be excited by irritating the nerve either mechanically or by a chemical stimulus, caustic potash, or by galvanism ; nor by irritating the muscle itself, although the rabbit had plenty of vital power. On the left side the muscles were found irritable, as in the other cases, both before and after death.

“The foregoing experiments prove, at least, that when the communication of the nerves with the brain is wholly cut off, they gradually lose the power of exciting the muscles to contraction, while the muscles lose their irritability. The result would, however, have been still more decisive if, in place of a single pair of plates, a small galvanic battery had been employed to stimulate the nerves and muscles. That, and that alone, would have enabled us to determine with certainty whether all the power of the muscles, in two of the cases, had been lost. The experiments as they were made, however, prove distinctly enough the necessity of communication with the brain for the preservation of nervous and muscular power. We may from them conclude also that if, after the division of a nerve, the excitability of the lower portion, and the irritability of the muscles are restored, the nerve has itself been completely

reproduced ; and that this has not been the case if the nerve and muscle do not retain their vital properties."

I may here observe, that an experiment, similar to those of Professor Müller and Dr. Sticker, in which Sir Astley Cooper assisted the late Dr. Haigh-ton, was made in this country many years ago, but never published. The sciatic nerve was divided in a dog. In a few days the lower portion had lost its power of exciting muscular contraction.

These statements appear, then, sufficiently opposed to each other ; how shall we explain or reconcile them ? Before I proceed to discuss this question, I must beg the attention of the Society to a third series of observations and experiments, in a certain sense at variance with both those which have been detailed.

My own attention was first drawn to this interesting point by the fact, well known to physicians, that if we administer strychnine to patients affected with paralysis, it is frequently the paralytic limbs which first manifest the peculiar influence of this powerful remedy. M. Fouquier has, I believe, too hastily generalized this effect of strychnine on the muscles of paralytic limbs. And how well do I remember the same remark being made by M. Louis, as, in our visit round his wards at La Pitié, we came to a case in point. From that moment I did not cease to revolve the question in my mind, and to devise modes of observation and experiment to solve it. Certainly the conclusion of

M. Ségalas d'Etchepare in regard to it, is anything but satisfactory. M. Ségalas observes :—

“ Ces expériences réunies autorisent donc à conclure que le tétanos produit par la noix vomique a pour condition première de son développement la présence du poison dans le sang, et que les phénomènes qui l'accompagnent sont dus à l'action anormale de ce fluide sur le système nerveux.”

“ Cette manière de considerer l'action de la noix vomique donne un moyen simple d'expliquer les effets de cette substance chez l'homme, et particulièrement ce fait si remarquable de la contraction des muscles paralysés plus prompte et plus énergique que celle des muscles sains, fait observé d'abord par M. Fouquier,* et constaté depuis par tant de praticiens du premier ordre. Il est facile, en effet, de concevoir que les muscles sains, soumis à la fois à l'empire du cerveau et à l'action du poison, résistent à celle-ci plus que les muscles paralysés, qui, soustraits à l'influence cérébrale, ne sont plus commandés que par le poison.”

Upon these observations of M. Ségalas, M. Ollivier remarks—“ Mais s'il en est ainsi, comment se rendre raison d'un fait observé depuis long-temps par tous les praticiens, et sur lequel je viens d'appeler l'attention, c'est que la noix vomique cause souvent de violentes douleurs dans les membres paralysés, sans apporter aucun trouble dans les parties saines ? Pourquoi cette action spéciale sur

* Memoire sur l'emploi de la noix vomique dans les paralysies, par M. Fouquier ; 1815.

les seuls organes paralysés? et, d'un autre côté, la douleur perçue ne prouve-t-elle pas que les parties paralysées ne sont point isolées entièrement du centre nerveux, et qu'ainsi ce ne peut être à cette inconstance qu'on doive attribuer la localisation singulière des effets de la strychnine? ”*

It will soon be seen that this view, like a former one, is far too general, far too indiscriminate—that it is not in every case of paralysis, that the strychnine would first display its influence on the paralytic limbs. Meantime, however, I figured to myself the fact of the strychnine acting on the spinal marrow, and diffusing its power equally along the nerves, to the right hand and to the left, to the muscles to which they proceed respectively; and I asked myself the question—Is the difference observed in its ultimate effects on those muscles, the power being obviously the same, owing to a difference in the degree of the irritability of the muscular fibre itself? Is the irritability of that fibre actually augmented? If so, the phenomenon would be explained!

I waited with anxiety for opportunities of submitting this question to the decision of experiment. This I entrusted, in the first instance, to my young friend and intelligent pupil Mr. Dolman. The result was as I anticipated. A little child, aged two years, was perfectly paralytic of the left arm. The slightest shock of galvanism was directed to be applied which should produce an obvious effect. It was uniformly observed that the paralytic limb was agitated by a

* *Traité de la Moëlle Epinière*, 1827, p. 841.

degree of galvanic energy which produced no effect on the healthy limb.

A similar patient, with paralysis of one leg, was subjected to the same experiment by my friend and former pupil Mr. W. F. Barlow, and with the same result.

I repeated the trial on several patients affected with hemiplegia, at my own house, uniformly with the same event: the paralytic limbs were always moved by an influence which was lower than that required to affect the healthy limb, or if both limbs were agitated, it was uniformly the paralytic limb which was more shaken than the other.

I next repeated my observations upon a more extensive scale, at the St. Mary-le-bone and St. Pancras infirmaries. There were two exceptions to the rule; whilst the numbers in which the phenomena already described were observed, were considerable.

These exceptional cases I shall notice particularly hereafter. I must now remark that these observations seem, even more than those of Prochaska, Nysten, and Legallois, at variance with the experiments of Professor Müller and Dr. Sticker. Before I proceed to discuss this question I must, however, detail some experiments of my own.

They were made on six frogs. I divided the spinal marrow immediately below the origin of the brachial plexus; and I removed a portion of the ischiatic nerve of the right posterior ex-

tremity. I had immediately, or more remotely, the following interesting phenomena.

1st. The anterior extremities alone were moved spontaneously ; both posterior extremities remaining entirely motionless, when the animal, placed on its back, made ineffectual efforts to turn on the abdomen.

2nd. Although perfectly paralytic in regard to spontaneous motion, the left posterior extremity, that still in connexion with the spinal marrow, moved very energetically when stimulated by pinching the toes with the forceps.

3rd. The right posterior extremity, or that of which the ischiatic nerve was divided, was entirely paralytic, both in reference to spontaneous and excited motions.

4th. After the lapse of several weeks, whilst the muscular irritability of the left posterior extremity was gradually augmented, that of the right was gradually diminished, phenomena observed when the animal was placed in water, through which a slight galvanic shock was passed accurately in the direction of the mesial plane.

In this interesting experiment we have, then, first the phenomena of loss of spontaneous motion on removing the influence of the brain, the excited or reflex actions remaining ; and the loss of these on removing the influence of the spinal marrow ; secondly, in the case of mere cerebral paralysis, we have augmented irritability, and in that of the spinal marrow we have the gradual diminution of this property.

5th. Strychnine being now administered, the anterior extremities and the left posterior extremity, or that still in connexion with the spinal marrow, became affected with tetanus; but the right posterior extremity, or that severed from all nervous connexion with the spinal marrow, remained perfectly flaccid.

6th. Lastly, the difference in the degree of irritability in the muscular fibre of the two limbs was observed when these were entirely separated from the rest of the animal.

In a word, the muscles of the limb paralysed by its separation from both cerebrum and spinal marrow, had lost their irritability; whilst those of the limb separated from its connection with the cerebrum only, but left in its connexion with the spinal marrow, not only retained their irritability, but probably possessed it in an augmented degree. The next question came to be,—Do these phenomena obtain in the human frame? I visited a patient affected with hemiplegia, including paralysis of the face, and I passed a slight galvanic shock through two pieces of metal, of which one was placed over each cheek. The muscles of the paralytic side were most affected. I repeated the experiment with the same result. I now compared with these, two cases of injury of the facial nerve, passing the galvanic shock in the same manner, through the fibres of the orbicularis: it was now the muscle of the healthy side which was affected by the galvanism, the eyelid of that side being closed, whilst that of the paralytic side gaped

as before. I next compared the effect of galvanism in two cases of complete paralysis of the arm, one hemiplegic, the other the result of dislocation of the shoulder. The muscles of the former were more, those of the latter less, irritable than those of the healthy arm respectively, as were also those of the arm of a patient affected with the paralysis induced by lead. Lastly, I compared the cases of paralysis of the lower extremities, one arising after pertussis, and therefore cerebral, the other, I think, from disease within the lumbar vertebræ: in the former there was augmented, in the latter, diminished, irritability.

By means of these experiments and observations we are enabled, I believe, to explain all the apparent discrepancies between the statements of former authors, and between each of them and my own.

The observations of Nysten, and others, determined that the irritability of the muscular fibre still existed in ordinary hemiplegia; but they did not extend far enough to determine the comparative degree of irritability of the paralytic and of the healthy limbs, or the question whether, in the former, the irritability was diminished—the event probably expected—or augmented, a result, I believe, never anticipated.

Prochaska and Nysten and Legallois failed in their experiments, too, by not allowing time for the change in the condition of the irritability of the muscular fibre to take place.

Professor Müller and Dr. Sticker, on the other hand, did not distinguish between paralysis arising

from separation from the cerebrum merely, and paralysis arising from separation from the spinal marrow, a distinction of the utmost importance in every point of view, and that which explains the phenomenon under discussion. The term paralysis has been used by all the authors whom I have quoted, in too general a sense. This is so true that I may affirm that in one kind of paralysis, that which removes the influence of the cerebrum, and which is therefore paralysis of spontaneous or voluntary motion, there is augmented irritability ; whereas in the other, that which severs the influence of the spinal marrow, the irritability is diminished or even annihilated.

We may conclude that, in cerebral paralysis, the irritability of the muscular fibre becomes augmented, from want of the application of the stimulus of volition ; in paralysis arising from disease of the spinal marrow and its nerves, this irritability is diminished, and at length becomes extinct, from its source being cut off.

We may further deduce, from the facts which have been detailed, that the spinal marrow, and not the cerebrum, is the special source of the power in the nerves of exciting muscular contraction, and of the irritability of the muscular fibre ; that the cerebrum is, on the contrary, the exhauster, through its acts of volition, of the muscular irritability.

As a further deduction from the same facts, we may infer the diagnosis between cerebral and spinal paralysis : mere cerebral paralysis is attended by augmented irritability, whereas spinal paralysis is that

which is attended by diminished irritability. This fact will prove useful in many obscure cases.

Having thus cleared up the physiological question, I proceed to the application of the principle to pathology ; and I may here observe that there is a whole series of phenomena which admit of explanation by its aid.

And, first, the exception to the rule of augmented muscular irritability in paralytic limbs, is obviously dependent upon its existing in the cases of paralysis from the severed influence of the spinal marrow, as distinguished from those arising from the severed influence of the cerebrum merely.

Secondly, we understand at once why the influence of strychnine is first, and most, seen in cerebral paralysis, in the paralytic limbs.

But there are still some other points which I must bring before the notice of the Society.

The first of these is the influence of emotion in paralytic limbs.

The second is the similar influence of certain acts of respiration ; as yawning, sneezing, coughing, &c.

The third, the similar influence of the tonic power.

It must have occurred to us all to observe the influence of surprise or agitation, on the arm and hand, and perhaps on the leg, of a patient long affected by hemiplegia, whilst the limbs of the healthy side remained unaffected. In this case the influence of the emotion is, like that of strychnine in the case formerly discussed, exerted equally upon

the limbs of both sides ; but it is the muscles of the paralytic limbs which are most irritable, most susceptible of the stimulus ; it is therefore these limbs which are most convulsively affected.

The same phenomenon is not observed in paraplegia, because the influence of the emotion is cut off from the affected limbs.

CASE I.

I was called to a patient a short period ago, affected at that moment with bronchitis. He was forty-three years of age ; and at the age of twenty-four had been seized with hemiplegia. Recovering from the immediate danger of the attack, he remained hemiplegic, scarcely regaining the use of the hand and arm at all, and only partially that of the leg.

Whenever this patient is excited by meeting an acquaintance, or in any similar way, he has a little strabismus, and the hand and arm are contracted and convulsed in the most extraordinary manner : whenever he coughs, the leg is thrown involuntarily upwards. The arm is severed, as it were, from volition, but affected by emotion.

Similar facts have been observed in regard to the influence of certain respiratory acts, but especially those of yawning, sneezing, &c.

Dr. Abercrombie details the following interesting case in a note to the late Mr. Shaw :

“ I think the following case will be interesting to

you and Mr. Bell. I had some time ago under my care, a man affected with hemiplegia of the left side ; the palsy complete, without the least attempt at motion, except under the following circumstances : he was very much affected with yawning, and every time he yawned the paralytic arm was raised up, with a firm steady motion, until it was at right angles with his body (as he lay in bed on his back), the fore-arm a little bent inwards, so that his hand was above his forehead at its greatest elevation. The arm was raised steadily during the inspiration, and when the expiration began seemed to drop down by its own weight, with considerable force. He continued liable to the affection for a considerable time, and it ceased gradually as he began to recover the natural motion of the limb.”—That is, as I conclude, as the state of augmented irritability was removed by the returning acts of volition.

Not less interesting are the effects of the tonic power. In cases of hemiplegia of long duration, the paralytic limbs, but especially the arms and hands, are drawn into a state of chronic, rigid, contraction. This phenomenon is owing to the principle of tone constantly acting upon muscles now possessing augmented irritability, whilst they are never, or rarely, relaxed by acts of volition.

A similar effect is seen in idiots born with atrophied cerebrum : the influence of volition is wanting ; that of the spinal marrow, the source, at once, of the tone and of the irritability of the muscular system, is in constant action, and induces chronic

contraction, an effect which must, however, be distinguished from that of spasm, which is excited immediately by some disease of the spinal marrow itself.

I may now resume the subject of the action of strychnine on paralytic limbs. It is obvious that the generalization of M. Fouquier, M. Ségalas, and others, that the strychnine attacks the paralytic rather than the healthy limbs, was too hasty. This is only true in those cases of paralysis in which the muscles still remain in nervous connexion with the spinal marrow; the opposite result is observed in those other cases in which such connection between the muscles and the spinal marrow is intercepted.

I would here make another observation. The arms and hands, generally speaking, are more under the influence of the cerebrum than the lower extremities; and these, on the other hand, are more under the influence of the spinal marrow than the arms and hands. The superior extremities are more and more frequently affected by hemiplegia than the inferior; these are more influenced by tetanus, by strychnine, &c., than the former, a fact which I have observed, in regard to strychnine, in some cases of hemiplegia. These facts must be borne in mind in making our observations.

Another circumstance must also be noticed. The more perfect the paralysis, generally speaking, the more the irritability of the muscular fibre is augmented. In hemiplegia, the arm is generally at once more paralytic and more irritable than the leg.

In chronic cases, however, the irritability becomes impaired, together with the nutrition.

I will now adduce a few cases which, however succinctly detailed, will exemplify and substantiate the preceding observations.

CASE II.

On January the 16th, 1839, I visited a patient who had been seized with hemiplegia nine months before : the arm was perfectly paralytic, the leg less so, the face less so still. On passing the galvanic influence through the arms, the left or paralytic arm was much more affected than the right, and distinctly affected by a force which induced no effect whatever on the right, the tendons starting on each completion of the galvanic circle ; the contraction of the muscles of the left side of the face was seen in its effect on the features ; and that of the left gastrocnemius, in its effect on the tendo Achilles, when no effect was perceptible on the right side of the face, or in the right leg.

In this patient other and very interesting phenomena were observed :

1st. The arm has, from the beginning, been much more paralytic than the leg or the face :

2nd. The influence of strychnine was observed in the paralytic arm and leg only, in the latter more than in the former :

3rd. Any sudden noise, or other causes of emo-

tion, affect the paralytic side only—the leg, however, more than the arm :

4th. Yawning and sneezing move the paralytic limbs ; the former the arm, the latter the leg, principally :

5th. The act of stretching, and the act of raising the right arm above the head, induce unconscious movements of the left or paralytic arm :

6th. During sleep, the left or paralytic arm and hand are greatly contracted and painfully pressed to the side :

7th. The paralytic arm shrinks from the application of cold, as the sudden contact of a cold hand ; an example of the reflex action in hemiplegia :

8th. Lastly, the paralytic hand and arm are constantly in a state of contraction.

I repeated the trials with the galvanic shock, with the same results, on February the 14th.

CASE III.

On January the 15th and 22nd, 1839, I passed a slight galvanic shock through the orbicularis of each side of the face, in a patient affected with paralysis of the left facial nerve from exposure to cold, of six weeks' duration. Here the right eyelid was forcibly closed, the left or paralytic eyelid being totally unaffected.

CASE IV.

On February the 13th, I passed the galvanic shock through the two orbiculares in a patient whom I visited with Mr. Burford, and in whom the facial nerve was partially paralyzed by the removal of a considerable branch of the nerve, together with a tumour which had formed in its course along the cheek.

The muscle of the paralytic side was unaffected, whilst that of the healthy side closed the eyelids on every application of the galvanic influence.

CASE V.

I have more recently performed the same experiment on a patient affected with paralysis of the facial nerve, from otitis and disease of the temporal bone, with precisely the same result.

CASE VI.

On February the 9th, I compared the influence of the galvanic in two patients at the St. Pancras Infirmary: both were affected with complete muscular paralysis of the arm; the first case was cerebral, being hemiplegia; the second was an injury of the brachial plexus, having resulted from dislocation of the shoulder; the results were what I had anticipated; in the case of hemiplegia, the irritability of

the muscles of the paralytic limbs was greater than that of the muscles of the healthy limb ; in the case of injured brachial plexus, the opposite state of things was observed, the irritability of the muscles of the paralytic hand and fore arm being greatly diminished.

CASE VII.

On January the 23rd, 1839, I passed the galvanic shock through the hands of a patient who had been gradually affected with paralysis of the right, from handling leaden types, as a compositor. Here, again, the paralytic muscles were unaffected by a degree of galvanism, which induced an evident effect on the muscles of the healthy limb.

CASES VIII. and IX.

On January the 10th, 1839, I galvanized a little boy with paralysis of the left leg ; the muscles were more irritable than those of the healthy leg ; the affection had followed pertussis, and I concluded that it was cerebral. This conclusion was confirmed by a fact which I learnt afterwards, viz. that in the commencement there was imperfect closure of the eyelids during sleep. On the same day I tried the galvanic influence in a case of partial paraplegia in a little girl, a patient of Mr. Burford ; in this case the muscles of the paralytic limbs were less irritable than those of the healthy limbs ; I concluded that

the disease was seated in the course of the nerves, and probably within the lumbar vertebræ.

CASE X.

It has been suggested to me, that the loss of irritability in the cases of spinal paralysis might be owing to defective nutrition of the muscles. I therefore tried the effect of galvanism in a case of chronic cerebral paralysis, or hemiplegia, with much emaciation of the paralytic muscles. I found these muscles, as before, much more irritable than those of the unaffected limb.

I must repeat, that I am perfectly aware of the sketchy manner in which these notes of cases are given ; but I thought it better to leave the further details for another kind of communication to this Society.

In the meantime we may conclude, that by the test afforded by the galvanic trough, we are enabled to effect a diagnosis between the cases to which I now allude. Disease of the cerebrum itself,—disease of the dorsal portion of the spinal marrow,—induces cerebral paralysis, hemiplegia, or paraplegia ; disease compressing or destroying the facial nerve, or the cauda equina in the lumbar region, induces both cerebral and spinal paralysis. In the former case we shall observe augmented, in the latter diminished, irritability of the muscular fibre.

This conclusion is generalized in the sketch given opposite. In all cases of paralysis represented

by the lines A B, C D, E F, &c., the influence of the cerebrum is removed, that of the spinal marrow, the source of the excitor power in the nerves, and of the irritability of the muscular fibre, remaining; we have, therefore, augmented irritability. In all cases of paralysis represented by the lines G H, H I, the influence of the spinal marrow itself is removed; we have, therefore, diminished irritability. These lines

may be designated lines of cerebral, or of spinal, paralysis, respectively.

I may now resume the points of this paper, and observe,

1st. That the spinal marrow, exclusive of the cerebrum, is the source of the muscular irritability :

2nd. That the cerebrum is, in its acts of volition, an exhauster of that irritability :

3rd. That, in muscles separated from their nervous connexion with the brain, we have augmented irritability :

4th. That, in muscles separated from their nervous connexion with the spinal marrow, we have, on the contrary, diminished irritability :

5th. That the degree of the irritability of the muscular fibre of paralytic limbs, compared with that of the muscles of the healthy limbs, will afford us a source of diagnosis between cerebral and spinal paralysis, and especially between

- { 1. Hemiplegia of the face, and
- { 2. Paralysis of the facial nerve ;
- { 3. Hemiplegia of the arm or leg, and
- { 4. Disease of the nerves of these limbs ;*
- { 5. Disease of the spinal marrow in the dorsal region, and
- { 6. Disease of the cauda equina in the lumbar region ; &c.

* In disease of the cervical vertebræ, the arms are sometimes paralyzed without paralysis of the legs ; this probably arises from compression of the brachial plexus. See Sir B. Brodie's paper in

6th. That the greater influence of emotion, of certain respiratory acts, of the principle of tone, &c., on the muscles of certain paralytic limbs, than on those of healthy limbs, depends on their augmented irritability :

7th. That the same principle explains the greater susceptibility of the muscles in certain cases of paralytic limbs, to the influence of strychnine :

8th. That, in the conclusions of M. Fouquier, Professor Müller, &c., a sufficient distinction was not made between the influence of the cerebrum and of the spinal marrow, which in this, as in so many other respects, have such different properties :

9th. From these, and other experiments and observations, I conclude, too, that sleep restores the irritability of the muscular system, by arresting the acts of volition, which exhaust or diminish it ; muscular efforts, on the other hand, diminish the irritability and induce fatigue.

I may again observe, in conclusion, that I have purposely avoided giving cases in detail. I wished, in this communication, to restrict myself to principles ; in a future one, I may supply the defect to which I have alluded. On an early occasion, I propose to lay before the Society, in a second memoir, the results of my observations, 1st. On the reflex action in certain cases of paralysis, tetanus, &c. ; and, 2nd. On the retrograde action in certain cases of disease of the spinal marrow.

the transactions of this Society, vol. xx. p. 130 ; the galvanic trough would determine the question.