

due to the action of many muscles, but there is no safe ground for believing that the combination is of a functional character; the weight of evidence is against this.

As to the question whether a muscle, when supplied by several nerve-roots, is supplied by them in such a way that one piece of the muscle is supplied by one root, another by another, although there is certainly great interlapping of regions belonging to the individual roots, I cannot agree with Forgue and Lannegrace when they say, "Excitation of a spinal root determines in the muscles which it supplies a total, not a partial, contraction." Simple inspection is enough to convince one, that in the case of some of the larger muscles, *e.g.*, in the thigh and spinal regions, the nerve supply from the individual roots is distinctly partial, that a district of the muscle belongs to this root, another district to that, although always with a large mutual overlap; striking examples are given by the *sartorius*, 3rd and 4th (*Macacus sacrococcygeus superior*, 7th, 8th, 9th (cat), &c. On the other hand, as the distal end of the limb is approached, the intermingling of the root-districts in the several muscles becomes more intimate, and in the muscles of the sole the intermingling of the muscle-fibres belonging to individual nerve-roots is so complete as to baffle analysis, except by the degeneration method. In the sphincter muscle of the anus there is an overlap of the motor distributions of the right and left halves of the body. The sphincter ani is supplied by four nerve-roots, two right-hand, two left-hand. Any three of these may usually be cut through without the anus becoming patulous, or exhibiting asymmetry. Conversely, excitation of any one of the efferent roots supplying it causes contraction of both right and left halves of it. The innervation of the bladder from its right- and left-hand roots, is, on the other hand, neither in the case of its sympathetic nor its direct spinal supply of a bilateral character.

IV. "On the Causation of Diphtheritic Paralysis." By SIDNEY MARTIN, M.D., F.R.C.P., Assistant Physician to University College Hospital. Communicated by GEORGE BUCHANAN, M.D., F.R.S. Received March 2, 1892.

The paralysis following diphtheria in man is so closely associated with the acute disease that it is more correctly considered as a symptom and not a sequela. Its mode of production in man has not been demonstrated.

A chemical examination of the blood and spleen of eight patients who had died of diphtheria revealed the presence of two classes of substances not normally present in the tissues of the body, viz. (1) of

two albumoses or digested proteids, proto- and deuterio-albumose, giving the same chemical reactions as the albumoses of peptic digestion, and (2) of an organic acid, which is soluble in absolute alcohol and in water, to a less extent soluble in amyl alcohol, and insoluble in ether, chloroform, or benzene. There is no base or alkaloid present. Owing to the small quantities in which this acid was obtained, a more detailed chemical examination was not possible.

*Physiological Action of the Albumoses.*—When injected into the circulation of a healthy rabbit these albumoses produce fever. If a single dose only be given, the fever subsides, and the animal remains apparently well for months. A single dose, however, may kill in a few hours.

Repeated doses of the albumoses, besides producing fever, cause a paralysis which may come on in two days, but more often is evident in six or seven days, and may be delayed for twenty days if the dose is small.

The total doses given were between 0.083 gram and 0.157 gram per kilo. of body weight in rabbits weighing between 1000 and 2000 grams.

The paralysis is not complete, but is a paresis, and is not accompanied by any special wasting of the paralysed parts. The paralysis is progressive, and, if the dose be large enough (over 0.1 gram per kilo. of body weight), the animal dies in syncope with either slow or quickened respiration.

The animals that do not die, but show paralysis, may have syncopal attacks, with an affection of the respiration; but they recover from these.

Five animals were used for experiment, and they all showed the same symptoms, including a loss of body weight, which is proportional to the dose of the albumoses.

A *post-mortem* examination of these animals showed that the blood was slow in coagulating with the largest doses. Bacteria were absent from the blood and tissues, and in only one case was any œdema (of the abdominal wall) found.

After staining with osmic acid and counterstaining with borax-carmin, the nerves were found extensively degenerated, while the spinal cord, spinal ganglia, and brain were normal.

The degeneration of the nerves is what has been described by Gombault\* in his experiments on lead poisoning as “un névrite-segmentaire périaxile,” or a segmental degeneration.

This degeneration affects a segment of the nerve; the fibres at that part lose their white substance of Schwann, and the axis cylinders become attenuated, and, in many cases, ruptured. If the axis cylinder

\* ‘Archives de Physiologie,’ 1880-81, p. 11.

becomes ruptured, the nerve fibre below the point undergoes the Wallerian degeneration. The early stage of the segmental degeneration is the breaking up of the white substance of Schwann.

There may be more than one degenerated segment in the nerve which may then undergo completely the Wallerian degeneration. Above the degenerated segment the nerve is normal, the change being simply peripheral and not central in origin.

All nerves in the body may be affected by this degeneration: the motor nerves, the sensory, and the visceral (sympathetic).

An example may be quoted to show the extent of the nerve change. A rabbit, which received two doses, equal to 0.1 gram per kilo. of body weight, showed definite palsy on the twentieth day, and was killed on the twenty-fourth.

Segmental degeneration was found in the following nerves:—

#### I. MOTOR.

##### *Of leg.*

Nerve to sartorius.

- „ vastus.
- „ semimembranosus.
- „ semitendinosus.
- „ biceps.
- „ gastrocnemius.

##### *Of arm.*

Nerve to pectorales.

- „ triceps.
- „ biceps.
- „ flexor of forearm.

##### *Of diaphragm.*

Phrenic.

##### *Of laryngeal muscles.*

Left recurrent laryngeal.

##### *Of psoas.*

##### *Of eye muscles.*

Branches of third cranial nerve.

#### II. SENSORY NERVES.

Long saphenous nerve.

Cutaneous thoracic nerve.

#### III. VISCERAL.

The lower part of right cervical sympathetic.

The nerve change is, therefore, widely spread over the body.

*Physiological Action of Organic Acid.*—This is much less toxic than the albumoses, and I have not succeeded in producing paralysis with it. It, however, produces a moderate degree of nerve degeneration when injected into the circulation.

The nerve degeneration is associated with a fatty degeneration of the muscles, which is proportional to the degree of degeneration. The heart, in all cases, shows advanced fatty degeneration.

*Diphtheritic Membrane.*—The membrane in diphtheria consists chemically of fibrin, hetero-albumose, proto-, and deuto-albumose, *i.e.*, it is in a state of digestion. From it was obtained an extract which was 3—5 times as toxic as the albumoses removed from the body, producing the same symptoms (fever, paralysis) and the same nerve degeneration.

This poison is probably the same as that isolated by Roux and Yersin, and is presumably of a ferment nature, the albumoses and organic acid found in the bodies of the patients being the result of the action of the ferment on the proteids of the tissues.

Diphtheria would, therefore, be, from this point of view, a disease in which the *Bacillus diphtheriæ* growing in the membrane excretes a ferment which, being absorbed, digests the proteids of the body, with the formation of albumoses and an organic acid, the action of the former of which is to produce fever and paralysis dependent on nerve degeneration.

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