

ceeded against them. Their use was never intended to interfere with the legitimate business of a pharmacist, and their sphere of applicability has its limits like every other improvement. Physicians will prescribe them as the best means of administering some drugs, and will carry them to use in emergencies, and in cases where the cost to the physician is small and the saving to the patient relatively large. They will dispense them from their offices when they want a preparation with the action of which they are acquainted, or where it is necessary there should be no delay. In such instances as these the triturate fills a long-felt want. After more than four years' continuous use I can recommend them to the society as a safe, economical, and profitable way of administering medicines.

#### FOUR CASES OF "WESTPHAL'S PARADOXICAL CONTRACTION,"

WITH REMARKS ON ITS MECHANISM.

I. DISSEMINATED SCLEROSIS. — II. LOCAL INJURY.  
III. FOLLOWING SUNSTROKE. — IV. HYSTERIA  
FOLLOWING MALARIA.

BY MORTON PRINCE, M.D.,

Physician for Nervous Diseases, Boston City Hospital, O. P. D.

As is well known, when the tendons of certain muscles are suddenly stretched, a resisting contraction is excited in the muscle itself. As good examples as any of this are the knee-jerk and the ankle clonus. In contrast with this, Westphal has pointed out that, under exceptional conditions, a contraction lasting for some little time may be excited in the tibialis anticus, for example, not by stretching, but by *relaxing*, its tendon, as when the foot is suddenly flexed dorsally. Hence, in contradistinction to the first form of contraction, he has called this latter form the "paradoxical contraction." Considerable difference of opinion still exists regarding the mechanism of this contraction, as it still does in regard to that of the knee-jerk. Westphal's explanation is that the relaxation itself of the muscle is a source of irritation sufficient to excite a contraction.

Erlenmeyer<sup>1</sup> has disputed Westphal's explanation, on the ground that if the calf muscles be so manipulated that they cannot be stretched by dorsal-flexion of the foot, the contraction in the tibialis anticus does not occur, notwithstanding that it is completely relaxed. His method of accomplishing this is as follows: While the subject is lying in bed and the knee is bent, the calf is grasped firmly in the hand and pushed strongly towards the heel. In this way the muscles from the tendon to the belly of the calf are shortened, and are not stretched when the foot is dorsally flexed. If this be done, the paradoxical contraction does not occur; and, conversely, if the contraction be first excited, the foot immediately drops in manipulating the calf muscles in the above way.

From this Erlenmeyer concludes that the contraction is not brought about by relaxation of the muscle itself, but is a reflex contraction, caused by stretching its antagonists, the calf muscles.

To all this Westphal<sup>2</sup> replies that he in the first place doubts whether a muscle can be shortened

by the process described; and, in the second place, the results are to be ascribed not to shortening of, but to pressure upon, the gastrocnemius; for, if simply pressure be made upon the calf against the bones, without pressing downwards towards the heel, the same results are obtained; namely, the paradoxical contraction does not occur, or is abolished.

Mendelssohn<sup>3</sup> explains the phenomenon by a rupture of the equilibrium of the tonus in certain muscular groups and their antagonists.

Charcot and Richer, who have studied the matter in hysterical subjects in whom they have found an analogous contraction, coincide with the views of Erlenmeyer and Mendelssohn, and believe that the contraction in question is a reflex contraction excited by the stretching of the antagonistic muscles. Their main reason for these views is found in the following facts: It is well known, they say, that in the patients they are speaking of (*i.e.*, hysterical) contraction can be obtained by various methods; massage of the muscles is one of them. Thus, if the tibialis anticus be kneaded, contraction soon sets in, and the foot is fixed in the state of dorsal-flexion; massage of the gastrocnemius brings about the opposite result. Under other experimental conditions, however, different and opposite results may be realized; and this is the point to which attention is particularly drawn. If whilst the calf muscles are kneaded the foot is supported so as to be prevented from yielding to their contraction, we soon see it rise and assume a position of dorsal-flexion, the more marked the more prolonged the excitation of the gastrocnemius and soleus.

They conclude that when a muscle is stimulated, its antagonist is simultaneously excited, the latter having thus a regulating function; and that when the effect of the direct contraction is in some way impeded, the action of the antagonist may become predominant.

Then there are other ways of producing "paradoxical contraction" besides this mode just referred to. It may be produced in the foot, for example, by faradization of the tibialis anticus, and even by volitional impulses.

I have met with four cases in which this phenomenon was present, and, as such cases are comparatively rare, it is worth while reporting them here. Two cases, Nos. II. and IV., are unique.

CASE I. is one of well-marked disseminated sclerosis, characterized principally by paresis, tremor of both hands, head and jaw, on voluntary motion, and increase of the tendon reflexes. The tremor of the jaw is so violent that it is with the greatest difficulty that the thermometer can be kept in the mouth for the purpose of taking the temperature.

On flexing dorsally the feet and toes with the hand the extensors are thrown into strong tetanic contraction. The tendons are seen to stand out prominently under the skin, and the toes and feet to be held in strong dorsal flexion for some minutes. The return to the original position is gradual. By volitional effort on the part of the patient the contraction can be overcome.

CASE II. is one of considerable interest. The

<sup>3</sup> Charcot and Richer, *Brain*, October, 1885.

<sup>1</sup> *Centralblatt f. Nervenhellkunde*, 1880, No. 17, p. 345.

<sup>2</sup> *Ibid.*, No. 20, p. 417.

phenomenon is unilateral, and, as will be seen, depends on local causes. When the toes of the left foot are pressed upwards they are rigidly held by the extensor muscles, for a number of minutes (five to ten?), in the position in which they are placed; these muscles are thrown into strong tetanic contraction, and can be seen to stand out sharply defined beneath the skin; to the touch they are firm and hard. When the foot, as a whole, is pressed upwards the contraction of the *tibialis anticus* which ensues is much less in degree. The foot almost immediately begins to drop, and returns slowly to its original position in the course of five to ten seconds. Sometimes the foot during its return is attacked with tremor, as if the muscle only reluctantly yielded.

If, instead of passively pressing the toes up, the patient voluntarily raises his toes, they are seized in the same way with cramp of similar character and severity; likewise with the foot. So severe is this spasm that almost any effort to use his toes results in their being drawn upwards in strong tetanic spasm.

When the spasm has set in, the patient cannot for some seconds or minutes bend his toes, but if they and the foot be firmly grasped, and gently but slowly be worked back and forth, the spasm in a few seconds relaxes. Sudden and strong attempts to bend the toes downwards only tend to increase the spasm of the extensors; or at least are met with strong resistance. But if, while the muscles are relaxed, the toes be strongly bent (flexed) downwards, no contraction in the *stretched* extensors ensues, but when they are again raised, either passively or voluntarily, as soon as they arrive at a certain point they become "set," as the patient terms it, *i.e.*, firmly held by spasm.

The rationale of this spasm was not at first clear, but a little study cleared up the mystery.

The patient attributed the trouble to a gun-shot wound of the toes, the ball being supposed to have hit the great toe and cut the flexor tendons of the others; but a careful examination failed to detect any scar or other signs of injury. The larger joint of the great toe was, however, tender, and it was noticed that the patient sought in walking to relieve this joint of pressure by throwing his weight on the outer side of the foot, while at the same time he tended, as an associated movement, *to raise his toes from the ground*.

This constant action of the extensors of the toes, and in a lesser degree of the foot, was evidently the cause of the observed spasm. From being constantly thrown into contraction these muscles had become irritable, and any excitant, reflex or volitional, resulted in spasm.

A condition had been created similar in many respects to that of the muscles of the arm in writers' cramp.

The "paradoxical contraction" that here ensued on passively relaxing the muscles is beyond question a reflex spasm, originating either in a primary contraction of the calf muscles caused by their being stretched, or in an irritative impulse from the joints. That this latter may have been an active factor is suggested by the fact that in dorsally flexing the toes they became "set" at a fixed point, which seemed to correspond to the position in which they were held while walking.

That the flexor muscles of the toes (as is probably always the case) are also affected by spasm is evident from the position in which the toes are held. They do not, however, contract on being relaxed, as do the extensors. I think there is also a hypochondriacal element in this case, which tended to keep alive the tenderness of the joint for which there seemed to be no anatomical justification. The cramp on volitional action corresponds with what has been observed in other cases.

It should be added that this patient is blind in his right eye, the same being alleged as result of sunstroke some twenty-five years ago. The ophthalmoscope showed deep glaucomatous cupping and atrophy of disk. Left eye: fundus normal.

CASE III. is not a pure form, neither the symptoms being persistent nor the case characteristic of any known type of disease. There is a strong hysterical, or at least "functional," element in the case, with a tendency to exaggeration of symptoms from interested motives as a pension claimant. The patient attributes his condition to a sunstroke which he incurred during the late war. Principal symptoms are, dizziness, headache, and feeling of pressure on top of head. Staggered at times in the street, head seems to whirl round, and he is obliged to catch hold of something to save himself from falling. Feels weak generally; unable to work. These symptoms have been gradually coming on since his sunstroke. One year ago obliged to give up work as a carpenter.

Tongue protrudes slightly to right; staggers to right with eyes shut and feet together; voice slightly tremulous; pupils slightly unequal; hearing impaired, — more so, Dr. Leland reports to me, than can be accounted for by the coexisting catarrh of middle ear. Knee-jerks moderately exaggerated at times. No other signs, but he is at times nervous, excitable, and emotional. The "paradoxical contraction" is accompanied at times by spasm of the other muscles of the leg; sometimes cannot be incited at all.

CASE IV. This case I had originally supposed to be one of disseminated sclerosis, characterized by exaggerated knee-jerks, marked paresis, and typical tremor. The patient ascribed his condition to malaria contracted during the war.

The "paradoxical" phenomenon was present in the extensors of the toes and feet. Momentary Paralysis to these muscles, as well as to the quad. femoris, was followed by tetanic contraction, which persisted after interruption of the current.

But what was most interesting about the case was this: massage of the *tibialis anticus* was followed by contracture of all the muscles of the lower leg, but that of the calf preponderated, *so that the toes and foot were strongly drawn downwards* (flexed). Continued massage was followed by dorsal flexion, though my notes are not explicit on this point. Friction of the skin over the *tib. ant.* produced the same result. Both massage and friction, though applied to the leg, caused also contraction in the quad. femoris. This patient I have here to-night, and you will see the picture has in some respects changed. It is some six weeks since I first saw him. The tremor, paresis, and exaggerated knee-jerks are gone. He says that his health has greatly improved, and he is able to work. But the

phenomenon in question you will see still exists, though perhaps not in so marked a form as before.

In kneading the tib. anticus, or applying friction to the skin over it, you will see contracture sets in; but the toes and foot are not drawn downwards as before, but upwards; that is, contracture occurs in the muscles massaged. Massage of the calf muscles is not followed by contracture.

The similarity between this phenomenon and that produced on hypnotic subjects by Charcot and others is striking. As is well known, the Salpêtrière School report contractures following friction and massage as one of the phenomenon of hypnotism. Other experimenters, those of the Nancy School, have failed to confirm these results, and claim that these contractures are caused by suggestion. In this case of mine I think suggestion out of the question, as when first examined I was as much surprised at the result as the patient, and I had only a vague idea as to what would happen; nor had a word previously been said on the subject by me to any one. The idea of massage only occurred to me at the moment I applied it. The disappearance of the other objective symptoms shows the case to be of a functional nature, with something of an hysterical element in it, possibly caused by malaria.

To return to the mechanism of this contraction, a study of the effect of passive and volitional motion of joints in normal subjects will throw considerable light upon it, if this be still required.

In the first place, it is absolutely impossible, by any action of the will, to contract the flexors or extensors of a joint without at the same time contracting in a lesser degree the antagonists. If we could contract the flexors of the wrist, for example, without doing likewise by the extensors, the hand would flop over upon the forearm, as in the dead subject when the tendons are pulled. The simultaneous action of the extensors evidently has a regulating influence. If, again, in the normal subject we *passively* move a joint like the ankle, that is served by a tendon (*tendo Achillis*) that responds to stretching, it is easy to demonstrate that not only the muscles that are stretched contract, but there is always more or less contraction in the relaxed antagonists; that is, when the foot is dorsally flexed, not only do the calf muscles contract, but the tibialis anticus contracts, also, in a lesser degree. This observation I believe to be correct, and, though not easy always to make out, I have been able to demonstrate the fact on a number of normal subjects. When the foot is pressed upwards, if a finger of the other hand be placed over the tendon of the tibialis anticus, a distinct, though momentary and sometimes slight, often pronounced, jerk upwards of that tendon can be felt. This jerk follows the upward flexion of the foot by a distinct interval, as if it did not occur until the calf muscles had been put upon the stretch. This interval between the pressing up of the foot and the contraction of the tibialis anticus tendon I have also found very pronounced when the paradoxical contraction was present, showing another point of resemblance between the two. In examining this contraction of the tibialis anticus in normal subjects, great care must be taken to eliminate the effect

of volitional effort on the part of the patient, — not always an easy thing to do. From these facts I am disposed to regard the "paradoxical contraction" as *not entirely a new phenomenon, but only an exaggeration of a normally existing one*, and to agree with Erlenmeyer, that the so-called paradoxical contraction is not caused by a *relaxation* of the tibialis anticus, but is a reflex caused by the stretching of the calf, and possibly, I would add, by irritation of the sensory nerves of the joint. The difference between the normal and abnormal is one of degree, the mechanism being probably the same.

The nature of the pathological change upon which the increased irritability of the muscle in the abnormal phenomenon depends is as yet unknown.

The spasm of all the muscles moving a joint in any attempted movement is well observed in an inflamed joint. The spasm here is undoubtedly reflex, but the inciting impulses without question arise from the sensory nerves of the joint, as well as from the particular muscles that happen to be stretched.

Some further facts bearing on the mechanism of what I may call the antagonistic contraction are obtained from the phenomenon of hypnotism. It seems to be admitted that with subjects in the lethargic condition, and in some hysterical subjects, kneading a muscle is not only followed by contraction of the muscle kneaded, but its antagonists are, in a less degree, excited, an action that can only be reflex.<sup>4</sup> This was observed in Case V., narrated above.

The muscles in which this phenomenon is most commonly observed are, as has been said, the tibialis anticus and extensors of the toes. It has also been found in the flexors of the knee, and rarely in the arm muscles. In a case of hysteria or hypochondriasis in the male, I was able to obtain this contraction in the shoulder muscles as well as in the toes. It is fair to state, however, that I could not, in the one examination allowed me, completely satisfy myself of the absence of all volitional impulse in this case. As Westphal remarks, there are some people who seem to be unable to allow a joint to be perfectly passively handled, any attempt to move it being followed by volitional contraction of the relaxed muscles. It requires great care to eliminate all fallacy from this factor.

The diagnostic value of the symptom is still undetermined. Westphal observed it in cases of tabes, and in others in which disseminated sclerosis could, with probability, be diagnosed, although typical symptoms, such as muscular rigidity and tremor, etc., were absent.

In the cases of tabes, motor weakness was always present, so that it can be surmised that more than a pure posterior sclerosis was present. In other cases in which the symptom was present the clinical picture was so peculiar that they could not be classed with any known type of disease.

Westphal also observed the symptom in paralysis agitans.

Ross has found it in a case of hæmatomyelia, and Charcot and Féré in certain forms of hysteria, as above mentioned. In no case has there been observed muscular rigidity or excess of myotatic irritability.

<sup>4</sup> Binet and Féré. *Le Magnétisme Animal*, p. 53. Charcot and Richer, *op. cit.*