whether the symptoms were due to tetanus or whether they could not be entirely accounted for by serum sickness.

On March 18th the trismus had almost disappeared and the muscular pains were less severe. He had one dose of chloral hydrate (20 grains) during the day. On March 19th he could open his mouth to the full extent. The temperature was normal and the pain disappeared. Further progress was rapid and satisfactory. He was allowed up on March 23rd, and went to a convalescent home on March 25th.

If the symptoms were due to tetanus the infection might have taken place at one of the following times:

1. When he pricked his finger. Inquiry showed that the patient on whom the operation for empyema was performed made an uneventful recovery. But as he had received an injection of antitetanus toxin it is possible that tetanus bacilli were present in the wound.

2. When the finger was incised. This is almost unthinkable at a place where there is constant operating and a regular surgical technique.

3. From the needle, when the antistreptococcus serum was injected. This is also unthinkable.

4. The serum might have contained some tetanus toxin. This is possible, but unlikely, otherwise one would expect to have heard of other cases of a similar character.

The course of the symptoms and the rapid recovery point to the condition having been due entirely to the antistreptococcus serum.

I am indebted to Lieutenant-Colonel T. H. Goodwin, C.M.G., D.S.O., R.A.M.C., for permission to publish this case.

BABINSKI'S SIGN FROM THE POINT OF VIEW OF COMPARATIVE ANATOMY.

Abridged from a Paper by

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In a series of papers published in the Russian *Journal of Psychiatry*, Petrograd, I have brought forward arguments showing that in the explanation of symptoms observed in lesions of the pyramidal tracts it is necessary to call attention to some facts of comparative anatomy.

About twenty years ago Babinski enriched the symptomatology of nervous diseases with a very important sign, the causation of which remains hitherto unexplained.

To say that the extensor plantar reflex is a spinal reflex, while the normal plantar reflex is a cortical one, is no solution of the problem. Such a statement contains no clearing up of the nature of the phenomenon and is but a paraphrase of the question. In fact, the sign of Babinski is somewhat enigmatic; it is neither an exaggeration nor an abolition of a function, but an inversion of it. We must search for some special mechanisms which, being latent in the normal subject, are set in action by a lesion of the pyramidal tract—that is, when the communication between the spinal cord and cerebrum is interrupted.

What is the nature of these mechanisms? A reply to this question is hinted at by the fact that the extensor reaction of the great toe is a quite normal phenomenon in infants who have not learnt to walk. Thus the sign of Babinski appears to be a normal phenomenon during a period of the ontogenetic evolution of man. Hence it can represent a rudimentary function, which is common to an earlier period of phylogenetic evolution, and being manifest in man during a certain period of his ontogeny, becomes latent in the adult individual, to reappear again in the case of lesions of the pyramidal tracts.

To prove the supposed rudimentary nature of Babinski's sign we must consider whether there are facts supporting the assumption that a lesion of the pyramidal tracts is a condition generally suitable for the appearance of any rudimentary signs.

In its long way of evolution from a lower metameric animal to the highest mammals the nervous system has undergone great and complex changes of structure and function. There is, however, a part of the nervous system which, in spite of these great evolutionary variations, has retained its essential anatomic and functional features. This part is the "propriospinal" apparatus (*Eigenapparat des Rückenmarks* of Edinger). Even in the high stages of evolution it remains metameric in structure and reflex in function.

According to Edinger, there are to be distinguished in the central nervous system two parts essentially different from the point of view of their phylogeny—the neencephalon and the palaeencephalon. The increasing functional and structural complexity of the nervous system consists in the overgrowing of the neencephalic—that is, pallial—elements and in the adaptation of the palaeencephalic elements to new functional purposes. In man the neencephalon is represented by cortex and its projection fibres. In the spinal cord of man the part corresponding to the palaeencephalon is the grey matter with its metameric reflex "centres," whereas the white matter of the cord belongs to the neencephalon, and consists of fibres of the neencephalic elements penetrating into the spinal palaeencephalon to communicate with the neencephalon (cerebral cortex). The metamerio spinal segments, thus connected by the pyramidal tracts with the cortex, gradually lose their pure reflex function to stand under the control of the neencephalic impulses—that is, to serve the purposes of voluntary innervation. In addition, the metameric nerves become combined in groups to form plexuses. The first rudiments of plexus formation are observed in the *Selachia* in the form of the "nervus collector," by which the metameric nerves are connected; in the *Selachia*, also, we meet the first traces of the neencephalic elements of the cortex.

Thus the propriospinal apparatus, without losing its essential character (reflex action), transmits the cortical impulses to the groups of nerves (plexus) by means of which these impulses spread further to muscles. By this combination of metameric nerves into groups a possibility is created for "neencephalic" innervation of groups of muscles (voluntary movements of extremities). Thus, instead of metameric reflex innervation, arises voluntary innervation by segmental groups of nerves. To get this result the neencephalon suppresses the reflex action of the propriospinal apparatus (cortical inhibition), this latter becoming appropriated to the transmission of the impulses, not from one segment to another, as in lower metameric animals, but to the whole groups of segments according to the groups of the muscles of the extremities. This influence of the neencephalon on the propriospinal apparatus is realized in the main by means of the pyramidal tracts.

In a lesion of the pyramidal fibres—that is, in a case of separation of the propriospinal apparatus from the neencephalic elements of the cortex:

1. The voluntary impulses cannot reach the periphery, whence arises paralysis or paresis.

2. The inhibitory influence of the cortex on the propriospinal apparatus ceases—thence appear: (a) the increase of reflexes, the clonus; (b) the propagation of the reflex irritation from segment to segment in form of "réflexe de défense" and analogous symptoms (the pandiculation of Bertolotti, femoral reflex of Remak, etc.).

3. Lastly, there arise some reflex reactions corresponding to some earlier stage of phylogenetic evolution. These reactions are nothing but effects of mechanisms latent in normal cases and manifesting themselves in the case of loss of the cortical influence on the spinal cord.

And so Babinski's sign comes into existence; the normal flexion of the great toe is neither exaggerated nor diminished after a lesion of the pyramidal tract, but is inverted into an opposite reaction of the extensor type.

We will now try to explain the origin of Babinski's sign from the point of view of the evolution of the function of the great toe. The normal plantar reflex, that is, the synergic flexor reaction of all five toes, is a function peculiar to man. The lower extremity of man, with its purely static function, is evolved from an extremity with the function of grasping. In the act of grasping, the great toe makes no flexion, but a movement of opposition. The transition from the grasping function to the purely static function has been realized by the loss of the function of opposition. In man, unlike almost all other primates, the opponens hallucis muscle is absent, and the first os metatarsale is situated parallel to the other metatarsals, while in the other primates the first metatarsal makes an angle with the others. When, in the process of evolution, the grasping function is lost, there remains in the second, third, fourth, and fifth toes an aptitude for flexion, while the great toe loses its function of opposition absolutely. But for the act of walking a function of the synergic flexion of all five toes together is necessary. This act, as

already mentioned, is absent in a newborn child, and develops but gradually in learning to walk. In man the function of synergic flexion of all five toes is not an inherited capacity, but a special adaptation of the neencephalic elements and a result of the cortical influence. In man the centripetal impulses from the irritation of the foot sole reach the spinal segments corresponding to the flexor centres of all five toes. In other words, the normal plantar reflex in man is a function of the cortex, and, when the spine is separated from the cortex, this reflex—the synergic flexion of all five toes—disappears. In such cases, instead of spreading to the flexor centres of all five toes, the impulses from the sole spread only to segments to which they used to spread when there existed no special cortical mechanisms for synergic flexion of all five toes which do exist in man. The nearest function of the toes preceding their synergic flexion in man is the grasping function observed in other primates. So in pyramidal lesions, the impulses provoked by irritation of the sole must spread to the centres to which these impulses used to spread when the function of the foot was a grasping one. Thus they spread to the flexors of the second, third, fourth, and fifth toes. As for the great toe, its opponens muscle, to which in this stage of phylogeny have spread the impulses from the sole, is lost in man, therefore there would be no reaction of the great toe. This isolated flexor reaction of second, third, fourth, and fifth toes, the great toe remaining without reaction, is to be observed in some cases of pyramidal lesion, and is considered as a certain sign of pathological reaction, as a not well pronounced sign of Babinski, or an "allusion" to it.

The above arguments explain why, in the pyramidal lesions, the great toe does not participate in flexion of the toes as it does in a normal individual.

Now we come to the most important part of our discussion—namely, to the question of the extension of the great toe. This reaction realizes itself by means of the long extensor muscles, because the extensor brevis, being no separate muscle but a part of the extensor digitorum communis brevis, cannot act independently of the extensors of the other toes. We therefore must admit that in Babinski's reflex the impulse from the foot sole, instead of running to the spinal centre of the flexor hallucis, as it does in normal cases, goes to the centre of the extensor hallucis longus.

As the man's foot is evolved from a grasping organ, it is possible that in a certain stage of evolution of the grasping function into the pure static one there was a period when the flexor act was limited to the second, third, fourth, and fifth toes, the great toe having been during this act not only not flexed, but rather extended. Or, otherwise, we could admit that in the way of evolution the great toe has lost its grasping function most early, there having been a period when it used to be excluded by extension from the grasping act—that is, the flexion, of the other toes.

These suppositions are not mere hypotheses, but based on facts. The Western monkeys—Hapalidae—have claws on all digits except the great toe, which has a nail. Moreover, unlike the other monkeys and apes, the great toe of Hapalida is not opponible. These conditions are very important for the question we are discussing. They demonstrate that in the evolution of the static foot function the great toe has lost its grasping capacity earlier than the other toes. Moreover, the grasping act, like that of scraping, being limited to the second, third, fourth, and fifth toes, the great toe, not participating in these acts, must be removed from other toes, what can be done only by its extension. In Babinski's sign we probably have a rudiment of this condition.

In conclusion must be mentioned a modification of Babinski's sign, the *signe d'éventail*, which consists in the spreading out of the toes. It is very interesting that the function of the spreading out of the toes, which is absent or very limited in a normal individual, is sometimes well pronounced in cases of pyramidal lesions. Like the extensor reflex of the great toe, this phenomenon of the spreading out of the toes is observed in young children. According to the above stated arguments, it is not difficult to explain the nature of the *signe d'éventail*. It is a rudiment of mobility of the toes which existed in the grasping stage of evolution of the foot. As well as the extensor reflex of the great toe, the spreading out of the toes is present in a certain period of ontogeny, and becomes latent when the walking function is developed, but reappears when, in consequence of a pyramidal lesion,

the conditions arise for the manifestation of the phylogenetically older and more automatized mechanisms of the spinal cord. Perhaps the *signe d'éventail* is a rudiment of "showing the claws" act.

As to other phenomena analogous to the Babinski sign—those of Oppenheim, Gordon, etc.—their explanation is not difficult after what is argued with regard to the Babinski sign. Both Oppenheim's and Gordon's signs represent paradoxical extension reactions of the great toe in pyramidal lesions instead of the flexion observed in normal individuals. The synergic flexion of all five toes, seen in normal subjects at the manipulations of Oppenheim and Gordon, is, like the normal plantar reflex, a cortical function. In lesions of the pyramidal tracts this function disappears, and the spinal apparatus becoming automatic, there appear rudimentary functions explained by the facts discussed above.

Memoranda :

MEDICAL, SURGICAL, OBSTETRICAL.

A PORTABLE APPARATUS FOR THE CHLORINATION OF WATER.

In the *Journal of the Royal Army Medical Corps* for October, 1913, Colonel F. H. Trehearne and Captain J. J. Harper Nelson describe a method of generating chlorine and using it for sterilizing water. After a series of experiments at the Bangalore Brigade Laboratory a small apparatus was designed to facilitate the production of chlorinated water in the field. It consists of a tin case which could be carried from the shoulder by a strap, divided into two compartments to hold two bottles, a generator and a receiver. The apparatus was said to weigh not more than 12 lb., and was fitted to carry enough chlorate and acid to sterilize 1,960 gallons of water without replenishing. A subsequent design had a sterilizing capacity of 9,600 gallons. This appeared a practical apparatus, and was very favourably reported upon by Major H. C. R. Hime during the battery practice camp of December, 1913, at Rajankunti. I took over charge of one of these apparatus during the medical interdivisional manoeuvres at Poona later in the same year. I carried the apparatus about with me, and each evening prepared 20 oz. of chlorine solution, adding the required quantities to the ambulance packals. Although weighing only 12 lb., I learnt from personal experience that the box is sufficiently bulky to be cumbersome, and felt that something much simpler, stronger, and especially quicker in use was wanted. The making of a reliable chlorine solution when temporarily encamped on rough ground, by lamplight, with an apparatus consisting of glass bottles, glass and rubber tubing, and slippery stoppers, presents practical difficulties. In stationary camps or at head quarters the difficulties are less, but one of the great advantages of the chlorine method is, or should be, its practicability with small bodies of men detached from a permanent base or with large bodies on the move. It may occur in practice that the acid fails to produce the total quantity of gas unless the generating flask is warmed, and the chemical action is also hindered in some way by an increase of pressure in the generator.

I venture to put forward the following suggestion for an apparatus. Briefly the method depends upon the use of steel bulbs containing chlorine, under pressure, in sufficient quantities to make a stock solution of definite strength, when allowed to escape into a known volume of water. These bulbs I propose using with an apparatus similar to the ordinary commercial siphon soda flask, and I hope shortly to have a practical chlorine flask constructed of 20 oz. capacity, graduated, to facilitate the use of the stock solution when made. The solution will be of a strength of 1 in 550, for which purpose 15.9 grains of gas will be required for each 20 oz. of water. Steel bulbs each containing 15.9 grains of chlorine under pressure, together with a siphon flask of 20 oz. capacity into which these bulbs can be discharged, are the essentials of the apparatus. I am also arranging to have a 10 oz. chlorine siphon flask constructed of a similar pattern. The ordinary 20 oz. flask weighs 4 lb., and equipped with 6 dozen bulbs will weigh 4 lb. more. Six dozen bulbs are sufficient to sterilize 14,400 gallons of water, which to take as an example is enough, at the rate of a gallon a day per man, for a hundred