

Dogs that had received by vein the minimum uniformly lethal doses of mercuric chlorid died in spite of intravenous injections of sodium acetate-sodium phosphite solutions, even when the latter were given immediately after the poison had been given, and when the weights of sodium phosphite were from twenty to thirty-five times as great as the weights of the mercuric chlorid administered. The sodium phosphite-sodium acetate therapy has proved of no value in counteracting or preventing the deleterious effects of intravenously administered mercuric chlorid. Dogs and rabbits that had received by vein the minimum uniformly lethal dose of mercuric chlorid died in spite of the use of the best known forms of alimentary medication.

CONCLUSIONS

1. There is no sound experimental basis for the belief that the promotion of free diuresis contributes materially to the chances of recovery in mercuric chlorid poisoning, and this phase of treatment should not be permitted to obscure that which is more essential.

2. Combined treatments which involve sweating, diuresis and increased elimination from the bowel probably owe their value chiefly to the latter effort.

3. It would appear in the light of the present study that when 4 mg. or more of mercuric chlorid per kilogram of body weight has entered the tissues at large, death regularly occurs, and that we have no adequate grounds for believing that death is preventable by any known form of treatment. Whereas, subsequent studies may add to our knowledge, it would appear that persons who have recovered from mercuric chlorid poisoning owe their lives to the fact that a lethal dose has never gained access to the extraportal circulation. Practical therapeutic efforts should be directed frankly toward the accomplishment of two things: (1) Mechanical removal of the poison from the lumen of the alimentary tract. (2) Antidoting the poison before it leaves the portal circuit, that is, particularly before absorption.¹⁵

15. Before the completion of the work described above a patient who had entered the Presbyterian Hospital on account of mercuric chlorid poisoning was treated at the request of Dr. Frank Billings, by means of intravenous injections of glucose and of hypertonic salt and alkali solutions (1.4 per cent. sodium chlorid in 0.3 per cent. sodium carbonate-Fischer), and also by renal decapsulation. The negative results of treatment paralleled those observed in animals. None of the methods restored a flow of urine, and the patient died on the seventh day.

Milk.—The commission appointed by the food administrator to study the cost of milk delivered in Chicago, and to fix the price to be paid to producers has made its report on a basis that makes the price of milk delivered to consumers at 12 cents a quart. By the arrangement of the health commissioner, a number of depots have been established where milk can be purchased without delivery at 10 cents a quart. After taking testimony at numerous hearings extending over several weeks, the commission fixed the price to be paid to producers. From October 1 to November 1, the milk producers arbitrarily fixed the price to the distributors at \$3.42 and milk delivered retailed at 14 cents a quart. From November 1 to February, the price to distributors was \$3.22. The price as fixed by the commission allowed the contention of the distributors as to the cost of delivering the milk and the reduction fell entirely on the producers. As a protest against being obliged to shoulder all the reduction, the producers in many instances refused to ship their milk and Chicago has been on a short supply for a week or more. A new commission is to be appointed by the local food administrator to consider the question of waste in delivery of milk, on account of the fact that many distributors cover the same territory.

SYSTEMATIC THERAPEUTIC EXERCISES IN THE MANAGEMENT OF THE PARALYSES IN HEMIPLEGIA

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In considering the treatment of cerebral hemiplegia, Thomas¹ states that "the paralyzed limbs should be rubbed, moved passively," and "when voluntary power begins to return, this should be encouraged by practice, and the patient should have regular gymnastic exercises." Church² says that "as soon as the apoplectic coma has passed away, gentle massage of the paralyzed side and exercise of all the paralyzed muscles by mild faradism should be instituted.

As soon as there is any reappearance of voluntary motion the patient should be encouraged to exercise it. These measures are usually postponed to the end of ten days or a fortnight in fear that, by instituting them early, the brain lesion may in some way be increased." Then he suggests that the fear of greater injury is without reason, if the measures are properly carried out. These two statements from standard medical works illustrate the mode of treatment that has been advocated, and perhaps used, in most countries. Further statements would lead to the belief that some of the treatment is to be directed to the prevention of the deformity of contracture, and that the method of treatment does not insure a betterment in all cases. It has, in fact, been stated and is commonly assumed that in some cases there may be a persistent paralysis, and that if there is no return of voluntary movement within a period of two years, there is little or no chance that there will be improvement.

Much more hope is held out for the patient, and much greater detail of methods of treatment is given, by those who have developed and followed the Swedish system of therapeutic exercises. When these exercises are given in a proper, including systematic, manner the results are so encouraging that it seems probable they are not so well known as they should be, and that the advantages of gymnastics (with massage) are not fully recognized in the treatment of hemiplegic cases.³ It is because of these two considerations that it appears well to describe some of the methods of dealing with hemiplegics, as taught and practiced by the leading masseurs and recommended by the foremost physicians in Sweden, and to give some indications of their value by the citation of some experimental work with artificially produced hemiplegia in monkeys, and of some brief case records.

KINDS AND USES OF MOVEMENTS

In order to make matters plain, it will be well to define the terms that are used and to describe the methods named. Movements may be divided into the two general classes of "active" and "passive." The active movements are those that are brought about by the volition or the effort of the patient. These movements are called "free" when they are made without any resistance or without the performance of work

1. Osler and McCrea: *Modern Medicine*, 1915, 5, 469.

2. Church and Peterson: *Nervous and Mental Diseases*, 1914, p. 223.

3. Attention has recently been called to this matter by Franz, S. I.; Scheetz, Mildred E., and Wilson, Anita A.: *The Possibility of Recovery of Motor Function in Long Standing Hemiplegia*, *THE JOURNAL A. M. A.*, Dec. 18, 1915, p. 2150; also by Elliott, G. R., and Boorstein, S. W.: *Orthopedic Treatment in Hemiplegics of Long Standing*, *ibid.*, July 1, 1916, p. 31.

beyond that of moving the part; but when the movements are resisted by an operator or masseur, they are called "duplicated" or "resistive." The passive movements, to which the term "massage" is more often applied in English speaking countries, are applied by the masseur or by the physician to the patient, the latter remaining inert, or in as relaxed a condition as is possible. These passive movements may be applied on the part (the muscles, for example) or with the part (by moving it). There are four different kinds of passive movements applied on or to the part: effleurage, petrissage, friction and tapotement.

Effleurage, or stroking, is performed by laying the palmar surface of the hand, or the thumb or the fingers, on the part that is to be treated, and making strokes centripetally with an amount of pressure that can be determined only by the amount of muscular contraction of the part or by venous stasis, or by any other condition that is to be dealt with. This process is believed to stimulate the venous and lymphatic flow, and to bring about relaxation of contracted muscles. In petrissage, the tip of the thumb, or the tips of the first three fingers, are employed to make circular and loosening movements. This kind of passive movement is used to loosen adhesions, to disperse infiltrations, and to promote the circulation in the part that is manipulated. When applied in a light way, it is thought that this procedure stimulates the part. Friction consists in grasping a muscle, for example, the biceps, and thoroughly kneading it between the fingers. This gives a great mechanical stimulus to the muscle, and stimulates the part similar to the process of petrissage; but a much larger area is taken care of, and the stimulation is more intense. A special form of friction is given to nerve trunks, by drawing the fingers sharply across the long axis of the nerve and at right angles to it. It has been demonstrated that this nerve friction can at times cause contractions of muscles, which will not react to electrical stimulation, and the application of the stimulus to the nerve, rather than to the muscle, brings about a greater contraction of the muscle when one is obtained. Apart from the immediate motor effects, this nerve stimulation also starts afferent processes, perhaps somewhat similar to those that are produced by muscular contraction, and in this way by reflex conduction the motor apparatus is also stimulated indirectly. In tapotement, the part that is to be treated is struck sharply again and again. The striking is usually done with the ulnar surface of both hands, the blows being made in quick succession, the motion coming from the carpal joints as in ordinary percussion, and the whole hand being held in slight ulnar flexion. The effect of tapotement is chiefly that of stimulating the muscles mechanically. It increases their irritability, and when slight nerve impulses come to them they are thrown into marked states of contraction. Nerve friction after tapotement of the muscles may bring about a clonic kind of muscular activity, which persists during the time the nerve is being stimulated.

Each of these types of passive movements has its use in the treatment of the paralyzed state. Effleurage is chiefly, but not exclusively, valuable in loosening the tight contraction of the muscles in the condition known as contracture, and in keeping certain muscles, such as the flexors, from getting into a state of contracture. The value of petrissage has already been

mentioned. The use of friction is to increase the nutrition of muscles which, on account of disuse, are apt to atrophy, and to prevent or to overcome the atrophic tendency. When applied to the nerve it tends to increase its conductivity and to increase the mechanical irritability of the muscle. Tapotement also increases the irritability of the muscles, so that in cases in which only slight nerve impulses are being received these may have more motor effect than under ordinary circumstances. Friction in newly produced cases of paralysis should be applied to the extensor muscles of the arm and to those muscles of the leg which in old cases show the most lack of power or control, such as the peroneus. In those cases in which there are residual paralytic symptoms the friction should be directed against those muscles which cannot be moved, or which are not in a state of contracture, and those muscles, control of which is most important for the individual to acquire, for example, the extensors of the forearm, the peroneus, etc. In no case should friction be applied to the muscles that are in a state of contracture, and this, it should be remarked, is not distinctly specified in many neurologic textbooks that deal with the treatment of paralytic cases. In fact, if the statements quoted at the beginning of this article are read literally, they seem to indicate that massage should be used for *all* of the muscles of the paralyzed segments.⁴

When, however, we consider in detail the paralyzes of apoplectic origin, we find that certain muscles are more involved than others; or, to put the matter in strict form, we may say that certain muscles are apt to get into a state of tonic or forceful contraction, and that others remain in a state of flaccid paralysis. Thus, in the upper extremity, the muscles which usually cannot be moved and which are flaccid are the lateral retractors of the arm, the supinators and extensors of the forearm, and the extensors of the fingers. In the lower extremity, the muscles chiefly affected are the adductors of the thigh, the flexors of the leg, and the dorsiflexors of the foot. In the upper extremity, contractures are found; some come early and some only after a considerable period according to the site of the lesion (cortical or subcortical). The contractures of the arm produce an adduction of the arm on the body, flexion at the elbow, wrist and fingers, and some pronation of the hand. In the leg, the knee is usually extended, the angle is dorsiflexed, and these two conditions with the accompanying inability to overcome them with the appropriate muscles bring about the outward swinging and dragging of the foot that characterizes the hemiplegic gait.

While these are the usual conditions to be found in hemiplegia, each case should be dealt with individually, for there are considerable differences in degree and distribution of the paralyzed muscles. At the same time, each muscle or muscle group should be considered in relation to its condition, for example, its tonicity. When these points are worked out, it will be simple to determine which muscles should be stimulated and which should have the treatment to bring about a relaxation. Thus, when there is a contraction, the muscles should be treated by effleurage of a very light form, and the corresponding antagonists should be exercised by friction and tapotement. The nerves to the relaxed muscles also should be stimulated by friction; but it must be kept in mind that too strong stim-

4. Mention will be made of this matter in one of the case reports.

ulation may be of no value, or it may even be harmful (in this respect there being a condition like that of Pflüger's law), since strong stimuli may not only decrease but also temporarily abolish nerve irritability. In the clinical cases that are described, the patients have been referred to me from time to time, usually by neurologists who have appreciated the necessity for the methods employed.

REPORT OF CASES

CASE 1.—A man, aged 59, German, owner of a sanatorium with complete hydrotherapeutic outfit and with the facilities for massage and gymnastic exercises, referred to me while I was at Bad Oehenhäusen, had an apoplectic stroke nine months previous to his visit to Bad Oehenhäusen, and his physician had advised "general" massage and Swedish movements seven weeks after the cerebral accident. There treatments were carefully carried out for about seven months with no apparent good effect, and finally, in conformity with advice, he came to Bad Oehenhäusen for treatment. Two days after his arrival, the patient was sent to me by the physician whom he had consulted. At that time there was a right-sided hemiplegia which was evidenced by the following symptoms: There were facial paralysis, drooling of saliva, poor speech, and atrophy of the outer part of the trapezius muscle at the shoulder; the biceps was strongly contracted, and likewise the flexors of the forearm; there was marked atrophy of the extensors of the forearm, and the leg was equally involved, there being a marked peroneal dragging of the foot. The voluntary motor ability of the patient was greatly restricted by the flaccid paralysis and by the contractures and atrophies.

The patient was treated in the manner that has been described above instead of by general massage, the effort being made toward getting the muscles that were atrophied into better condition, and toward loosening the contracted muscles that prevented the use of the arm and hand. The systematic exercises were given in such a manner as to prevent stimulation of the contracted muscles, but to bring about as much power as possible in the flaccid and atrophied muscles. The exercises were given daily, including Sunday, for three and one-half months, and during that time there resulted a great improvement. The facial muscles had improved in tone, the patient was able to control them to such an extent that saliva no longer drooled from his mouth, he could talk very well, although his speech was slow, and it was only on close observation that it could be determined that the muscles on the right side of the face did not have as good tone as those on the left, and that the right side could not be used with the same accuracy and rapidity as the left. The trapezius paralysis had apparently been entirely overcome and that muscle could be very well used for all the operations that it is normally used for. The contracture of the arm had largely disappeared, and the extent of the improvement in this respect was evidenced by the ability of the patient to make a complete extension of the forearm. While the hand had not completely recovered, it also had improved to such an extent that casual observation did not disclose a difference from the left. It should, however, be stated that the movements of the right hand and arm were much slower than those of the left, but this was not so obvious as to cause a visitor to remark it. The leg was so much improved that the patient could both flex and extend it, and the movements of abduction and adduction were performed perfectly, or almost perfectly. The peroneal lameness persisted to a slight extent, but it gave the impression of a peculiarity of walk rather than an actual paralysis.

This patient is a good example of the apparently poor effects of general massage, and the good effects that may be obtained when attention is directed to increasing the tone and the strength of those muscles that are flaccid and atrophied, and to reducing the contracture state in the muscles that are tightly contracted.

CASE 2.—A German merchant had had an apoplectic stroke five years previous to the treatments that were given by me. For three years after the apoplexy he had received daily general massage for eight months of each year, and during the succeeding two years he had been given general massage three times a week. He took the treatments not in the hope of getting over the paralysis but solely because they gave him a general feeling of well-being. When first seen by me there was an evident left-sided paralysis, which involved the face as well as the arm and the leg. The patient's speech was poor, owing to the facial paralysis, the left arm was very much contracted, the forearm was bent on the upper arm, the arm was adducted, the fingers were flexed into the palm, the left side of the second layer of the scapula was atrophied, and the adductors of the leg were contracted. The patient could not abduct the arm or extend the forearm, nor could he flex the leg or extend it to full extent. Walking was impossible, and the patient was taken around in a wheel chair.

The patient was treated daily, excepting Sundays, with the special exercises that have been described, the flexors being stroked to bring about relaxation, but the extensors of the forearm and the other flaccid muscles being stimulated by friction and by tapotement, and the nerves of the flaccid muscles being stimulated with friction. At the end of three months, the arm segment had improved to such an extent that the patient was able to adduct it horizontally with the shoulder and to draw it forward so that he could touch the right shoulder with the knuckles of the left hand; but no improvement of the flexors of the forearm and the fingers had taken place up to that time. The leg improved to such an extent that he could flex and extend it almost to the limit, and the adductors of the thigh became considerably relaxed. Because of the improvement in both legs and in the left arm, the patient was at this time able to walk with the aid of a specially constructed pair of crutches.

CASE 3.—A man, aged 56, was visiting a friend who was taking the "cure" at the spa. Five days after his arrival he had an apoplectic stroke while talking with friends. The stroke produced a right-sided hemiplegia which involved the face as well as the arm and leg. The patient was almost immediately referred to me because of the paralysis, and I began the systematic exercises at once. The patient did not talk and did not appear to understand what was said to him. His right arm was slightly flexed, and there was little tone in the muscles of the arm and the leg. The treatments were directed to those parts which in older cases of hemiplegia exhibit the "residual" paralysis. After daily exercises and massage for ten weeks the patient was apparently perfectly normal in voluntary control of the movements of the arm and leg. He could use both of these members as well as the corresponding ones on the unparalyzed side, and the movements in strength and in rapidity were as well executed as by a normal person. The only defect that could be determined was a slowing of motor speech. This may have been partly due to some sensory aphasia, an inability to take things in readily, or it may have been a real motor defect due to a slowness in coordination of the muscles used in phonation.

This case, it may be stated, is not a clear-cut example of the value of the systematic exercises, for there is the possibility that the paralysis would have disappeared without treatment. On the other hand, it should be said that seldom does the paralysis disappear so quickly, and it is reasonably certain that even though the paralytic condition might have passed away, the inactivity would have left a weakness of some duration. If it be assumed that the paralysis would have disappeared without treatment, the treatments may then be said to be helpful in the prevention of the weakness; if we assume that probably not all of the paralysis would have disappeared, then we should conclude that the treatments have prevented the long-continued paralysis. An interesting feature of the case

is that the treatments were begun almost immediately after the apoplectic stroke, and the treatments were so graduated that there was benefit. There appears to be no good reason why suitable exercises may not be given within a day after the occurrence of an apoplectic paralysis.

CASE 4.—A retired professional man, aged 60, while abroad, had an apoplectic stroke with hemiplegia, and was cared for by a physician until he was able to return home. He had been given "general" massage by his nurse daily for about two months.

On his return to Washington he was sent to me by his physician. This was about ten weeks after the beginning of the paralysis. At that time it was found that his speech was slow, there was an obvious paralysis of the facial muscles on the right, the right arm and the leg showed muscular atrophy, and there were contractures, the forearm being tightly flexed on the arm. The patient could not carry out any movements with the arm, there was a peroneal lameness, and he could walk only when assisted and held up by attendants on both sides.

Daily treatments directed to the paralyzed muscles were given to the patient at a hotel at which the family resided. These were continued for three weeks. Because of the projected continued absence of his physician for the summer he was then sent to a hospital, where the treatments were continued for five weeks, but under protest from his new medical adviser, who recommended "general massage," and wished to insist on it. The treatments had been continued for about two months, and at the end of that time the patient could abduct and adduct his arm and use it to nearly the normal extent, but not with normal force. He was able to walk without difficulty, with one attendant supporting him on the lame side.

The patient was then sent North, and on his return it was not possible for me to continue his treatments. By direction of his physician, "general massage" was then given to him; but although I have seen the patient several times, it is apparent that no further improvement has taken place; in fact, there has been a retrogression, and this I attribute to the fact that the muscles that should not be massaged have been equally worked with those that should be given stimulating treatment.

This case illustrates two points of importance. The first is that general massage, by which I mean the rubbing and kneading of the muscles, is not beneficial to this class of patients, because the muscles which are contracted or which have a tendency to contracture should not be stimulated. They are already being stimulated by the efferent impulses coming from the spinal cord, and by the lack of inhibition which is probably normally exerted by the cerebrum. The second is that the physiology of the condition is not always appreciated by the attending physician, who has been taught and who has read that massage should be given, and who consequently wishes to insist that the flexors be massaged as well as the extensors. It is not the quantity of the massage which is of benefit, but the quality, the latter including the direction of the treatments to the muscles and nerves that need them most.

CASE 5.—Three years ago, a man at the age of 59 had a stroke with resulting hemiplegia on the right. From this he recovered to a great extent without treatment, but he was weak and "lame," and could not perform movements that required a great degree of accuracy. A year subsequent to the first stroke he had a second, which also left him with a right hemiplegia. He had been in bed for the following two years; but whenever his condition would permit, he was lifted from it daily and placed in a chair. At times also he has been carried out to a carriage or to an automobile and given a ride, but he has tended to slip off the seat. For the

two years he had been given "general" massage by his nurses, and several neurologists who examined the patient said that nothing could be done for him, and that the paralysis as it existed would be permanent.

He was given special treatments directed to the paralyzed muscles for ten weeks, twice a week, with some improvement in his condition, and the patient was then sent to me. The examination revealed the following: The right side of the face was paralyzed, and saliva drooled from that corner of his mouth, especially when he made an effort. There was no reaction of the muscles when the nerves were stimulated. The muscles were somewhat atrophied, and he showed no voluntary control of most of them. His speech was slow and very poor, and only a few things that he attempted to say could be understood. There was a contraction of the right sternocleidomastoid, the right trapezius was very much atrophied, and the right pectoral was contracted. The right arm was contracted and flexed, with considerable shortening of the flexor muscles, the forearm was flexed on the arm at an angle of about 70 degrees, and the wrist on the forearm at an angle of about 160 degrees, with the fingers tightly flexed on the palm. There was only a little voluntary flexion or extension of the arm, and the patient could abduct it about 20 cm. from the body. Both legs were atrophied, and the feet were turned inward, the right more so than the left. There was some change in the articulations of the tarsal bones. There was no reaction of the muscles when they were stimulated. There was a strong contraction of the ileopsoas. The patient could not move himself to any appreciable extent in bed, and when he was moved by assistants he showed great fear that he would fall.

It was reported to me that the twenty special treatments that were given previous to those given by me had resulted in some slight improvement, which can be estimated by the betterment in the position of the arm at the beginning and end of the series. At the beginning the forearm was flexed on the arm at an angle of 55 degrees, and the hand on the forearm at an angle of 110 degrees; while at the end of the series there had been a straightening, respectively, to 70 and to 160 degrees. At the same time, while at the beginning he was unable to move the arm at all, he could lift the hand almost to the chin after the twenty treatments; and although the right foot could not be lifted at the beginning, it could later be brought up to touch the middle of the tibia of the left leg. At the beginning, also, stimulation of the muscles and nerves produced no reactions; but subsequently an occasional effect could be obtained from the peroneus, and usually from the extensors of the forearm; but the latter were not contracted when the nerve was vibrated.

Up to the present writing I have given the patient three treatments a week for eleven weeks. There has been a gradual improvement in the condition of the muscles of the paralyzed segments and in his voluntary control of them. Speech is slightly improved, there is some reaction of the facial muscles when they are stimulated, there is less drooling of saliva, and the patient can extend his tongue and carry it over to the right angle of the mouth. He can abduct the right arm to the level of the shoulder (about 90 degrees instead of about 30 as at the beginning), and he can draw the arm forward across the chest and touch his chin. With the aid of his left arm he is able to put his right hand on the top of his head. The pectoral muscle is now very slightly contracted, the sternocleidomastoid little, if any. He now lifts his right leg, flexes it, and can touch the knee cap of the left with the heel of the right. The left leg is less atrophied, and he flexes and extends it with good force. The patient is also able to move himself from the longitudinal position on the bed to the transverse position without any aid, and when he is assisted to a sitting position he can maintain it without help. He can return to the longitudinal bed position from the sitting position without assistance. He can also stand on the left leg for short periods when he is assisted.

From the therapeutic standpoint the case is not encouraging because everything that can be done for the patient by others is being done for him, and he has been relying on his wife, his physician, and his nurses to do everything. Because

of this he is deprived of the much needed effort to help himself; and since he has been petted so long he does not care to exert himself to the slightest degree, and he can be made to do so only by insistence that he help. It is also likely that if it were possible to give the patient more frequent treatments, some of the results would have been bettered, for by having only three a week there is time for some of the good effects to pass away between the individual treatments, and the cumulative effects are not so readily obtained.

COMMENT

These five cases illustrate very well that improvement, and in many cases a considerable amount of improvement, can be brought about in the condition of a hemiplegic if appropriate exercises are given to the involved muscles. They also show that "general" massage, as indicated in Cases 1, 2, 4 and 5, has not brought about such improvement, although it is reasonable to suppose that the promptness and the extent of this form of treatment could have demonstrated its efficacy if any existed. It should be remembered that the amount of special treatment that I gave these patients was much less than the amount of "general" massage that had been given to them. It may be remarked that the amount of improvement in four of the cases did not go to the extent of a complete recovery, and that Case 3 should not be considered in connection with the other four. With both of these remarks I am willing to agree; but with respect to the lack of a complete recovery, it should be borne in mind that in all cases the treatments did not extend over a sufficient time to show the full possibilities. Although small in amount, they have shown that much more can be done than with "general" massage, which is usually advocated, and they show that we have not reached the limit of possibility. Patient 1, who had been paralyzed for nine months, was almost completely "cured" by special treatments for three and one half months, although during the nine months he had not improved under "general" massage. Patient 2 improved under three months' treatment, although he had not improved under five years' "general" massage. Patient 4 improved in two months, although he had not improved in the preceding two months' treatment with "general" massage, and has deteriorated in the succeeding time when general massage has been given. Patient 5, who has received the equivalent of nine weeks' treatment, has improved, although in two years with "general" massage he had been getting worse in that the contracture state was being exaggerated and the muscle atrophy was increasing. In most cases the patient or his physician or his relatives, seeing the improvement that takes place, thinks this will continue by itself, and the patient is either given no treatment or is turned over to a cheaper operator, who again gives "general" massage; and since the proper physiologic efforts are not made, there is a retardation or a stopping of the improvement. This is the same as others have found, and is the same condition encountered with other kinds of chronic cases. It is unreasonable to suppose that the treatments for two or three months will bring about a complete recovery in those who have had the paralysis for some time. It is well known that if an athlete ceases to exercise for a time, it is difficult, most frequently impossible, for him to return to his former level of ability, even though he practice for a considerable period of time. At the same time it is well recognized

that after a certain age the adaptability decreases, and this lowering of the individual's capacity for new adjustments is probably both nervous and muscular. The results that have been obtained do indicate that a considerable amount of voluntary control follows the treatment of the paralyzed muscles and their nerves. It should also be mentioned that the contracture is overcome; and although this is a matter more of cosmetic interest, it is not unimportant that the deformity be improved.

It might also be remarked that we do not know, but can only estimate from the combined clinical symptoms, how extensive the cerebral lesions in these cases were, or what special parts of the brain have been destroyed, and that only the examination of the brains will show the extent and the limits of the destructions. Although this criticism has actually been made, it appears to be forgotten that competent physicians, and especially neurologists, can estimate quite closely, and it is possible to predict within a fair degree of certainty that in the cerebral paralyzes either the cortical motor area or the motor fibers have been destroyed. The durations of the paralysis in Cases 1, 2 and 5 previous to the treatments are indications that the conditions were of the nature of residual defects, and that if treatments had not been instituted the motor deficiencies would have persisted. As far, therefore, as this criticism is concerned, I need only say that it is unjust with respect to probability, and furthermore, from the patient's standpoint it makes little difference about the nature of the lesion if an apparently permanent defect can be overcome, and the imperfection give place to a more normal state. It may be necessary to know the exact location, the degree, and the extent of the lesions if we wish to translate the results into terms of a hypothesis; but this can be done best by a suitable series of experiments on animals, or only after the accumulation of numerous cases of recovered hemiplegia. The experiments on animals have been carried out, and the results of the series will be briefly cited⁵:

REPORT OF EXPERIMENTS

EXPERIMENT 1.—A monkey had the left motor cortex cauterized with an electric thermocautery, which produced a right hemiplegia. The left arm was strapped to the body so that it could not be used and so that the animal would be compelled to use the right. At the same time the extensor muscles of the right arm and the arm nerves were stimulated by friction. The animal was also held by its strap and the right hand was struck by another piece of strap. This made the animal attempt to escape the irritation, and although at first the right arm could not be moved away from the irritating stimulus, in a few days the monkey was able to draw away the hand and also to grasp, but with little power, the irritating strap. At the end of two weeks the animal could use its arm and leg very well, and three weeks after the cortical destruction it could pick small pieces of food from the floor, it could climb and walk, and showed in the paralyzed segments no obvious incoordination. A week after it had recovered the use of the right arm and leg the right motor cortex was destroyed in the same manner as the left. This produced a complete left hemiplegia. No treatment was given to the animal for this paralysis; it was permitted to recover by itself if it could, and to date (at the end of six months) the paralysis of the arm has persisted, although there is considerable recovery in the leg segment.

5. The results of these experiments will be reported in greater detail in a forthcoming paper with S. I. Franz. The monkeys used in the experiments were supplied to Dr. Franz through a grant to him, and acknowledgment of the assistance of the Carnegie Institution in this regard is here made.

EXPERIMENT 2.—A monkey had the left motor cortex cauterized, June 2, producing a complete right hemiplegia. The animal was given "general" massage to the paralyzed limbs, and all the muscles were thoroughly kneaded daily. This treatment was carried out for twenty-six days, and at the end of that time the animal used the left arm exclusively. The right hand showed marked wrist drop; there was some possibility of flexion and extension, but there was little strength. The right leg also showed little improvement. There was a dragging of the foot when the animal walked or crawled. Four weeks after the first operation, the right motor cortex was cauterized. The right arm was also bound to the body of the animal, and the nerves and muscles of the left arm and leg were given the special treatments. This was continued about four weeks, at the end of which time the movements on the left could not be said to differ in any respect from those of a normal animal. Improvement on the right has continued, and that side is almost well; but the left hand is used more frequently than the right in taking food, etc.

EXPERIMENT 3.—The left motor cortex of a monkey was cauterized, June 2, resulting in a right hemiplegia. The left arm was strapped to the body of the monkey and its movements were prevented, but no other kind of treatment was given. At the end of four weeks, the amount of recovery was slight. Some movement of the right arm and leg was possible, but there was marked incoordination and incompetence. After the four weeks of *laissez faire* management, the muscles and nerves of the right side were stimulated and the treatments continued for four weeks. At the end of that time the right arm and leg had regained their normal power and accuracy. After the recovery from the right hemiplegia, a left hemiplegia was produced in a similar manner. Following this operation the left side was given "general" massage without special attention to the individual muscles and nerves. The animal continued to use its right arm almost exclusively, although after a few months both were used, and they can be used together when necessary. The animal now climbs and jumps, but its movements, especially of the left hand and arm, are awkward. It holds its food awkwardly, and does not carry it full way to the mouth, but the head is inclined to meet the food as it is brought upward by the hand, usually the right.

EXPERIMENT 4.—A monkey had the left precentral area cauterized, July 25. A typical right hemiplegia resulted. The movements of the left arm were restricted by tight bandaging, and the animal was given special treatments such as have been described. The recovery of the right side was rapid, and after three weeks it was not possible to detect any difference in motor capacity for the two sides of the body. The animal was shipped North, but developed pneumonia and died in three days. The brain showed a very extensive lesion involving the left motor cortex.

COMMENT

It should be pointed out that the results which have been described differ in at least one respect from those of investigators who have previously produced experimental hemiplegia in monkeys. This is the time of the recovery. Previous investigators have shown that if a monkey is paralyzed by the destruction of the motor cortex, recovery takes place "spontaneously." But the period for the recovery is one of months, and is well illustrated by the results of the second part of Experiment 1, in which at the end of six months the monkey has not fully recovered the use of the left hand and leg. The present work shows that the period of recovery may be much shortened and that the full return of voluntary control may take place in a few weeks, if suitable stimulating exercises are given.

The results of the experiments on the artificially paralyzed monkeys may be thus summarized: They show that (1) very little improvement takes place

if the animals are given no treatment; (2) when "general" massage is used there may be some improvement, perhaps more than without treatment, but not very extensive, and (3) when the therapeutic attack is directed to specific muscles and nerves, the recovery is rapid and complete. These results are almost directly in accord with those which have been obtained with the human cases of hemiplegia which have been cited; but the rapidity and completeness of the improvement in the animals may be the result of different inherent qualities of the nervous system. It has already been pointed out that there is an almost complete recovery of the monkey after the destruction of the motor area or of the pyramidal fibers, but this recovery is very slow if the animal does not receive treatment. In the human cases, on the other hand, it has been believed that a paralysis which is not appropriately treated is not followed by recovery. Perhaps it would be more accurate to say that at present we are ignorant of the possibility of spontaneous recovery in human paralytics. One reason may be that the occurrence of the contracture which is an almost constant phenomenon may help to prevent or to mask the spontaneous recovery in man, and, secondly, the correlation of the anatomic data with the clinical symptoms has frequently been made without a sufficiently exact histologic knowledge of the destroyed area. If we are willing to conclude that recovery of voluntary motor function in man may take place after the destruction of the precentral cortex or of the pyramidal fibers, as is indicated in the records of the present series of cases, as well as by those reported by Franz, Scheetz and Wilson, and by Elliott and Boorstein, there appears to be no cogent theoretical reason why we must assume that some spontaneous recovery does not take place. It may be that there is no difference in kind but only a difference in degree between man and the monkey and other animals in this respect, and that our assumptions regarding the necessity for continued paralysis are not well founded.

From the work reported, I believe that every case of cerebral paralysis should be given the special treatments that have been found successful, and that we should give to every patient the fullest opportunity for betterment. It is too soon to predict with certainty how much improvement will result in any individual case; but the success noted in the cases that have been cited here and in the other cases that have been reported warrants the belief that the systematic effort of the physician should be directed to the alleviation of the distressing condition, which in the past has all too frequently been left for spontaneous recovery. It may be that further study will show that some patients will progress to a certain point, others may go to a point at which there is almost complete return of function, and others may show no obvious benefit. Further work is necessary for the differentiation of cases; but the facts at hand hold hope that many, probably most, perhaps all, cases of cerebral paralysis may be relieved; and even though the improvement may not extend to the ability to perform all kinds of finely coordinated movements, the prevention or the cure of the deformity of contracture, and the therapeutic production of even gross movements, are ends not to be despised, since they make the patient happier and less helpless.