manner in which it is grafted. The chosen tendon should be a normal one of good power—a weak muscle is useless. The tendon should be brought down along a gradual path to its new insertion; a sudden twist or turn in its course is fatal to its working efficiency. Where possible it should be inserted into bone. One of the most successful transplantations is the transference of the tibialis anticus to an insertion into the cuboid to act as an evertor of the foot where the peronei are paralysed. [In one of the cases shown the peroneus brevis had been grafted into the tibialis posticus to aid inversion of the foot in paralytic valgus.] The transplanted tendon should be relieved of all strain for at least two months, and if the appliance has been worn this should be continued for a little while longer.

Tendon fixation originated in 1898 with Tilanus of Amsterdam when operating upon a girl with paralytic equino-varus. The tendo Achillis was cut subcutaneously, the extensor proprius hallucis was then cut by open section and the central end attached to the extensor longus digitorum, and the peripheral end to the periosteum of the tibia. Codivilla extended the method further, and latterly Gallie¹³ of Toronto has brought it prominently forward. The paralysed tendons are converted into ligaments to correct the disability¹⁴—for example, in paralytic varus the paralysed peronei are permanently fixed to the external malleolus so as to check the deformity. Two grooves are gouged—one on the anterior and the other on the posterior aspect of the external malleolus. The tendons are pulled taut, correcting the deformity, and are buried in these grooves, the longus in front and the brevis behind. The periosteum is brought over and sewn to the tendons, and the foot is encased in plaster-of-Paris for two months. The cast is then removed and the patient allowed to walk without an appliance.

In some cases the paralysis is so extensive that an instrument is a permanent necessity, for no operation is likely to succeed in dispensing with it. One child seen here to-day had not walked for four years owing to complete paralysis of the lower limbs with fixed hip and knee flexion. Soutter's operation was performed on each hip and the knees were straightened by extension. This enabled her to be fitted with callipers and so to walk about. There are exceedingly few cases so badly paralysed that they cannot be made to walk. Even if three or four limbs are paralysed, provided there remains sufficient power in the hands to grasp a pair of crutches, walking is still possible by means of artificial support.

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THE TREATMENT OF CONGENITAL SPASTIC PARAPLEGIA BY SYMPATHETIC RAMISECTION.

BY

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DR. N. D. ROYLE has contributed to the *Medical Journal of Australia* the full text of a paper on the treatment of congenital spastic paraplegia by sympathetic ramisection. By arrangement with the editor of our contemporary the following abstract appears simultaneously here.

It had occurred to Dr. Royle that in spastic paralysis the resistance offered to the moving group of muscles by its antagonists was due to a fault in reciprocal innervation; and when, subsequently, the discovery was made that the

voluntary muscles have a dual innervation, he carried out a series of experiments on goats to ascertain whether any deductions could be drawn as to the part played in the causation of the spasticity by the sympathetic element in this dual innervation. The results were published in the *Medical Journal of Australia* in January, 1924.

EXPERIMENTAL.

It was found from these experiments that animals from which the left abdominal sympathetic trunk had been removed could walk well after a short interval, but exhibited the following peculiarities. When the animals were placed on the back both lower limbs were at first held extended, but after an interval the left limb gradually fell into a more flexed and abducted position than the right. The relaxation time of the left knee-jerk was found to be much shorter than that of the right; the relaxation and extension times were, on the operated side, approximately equal, and the whole movement was more quickly performed than on the right side. In addition, resistance to passive flexion and extension was greater on the normal side. These differences were more evident when the animal was placed under light anaesthesia; and when partially anaesthetized the animals were unable to support weight on the limb from which the sympathetic had been removed. The ability to maintain posture voluntarily in the operated limb, however, was retained, and only disappeared under anaesthesia. If the operation were performed on a decerebrate animal similar changes were observed; and further, the extension of the limbs peculiar to the decerebrate condition, although usually present, was not well maintained on the operated side.

In order to obtain independent testimony as to the accuracy of his conclusions, Dr. Royle called in the aid of an experienced neurologist, Dr. Campbell, who examined one of the goats operated on and fully confirmed Dr. Royle's observations and added several details to those mentioned above. He noted that the muscles of the operated limb were softer, the relative lack of tension being particularly noticeable on pressing the tendo Achillis against the bone; further, although the difference in the knee-jerks was as Dr. Royle had described, the least degree of excitement in the animal immediately caused them to become similar in character on the two sides. Some investigators have failed to verify Dr. Royle's results, but it is to be noted that they have experimented on small animals only, in which the changes are less readily detected than in goats; the results, however, have recently been corroborated by Kuntz and Kerper, who experimented on dogs.

THE FIRST CASE.

These experiments confirmed Dr. Royle in his opinion that the sympathetic system was responsible for the occurrence of spasticity, and he considered it justifiable to apply the operation in the human subject. An apparently suitable case came under his notice in September, 1923.

The patient, a man aged 30, had received a gunshot wound seven years before. The bullet, entering above the left ear, caused extensive laceration in the region of the left central sulcus, and the wound extended across the middle line to the opposite hemisphere. The patient was unable to speak for three months, and unable to walk for two years, after the injury. On examination there was found to be right spastic hemiplegia affecting both limbs, with spasticity in the left leg and foot. On the right side the knee-jerk and ankle-jerk were exaggerated and there was patellar clonus; on the left side there were exaggerated ankle-jerk and ankle clonus. The Babinski reaction was present in both limbs. The patient could walk, but had great difficulty in controlling the right leg, and when bearing on it exhibited a coarse, uncontrollable tremor. He could walk forwards, but not laterally or backwards. Occasional tonic fits occurred, but were readily controlled. The genito-urinary system was normal, but the patient suffered from chronic constipation.

This patient exhibited a change for the better within six hours after the operation. While the right foot immediately fell into plantar flexion after being passively dorsiflexed, the return in the left foot was slow and gradual. The clonus on the right side became progressively less, while persisting on the left. There was an immediate improvement in voluntary movement; the range increased and muscular control was more effective; the patient was able to support himself on the right leg, an impossibility before the operation, and he could walk readily both backwards and forwards; there was also an improvement in balance, and the tremor affecting the right leg disappeared. The limbs showed an increase in size and power, and resistance to fatigue gradually became greater. The chronic constipation was permanently relieved.

This case has been subjected to criticism by Dr. Walsh and Dr. Adrian, and the following statement by Dr. Noble, honorary neurologist and psychiatrist to the Lewisham Hospital, is of interest in this connexion:

"I handed this patient over to several specialists who had much experience in Seale Hayne and other hospitals for functional nerve cases. He was given suggestion, re-education, and other forms of psychological treatment by competent physicians, but without success. He was married to a trained masseuse, who spent much time in re-educative methods before operation, but without result."

The effects of section of the sympathetic as exhibited in this patient, and in the laboratory experiments above described, were subsequently illustrated by some experiments of the late Professor John Irvine Hunter on the wing of the bird. A full account of Professor Hunter's researches was embodied, shortly after his death, in a series of lectures given at University College in January and February, 1925, by Professor Elliot Smith, and they appeared in our first volume for that year.

CONGENITAL SPASTIC PARAPLEGIA.

Dr. Royle considered that the results obtained in his first patient justified the adoption of a similar procedure in other patients suffering from spastic paralysis, among whom were a number of cases of congenital spastic paraplegia. This disease presents two main types—a rigid type and a choreic type. The rigid type falls into two groups: (a) in which the patient retains or has developed muscular control, and (b) in which no voluntary control is present. Muscular control, even when present, is always deficient and is limited by the difficulty experienced in moving against the rigidity of the antagonistic muscles; and conscious effort increases the rigidity. During rest evidence of rigidity is usually slight and the limbs may appear flaccid, while extensor and adductor spasm and other evidences of defective cortical control may make their appearance when an attempt is made to stand or walk. The range of passive movements in such patients is also limited in varying degrees. Increase in muscle tone is revealed in the abnormal character of the tendon reflexes, provided they are not masked by the rigidity. The relaxation phase is prolonged, and this may lead to the step-ladder phenomenon in the knee-jerk, in which successive contractions leave the leg in a more and more extended position. The Babinski reaction may be present or not. A feature which is present in all cases of spastic paralysis, and often well marked in congenital spastic paraplegia, is inadequacy of inhibition of muscular contraction. For example, a patient may be able to extend the knee, but finds a difficulty in relaxing the quadriceps afterwards. This may be regarded as evidence of a lack of control over the factor determining the maintenance of posture.

In the second group of cases referred to, in which muscular control is absent, the rigidity is part of a general condition in which the patient is subject to extensor spasms resembling those of the decerebrate animal. Postural tone may also be increased. On the other hand, a paralytic condition may be present, due, it may be, to an injury at birth resulting in a more or less complete physiological block.

The choreic type of the disease is characterized by persistent choreiform movements when the patient attempts to move, and in certain emotional states. An increase in postural tone may be present or not, and there may be increased reflex activity when the patient is at rest. There is, however, a rigidity imposed by the patient himself on his limbs, in order, apparently, to minimize the effect of the choreiform movements and that he may maintain his equilibrium on standing.

RESULTS OF OPERATION.

Dr. Royle reports the effect of sympathetic ramisection in twenty-six consecutive cases of spastic paraplegia, complete histories of which are given in the original paper. The operation was in all cases carried out on both lower limbs. The cases were of the rigid type, except one of the choreic type. The accompanying table summarizes the details.

As regards walking, there was a diminution of the disability in all patients except one, who was able to walk

before the operation. Sixteen were unable to walk alone, and of these, fourteen learnt to walk within six months. In some cases the improvement was remarkable; thus, one patient, who could only walk with the aid of crutches, was able to play tennis one year after the operation, and a child exhibiting extensor and adductor spasms on attempting to stand could walk without assistance at the end of twelve months. Another notable effect of the operation is relief from the necessity for mechanical support; and ability to walk increasing distances without fatigue is a constant post-operative result. The improvement in walking is necessarily relative, for a patient who has had spastic paraplegia for a number of years cannot be expected to lose all trace of the disease. On the other hand, if the operation is done before contracture sets in, a child may acquire a gait which differs but little from the normal.

All the patients exhibited changes which can only be ascribed to altered tone. The rigidity of the limbs was invariably diminished and resistance to passive and active movement usually disappeared. Both the limitation of range and the resistance to movement in these cases of spastic paraplegia are always to a certain extent structural, and a gradual improvement is observed over and above that directly due to the operation. The excitability of the knee-jerk and of ankle clonus was diminished in the majority of cases. In a few instances the relaxation time remained prolonged, but in all cases it was lessened by the operation. It should be remarked that the complete removal of the sympathetic nerves to a limb does not diminish a patient's ability to maintain a posture voluntarily, and it has been observed in children after ramisection that extensor and adductor spasm may reappear when they are being examined by strangers; this is apparently due to cortical influence set in activity by emotion.

The faculty of balance or increased facility in balance is an invariable immediate post-operative effect, and accounts for the rapidity with which these patients learn to walk. It must be ascribed to an alteration in tone without sensory loss, and the greater power of inhibition which appears after removal of the sympathetic is an expression of the same change.

Almost every patient reported increased facility in performing active movements, a result which is directly due to the operation, since the gain in the range of active movement occurred immediately after it. Physical education, however, effects further improvement, and the improvement may continue for years.

Another important acquisition is the power of inhibition. In one patient, for instance, extension of the knee in the recumbent posture could not be inhibited even when the flexion was assisted by gravity, whereas after the operation the patient could immediately relax the contracted muscle. It is hardly necessary to point out that the presence of deformity and contracture, more especially as affecting the hamstring and calf muscles, militates against a complete result in sympathetic ramisection. Structural changes of this kind need to be dealt with surgically before the full effect of ramisection can become apparent. Further, it should be clearly understood that sympathetic ramisection is not advocated as a cure for spastic paralysis; it merely removes a factor which interferes with the normal physical education of the individual. The essential treatment of spastic paralysis is education of the central nervous system: the muscles themselves do not usually require attention; indeed, their treatment with massage and electricity only tends to stimulate the sensory end-organs, and this inevitably leads to an increase in tone.

SPASTIC CHOREA.

Spastic paralysis complicated by chorea or athetosis was formerly regarded by the author as unsuited for operation by sympathetic ramisection. The following case (No. 26 in the table) illustrates what may be expected in certain circumstances.

The patient, a female aged 19, was unable to walk or stand, and could sit only when supported. Choreiform movements affected all four limbs and the face and tongue; the limbs were under-developed through disuse; the knee-jerks were exaggerated and indicated an increase in tone by the prolonged relaxation

Table showing the Effect of Sympathetic Ramisection in Twenty-six Consecutive Cases of Spastic Paraplegia.

BEFORE OPERATION.									AFTER OPERATION.						
Case No.	Age.	Able to Sit Up.	Able to Stand Alone.	Able to Walk Alone.	Able to Walk with Support.	Able to Balance on one Limb.	Was Patient Constipated?	Mentality.	Stand-ing.	Walk-ing.	Balance on one Lower Limb.	Ease in Performing Active Movements.	Constipation.	Mental Condition.	Time in Months Since Operation.
1	14	+	-	-	-	-	+	-	+	+	+	+	+	+	35
2	6	-	-	-	-	-	++	?	++	+	+	++	++	...	9
3	13	+	+	+	+	-	++	+	++	++	++	+	++	...	4
4	23	+	+	-	+	-	+	?	+	+	++	++	-	+	14
5	5	-	-	-	-	-	+	?	+	+	+	+	+	...	17
6	27	+	+	+	+	?	+	-	-	-	-	-	-	-	28
7	5	+	-	-	-	-	-	+	+	+	+	++	...	...	14
8	38	+	+	+	+	-	-	+	+	+	+	+	...	...	6
9	11	-	-	-	-	-	-	-	-	-	+	+	...	+	20
10	31	+	+	+	+	-	-	-	+	+	+	+	...	+	21
11	7	+	-	-	-	-	+	-	+	+	+	++	++	+	20
12	12	+	-	-	-	-	+	-	+	+	-	+	...	+	17
13	19	+	+	+	+	-	-	+	+	+	++	+	...	+	33
14	14	+	+	+	+	-	-	+	+	+	+	+	...	...	14
15	3	+	-	-	-	-	+	+	+	+	+	+	+	...	4
16	11	+	-	+	+	-	+	+	+	+	+	+	+	...	9
17	3	+	-	-	-	-	+	+	+	+	+	+	?	...	30
18	17	+	+	+	+	-	-	+	+	+	+	++	...	...	18
19	15	+	-	-	-	-	+	?	+	++	++	++	+	+	36
20	30	+	+	+	+	-	-	+	+	+	+	+	...	...	7
21	15	+	+	-	+	-	+	-	+	+	+	+	+	...	30
22	23	+	-	-	-	-	+	+	+	++	++	++	+	...	21
23	14	+	-	-	-	-	+	-	+	+	+	+	+	+	18
24	15	+	+	-	+	-	+	+	+	+	+	+	+	...	17
25	9	+	+	+	+	-	+	-	++	++	+	+	+	...	1
26	19	?	-	-	-	-	-	+	++	++	++	+	-	+	9
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	

Explanation of Signs Used in the Table.—In (1), (2), (3), (4), (5), and (6) the sign + signifies "Yes," the - sign "No." In (7) the + sign signifies normal mentality, the - sign signifies subnormal mentality, and the mark ? indicates mainly a defect through lack of education. The + sign in (8), (9), (10), (11), and (12) indicates the degree of improvement after operation. In (13) it indicates a noticeable improvement.

period; the Babinski test was doubtful. After a bilateral sympathetic ramisection there was an immediate change for the better in tone in the limbs operated on. Six weeks after the operation the patient was able to stand, and a few days later commenced to walk. Eight months after the operation she could stand unsupported for at least ten minutes and could walk alone for a hundred yards. The choreic movements have disappeared from the lower limbs when the patient is not excited, and there is some improvement in the upper limbs also.

Other cases which have been operated on are too recent to merit report.

In the concluding part of his paper Dr. Royle deals with the physical education of the spastic paralytic.

"It must," he says, "be clearly understood that the operation of sympathetic ramisection is not advocated as a cure for spastic paralysis. . . . It merely removes a factor which has been interfering with the normal physical education of the individual, and the essential treatment of spastic paralysis is education of the central nervous system. . . . It is true, however, that the treatment of paralysis of any variety has a peripheral as well as a central aspect, but in spastic paralysis the muscles themselves usually do not need attention; indeed, treatment with massage and electricity only tends to stimulate the sensory end-organs in the muscles, and this inevitably leads to an increase in tone. . . .

"It is sometimes thought that the operation of sympathetic ramisection should confer full and normal use of the muscles immediately, but this is a misconception. We can no more expect the subject of a congenital spastic paralysis to walk immediately after operation than we can a newborn infant. The normal child takes a year or longer to acquire control over the lower limbs sufficient to enable

it to walk, and a similar time must be allowed for the spastic child. . . . Even when movements can be performed voluntarily in the lower limbs, control of the various groups is imperfect and the first consideration in education is to establish group control.

"The minimizing of mental effort must next be aimed at. On account of the fact that the patient's muscles have always been opposed by the rigidity of their antagonistic muscles, his mental effort is exaggerated and this tends to the use of unnecessary muscles. This mental habit persists and must be counteracted by teaching inhibition in the groups whose contraction would render the given movement defective."

VASCULAR DISEASES AND THE SYMPATHETIC SYSTEM.

BY

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SIR W. I. DE C. WHEELER'S¹ recent report on two cases of thrombo-angiitis obliterans calls attention to problems of great interest. It may be useful to give an account of what is being done by investigators working in the various departments of medical inquiry to interpret the significance of disease in the blood vessels and the part possibly played by the sympathetic nervous system in their causation. In his Oliver-Sharpey lectures Dale² gave an excellent summary of the history of our present knowledge,