Muscle Recovery in Poliomyelitis

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How much recovery will take place? For how long will improvement continue? In every case of paralytic poliomyelitis these two questions are asked. Some would echo Courtney (1896) in answering that "the disease is so variable that it is very difficult to say anything about prognosis at all." While this may be the correct answer during the acute stage of the disease, it should be possible, after the first four weeks, to give a less guarded reply.

With the development of manual methods of muscle testing first introduced by Lovett and described by his assistant Wright in 1912, the grade of paralysis of a muscle may be defined in terms that allow the progress of its recovery to be followed. In recent years results obtained by these methods have been analysed to show the extent of muscle recovery in poliomyelitis (Harry 1938, Carroll 1942, Lenhard 1943, Watkins 1949, Green 1949, Grossiord and Husson 1953). Though these studies indicate the general potentialities for recovery in paralysed muscles, their usefulness in clinical practice is limited. In most, the muscles investigated have been too few and the tests too infrequent to allow the progress of muscle recovery to be followed in detail. The recovery of individual muscles has received attention from only one author (Skinhøj 1949) and differences that may exist in the rate of recovery at different ages have not been investigated.

The object of this paper is to show how a knowledge of muscle recovery may be of practical value in the management of patients in the convalescent stage of poliomyelitis.

MATERIAL AND METHOD

Between November 1949 and December 1950, 185 patients who had suffered a recent attack of paralytic acute anterior poliomyelitis were admitted to the Stanmore section of the Royal National Orthopaedic Hospital. In 149 patients the onset of the paralysis had occurred less than thirty-two days before admission. These were the cases in which a three-year study of recovery was begun.

Each patient was examined on ten occasions, at one, two, four, six, eight, ten, twelve, eighteen, twenty-four and thirty-six months after the onset of the paralysis. A complete muscle test was made on each occasion. So far as possible, testing was always performed with the patient in a warm room, after rest. Standard methods of manual muscle testing were used (Daniels, Williams and Worthingham 1947;

Kendall and Kendall 1949). The grade recorded depended upon the power of a muscle in the third of three contractions through the greatest range of movement of the joint concerned. The scale of muscle power ranging from 0 to 5 recommended by the Medical Research Council (1942) was used during the making of the observations, though, for reasons given below, it was modified in the analysis of results. All the tests were made by the author.

At the end of three years a complete follow-up had been obtained in 142 patients, seven of the original number having moved to a distance too great to justify repeated attendances for examination.

All the patients received the same treatment during the investigation. This was the standard treatment given at the hospital and consisted in daily passive movements to the joints and active exercises to the muscles of an affected limb up to, but not beyond, the point of fatigue. After three to four months, increasing functional activity was added to the regime in most cases, with diminishing attention to individual muscles. The duration of in-patient treatment varied between one month in cases of mild paralysis of one upper limb, and two years or more in severely paralysed individuals. The mean duration of active physiotherapy was ten months.

The accuracy of manual muscle testing --The investigation of muscle recovery by manual methods has recently been the subject of some criticism by those who advocate a return to mechanical methods of measurement of muscle power (Russell 1952) -- notably that, in the assessment of the power of a muscle, it is not certain that two observers will assign the same grade to it.

In most muscles and muscle groups the Medical Research Council scale can be used to give an unequivocal result. An incorrect assessment is almost always due to ignorance of the method, inattention to detail, lack of appreciation of the action of the muscle under test, or the deception of the trick action of another muscle. A high degree of objectivity is necessary in manual muscle testing; all too frequently the task is delegated to the physiotherapist who is treating the patient, and the desire to record an increase in power may supersede the strict evidence of the test.

Ideally, therefore, muscle tests should be made by someone who does not see and treat the patient every day. They should be performed without reference to the results of previous tests and the same observer should be responsible for all the tests in a given patient. It is true that the assessment of the power of certain muscles, such as the muscles that act upon the digits, is difficult to make in the exact terms of the Medical Research Council scale and is partly dependent on the pure judgement of the particular observer; even so, the assessments of that observer should be consistent.

Table I

The Distribution of Paralysis in Muscles of the Lower Limb

Muscle	Total of all grades of paralysis one month after the onset of the paralysis	Number completely paralysed three years after the onset of the paralyis
Hip flexors	198	34
Hip abductors (gluteus medius and minimus)	201	47
Hip adductors	193	36
Gluteus maximus	203	33
Biceps femoris	202	54
Inner hamstring muscles	204	43
Quadriceps	204	46
Tensor fasciae latae	189	38
Tibialis anterior	182	103
Tibialis posterior	169	89
Peronei	165	60
Extensor hallucis longus	157	66
Extensor digitorum longus	161	63
Triceps surae	162	57
Flexor hallucis longus	154	84
Flexor digitorum longus	155	85
Intrinsic muscles of the foot	140	24

In this investigation I have checked the constancy of my own muscle testing by occasionally repeating a test after an interval too short for any recovery to have taken place, so that the results of the second test should have been identical with those of the first. The muscles listed in Tables I and II, and included in the analysis to follow, gave constant results. The results for some muscles, such as the small rotator muscles of the hip, serratus anterior, and the muscles of the trunk, proved to be unreliable and were therefore excluded from the analysis. On rare occasions the results of muscle tests could be compared with the findings in muscle at necropsy. The proportion of residual normal muscle fibres always corresponded well with the clinical assessment in the muscles listed in Tables I and II. In muscles that were unreliable in the clinical test the clinical grade was often at variance with the necropsy findings.

An enormous mass of data resulted from the observations, there being over 110,000 individual assessments. At the first examination there were 3,033 muscles in 211 lower limbs and 1,905 muscles in 126 upper limbs whose power had been graded as less than normal. It is the progress of recovery in these muscles that will now be described.

Table II

The Distribution of Paralyis in Muscles of the Upper Limb

Muscle	Total of all grades of paralysis one month after the onset of the paralysis	Number completely paralysed three years after the onset of the paralyis
Trapezius	81	3
Pectoralis major	108	9
Deltoid	127	25
Lateral rotators of shoulder	107	14
Latissimus dorsi	95	11
Triceps brachii	118	15
Elbow flexors	97	10
Extensor carpi radialis longus	69	17
Extensor carpi radialis brevis	67	8
Extensor carpi ulnaris	65	7
Extensor digitorum	66	8
Extensor pollicis brevis	65	10
Abductor pollicis longus	65	12
Extensor pollicis longus	68	5
Pronators	68	11
Flexor carpi ulnaris	62	12
Flexor carpi radialis	68	16
Flexor pollicis longus	58	8
Flexor digitorum profundus	56	2
Flexor digitorum sublimis	56	5
Opponens pollicis	75	30
Flexor pollicis brevis	66	23
Abductor pollicis brevis	75	30
Interossei	63	13
Hypothenar muscles	60	16

The uniformity of the Medical Research Council scale of muscle power -- Because the power of a muscle is denoted by a numeral it is tempting to imagine that the figures bear a mathematical relationship to one another. Although, from the arbitrary nature of the system of grading, any such relationship would be coincidental, the clinical impression gained from experience in muscle testing is that some uniformity does exist in the " steps " between one grade and the next: that, for instance, the amount of recovery indicated when a muscle increases in power from grade 2 to grade 3 is comparable with that when it increases from grade 3 to grade 4. The data from this study have been used to deduce mathematically whether this is the case.

The proportions of muscles in grade 1 that reached grade 2, of grade 2 muscles that reached grade 3, of grade 3 muscles that reached grade 4, and of grade 4 muscles that reached grade 5 in the interval between the first and second muscle test (one to two month interval) were calculated. Proportions were worked out in the same way for the two to four month, four to six month, and six to eight month intervals. During any of these intervals, the proportion of grade 4 muscles that increased in grade was consistently about one-half that of any of the other grades; that is to say, while it was as easy for a muscle to proceed from grade 1 to grade 2 as from grade 2 to grade 3 or as from grade 3 to grade 4, it was nearly twice as great a step for it to proceed from grade 4 to grade 5.

A second analysis was then made in which muscles that had been assigned a grade of 4+ were considered as being in a separate grade; the possible moves in grade that could occur were then: 1 to 2, 2 to 3, 3 to 4, 4 to 4+, 4+ to 5. The results using this modified scale showed that a surprising uniformity now existed in the steps between all the grades.

As a result of this finding, all muscles previously designated grade 4+ were rechristened grade 5, and all those of grade 5 became grade 6. The new 0 to 6 scale, in the terms of which subsequent analyses were made, becomes:

0 = No contraction.

1 = Flicker or trace of contraction.

2 = Active movement with gravity eliminated.

3 = Active movement against gravity.

4 = Active movement against gravity and some resistance.

5 = Active movement against gravity and considerable resistance.

6 = Normal power (within the limits of manual assessment).

THE RATE OF RECOVERY IN THE MUSCLES OF THE LOWER LIMB

Of the 3,033 lower limb muscles of all grades of paralysis at the first muscle test 962 remained completely paralysed (grade 0) throughout the three-year period. These irrecoverable muscles never partook in the process of recovery and were, therefore, separated from the total. Evidence from muscle biopsy and necropsy suggests that permanently paralysed muscles are completely denervated at the acute stage of the disease, and findings in the anterior horn of the spinal cord support this view (Sharrard 1953). The remaining 2,071 muscles form a "working total" in which recovery during the one to two month interval may be calculated.

The unit of recovery in this analysis is an upward move in grade. An upward move of one grade, as from grade 2 to grade 3, represents one unit of recovery; an upward move of two grades as from grade 2 to grade 4, represents two units of recovery. The total number of such moves in grade between the one month and two month muscle test was found to be 1,128; that is, 54·5 per cent of the working total of 2,071 recoverable muscles.

At the two month muscle test sixty-one muscles had reached grade 6 and, so far as muscle testing was concerned, had become incapable of further recovery. This number was subtracted from the original total of 2,071 muscles to give a *new* working total of 2,010 muscles for the calculation of recovery in the two to four month interval. The total number of upward moves in grade during this period was 1,114, that is 55·4 per cent of the working tota of 2,010 muscles. But this proportion of muscles recovered during a period of two months, so that the rate of recovery per month becomes 27·7 per cent.