CLINICAL USE OF ELECTRICAL STIMULATION FOR REDUCING SPINAL SPASTICITY

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ABSTRACT

To evaluate the clinical value of electrical stimulation for reducing spinal spasticity, electrical stimulation was applied to two patients who have severe spinal spasticity. Spasticity was assessed both on single session stimulation and prolonged stimulation by clinical methods and a quantitative method. For the quantitative assessment, pendulum test was used from which relaxation index was calculated.

The single session stimulation reduced spasticity at least during the daytime if it was given in the morning which was assessed both by clinical methods and relaxation index. The prolonged stimulation reinforced effects of the single session stimulation clinically, although it did not result in any remarkable change of relaxation index.

We concluded that electrical stimulation is usefull clinically for relieving spinal spasticity if it can be applied every morning.

key words: spinal cord injury, spasticity, electrical stimulation, pendulum test, relaxation index

INTRODUCTION

Spasticity is one of the complication which frequently follows central nervous system lesion. The muscles involved develop a pathological resistance to passive stretch. The muscle spasm frequently accompanies the spasticity on central nervous system lesion and is often observed in the patient with spinal cord injury. The spasm in the paralysed limbs of the patient with spinal cord injury can obviously interfere with activities of daily living. In case of paresis, voluntary movement is interfered by spasm. Even in a case where one is dependent on others in the performance of his daily activities, spasm can frequently interfere while assistance is being given by other persons. Also, spasm can lead to contracture and dislocation of joints (Kuhn, 1950; Kawamura et al. 1986).

The use of electrical stimulation for reducing spasticity can be traced back to Duchene in 1871. However, clinical use of electrical stimulation for reducing spasticity is so far not popular. Continued controversy concerning as to what parameters should be chosen and as to what extent and how long it is effective still exists, mainly because of lack of established

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measurements evaluating spasticity objectively and quantitatively (Lee et al.1950; Levine et al.1952; Newman et al.1954; Benton et al.1981; Walker,1982, Alfieri,1982). Bajd and Vodovnik (1984) evaluated spasticity by pendulum test using electrogoniometer. They concluded that their instrumentation provide an effective spasticity testing in the clinical environment. Furthermore, Vodovnik et al(1984) applied four channel rhythmical electrical stimulation of the knee muscles to the patients with spinal spasticity and evaluated its effects by pendulum test.

In the present paper, electrical stimulation which is based on the method used by Vodovnik is applied on two patients who have severe spinal spasticity and its effects were evaluated by pendulum test of the knee joints both on single session stimulation and prolonged stimulation.

SUBJECTS

Two patients with cervical spinal cord lesion were selected from the in-patients at the Osaka Rosai Hospital (Table 1). Although both of them were incomplete C5 level quadriplegic patients who had retained some voluntary movements of their lower-limb, their motor disability impaired their gait and other daily activities except feeding himself with the self-help device and controlling powered wheelchair. Both of them showed severe spasticity in upper-limb, lower-limb and trunk with frequent spasm that caused them to suffer difficulties of their voluntary movements and also in assistances being given by other persons. Their sleep were frequently disturbed at night because of spasm.

Table 1. Clinical data of subjects

Patient	S	T
Sex	M	M
Year of birth	1934	1943
Age at injury	49	36
Functional level	C5	C5
Degree of paralysis	incomplete	incomplete
Walking ability	lost	lost
ADL ability	eating with adapted device control power. W/C	eating with adapted device control power. W/C

STIMULATION

The four channel stimulator was used (Figure 1). The stimulation parameter included compensated monophasic square pulses at a rate of 30 pulses per second with a 200 usec pulse duration and 1.0 sec rise time of the pulse train. A stimulation amplitude was set between 40-130 volt to cause muscle contraction.

The electrical stimulation was dilivered through carbon rubber electrodes 100 x 45 mm in size. Between the electrodes and the skin, water-soaked cotton was laid. The electrodes were

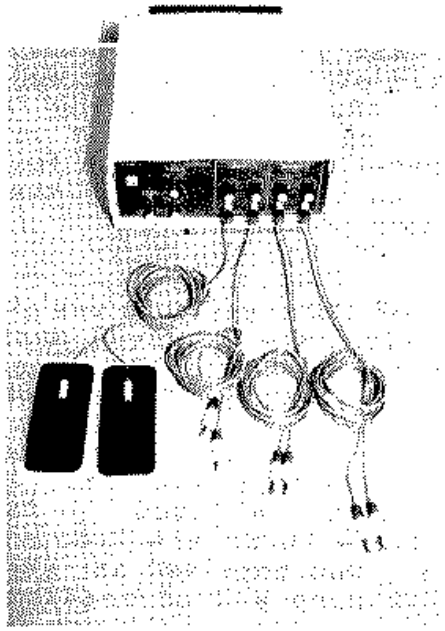


Figure 1. 4-channel stimulator and electrodes

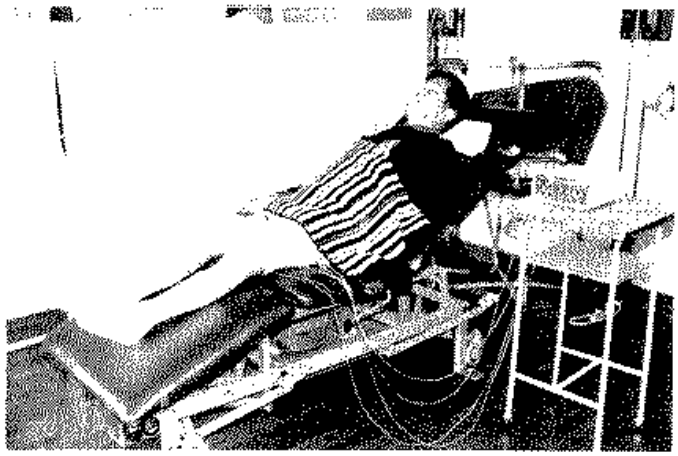


Figure 2. Patient's position during stimulation

placed over the motor points of the quadriceps and hamstrings muscles. The patients were positioned in a semiprone position on a table with slight knee joint flexion (Figure 2).

During the first half-period of stimulation which lasted for 5 seconds, the hamstrings muscle of one leg and the quadriceps muscle of the other leg were stimulated. In the second half-period, the remaining quadriceps muscle and hamstring muscle of the other leg were stimulated. Such a stimulation pattern was applied for 30 minutes a day. All treatments were performed in the morning from Monday to Friday for 5 weeks or more.

EVALUATION

Spasticity of these patients was evaluated both clinically and quantitatively. The clinical methods of evaluation were based on comments by the patients and assessment of their activities of daily living. The quantitative measurements of spasticity were carried out by the pendulum test. For this test, the patient is laid supine on a table. The examiner grasps the patient's foot and brings the leg to a horizontal position. The limb is allowed to fall freely as the knee angle is recorded with an electrogoniometer (Figure 3). A relaxation index was obtained as the ratio between the knee angle of initial drop and of resting position (Figure 4). In normal _____ this ratio was found to be 1.8 according to our measurements.

The pendulum tests for measurering the effects of the single session stimulation were carried out twice before stimulation, immediately after stimulation followed by five hourly tests and three times the next morning.

The pendulum tests for measurering the effects of the prolonged stimulation were carried out once before the prolonged stimulation started and immediately before the session on each Friday morning.

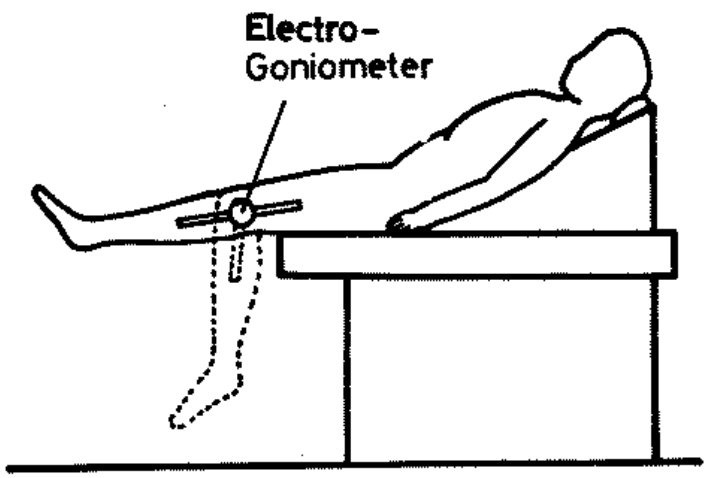


Figure 3. Pendulum test using goniometer

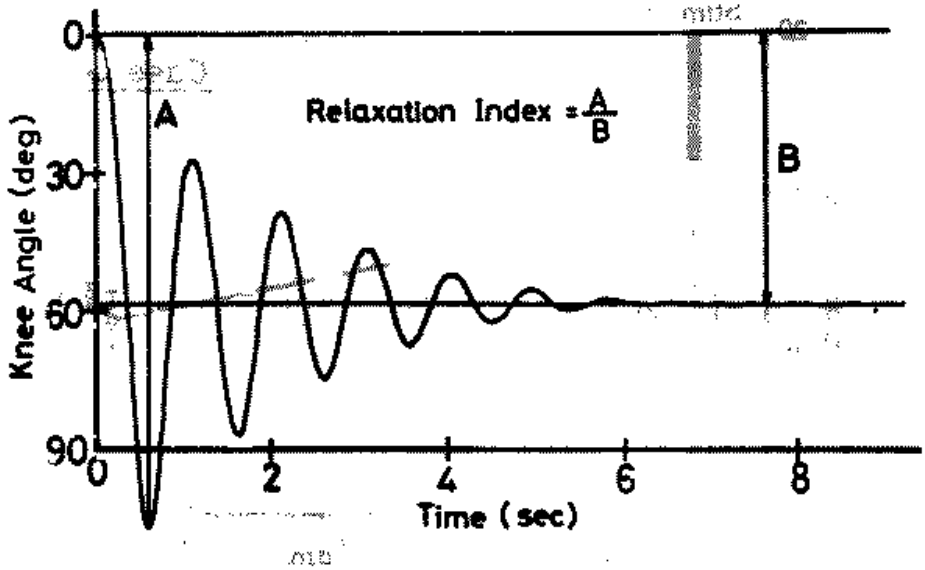


Figure 4. Definition of relaxation index

In case T, furthermore, the pendulum tests were continued for 3 weeks after the prolonged stimulation was terminated. And also, the pendulum tests without electrical stimulation were carried out for 26 hours in the same program where single session stimulation was given.

RESULTS

1. Single session stimulation :

Although patients felt reduction of spasticity immediately after the session, maximum reduction of spasticity was felt between three and five hours after the session. Reduction of spasticity was felt until next morning. Duration and degree of spasm not only at lower-limb but also upper-limb and trunk were diminished so that both difficulties in their daily activities by themselves and by assistants were reduced. Frequency of spasm was not changed in case S and was reduced in case T. Sleeping disturbance caused by spasm disappeared.

The single session stimulation increased the relaxation index and the maximum relaxation index was obtained three to five hours after the stimulation. On the following morning, relaxation index returned to became almost the same level as the level before stimulation (Figure 5 and 6).

2. Prolonged stimulation session:

Both patients felt further relief of spasticity after more than one week from the beginning of prolonged stimulation. After that, spasticity was retained at the same level. After the prolonged stimulation was terminated, patients felt gradual increase of spasticity. Clinically, spasticity returned to the same level as before the stimulation in one or two weeks from the end of the stimulation.

Relaxation index during prolonged stimulation increased promptly from beginning of the stimulation but after that it

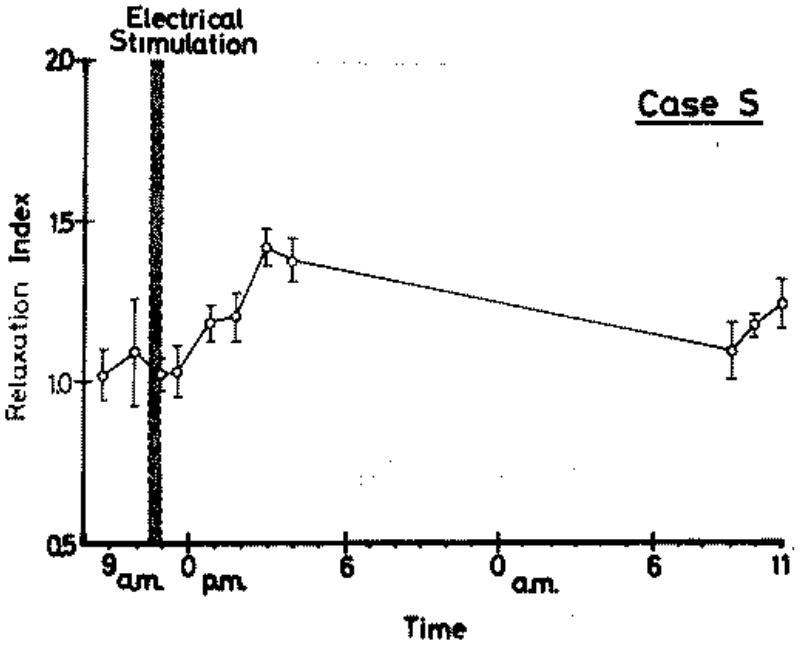
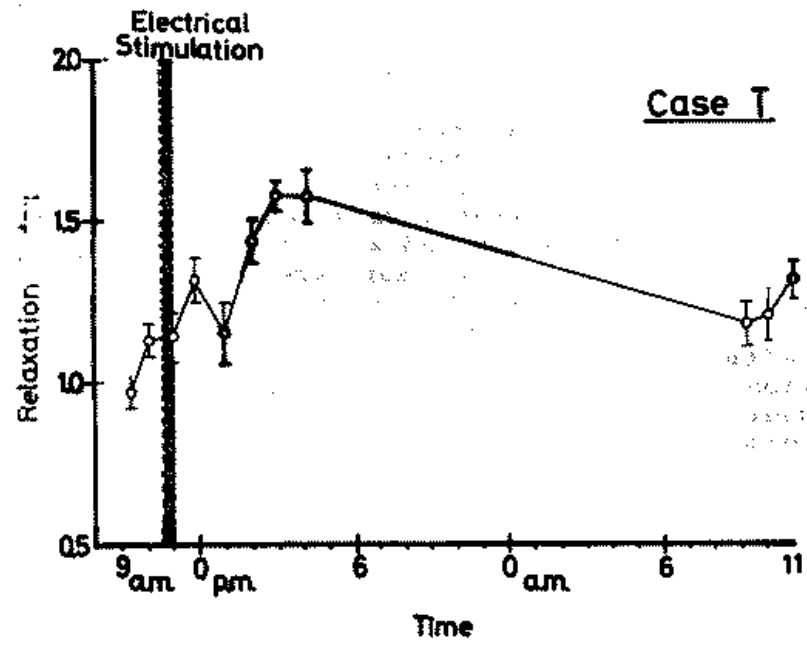


FIgure 5. Relaxation index after single session stimulation (Case S)



. Figure 6. Relaxation index after single session stimulation (Case T)

fluctuated inspite of continued stimulation in case S. Consequently, the prolonged stimulation could not show any remarkable improvement of relaxation index in this case (Figure 7).

In case T, the prolonged stimulation did not result in any remarkable change in relaxation index. After the end of the stimulation, relaxation index did not show any remarkable change also (Figure 8).

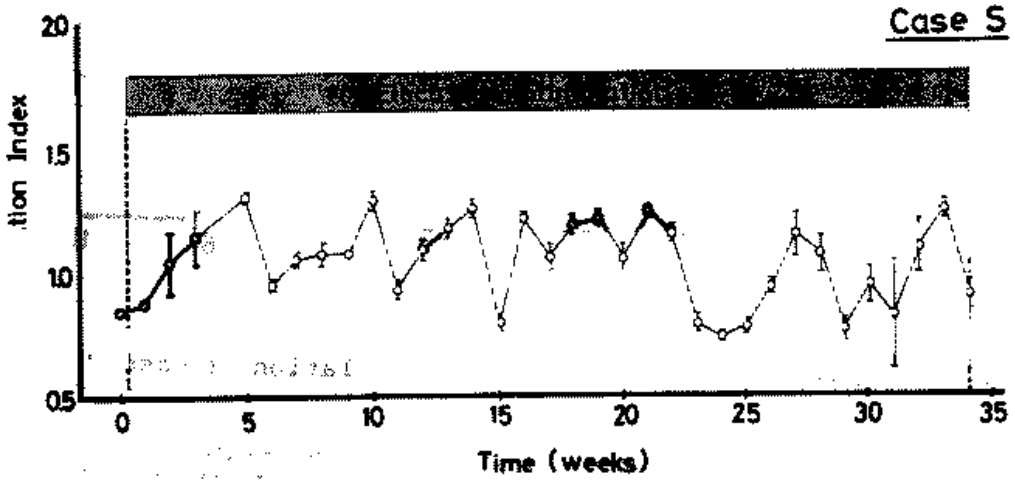


Figure 7. Relaxation index during prolonged stimulation (Case S)

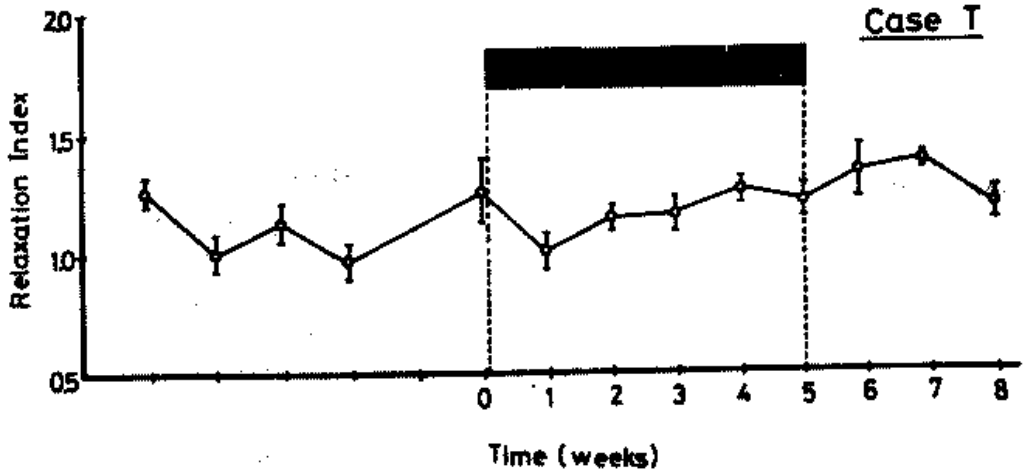


Figure 8. Relaxation index during and after prolonged stimulation (Case T)

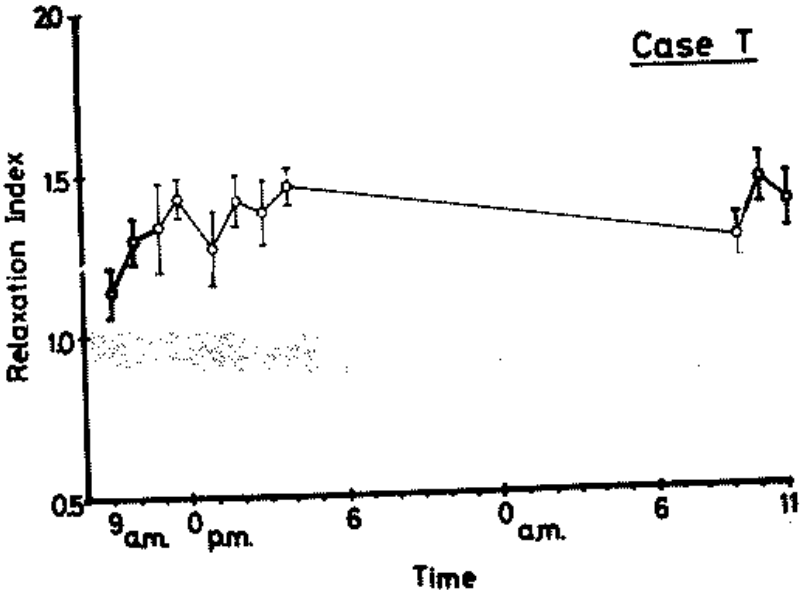


Figure 9. Relaxation index without stimulation (Case T)

3. Measurements of relaxation index without stimulation:

In Case T, relaxation index without stimulation was measured every hour from 9 in the morning to 5 in the afternoon and from 9 to 11 the next morning. Relaxation index increased from 9 in the morning to 12 noon but dipped at 1, after that increased between 2 and 4 again. In the next morning, relaxation index was almost at same level as that in the morning of previous first day (Figure 9).

DISCUSSION

For clinical use, instrumentation for assessing spasticity should be simple and inexpensive. The pendulum test which can measure the knee extensors reflex quantitatively is extremely very suitable for the evaluation of spinal spasticity in the clinical environment, because of its simplicity and reliability. Furthermore, relaxation index which can be calculated from the pendulum test is most suitable for quantitative comparison of spasticity.

Four channel electrical stimulation to bilateral extensor and flexor muscles of knee joints based on method of Vodovnik decreased spasticity in patients with spinal cord injury not only to lower-limb but also upper-limb and trunk. Thus, it improved daily activities of these patients carried out both by themselves and by assistants. Its effects reached in maximum several hours after the single session stimulation and continued at least during daytime when it was given in the morning. The clinical methods and relaxation index for evaluating spasticity showed very similar results for the single session stimulation.

Although results of measurements of relaxation index

without the stimulation showed fluctuation during a day, its change was not as wide compared with fluctuation after the stimulation. We concluded that improvement of relaxation index after the stimulation, including its maximum improvement after several hours from the stimulation, is mainly caused by the stimulation.

While prolonged stimulation improved spasticity clinically, relaxation index measured on Friday morning did not show any remarkable improvement. We think there remains the possibility that we can obtain improvement of relaxation ind x with the prolonged stimulation if we measure relaxation index during daytime after each stimulation session. However, we think electrical stimulation can relieve spasticity neither completely nor permanently.

Presently, both patients are continuing to receive electrical stimulation every morning, at another convalescent home in case S and at our hospital in case T.

CONCLUSION

1. Relaxation index is an excellent method to evaluate spinal spasticity in the clinical environment, since it gives similar results to those obtained by clinical assessment employed heretofore, and it is economical.
2. Electrical stimulation for reducing spasticity is worth to use clinically. Its effects last at least during the daytime, if it is given in every morning.
3. Prolonged stimulation seems to reinforce clinical effects of the single session stimulation but does not show any remarkable change in relaxation index.

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