QUANTITATIVE EVALUATION OF SHORT TERM EFFECTS BY TES FOR MOTOR DYSFUNCTION
—Using H wave—

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Abstract

□□□□□The purpose of this study is to establish the quantitative evaluation of short-term afferent effects by therapeutic electrical stimulation□(TES) for the patient with upper motor neuron disorders. Eight patients with incomplete paralysis of the lower extremity due to stroke participated in H-wave recordings from the soleus before and after TES applied to the common peroneal nerve for 15min. A test H-reflex in the soleus was evoked by electrical stimulation of the tibial nerve at the popliteal fossa. The stimulation intensity inducing the H-reflex was fixed to a subthreshold level of M wave. This H-reflex was conditioned by electrical stimulation of the common peroneal nerve at the level of the caput fibulae. The time interval between test and conditioning stimuli was 0, 1, 2, 3 ms. Reciprocal inhibition of the H-reflex was induced by conditioning stimuli after TES but not before TES in five patients with spasticity. However, four cases did not show the reciprocal Ia inhibition even after TES.

Introduction

In stroke patients with moderate or severe spasticity, pes equinovarus of the ankle joint is observed very frequently and they are inforced to drag their foot during walking. This is generally considered to be due to spasticity of the triceps surae or co-contraction of the triceps surae and tibialis anterior muscles. These symptoms are also assumed to be due to the change of tonic balance between agonist and antagonist muscles [1), 2)].

The electrical treatments such as TENS, FES and TES are used for reducing spasticity in such patients. Although it was reported that spasticity was suppressed by the afferent effects of the TES [3)], exact mechanism of this suppression by TES is not known yet.

H-reflex has been utilized as one of the potential methods for evaluating spasticity. The aim of this study is to establish the quantitative evaluation of afferent effects of TES on spasticity using H-reflex in stroke and spinal cord injury patients.

Method

Subjects and General Procedures

Eight patients (mean: 54.3 years, S.D. 9.8) with hemiplegia following stroke and four healthy subjects (mean: 24.5 years, S.D. 2.5) participated in this study. All subjects gave informed consent following a full explanation of the purpose of the research and nature of the experimental procedures, and were alert and cooperative. The interval between the onset of the stroke and the experiment ranged from two years to fifteen years. All of the patients showed hyper-reflexia on the affected ankle joint and marked weakness (less than grade 3 on the SIAS [4] scale) in the tibialis anterior muscle. None of them had contracture on the ankle joint.

□□□The experimental procedures were similar to those previously described [1), 2)]. Subjects laid prone and relaxed on the bed with the foot of the examined side resting on a pillow. The angle of the ankle joint was fixed at 0 degree by the Ankle Foot Orthosis (AFO) to make the muscle length constant.

TES was applied to the common peroneal nerve through portable stimulators for 15 minutes with maximum stimulus intensity inducing ankle dorsiflexion without pain. Duration of a stimulating pulse and stimulus frequency were 0.2ms and 20 Hz, respectively. Six of nine patients and the healthy subjects received TES by the surface stimulating electrode with 10 cm×7 cm in size which was placed over the anterior part of the head of the fibulae.

Other two hemiplegic patients received TES through percutaneous intramuscular electrodes which were implanted to the common peroneal nerve.

Test stimuli

□Excitability of a motoneurone pool was assessed by the size of the test H-reflex responses recorded from the soleus using bipolar surface electrodes in every subjects. Paired electrodes were placed 2cm apart. The muscles for investigation were in a relaxed state and EMG was monitored to ensure that no voluntary activity was observed during stimulation. The posterior tibial nerve was stimulated through a monopolar stimulating electrode (diameter 1 cm) at the popliteal fossa to elicit H-reflexes from the soleus. The anode, a 3 cm×2.5 cm metal plate, was placed over the anterior part of the patella. The test H-reflexes in the tibialis anterior were elicited by stimulating the common peroneal nerve at the level of the head of the fibula. The position of the cathode for peroneal nerve stimulation was adjusted to evoke selective contraction of the tibialis anterior without activation of the peroneal muscles. The duration of the test stimulus was 1 ms for both tibial nerve and deep peroneal nerve. The H-reflex responses were amplified and stored on Nicolet Viking Four.

Conditioning Stimuli

Conditioning Stimuli was applied to the peroneal nerve or the tibial nerve for testing

reciprocal inhibition of H-reflex in the soleus or tibialis anterior, respectively H-reflex, using the same electrodes as used in the test H-reflexes. Single pulses of 1 ms duration were applied to both peroneal and tibial nerve stimulation. The intensity of the conditioning stimulus was expressed in multiples of motor threshold (×MT). For stimulation of the peroneal nerve, the intensity was always kept just at motor threshold (1.0×MT) for tibialis anterior. Current intensities less than the motor threshold of the soleus (0.8-1.0×MT) were used for conditioning stimuli to the tibial nerve.

Stimulus Protocol and Data Analysis

□□□The unconditioned (test) and conditioned stimuli were randomly applied every 5 seconds. Ten conditioned H-reflexes and the same number of the test H-reflexes were recorded for each conditioning-test interval. Reciprocal inhibition was demonstrated by plotting the amplitude of the conditioned H-reflexes as a percentage of the control H-reflex, and the time course of this relationship was examined for conditioning-test interval ranging from 0 to 3 ms. Statistical comparisons were made using with repetition in analysis of variance (ANOVA). For multiple comparisons, the Scheffe method used when ANOVA showed a significant difference and probability values less than 0.05 were considered significant.

Results

□□□□In control subjects, maximum reduction of the soleus H-reflex amplitude, which was attributable to reciprocal inhibition through conditioning stimuli to the common peroneal nerve, was shown at 2 ms conditioning-test interval as reported by many investigators. However, there was no change in the amplitude of the soleus H-reflex before and after TES. □□The percentage of conditioned H-reflex to test H-reflex was 93 % before TES and 92 % after TES, and there were no statistical differences between these percentages before and after TES in every conditioning-test interval by ANOVA.

□□□□In the patients with spasticity, the H-reflex showed an increase in amplitude with an increase in conditioning-test interval before TES. This could be due to reduction of reciprocal inhibition through conditioning stimuli to the peroneal nerve. TES application for 15minutes caused a decrease in the H-reflex amplitude at conditioning-test interval 1, 2, and 3 ms. The percentages of conditioned H-reflex to test H-reflex at 1, 2, and 3 ms intervals were 103, 105, and 108% before TES, and then 98, 95, and 94% after TES, respectively. There were significant differences between these percentages before and after TES at conditioning-test interval 2 and 3 ms.

In contrast, four cases showed a decrease in H-reflex amplitude before TES. The percentages of conditioned H-reflex to test H-reflex were 92, 95, 94, and 96 % at every conditioning-test intervals. After TES, however, the H-reflex amplitude tended to increase at

every conditioning-test interval, i.e., 105, 103, 106, and 103 % at 0, 1, 2, and 3 ms intervals, respectively. There were significant differences between the percentages before and after TES at every conditioning-test intervals.

Discussion

□□□It was found that TES for fifteen minutes caused a significant reduction of H-wave accompanied by reduction of spasticity in five patients with moderate or severe spasticity. It is likely that afferent volleys induced by TES applied to the peroneal nerve decreased neuronal excitability of the tibial nerve via inhibitory interneurones, and thus, resulting in a decrease in H-wave amplitude. In four patients out of nine, however, conditioned stimuli caused an increase in H-wave amplitude after TES though it was decreased before TES. This discrepancy on the effect of TES cannot be explained at moment.

Thus, H-reflex could be used as one of quantitative evaluation of the afferent effects of short-term TES on spasticity in stroke and SCI patients.

Reference

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