Combination therapy of Botulinum toxin type A with therapeutic electrical stimulation for chronic spastic upper limb paralysis

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Abstract

We applied combination therapy of Botulinum toxin type A (BTXA) injection with therapeutic electrical stimulation (TES) for the upper limb with chronic spastic paralysis to improve motor function and muscle tone.

Spasticity reduction within 3 months after BTXA injection was remarkable. Voluntary extension in the elbow and wrist improved almost parallel with the spasticity reduction. The level of function in the upper extremity with spastic paralysis continuously elevated during the treatment period. We concluded the combination therapy of BTXA with TES could improve upper extremity function in the patients with chronic spastic paralysis even without any physical exercises. Multiplier effect between facilitation based on TES and long-lasting spasticity reduction by BTXA might be hypothesized.

1 Introduction

Spasticity in the upper extremity associated with central nervous system damage usually appears in flexor muscles. Synergic flexion movement in elbow, wrist and fingers disturbs practical use of upper extremity with central type paralysis in activities of daily living.

Therapeutic electrical stimulation (TES) using surface electrodes is effective to reduce spasticity. We have used TES for hemiparetic stroke patients in chronic stage to control spasticity by stimulating antagonist of the spastic muscle in the paralytic upper extremity. However, carry over effect after TES is usually short and only small amount of spasticity reduction can be obtained. On the other hand, TES has some facilitating effect to provide voluntary movement in the paralytic muscles although the physiological background mechanism is unknown. Probably it is based not only on the peripheral mechanism but also on modification of the neural network in the central nervous system including brain.

Botulinum toxin type A (BTXA) has a strong effect to reduce muscle tone in the spastic limbs and its effect usually lasts 3 months. There are many studies reported on the clinical effect for spasticity control. In many countries injection of BTXA to the spastic muscles is common way to reduce spasticity. However, there are not so many studies found in the field of functional recovery of the spastic paralysis in the upper extremity. Reduction of spasticity is not necessarily related to regaining function of the upper extremity with synergistic flexion movement. It is undoubted that excessive spasticity disturbs functional recovery, particularly acquiring total extension movement.

It is valid to think that combining use of BTXA with TES is more useful to regain function of the upper extremity with spastic paralysis than single use of each treatment method. Strong and long-lasting effect for spasticity reduction by BTXA is expected to inhibit synergistic flexion and facilitating effect of TES for extensor muscles has a possibility to induce some voluntary movement in the extensors. There are some reports found on the field of such combining use of BTXA and electrical stimulation for spastic muscles [1]. Combination therapy of BTXA with electrical stimulation to improve equinus foot was reported by Galen [2]. However, therapeutic use of BTXA with TES to recover function has not been applied to spastic upper extremity in chronic stage.

The purpose of the present study is to investigate the effect of combination therapy of BTXA with TES for reduction of spasticity and functional recovery in the paralytic upper extremity after central nervous damage.

2 Methods

Nine patients with unilateral spastic upper extremity paralysis participated to this study (7 males and 2 females). Cause of spastic paralysis was stroke in 8 patients (cerebral hemorrhage in
Functional assessment was performed to reveal the change of spasticity, arm and fingers function and voluntary movement. Spasticity in the joint of elbow, wrist and index finger (DIP) was evaluated by the score of Tardieu scale (TdS) in each. It is the difference between passive range of motion and catch angle. Function of arm and fingers was evaluated by the score of Manual Function Test (MFS: 0 ~ 100%). 3-D motion analysis (Kinematracer, Kissei co., Japan) was used to examine the angle of elbow and wrist when the subjects performed voluntary total extension of each joint (angle of voluntary extension: AVE).

The changes of MFS were compared among the mean values calculated for each score obtained as below: score before TES, score 1 month after TES (1st injection), maximum score till 2 months after 1st injection, maximum score till the end and score at the end. The mean values of MFS were calculated by the scores in 7 subjects because 2 subjects had no functional problems in the fingers. The changes of TdS and AVE were compared among the mean values calculated for each score or angle obtained as below: score (angle) at 1st, 2nd, 3rd injection and minimum score (angle) till 2nd injection, 3rd injection and the end. The mean values of AVE were calculated for all of the subjects, but those of TdS were calculated for 8 subjects because, in the subjects, there was a patient with no functional problem in the elbow and a patient who had no functional deficits in the wrist and fingers.

Friedman’s test and Wilcoxon’s signed rank test as post hoc test was used for statistical analysis among the values measured at the timing mentioned above. The level of significance was set at 5%.

### 3 Results

The values of TdS significantly decreased after BTX A injection in all of the joints evaluated. The score, however, returned to almost initial level by the time of next injection. Such up & down phenomena repeated during the treatment period (Fig 1). AVE significantly decreased after BTX A injection. Tendency of the change was similar to TdS.

MFS significantly increased during the period of only TES application. After BTX A injection the level reached higher position than that at 1st injection and did not return to the initial level till the end of the treatment (Fig 2).
4 Discussion and Conclusions

Spasticity remarkably reduced in each target joint after BTXA injection though the score of TdS elevated again at the next injection. We expected multiplier and accumulated effect of TES added to BTXA for spasticity reduction. On the contrary, the scores of TdS among 1st, 2nd, and 3rd injection had no significant differences in all of the joints evaluated. However, particularly in the wrist, the score seemed to decrease gradually. The period of observation was about 1 year in the present study. Longer time for treatment and observation might be necessary to show such multiplier and accumulated effect of combination therapy.

The angle of voluntary extension in the elbow and wrist changed almost parallel with the change of spasticity. The gain of extension in each joint was at most 20 degrees. This is not enough for practical use of the joint but sufficiently prominent as a change occurred in the patients with a chronic spastic paralysis. The change of voluntary extension in the fingers could not be revealed. However, in clinical observation, there were some patients who regained grasp and release function in the hand during the treatment period. Consequently, MFS improved gradually in all of the subjects. Improvement of MFS till 40% is achieved by the gross movement of the shoulder and elbow, while increase of the score more than 40% is dependent on acquiring grasp/release function and finger clumsiness. The initial score of MFS in 3 subjects was under 40% and the maximum gain they showed during the study was 16, 16 and 18% in each. Other 4 subjects showed the initial score more than 40% and their maximum gain was 6, 9, 10 and 16% in each. The effect of the combination therapy used in the present study might be more remarkable in the patients with lower function.

The value of MFS significantly increased after 1 month application of TES without BTXA injection. This result suggests even a treatment by only TES has an effect to elevate the level of upper extremity function with chronic spastic paralysis. MFS reached higher level after BTXA injection. The effect of TES to reduce spasticity usually diminishes within 1 or 2 hours after stimulation. Therefore, it is valid to think the continuous elevation of MFS observed during the treatment period was provided by the multiplier effect between facilitation based on TES and long-lasting spasticity reduction by BTXA.

In conclusion, the combination therapy of BTXA with TES can improve upper extremity function in the patients with chronic spastic paralysis even without physical exercises.

Fig 1  Change of TdS in the wrist

![Graph showing change of TdS in the wrist](image1)

Fig 2  Change of MFS

![Graph showing change of MFS](image2)

References
