The Effects of Electrical stimulation on Nerve Regeneration in Brachial Plexus Injuries using Implantable Electrodes

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Abstract

The purpose of this study is to review the clinical result of electric stimulus on the restoration of motor and sensory recoveries in the brachial plexus injuries. We had evaluated retrospectively 20 cases of brachial plexus injuries who were treated by surgical reconstruction of their damaged nerves and electrical stimulation. Among 20 cases, 18 cases were treated by insertion of electrode to the nerves, and 2 cases to the motor points of muscles. For the comparison, 24 cases were selected who were received similar operation without electrical stimulation. All cases were followed up for at least 24 months, as a rule. As a result, we had a significant difference in the power of elbow flexor, shoulder abductor and sensibility of forearm between two groups, suggesting that the electrical stimulation to nerve and muscle enhanced the progress of nerve regeneration or muscle strength retrospectively. The result suggests that the electrical stimulation is a promising supplementary method for functional recovery in peripheral nerve surgery.

Introduction

By the development of microsurgical technique, surgical reconstruction of injured peripheral nerve has been quite successful. Even in the complex plexus injury, many promising surgical techniques were introduced recently. However, we have several problems in the peripheral nerve surgery. The first one is that the axonal regeneration after the nerve re-anastomosis is so slow that the patient should wait for a long time, one or two years or more, in case of brachial plexus injury. Another disappointing aspects of peripheral nerve surgeons is that we have nothing to do for the motor recovery in case of neglected cases who lost the chance of nerve reconstruction within one year after injury. The third problem is insufficient recovery of muscles after nerve surgery. The muscle power is trace or poor which is so weak to use in daily life. The authors tried to use TES in case of brachial plexus injuries with the purpose of stimulating the axonal regeneration and improving the muscle power.
Materials and Methods

44 patients who had had nerve surgery with or without electrical stimulation for traumatic brachial plexus injuries participated in this study. Studied subjects were divided into 2 groups based on treatment methods, that is, whether they had got supplementary electrical stimulation in addition to nerve surgery or not. We applied the TES in 20 operated cases of brachial plexus injury, for two years from 1993 to 1995. Eighteen cases were inserted the percutaneous electrode to the nerve during the surgery, at the proximal point of nerve suture. In two cases, electrodes were inserted to the motor point of biceps brachii which did not recovered useful muscle power (below fair grade) after the nerve surgery and regular physical therapy for two years. We selected 24 cases of brachial plexus injuries who were done nerve surgeries only (without TES), for comparison. All the patients’ ages ranged from teens to thirties. We put the ground electrodes around the shoulder area.

The electrode that we used is spiral-coiled, Teflon-coated stainless steel wire, which was made in Sendai, Japan, and the diameter is 0.45 mm. The stimulator was made in our laboratory which produces the electrical pulse train with pulse frequency of 20 Hz, pulse width of 0.2ms, and pulse amplitude of 1.0V. One stimulation session was consisted of iteration of stimulation (5 seconds) and rest (5 seconds). Finally the patient do the stimulation 6 times a day, 30 minutes per each session.

Results

In two cases of Biceps brachii stimulation, we had a good recovery within three months. The muscle power were improved from trace to fair or good degree of muscle power by the stimulation of motor points for two months.

All patients were evaluated to compare the result of electrically stimulated group with non-stimulated group by assessment of functional restoration in suprascapular nerve, musculocutaneous nerve and median nerve.

In the stimulated group of suprascapular nerve, the initial muscle power (trace grade) were recovered in 2.7 months after nerve surgery. In the stimulated group of musculocutaneous nerve, the power of biceps brachii became trace within 3.4 months. But in the nonstimulated group, the initial recovery were started from 9.6 months in supraspinatus and 9.1 months in biceps after nerve surgery.

For the sensory function, in the stimulated group of median nerve, initial deep touch recovery started from 4.5 months. But in the nonstimulated group, the initial sensory recovery started from 9 months after the surgery. The result of long term follow up for 2 years are also superior in the stimulated group than nonstimulated group (Fig 1, Fig 2).
Discussion

According to the latest experimental reports, there were a few examples that electrical stimulation can accelerate the regeneration of axon. However, the mechanism of biochemical effect of electricity, i.e., how the electrical stimulation effects the regeneration of axon of damaged nerve is not known yet.

But according to the Shen and Zhu, the electrical stimulation increase the number of the endoneurial vessel and enlarge the vessel so that improves the ischemic state of damaged nerve and accelerate the Wallerian degeneration. As a result, it can provide the proper inner environment for axonal regeneration. Also the electrical stimulation gives effects for the direction of inner electric current so it brings the growth in quality of nerve fiber and brings the mature effect. And those effects are main reasons to accelerate the function of damaged nerve.

Besides, it is not known clearly about the biomechanical effect of electrical stimulation on the muscles until now. However, the increase of local vascularity, the change of cellular structure of muscles, and the increase of the neurotropic factors were proposed as hypotheses for the proofs of the effect of electrical stimulus on muscles. Errikson and Haggma RK reported succinate dehydrogenase is activated during the intracellular metabolism of muscle cell by electrical stimulus, so it can prevent the decrease of activity of oxidase. Also, according to the Goldberg and his colleagues, the electric stimulus accelerate the active movement of certain amino acid inside of muscle cell so it increase DNA synthesis. By the result, the muscle fiber grows and this growth is explained as a generation of electricity which brings the hypertrophy of muscle. Especially, Brevet reported the muscular hypertrophy and increase of muscular power because of the increase of myosin synthesis which is an amino-acid for muscle contraction after the electric stimulus.
References