SHORT TERM EFFECTS OF SURFACE ELECTRICAL STIMULATION ON SPASTICITY: PRELIMINARY RESULTS

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Abstract – *The aim of this work is to present preliminary results of a study to assess short term effects of electrical stimulation on spastic knee extensors. The study consisted of patient selection, a 20 minutes session of electrical stimulation and the recording of goniogram while pendulum test is performed. Patient opinion and Ashworth test were also considered. Twenty-five patients with clinical signs of quadriceps spasticity were involved. Ten were later discarded due to wrong evaluation. Ashworth scores showed that 60% of patients decreased their spasticity and 40% did not change their condition. All patients reported spasticity relief. Parameters extracted from goniograms did not indicate a significant change in spasticity level before and after stimulation. This study revealed that more than a half of patients with knee joint spasticity improved their condition, so we are able to support the concept that surface electrical stimulation may be employed in rehabilitation programs to reduce muscle spasticity.*

Keywords: Spasticity, Electrical Stimulation

1. Introduction

Persons with lesions in the Central Nervous Systems are often afflicted with spasticity of several muscles. In some cases this increased muscle tone is beneficial. However in hemiplegics the spasticity of the quadriceps reduces the range of the knee flexion during swing phase of gait. In spinal cord injured (SCI) patients, the spasticity limits the functional activities.

Spasticity is a complex phenomenon. It has raised numerous definitions. In the article of Levine et al. [4], Pollock defines spasticity as a condition that is "demonstrable by a sustained increase in tension over normal when the muscle is passively lengthened. The increase is felt from the beginning of the passive movement, and is in proportion to the extent to which the muscle is lengthened". Levine et al [4], define spasticity as "a condition of paralysis or muscular weakness associated with hiperreflexia, the symptoms of which include increased resistance to manipulation, exaggeration of the deep reflexes, and clonus". Stefanovska et al [8] suggest to define spasticity as "an exaggerated activity of the stretch reflex loop with a length-dependent increase in tonic reflexes and a velocity-dependent increase in phasic reflexes". They distinguish two kinds of spasticity: tonic and phasic.

Much effort has been expended to find the best method to decrease the spasticity. There are various therapeutic procedures to reduce the spasticity: active exercise, passive stretching and pharmacological and physical agents. Some physical agents are cold, heat and electrical currents [2]. Since fifties, several authors described the utilization of electrical stimulation for the treatment of spasticity. In several articles, a modification of spasticity because of the treatment for muscular strengthening and accomplishment of functional activities is described [5,7,9]. Other authors presented studies performed to assess specifically the effect of electrical stimulation on spasticity [1,4,6,10, 11].

In our country, there are few centers where electrical stimulation is applied to reduce the spasticity. Most of the professionals believe that electrical stimulation increases the muscular spasticity. To reproduce the good experiences performed by other groups, we decided to assess the short term effects of surface electrical stimulation on spasticity. We present the preliminary results, which are analyzed in order to evaluate the performance of the proposed test.

2. Methods

The study consisted on three stages: patient selection, an electrical stimulation session and an qualitative and quantitative evaluation.

The protocol for patients selection allowed to incorporate subjects affected by Cerebral Vascular Accident (CVA) and SCI patients, with clinical signs of quadriceps spasticity, ages between 20 and 70 years and without uncompensated cardiovascular illness, acute infections, wounds, tumors, convulsions, pacemaker and metallic implants. They had to be able to understand the instructions and to give the consent to participate in this study.

The 20 minutes session of electrical stimulation was performed while the patient was lying down in a supine position on a stretcher with their legs in a flexion of 30°. The affected limb of the hemiplegic patients and the

most spastic in the SCI patients were stimulated. Stimulation parameters included a pulse rate of 30 per second, monophasic pulses of 300 microseconds duration and amplitude that caused contraction without movement. Stimulation was 5 seconds on and 5 seconds off. Two pairs of adhesive conductive rubber electrodes (5 x 5 cm) with incorporated gel were placed over the quadriceps, one 5 cm from upper edge of the patella and the other 10 cm below the groin.

The spasticity was assessed by Ashworth scale, the patient opinion and the recording of goniogram while pendulum test was performed. These evaluations were made before stimulation and 5 and 60 minutes after.

The patient was asked to lie down in a supine position on a stretcher with the lower limbs hanging free over the edge of it. First, the Ashworth test was performed, second the patient opinion about his condition was asked and finally the quantitative evaluation was made. To perform this last test an electrogoniometer was attached to the leg, with sensor aligned to rotation edge of the knee. The physician lifted the leg while the patient was requested to relax, then the leg was released and the recording of the oscillations was started by the experimenter.

The portable battery-powered electrogoniometer records during 20 seconds. Then, this recording is transmitted to a Personal Computer (PC) by parallel interface. Software designed for this study, which runs into the PC, stores the patient data, shows graphics of the goniograms and calculates indexes to evaluate the spasticity.

To quantify the observed changes in spasticity two parameters proposed by Badj et. al [3] were extracted: the normalized relaxation index (*RI*) and the area (*A*) above the resting angle and below the goniogram prior to the first crossing over the resting angle.

RI is the ratio between the amplitude of the first minimum and the difference between the resting and starting position, divided by a normalization factor *fn*. The parameter *fn* depends on the characteristics of the performed test and the electrogoniometer employed. *fn* is 1.55 in our case.

In cases of strong spasticity, *A* could be a rather sensitive measure for assessing spasticity. [3]

3. Results

Twenty-five patients were involved in this study. Ten patients were later discarded because their electrogoniograms were not properly registered. Characteristics of remaining subjects are presented in Table I.

Regarding the registered patterns of knee joint movement, patients were classified in two groups.

Patients with severe spasticity

Patients *1*, *2*, *3*, *4*, *5*, *6*, *10*, *13* and *14* belong to this group. These patients had strong hypertonia in the quadriceps and usually showed the goniogram pattern of Figure 1.

Relaxation indexes could not be computed from goniograms of patients *1* and *2* because they had not pendulum test oscillations. In these cases, quantitative evaluation was made with parameter *A*. Area before stimulation was 141.50 ± 44.55, five minutes after stimulation was 139 ± 5.66 and 1 hour after stimulation was reduced to 132 ± 31.11. *RI* obtained from the other seven patients were 0.46 ± 0.12, 0.47 ± 0.11 and 0.50 ± 0.11, before stimulation and 5 and 60 minutes after. The paired *t*-tests (α=0.01) failed to indicate a significant change between parameters obtained before and after stimulation.

Table I: General patient data

	Patient	**Lesion**	**Sex**	**Age**	**Other rehab. Program**	**Anti–spastic medication**	**Months post-CVA or injury**
1	P.A.	SCI	M	21	Yes	Yes	9
2	M.B.	CVA	M	22	Yes	No	5
3	J.C.	CVA	M	–	Yes	Yes	–
4	A.C.	SCI	M	24	Yes	yes	8
5	C.C.	SCI	M	52	Yes	No	10
6	F.M.	SCI	M	26	Yes	Yes	27
7	R.P.	SCI	M	29	Yes	Yes	7
8	A.Z.	CVA	M	58	No	Yes	50
9	R.B.	CVA	M	68	No	No	21
10	A.G.	CVA	M	58	Yes	Yes	18
11	M.H.	CVA	M	44	No	Yes	57
12	E.K.	CVA	M	69	No	No	35
13	T.R.	SCI	M	48	No	Yes	62
14	G.W.	CVA	M	47	No	Yes	30
15	|A.C.	SCI	M	29	No	Yes	2

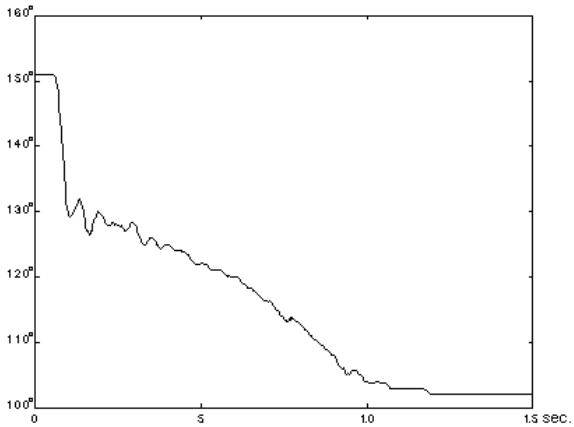

Figure 1: Typical pattern of knee movement during pendulum testing for patients with severe spasticity.

However, Ashworth scores for patients *2*, *3*, *10*, *13* and *14* revealed decreased spasticity and showed no change for patients *1*, *4*, *5* and *6*. None became worse.

Patient *14* described no change in his condition, but all other ones reported an improvement of their state.

Patients with mild spasticity

In this group are included patients *7*, *8*, *9*, *11*, *12* and *15*. A typical goniogram for these subjects is presented in Figure 2.

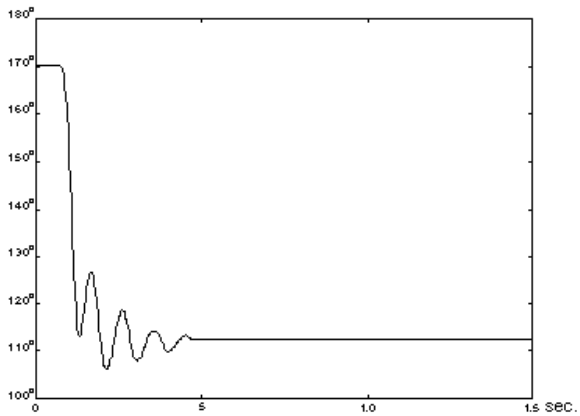

Figure 2: Knee goniogram from a patient with mild spasticity.

RI computed from goniograms of these patients were 0.52 ± 0.18, 0.61 ± 0.15 and 0.62 ± 0.17, before stimulation and 5 and 60 minutes after. Comparison of these data showed again a difference not statistically significant at a level α=0.01.

A spasticity reduction was revealed by Ashworth scores for patients *7*, *11*, *12* and *15* and no change in the condition for subjects *8* and *9* was observed.

Every patient experienced an amelioration of spasticity. They described relaxation of their stimulated leg and, in same cases, reduction of spasms.

4. Discussion and Conclusions

Taking into account results from Ashworth scores and patient opinions for both groups of subjects, we found that none of the patients' spasticity became worse following stimulation. Ashworth scores showed that 60% of patients decreased their spasticity and 40% did not change their condition. All patients reported an improvement in their condition, including those ones with parameters extracted from goniogram reflecting an increase of their spasticity.

The analysis of the parameters computed from goniograms did not indicate a significant change in spasticity level before and after stimulation. This could be because few cases were involved in this preliminary study.

We will use these results to adjust the experience in order to minimize human errors, to optimize data processing and to improve the experimental protocol.

This study revealed that more than a half of patients with knee joint spasticity improved their condition, so we are encouraged to continue working in order to be able to support the concept that surface electrical stimulation may be employed in rehabilitation programs to reduce muscular spasticity.

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