

Routine clinical use of surface applied FES in hemiplegia

Abstract

The aim is to highlight the Ljubljana approach in rehabilitation of hemiplegics by FES as supplementary therapeutic method. Since 1970, when only 20% of patients were included in FES program, in the last 20 years the percentage of the treated patients increased to 70%. In all treated patients clinical observations and FES test of relevant muscles of lower and upper extremity were performed to check out selective functional response. In selective groups of patients biomechanical measurement of gait was compared to clinical assessment. The average age of treated patients was 58 years, admitted 1- 6 months after the acute onset of the disease. The statistical data since the start of FES program in 1970, based on single channel stimulators, showed that initially the FES was planned as the orthotic device only, but in the five years, in 1975, the therapeutic use became five times larger compared to the orthotic use. Nowadays in most cases several different types of one- and two-channels stimulators are used in order to rationalize the demand to physical therapists, lower the encumbrance of the patients and to achieve reasonable costs. Supplement of FES therapy in our rehabilitation program of hemiplegics has shown to improve functional outcomes, allow patients to regain independence and shorten the hospitalization period.

Introduction

Republic of Slovenia has been maintaining during last 15-years approximately the same population of 2 millions. Stroke is the third leading cause of death. Roughly 30 % die during the acute phase, and of the survivors 40 % will have severe disability, what means that stroke is also the most common cause of adult disability in Slovenia. More than 26% of strokes appear in active part of population (employed). Unfortunately we have no annual incidence rate for stroke. The rough CVA incidence estimate is 4-6 cases/1000 population. In overall there are approximately 4800 hospitalisations a year, out of them 250 are accepted to the Rehabilitation Institute in Ljubljana.

Impaired sensory motor functions by stroke patients are typical persistent sequels after the onset in about 70% of cases. Because of specific problems such as spasticity, joint contractures, joint subluxation, inability to stand or walk, to perform hand functions, communication disability, rehabilitation treatment has to be organised. The use of electrical stimulation beside the other methods and techniques of neurological physiotherapy during the rehabilitation procedure has become even more extensive

After Liberson's et al. (1961) first experience with FES of peroneal nerve [5] the FES routine program in Ljubljana started in 1969. Since then about 5600 stroke patients have

been included in the FES routine program, 55% males (in average 57,5 years old) and 45% females (in average 61,9 years old).

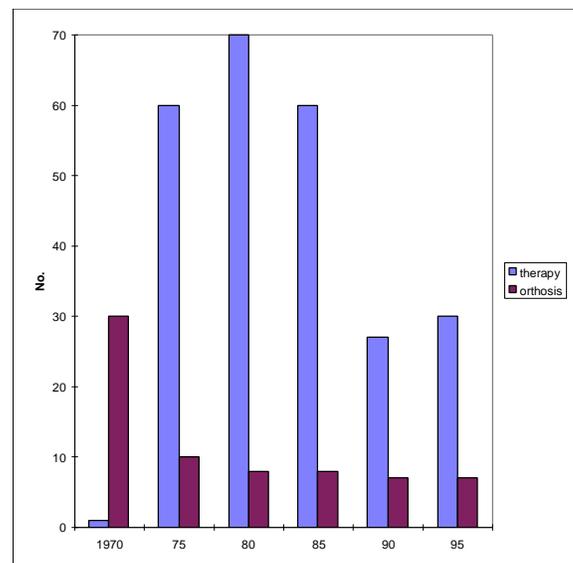
Different types of single channel, two channel or multi-channel stimulators have been developed and some of them being used in present under medical prescription. Multichannel electrical stimulators and two-channel ones are more suitable for therapeutic procedures.

Patients and technologies

After the first evaluations of one channel peroneal electrical stimulator FEPA-10 in 1971 the necessity of therapeutic use of ES in hemiplegic patients was recognised. Namely in the period of 3 years among 400 treated hemiplegics in chronic stage (6-8 years after the stroke onset) 60% did not need FES orthosis, in 10% after 6 months of use the FES was no longer needed and only in 30% orthosis FEPA10 was applied.

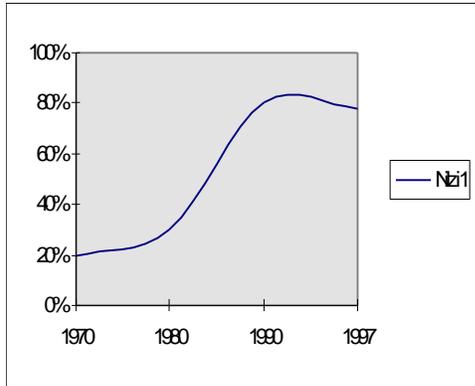
From 1972 the general picture has changed. The number of therapeutic treatments increased and the number of orthotic applications decreased. (Fig. 1) The treatment started much sooner, 6 weeks to 6 months after the onset.

Fig 1. Therapeutic versus orthotic use of FES single channel devices



In the recent 10 years the therapeutic value of FES in early initiation of gait and the training of the upper extremity, became even more pronounced. In Ljubljana nowadays we use ES in our rehabilitation program in 70-80% of patients.

Fig. 2. Increased number of hemiplegic patients treated by ES in the years 1970-1997 (n=5500)



Before starting any program of rehabilitation procedure very careful examination and assessment of functional disability for each particular individual is inevitable. So from this point of view the selection of patients and selection of electrical stimulators is very important. After the analysis of prevailing pathological symptoms and disorders of functionality being identified, the electrical stimulation program can start.

For starting electrical stimulation treatment multidisciplinary assessment has to be done. The investigation of somatic and psychic status is of most importance. After that careful examination of sensory motor disorders, inability of locomotion and activities of daily living, perceptual and intellectual activities and communicability must be determined and discussed. Determinations of points for the position of stimulating electrodes in prone, sitting and standing position is prepared during the observation of functional response due to FES application (so called FES test) [8].

Typical problems of the recovery phase can be:

- inability of independent verticalisation standing and walking,
- problematic pathological gait patterns with different anomalies
- no proper function of upper extremity,

Criteria: multidisciplinary assessment and biomechanical measurements, kinesiological analysis of gait, good condition of cardiovascular system, proper electrical excitability of muscles and peripheral nerves, good contractability of muscles, indications for short term or long term treatment concerning therapeutic or orthotic procedure, motivation of individual patients, special educated staff

Limitations: no motivation of patients, ncumbrance of patients due to too high complexity of surface FES.

The amount of recovery depends upon the severity of initial deficit. The more severe initial deficit, the less the ultimate degree of recovery. The principle when to start the therapy is »as early as possible« because the recovery is fastest in the first three months.

The propose of electrical stimulation is to overcome pathological activity associated with patients with spasticity, to prevent shoulder joint subluxation, joint contractures, to strengthen paretic muscles, to improve circulation in different phases of therapy. It is important to minimise effort during first trials of different activities to lessen stereotyped associated reactions and spasticity. It means that we want to

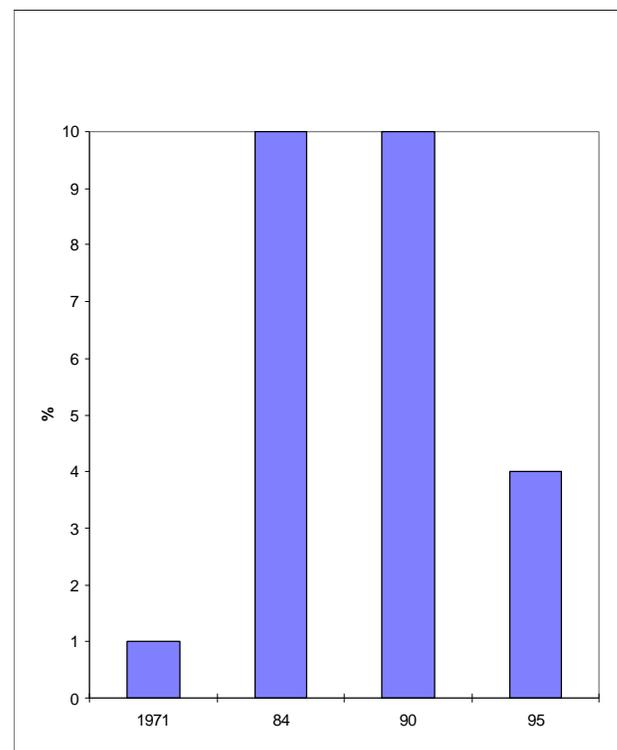
facilitate recovery of the impaired side performing isolated movements of upper and lower extremity.

The first group of patients that are candidates for FES are prolonged bedridden patients. Muscle weakness due to inability and disturbed muscle control are very often accompanied by balance problems, disturbance in proprioception, contractures of joints, cognitive dysfunction, emotional lability. Thus the relearning of gait is very difficult and long lasting. Multichannel functional electrical stimulation, in addition to the other rehabilitation programs especially added to neurophysiological physiotherapy, may enable the subjects to start gait training without special pre-training [3,6]. This modalities can accelerate spontaneous recovery and shorten the duration of rehabilitation procedure.

The second group candidates for FES are the subjects who need only the correction of pathological synergies during the gait. By multichannel electrical stimulation up to six muscle groups are stimulated. For each patient the set of muscles, electrode sites, stimulation sequences and stimulation parametres are individually adjusted.

During the treatment due to FES the anomalies diminish partially or completely, gait velocity increases and the gait simmetry improves. (In the years 1984-90 we evaluated routine application of surface multichannel FES). (Fig. 3)

Fig. 3. Proportion of patients using multichannel stimulators.



For this purpose also different types of two-channel or one-channel electrical stimulators are used. Two-channel electrical stimulators are suitable for long-term therapy at home or after finishing the treatment with multi-channel electrical stimulation. Namely, during the course of multi-channel electrical treatment (3-4 weeks) walking distance is gradually increased and finally the need of number of channels becomes lower. The program is transferred to two-channel electrical stimulator (Fig. 4) [4].

Fig. 4: Proportion of stroke patients with regard to the number of FES channels applied

year	1987	1994
one channel	60%	29%
two channel	30%	58%
more channels	10%	13%

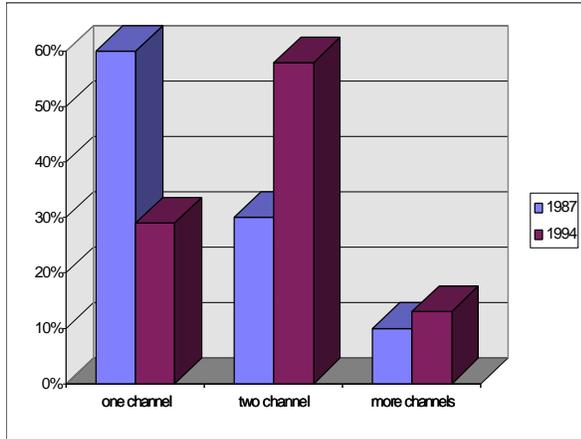


Fig. 5: Patient HD



Fig.6: Patient HS

Because of the progressive improvement of function due to the multichannel FES and physiotherapeutic special techniques the demand for stimulated sites changes and the adaptation of the FES therapy with readjustment of electrodes sides is necessary. That's why the use of surface electrodes is advantageous. At the end of the treatment in many cases only one channel FES or AFO is applied.

In routine clinical practice the single-channel peroneal electrical stimulator has been most common system for therapeutic and orthotic approach in the early or later phases. Commercial available are very popular FEPA 10 (Fig. 5) and Microfes (Fig. 6) with surface electrodes and several implantable versions with different types of subcutaneous implantable electrodes as well [1]. Good correction of drop-foot and perfect ground hill contact help to prevent positive support reactions and perform better posture control (Fig. 7, Fig. 8).

Fig. 7. Ground reaction forces measured by special force shoes in patient with left hemiplegia (— without FES, with FES). Also the hybrid approach has gained recently a momentum, where the plastic orthosis is used in combination with single-channel FES.

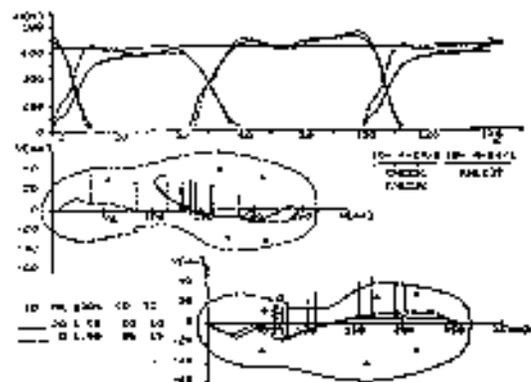


Fig. 7



Fig. 8.

Fig. 8: Gait training with the combination of plastic AFO for the good position of drop foot and FES of m. quadriceps (triggered by physiotherapist)

Nowadays, In Ljubljana, the objectives of the stimulation of upper extremities are based predominantly on its therapeutic value. FES of upper extremity muscles is principally useful in programs in muscle strengthening and facilitation.

FES of shoulder musculature has been noted to be effective in increasing muscle tone and reducing the subluxation in patients with glenohumeral subluxation, due to lax muscle and ligamentous support (Fig. 9).



Fig. 9

It is effective in inhibiting spasticity of shoulder adductors and in pain relief for some patients who suffer from shoulder-hand syndrome [2].

ES of elbow extensors is used for muscle strengthening, reeducation, facilitation of either specific elbow activity or a general extension pattern of upper extremity, for example to improve the rhythm and reciprocal movement during the gait. Correction of a flexion contracture and inhibition of biceps muscle spasticity can be achieved.

The most frequently stimulated muscles are undoubtedly wrist and finger extensors with the aim to open the hand (Fig. 10).



Fig. 10

The patients who at least partly retain voluntary control by means of the ES orthosis can either improve their function or even re-establish it [7].

Conclusion

In conclusion we can say that FES is very useful assistive technique incorporated into the comprehensive rehabilitation treatment. Patients included in the FES program have shorter hospitalization period, sooner became independent in ambulation and independent in the activities of daily living in comparison with classical rehabilitation treatment.

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