Abstract

The records of electrophysiological answers by FES (Functional electrical stimulation) of nerves in lower extremities in 11 chronic patients with upper motoneurone lesion were analysed. Efferent stimulation evoking direct responses (M-waves) in muscles belonging to stimulated axons in nerve trunk was confirmed. Afferent stimulation with appearance of other electrophysiological events (flexor reflex activity and evoked waves with longer latencies than M-waves) in several nonstimulated muscles was also proved.

1. Patients and Method

Occurrence of electrophysiological responses during FES was determined in two groups of adult patients:
- in 3 patients with cerebral lesions
- and in 8 patients with spinal cord lesions.

The selection of patients was limited to those with upper motoneurone lesions where motor units are relatively easily excitable through electric impulses. All of them had been preliminarily subject to a routine EMG examination which revealed no signs of affection in the lower motoneurones of the muscles where myoelectric responses were analysed.

In 3 patients with spastic hemiparesis due to stroke electrophysiological responses were detected in the pretibial musculature where FES was applied onto the peroneal nerve at the fibular head. This type of FES has been normally used for the correction of spastic equinovarus during gait (1). In one patient surface and the other two patients implanted FES system was used.

Occurrence of electrophysiological responses during FES was further analysed in 8 spinal cord patients whose locomotor rehabilitation included also the training of standing and gait; in 3 patients the paretic state was at different levels, in 5 patients paraplegia was clinically complete). In all 8 patients the cause of affection was a trauma involving a spinal lesion and an accompanying spinal cord lesion.

In patients with spinal cord lesions two positions of stimulation surface electrodes were chosen: for the FES of the femoral nerve branches, applied in a way which is normally used to achieve standing, square electrodes of 8 cm x 5 cm were used, positioned above the knee extensors muscles, while at the FES of the peroneal nerve smaller round electrodes of 3 cm diameter were chosen for the stimulation evoking a lower extremity movement suitable for the swing phase during gait.

The myoelectric signals were detected by electromyographic equipment from different muscles of lower extremities, using mostly concentric needle electrodes. In two hemiparetic patients surface electrodes were used for detection according to European recommendations (2).

2. Results

In all 3 patients with hemiparesis evocation of direct motor responses - M waves – in pretibial muscle group was stated, which means that the question was of efferent stimulation.

In patients with spinal cord lesions, two different kinds of responses were recorded:

I. At applying FES above the knee extensors (stimulation applied predominantly on the femoral nerve branches): direct responses in the muscles innervated by the stimulated nerve;

II. At applying FES near the fibular head (stimulation applied predominantly on the peroneal nerve): direct responses in the muscles innervated by the stimulated nerve and also the reflex responses in more distant muscles.

3. Discussion

The most obvious electrophysiological event in the stimulated muscles during FES is the generation and
propagation of direct or efferent responses - M waves. The occurrence of M waves also aroused the interest of several investigators e.g. Gračanin (3).

The relevant studies refer to a more or less permanent occurrence of M waves during FES in muscles controlled by the stimulated axons in the nerve stem. On the other hand, however, the occurrence of other electrophysiological responses is sometimes present also in muscles that are not controlled the stimulated nerve, are remote from it and whose innervation originates from different spinal segments.

In our up-to-now measurements of myoelectric responses in hemiparetics we in fact found predominantly M waves in the stimulated muscles. Besides, in muscles whose paralysis is incomplete it is often hard to distinguish between what is evoked and what facilitated voluntary motor activity.

At FES-supported standing in paraplegics it is crucial to obtain a sufficient contraction of both quadriceps femoris muscles. As we have found, the question is primarily of efferent stimulation evoking direct responses - M waves in the stimulated muscles also in these circumstances.

At testing the patients with clinically complete paralysis resulting from spinal cord lesions, we clearly proved, in addition to direct - efferent M waves, also the presence of reflex motor responses. The applicability of flexion reflex for "reflex walking" in paraplegics was described already by Liberson (4).

In our clinical practice, flexion response of the lower extremity has also been exploited in the training of gait of paraparetic and paraplegic patients (5, 6). In patients with clinically complete paraplegia, standing is achieved by using one-channel stimulation of the knee extensors (for each leg), while gait requires one further channel (also for each leg) for the stimulation of the peroneal nerve to evoke a flexion response of the lower extremity for the swing phase.

Standing and stance phase during gait, respectively, are achieved by efferent stimulation of the femoral nerve branches, while a flexion response of the lower extremity, suitable for the swing phase, is obtained by combining efferent and afferent stimulation (7).

In paraplegics during the stimulation of peroneal nerve the nature of electrophysiological waves, "clinically" registered as the flexion response of the whole lower extremity, was quite diverse. In two patients the stimulation of the peroneal nerve resulted in well expressed outbursts of flexor reflex activity in the thigh muscles both in the extensors (m. rectus femoris) and the flexors (m. biceps femoris). However, in the biceps femoris muscle of two other patients "belated responses" were found with a fairly stable latency of about 20 to 30 ms. In pretibial muscle group mostly direct – efferent responses were noted and only rarely bursts of flexion reflex activity.

It is interesting to note that in the rectus femoris muscle, the innervation of which, originates in part from higher segments (L2, L3, L4) than those of the stimulated peroneal nerve (L4, L5, S1), only such electrophysiological events could be found as attributable to polysynaptic flexor reflex. In the biceps femoris muscle (innervated by segments L5,S1,S2), more closely overlapping with those contained in the stimulated peroneal nerve, both were present: first polysynaptic flexor reflex, then more regularly repeated "belated responses". The type of these responses is not entirely clear, they might be more properly explained by micro electromyographic methods. It is obvious, however, that reflex responses are concerned; this means that in both above-mentioned types of responses the question is of afferent stimulation. In our study clear evidence of these events has been proved.

Conclusion

The M waves appearing during FES of muscles innervated by stimulated axons in nerve trunks point to efferent stimulation. During FES of certain nerve trunks, above all the peroneal one, concurrent electrophysiological events occur in the non-stimulated muscles of the nearby segments, its character being mostly one of flexor reflex, as well as other, not fully explained electrophysiological responses that may clinically manifest themselves as a flexion response, all of which supports the appearance of afferent stimulation.

References


ISEK regional meeting, Dubrovnik, Abstracts: 15.


