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F-waves in Spastic Cerebral Palsy

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Abstract： F-waves of the tibial nerve were studied in 10 children with spastic cerebral palsy and in 20 healthy control children. In comparison to healthy children, the F-wave amplitudes and F/M ratios significantly increased in all patients. The waveforms of F-waves usually demonstrated not only a high amplitude but they were also uniform. In addition, F－chronodispersion also decreased in all patients. Alterations in the F-waves parameters in children with spastic cerebral palsy were similar to those in adult patients with spasticity. Based on the above findings, the F-wave parameters may thus be possibly useful for the assessment of motor neuron excitability in children.

Key words：Spastic cerebral palsy, Children, F-wave F-chronodispersion

Introduction

F－waves are well recognized electrophysiological responses routinely used in clinical neurophysiology.[1)2)] Several investigations have been done to assess the a-motorneuron excitability in adult patients with spasticity.[3)-6)] In contrast, there have been few studies on F-waves in children,[7)8)] and there have been even fewer reports on spasticity in children. The purpose of this report is to evaluate the alterations in the F-wave parameters observed in children with spastic cerebral palsy and then compare these findings with those from healthy chidren.

Subjects and Methods

Ten patients (6 males and 4 females) with spastic cerebral palsy were studied. The patients' ages ranged from 3 to 13 years (mean 9.6±4.1). The causes of cerebral palsy are indicated in Table 1. All patients had exaggerated tendon reflexes. The degree of spasticity varied, but none of the patients were able to walk alone. In addition, none of the patients had any clinical findings of neuropathy, and the motor and sensory nerve conduction studies were both within the normal limits.

As a control group, twenty age-matched healthy children (from 3 to 13 years of age, mean 9.1±5.1) were studied. All patients and controls gave their informed consent to undergo this examination. The M- and F-waves were recorded from the abductor hallucis muscle using surface electrodes. The tibial nerve was stimulated transcutaneously at the ankle with electrical impulses of 0.2 msec duration. The stimulus frequency was

Table 1. Causes of cerebral palsy

Hypoxic-ischemic encephalopathy	6
Congenital hydrocephalus	2
Cerebral dysplasia	1
Cerebral hemorrhage in LBWI	1

LBWI：low birth weight infant

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one per second, and the stimulus intensity was adjusted to be 20% supramaximal for the M wave. During the recordings, the subjects were all placed in a supine position and were told to stay as relaxed as possible. The room temperature was kept at about 25℃. Fifty stimuli were delivered to each control subject and 20–50 stimuli to each patient.

The latency, duration and peak-to-peak amplitude of each response were measured on single record traces. F-waves with an amplitude of less than 15 μV were considered to be absent. The persistence of the F-waves was defined as the number of measurable responses divided by the total number of supermaximal stimuli.

The following parameters were measured: (1) maximal M-wave amplitude, (2) F-wave latency divided by height (m), (3) maximal, minimal and mean F-wave amplitude, (4) maximal, minimal and mean F/M ratios, determined by dividing F-wave amplitude by the maximal M-wave amplitude, (5) mean F-wave duration, and (6) F-chronodispersion. The histograms of F-chronodispersion were plotted as the latency difference between each F-wave (Fx) and the shortest F-wave (F-shortest).[9]

Results

The F-waves in the control group usually showed varying latencies, waveform and amplitude potentials (Fig. 1). In contrast, in patients with spastic cerebral palsy the F-waves usually demonstrated a high amplitude, and uniform potentials (Fig. 2). The parameters of the F-waves in the control group and the patients are summarized in Table 2.

There were no significant differences in either the F-wave latencies or the durations between the control subjects and the patients. In comparison with the control subjects, the patients showed significantly large maximum, minimum and mean F-wave amplitudes ($p<0.01$), increased maximum and minimum F/M ratio ($p<0.01$), and increased mean F/M ratio ($p<0.05$). In addition, the F-chronodispersion decreased more in the pa-

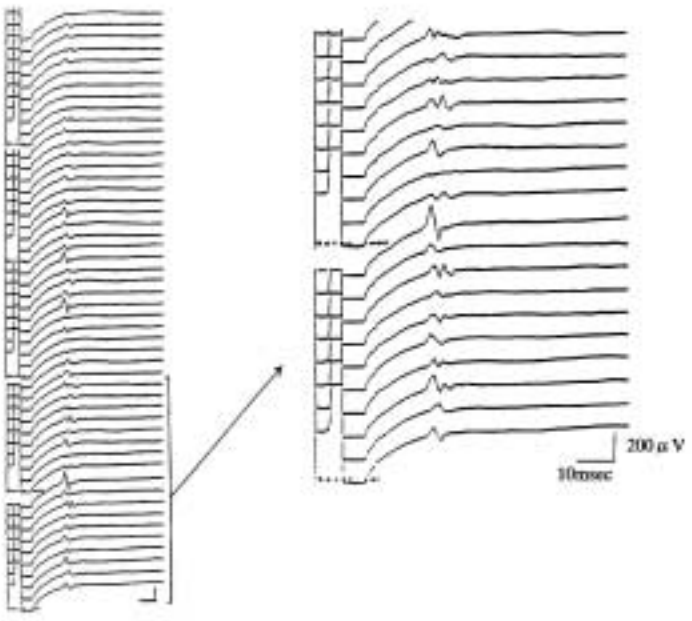

Fig. 1. F-waves of the tibial nerve at the ankle in a 6-year-old girl (control). The latencies, waveforms and amplitudes all varied. The mean amplitude was 114.3±68.2 μV.

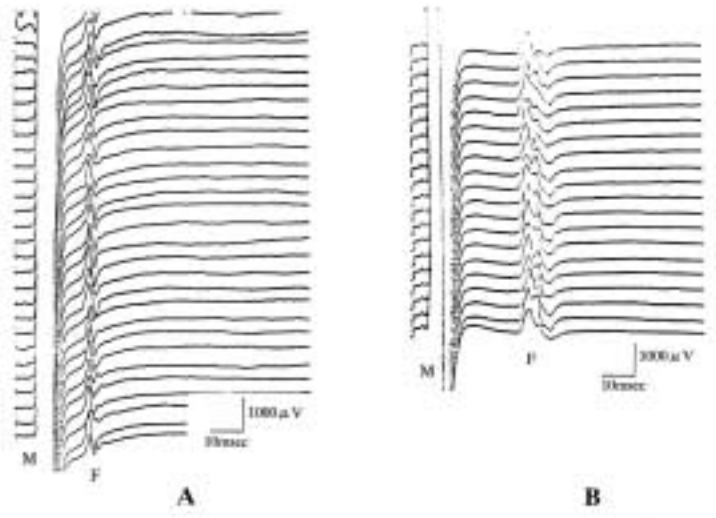

Fig. 2. F-waves in spastic patients (A : 3-year-old boy, B : 8-year old boy). The waveforms are relatively uniform and the amplitudes of the F-waves are higher than 1,000 μV.

Table 2. F-wave measurements in spastic patients and controls (mean±SD)

Parameters of F-wave	Spastic group	Control group
N	10	20
Age (year)	3-13 (9.6±4.1)	3-13 (9.1±5.1)
Persistence (%)	100	91.5±2.6
Amplitude (μV)		
Max	759.0±466.2**	130.0±75.6
Min	290.8±260.8**	26.7±7.1
Mean	482.1±345.9**	58.6±22.3
F/M ratio (%)		
Max	17.1±14.5**	9.6±3.3
Min	6.4±7.6**	2.2±0.8
Mean	10.7±10.5*	4.5±1.4
Latency[1] (msec)		
Max	29.1±1.6	30.2±1.9
Min	27.1±1.7	26.2±2.2
Mean	28.0±1.7	28.2±1.9
Duration (msec)		
Mean	12.9±1.5	11.2±1.6

[1] divided by hight (m)
*p<0.05 **p<0.01

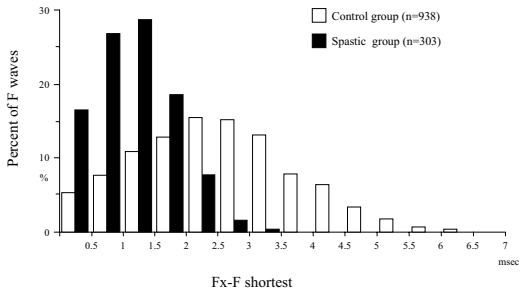

Fig. 3. F-chronodispersion. The distribution difference between the latency of each F-wave (Fx) and the shortest (F shortest) in each subject for all patients and all control subjects.

tients than in the control group (Fig. 3).

Discussion

In the present study, the F-wave persistences, amplitude and F/M ratio increased in patients with spastic cerebral palsy. Our data in children are thus similar to those in adult patients with spasticity.[3)-6)] The F-waves may be influenced by the state of both the peripheral and central nervous system.[1)10)] However, alterations in the F-

wave parameters could not be attributed to peripheral neuropathy, because no significant differences were observed in the F-wave latencies between the patients with spastic cerebral palsy and control subjects. F-wave persistence increased in spastic adult patients.[3)4)6)11)] The waveforms of the F-waves were not observed in most previous reports. Milanov[6)] reported an increase of F-wave phases in spasticity. We did not observe this finding, however, we did observe that the waveform was usually uniform in patients with spastic cerebral palsy.

We suppose that the uniform and high amplitude F-wave in spastic patients may be due to the participation of numerous motor neurons in the discharge.

Both the F-wave amplitudes and F/M ratios increased in the patients with spasticity.[3)-6)12)] The present study showed similar results. These findings indicate that the number of motoneurons in the discharge may thus increase in patients with spastic cerebral palsy. Bischoff et al.[5)] reported that the duration of F-waves was significantly larger in spastic legs than in uninvolved legs. Eisen and Odusote,[3)] in contrast, did not find any increase in the F-wave duration. Bischoff et al.[5)] supposed that this discrepancy might be due to differences in the methodology: while Eisen and Odusote[3)] measured the durations of the averaged F-waves. They calculated the mean durations of the individual F-waves, we also measured the mean durations of the individual F-waves, however, we could not find any significant difference in the duration of F-waves between those observed in patients with spastic cerebral palsy and in control subjects.

F-chronodispersion is prolonged in patients with polyneuropathy and tends to be larger in nerves with demyelination.[8)13)14)] F-chronodispersion also tends to decrease with conduction block.[14)] In the present study F-chronodispersion in patients with spastic cerebral palsy decreased in comparison to that in normal subjects. In our patients no demyelinating neuropathy or conduction block was suggested because their M-waves and nerve conduction velocities were all normal. F-chronodispersion in spastic cerebral palsy thus still needs further investigation.

Dressnandt et al.[15)] reported the influence of baclofen on spasticity by means of an F-wave analysis. They considered the F/M ratio to be useful for the quantitative assessment of spasticity both before and after treatment. The present study showed that alterations in the F-wave parameters in children with spasticity were similar to those in adult patients with spasticity. Based on the above findings, the F-wave parameters are therefore considered to be useful for the assessment of motoneuron exacitability in children.

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