Lower Motor Neuron Changes Related to Upper Motor Neuron Lesion : Evidence from Electrophysiological Study in Patients With Hemiplegia

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The purposes of our study were to evaluate whether patients with upper motor neuron lesion have functional changes in lower motor neurons, as reflected on nerve conduction velocity (NCV) study and electromyography (EMG), and to investigate the significance of the changes. Twenty-nine patients with hemiplegia due to cerebrovascular accident were included. The patients' ages ranged from 43 to 80 years (average, 61.8 ± 10.9 yr). Patients with history or physical findings of peripheral nerve involvement were excluded. Nerve conduction studies of median nerve and ulnar nerve in upper extremities, and tibial nerve and peroneal nerve in the lower extremities, were performed. EMG studies of abductor pollicis brevis and tibialis anterior of the patients with hemiplegia were also carried out. Our nerve conduction studies revealed a significant decreasing in compound motor action potential (CMAP) amplitude of the median and ulnar nerves ($p < 0.01$), and a significant decreasing in NCV of tibial motor nerve on the hemiplegic side ($p < 0.05$). EMG examination revealed spontaneous activities in 54% of the hand muscles and 43% of the leg muscles studied on the hemiplegic side. Spontaneous activities tended to occur simultaneously in the upper and lower limb muscles ($p < 0.05$). Our study supports the hypothesis that there are functional changes in the lower motor neurons as a result of an upper motor neuronal lesion. **(Mid Taiwan J Med 1999;4:229-34)**

Key words

electromyography, hemiplegia, lower motor neuron, nerve conduction velocity, upper motor neuron

INTRODUCTION

Conflicting results of motor nerve conduction velocity (MNCV) and electromyography (EMG) studies in patients with hemiplegia have been reported. In 1965, Panin et al [1] reported reduction in the ulnar MNCV in the paretic extremities of hemiplegic patients. Subsequently, Takebe et al [2] reported statistically significant slowing of MNCV of the ulnar and peroneal nerves in the affected limbs. Chokroverty and Medina [3] and Martinez [4] found significant slowing in certain nerves but not in others. Namba et al

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[5] demonstrated decreasing conduction velocity mainly in slow-conducting motor nerve fibers of the hemiplegic limb. However, Sutton and associates [6], Goldkamp [7], McComas et al [8], Zalis et al [9] and Spaans and Wilts [10] did not observe significant alteration of the MNCV in the affected extremities of patients with hemiplegia.

In 1967, Goldkamp [7] reported an unusually high incidence of spontaneous EMG activity on the hemiplegic side of patients with hemiplegia. Since then, various studies [11,12] have indicated the presence of spontaneous EMG activity in the relaxed muscles of many hemiplegic patients. However, other studies by Alpert et al [13,14], Chokroverty and Medina [3], and Rizk et al [15], did not produce similar findings.

Against this background of conflicting opinions regarding changes in electrophysiological studies of patients with hemiplegia, we undertook this study to evaluate whether there are related changes in the lower motor neurons as a result of an upper motor neuron lesion reflected on nerve conduction velocity (NCV) and EMG studies.

SUBJECTS AND METHODS

Twenty-nine patients with hemiplegia due to cerebrovascular accident were included. The patients' ages ranged from 43 to 80 years (average, 61.8 ± 10.9 yr). There were 22 male patients and seven female patients. Careful histories were taken and examinations made in an attempt to rule out all possible causes of peripheral nerve involvement resulting from diabetes mellitus, thyroid disease, renal failure, alcoholism, collagen diseases, carcinoma, radiculopathy or plexopathy. Duration between onset of hemiplegia and time of examination ranged from 8 days to 111 days with an average of 38 days. Fourteen patients had right hemiplegia and 15 patients had left hemiplegia. Ten patients had voluntary movements in the hemiplegic upper limbs while 19 patients had voluntary movement in the hemiplegic lower limbs. Twenty-six patients were right-handed and three were left-handed. Fifteen patients had lesions in the dominant hemisphere and 14 patients had lesions in the nondominant hemisphere. Eighteen patients had ischemic stroke, and 11 patients had hemorrhagic stroke.

A Dantec Counterpoint II EMG machine was used. All studies were performed at a controlled ambient room temperature of 25^{0}C. Motor nerve conduction of median nerve and ulnar nerve in the upper limbs, and tibial nerve and peroneal nerve in lower limbs, studied on both the hemiplegic and contralateral side. Sensory nerve conduction of median and ulnar nerves in the upper limbs was studied antidromically. The conduction time between stimulation and beginning of the evoked response was recorded to measure the conduction velocity. In our motor nerve conduction studies, the sensitivity was set at 5 mV/division. The sweep speed was set at 2 ms/cm. The stimulus was a square wave impulse with a duration of 0.2 ms at a frequency of 1 Hz. In sensory nerve conduction studies, the sensitivity was set at 20 μV/division. The sweep speed was set at 1 ms/cm. The stimulus was a square wave impulse with a duration of 0.2 ms at a frequency of 1 Hz. Concentric needle electrodes were used for EMG studies. Abductor pollicis brevis and tibialis anterior of the hemiplegic upper and lower limbs were examined. In our study, the spontaneous EMG activity refers to the activity observed in the resting muscles in more than one site, and includes fibrillations and positive waves. We compared the mean values of nerve conduction study parameters between the hemiplegic side and the contralateral side of the hemiplegic patients using paired t-tests. The EMG findings of the hemiplegic upper and lower limbs were evaluated using the chi-square test. A p value less than 0.05 was considered to be statistically significant.

RESULTS

Nerve Conduction Velocity Study

Table 1. Nerve conduction velocity study in 29 patients with hemiplegia due to cerebrovascular accident

Site of stimulation	Hemiplegic side	Contralateral side	*p* value
Median CMAP (mV)			
Elbow	5.9 ± 3.3	7.9 ± 2.4	0.002
Wrist	6.5 ± 2.9	8.3 ± 2.5	0.001
Median SNAP (μV)			
Wrist	19.1 ± 6.2	22.7 ± 8.7	NS
Ulnar CMAP (mV)			
Above elbow	6.6 ± 1.8	8.3 ± 2.0	0.0016
Below elbow	6.8 ± 2.1	8.9 ± 2.1	0.0003
Wrist	7.1 ± 2.0	9.6 ± 2.0	0.0001
Ulnar SNAP (μV)			
Wrist	14.9 ± 7.9	16.8 ± 9.4	NS
Tibial CMAP (mV)			
Knee	8.0 ± 2.7	8.4 ± 2.0	NS
Ankle	10.0 ± 3.2	10.9 ± 3.0	NS
Peroneal CMAP (mV)			
Above FH	3.0 ± 2.0	3.6 ± 1.9	NS
Below FH	3.0 ± 2.0	3.8 ± 1.9	NS
Ankle	3.3 ± 2.4	3.7 ± 2.2	NS

CMAP = compound motor action potential; SNAP = sensory nerve action potential; FH = fibular head; NS = not significant.

Table 2. Compound motor action potential in patients with or without voluntary movement in the hemiplegic upper limbs (n = 29)

Patient group	Site of stimulation	Hemiplegic side	Contralateral side	*p* value
With voluntary movement (n = 10)	Median motor (mV)			
	Elbow	7.25 ± 2.73	8.42 ± 2.48	NS
	Wrist	7.45 ± 2.82	9.01 ± 2.53	NS
	Ulnar motor (mV)			
	Above elbow	6.76 ± 1.11	8.79 ± 2.03	0.0198
	Below elbow	6.99 ± 1.77	9.19 ± 2.19	0.0042
	Wrist	7.20 ± 1.81	9.78 ± 2.05	0.0015
Without voluntary movement (n = 19)	Median motor (mV)			
	Elbow	5.23 ± 3.38	7.58 ± 2.30	0.001
	Wrist	5.93 ± 2.82	7.87 ± 2.39	0.001
	Ulnar motor (mV)			
	Above elbow	6.57 ± 2.05	8.14 ± 1.97	0.028
	Below elbow	6.75 ± 2.25	8.71 ± 2.15	0.015
	Wrist	7.03 ± 2.21	9.43 ± 1.97	0.025

NS = not significant.

Table 3. Specific electromyographic findings on the hemiplegic limbs of 28 patients

Electromyographic findings	Abductor pollicis brevis	Anterior tibialis
Spontaneous activity	15 (54%)	12 (43%)
Fibrillation	11 (39%)	9 (32%)
Positive waves	10 (36%)	6 (21%)
Fibrillation and positive waves	6 (21%)	3 (11%)

There were no significant differences in onset latencies between the hemiplegic and contralateral sides. Among the nerves studied, only the tibial motor nerve showed a statistically significant decrease in NCV on the hemiplegic side when compared with the contralateral side (46.1 ± 4.7 m/s *vs* 47.6 ± 4.4 m/s, $p < 0.05$). Significant decreases in CMAP amplitudes of the median and ulnar nerves were noted on the hemiplegic side when compared with the contralateral side ($p < 0.01$, Table 1). The decrease in CMAP reached statistical significance in the median nerves of the hemiplegic upper limbs with no voluntary movement but not in the median nerves of the hemiplegic upper limbs with voluntary movement (Table 2).

Electromyography Examination

One patient refused the needle EMG examination due to pain intolerance. Therefore, 28 patients received EMG study. Spontaneous activity was noted in 17 (61%) of the patients examined including 10 (36%) patients had spontaneous activity on both anterior tibialis and abductor pollicis brevis, 5 (18%) patients had spontaneous activity on the abductor pollicis brevis alone and 2 (7%) patients had spontaneous activity on the anterior tibialis alone. In 54% of these patients, spontaneous activity was demonstrated in the hands while in 43% of these patients, spontaneous activity was demonstrated in the legs (Table 3).

DISCUSSION

Tibial motor nerves in the affected limbs were found to have decreased NCV when compared with the contralateral side. Our study did not reveal slowing of the fast conducting nerve fibers for most of the peripheral nerves studied. We only found slowing in tibial motor NCV on the hemiplegic side when compared with the contralateral side, as in some of previous studies which showed statistically significant slowing in certain nerves but not in others [3,4]. Possible causes for these findings include: the lowering of skin temperature in the affected limb as a result of inactivity [2], compression factor [3], traction injury [3], and atrophic thinning of the nerve fibers [2]. However, we do not have evidence to support the above proposed causes.

Some previous researchers [9,10] noted diminished mean CMAP amplitudes in the hemiplegic versus the contralateral hand; while other researchers [5,16] demonstrated this loss of amplitude with statistical significance. We also noted a decrease in CMAP in each of the nerves tested in the hemiplegic side when compared with the contralateral side and reached statistical significance in median and ulnar nerves. When correlating the decrease in CMAP with the severity of stroke, we noted a significant decrease in CMAP of the median nerves in the hemiplegic upper limbs only among patients with no voluntary movement in those limbs (Table 2). The possible causes for these findings include: the reduction in the number of functioning motor units [8], functional blockage of nerve excitability [17], and atrophy due to disuse [17]. A recent study [16] supports the first two mechanisms. Our study also revealed lower CMAP amplitude in all the nerves studied in the hemiplegic limbs than in the contralateral side without slowing of NCV (with the exception of tibial nerve). In a previous study, researchers suggested that the fast conducting nerve fibers were less likely to be affected by upper motor neuron lesion; on the other hand, the slow conducting nerve fibers of lower motor neurons may have been affected [5]. Our results support this hypothesis.

Spontaneous EMG activities were observed in the hands of 15 (54%) patients and in the legs of 12 (43%) patients (Table 3). In our study, a higher proportion of patients (36%) had spontaneous activities occurring simultaneously in the upper and lower limbs than in either extremity alone (chi-square test, $p < 0.05$). In previous studies [7,10-12,18], researchers have noted a higher incidence of spontaneous EMG activity in the upper versus the lower limbs of stroke patients. Our study also revealed a higher percentage of spontaneous activities in the upper limbs, although it did not reach statistical significance. In patients with stroke, we often noted more severe involvement of the upper extremities. In our study, sensory nerve examinations did not reveal abnormalities, which further eliminates the possibility of entrapment neuropathy in our patients. The findings in our study support a cerebral pattern [7] or central origin [18] of lower motor neuron changes. It is a conceptual error to assign fibrillation potentials and positive waves as EMG abnormalities occurring only in lower motor neuron diseases [19]. In this study and in previous reports [4,7,11,12,18,19], high percentages of patients with spontaneous activities on the hemiplegic side were noted. Therefore, it is appropriate to consider spontaneous activities as alterations in the excitability of the muscle cell membrane produced by a variety of circumstances [19] including upper motor neuron lesions.

In previous studies, researchers have suggested transynaptic degeneration of lower motor neurons following upper motor neuron lesion [4,10,18]. Loss of central trophic influences has also been hypothesized [12,19]. The electrophysiological changes in lower motor neurons among patients with hemiplegia as revealed in our NCV and EMG studies support these hypotheses.

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上運動神經元病變導致下運動神經元之變化：偏癱病患神經傳導及肌電圖之驗證

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以往的研究指出腦中風可能導致下運動神經元(lower motor neuron)之退化現象(transynaptic degeneration)。但過去之文獻對偏癱病人患肢之神經傳導及肌電圖發現頗具爭議。故此吾人研究比較偏癱病人患側肢體與健側肢體的電氣生理檢查，藉以了解其兩側差異之特性。本研究選擇住院或於門診接受復健治療之腦中風患者(經病史或理學檢查懷疑有周邊神經病變者，則排除之)，共有29名(男性22名，女性7名，平均年齡61.8 ± 10.9歲)，檢查其兩側正中神經、尺神經、脛神經、腓神經之神經傳導，並進行患側上下肢肌電圖檢查。以paired *t*-test比較患側與健側檢查所得數據。在神經傳導方面，患側上肢正中神經及尺神經之近端及遠端複合肌肉電位波(compound motor action potential)之波幅(amplitude)都較健側低($p < 0.01$)。患側下肢脛神經之運動神經傳導速度較健側爲慢($p < 0.05$)。接受肌電圖檢查之患者共28名，其中12人(43%)於脛骨前肌出現自發性電位(9人有fibrillation，6人有positive waves)；15人(54%)於外展拇短肌出現自發性電位(11人有fibrillation，10人有positive waves)；10人(36%)同時於外展拇短肌及脛骨前肌出現自發性電位，卡方檢定顯示有統計上之意義。本研究結果支持上運動神經元病變導致下運動神經元退化現象之可能性。（中台灣醫誌　**1999;4:229-34**）

關鍵詞

肌電圖，偏癱，下運動神經元，神經傳導速度，上運動神經元

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