HEMIPLEGIC AMYOTROPHY AND MOTOR NERVE CONDUCTION VELOCITY IN HEMIPLEGIC PATIENTS

II. MOTOR NERVE CONDUCTION VELOCITY OF THE ULNAR NERVES IN HEMIPLEGIC PATIENTS

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(Received for publication June 12, 1972)

INTRODUCTION

In a previous paper, several theories as to the etiology of hemiplegic amyotrophy and its mechanisms were introduced and discussed. From the author's investigations, another possible explanation for the occurrence of hemiplegic amyotrophy is, in addition to the vasomotor theory, that loss of control from the central trophic system of the muscle and/or peripheral nerves (where a central lesion might be) induces muscle wasting and/or denervation of the lower motor neurons, thus secondarily contributing to muscle atrophy. Recently, some investigators have reported peripheral nerve lesions in the involved extremities of hemiplegic patients, resulting from the deprivation of central nervous system control. However, other examiners hold these results in question.

By measuring the maximum motor nerve conduction velocity (MCV) of the ulnar nerves in the involved and uninvolved extremities of hemiplegic patients, the author attempted to determine whether lower motor neurons were involved in the development of hemiplegic amyotrophy. On the whole, results of the MCV study of 86 cases revealed a statistically significant lower motor nerve conduction velocity of the ulnar nerve in involved extremities as compared to uninvolved extremities. In further investigating the results, the author correlated the motor conduction velocities of ulnar nerves with clinical data.
MATERIALS AND METHODS

Eighty-six patients were selected at random from the 100 patients described in a previous study. The patients' ages ranged from 40 to 77 years. There were 66 men and 20 women. The duration of lesion from onset ranged from two months to fifteen years. Fifty-seven patients had right hemiparesis, and twenty-nine patients had left hemiparesis. All patients were right-handed.

The MCV was measured from February, 1970, to December, 1971, under the same room temperature, 18 to 22°C.

A Sanei biophysiogram, 130 system, two-channel EMG unit was used for measurement of MCV. A Canon camera was attached to the EMG machine. At least three photographs of each MCV measurement were taken for accuracy. These pictures were enlarged by a projector on the screen for measurement of conduction time. A Sanei 3F-31 electrostimulator was used with a stimulation rate of two per second. Nerve stimulation was done at supramaximal intensity with rectangular pulses of 0.1 m/sec duration. The ulnar nerves in the involved and uninvolved extremities were used for the MCV measurements. The tests were conducted with the patients in a sitting position.

Surface electrodes were used as grounding. The stimulating electrode was placed along the trunk of the nerve being stimulated, with the cathode located distally. When examining the MCV of the ulnar nerve, the stimulating electrode was placed in the ulnar groove at the elbow; the response was recorded by surface electrodes placed over the abductor digiti quinti muscle and over the proximal phalanx of the fifth finger. Subsequently, the ulnar nerve was stimulated at the wrist, and the response recorded. With the arm extended, the distance in centimeters between the two points of stimulation was then determined. Using these data, motor conduction velocities were calculated in meters per second.

Results of MCV of ulnar nerves on both the involved and uninvolved sides were compared and then evaluated in comparison with the following: patient's age, sex, duration of lesion, handedness (side of lesion), motor function, degree of spasticity, differences in skin temperature, central sensory impairment, and muscle atrophy.

To rule out the possible effect of low skin temperature in the involved extremity on the ulnar MCV, fifteen patients with lower skin temperature in the involved extremities were selected for a preliminary study. Both forearms of each patient were heated by hot packs at the same time, until a bilateral skin temperature increase of 40°C was obtained. The MCV of the ulnar nerves were measured before and during hot packs in this procedure, and these results were
RESULTS

(1) Unlar MCV in a Total of 86 Patients

In a group of 86 patients, maximum ulnar nerve motor conduction velocities of both involved and uninvolved extremities were measured. A statistically significant lower MCV value was found in the ulnar nerve of the involved extremity as compared to the uninvolved extremity, as shown in Table 1.

<table>
<thead>
<tr>
<th>Extremity</th>
<th>No. of patients</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy</td>
<td>86</td>
<td>56.3</td>
<td>±7.4</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td>Involved</td>
<td>86</td>
<td>53.0</td>
<td>±7.2</td>
<td></td>
</tr>
</tbody>
</table>

(2) Relationship of Age to Ulnar MCV of the Involved and Uninvolved Extremities

Patients were divided, as mentioned before, into the following groups: below 50 years, 50 to 60 years, and over 60 years. As shown in Table 2, in the group below 50 years of age, the ulnar MCV tended to be lower in the involved sides; however, the patients in the 50 to 60 age group and the over-60 group had a statistically significant decrease in ulnar MCV (P<0.05).

A significantly higher ulnar MCV was found in both the involved and unin-
volved extremities in the group below 50 years of age (upon comparing all involved extremities to each other and all uninvolved extremities to each other), as compared to the 50-60 and the over-60 age groups. The same manner of comparison yielded no significant difference in ulnar MCV in either involved or uninvolved extremities, when the 50-60 age group was compared to the over-60 age group. Accordingly, to exclude the age factor, the twelve cases below 50 years of age were dropped from the following studies.

(3) Relationship of Sex to Ulnar MCV of the Involved and Uninvolved Extremities

No statistical relationship was noted between the sex of the patients and the ulnar MCV of the involved and uninvolved extremities.

(4) Relationship of Duration of Lesion from Onset to Ulnar MCV of the Involved and Uninvolved Extremities

Patients were divided into four groups according to duration of lesion from onset: less than 4 months, 4 to 6 months, 6 to 12 months, and over 12 months. As presented in Table 3, the ulnar MCV's of the involved extremities were sign-

<table>
<thead>
<tr>
<th>Duration of lesion</th>
<th>Extremity</th>
<th>No. of patients</th>
<th>Mean</th>
<th>S.D.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 4 months</td>
<td>Healthy</td>
<td>7</td>
<td>56.0</td>
<td>±7.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td></td>
<td>53.0</td>
<td>±8.5</td>
<td></td>
</tr>
<tr>
<td>4 to 6 months</td>
<td>Healthy</td>
<td>12</td>
<td>56.5</td>
<td>±6.1</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td></td>
<td>50.4</td>
<td>±7.1</td>
<td></td>
</tr>
<tr>
<td>6 to 12 months</td>
<td>Healthy</td>
<td>13</td>
<td>55.9</td>
<td>±5.9</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td></td>
<td>50.0</td>
<td>±7.1</td>
<td></td>
</tr>
<tr>
<td>Over 12 months</td>
<td>Healthy</td>
<td>24</td>
<td>56.5</td>
<td>±6.6</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td></td>
<td>50.0</td>
<td>±7.2</td>
<td></td>
</tr>
</tbody>
</table>

ificantly lower in each group of cases in which a lesion had been present for more than 4 months (P<0.05). Therefore, the statistical analyses described hereafter will concern only those among the 67 cases in which the duration of lesion is more than 4 months. No statistical difference was found in comparing the involved extremities in each group to each other nor in comparing the uninvolved extremities to each other.
(5) Relationship of Degree of Motor Impairment to Ulnar MCV of Involved and Uninvolved Extremities

Patients were divided into three groups according to degree of motor impairment: Br. 1-2 (severely impaired), Br. 3-4 (moderately impaired), and Br. 5-6 (slightly impaired). In each of these groups, no significant values were determined in comparing involved sides to uninvolved sides. The data obtained are presented in Table 4. No significant difference was noted in comparing degree of motor impairment and ulnar MCV of the involved extremities of each group. There was also no significant difference noted in the comparison of ulnar MCV of uninvolved sides in each group.

(6) Relationship of Groups Without Central Sensory Impairment and With Central Sensory Impairment to Ulnar MCV of the Involved and Uninvolved Extremities

The patients were divided into two groups: those without sensory impairment, and those with sensory impairment in the involved side. MCV of the ulnar

Table 4
Ulnar MCV in relation to degree of motor impairment

<table>
<thead>
<tr>
<th>Degree of motor impairment</th>
<th>Extremity</th>
<th>No. of patients</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Br. 1-2</td>
<td>Healthy</td>
<td>15</td>
<td>56.6</td>
<td>±6.6</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td></td>
<td>52.8</td>
<td>±6.5</td>
</tr>
<tr>
<td>Br. 3-4</td>
<td>Healthy</td>
<td>20</td>
<td>55.1</td>
<td>±6.9</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td></td>
<td>51.7</td>
<td>±8.2</td>
</tr>
<tr>
<td>Br. 5-6</td>
<td>Healthy</td>
<td>20</td>
<td>56.3</td>
<td>±6.3</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td></td>
<td>52.1</td>
<td>±9.6</td>
</tr>
</tbody>
</table>

Table 5
Ulnar MCV in relation to central sensory impairment

<table>
<thead>
<tr>
<th>Degree of impairment</th>
<th>Extremity</th>
<th>No. of patients</th>
<th>Mean</th>
<th>S.D.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>−</td>
<td>Healthy</td>
<td>32</td>
<td>56.2</td>
<td>±8.1</td>
<td>p &lt; 0.1</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td></td>
<td>52.4</td>
<td>±8.8</td>
<td></td>
</tr>
<tr>
<td>+</td>
<td>Healthy</td>
<td>36</td>
<td>57.3</td>
<td>±7.1</td>
<td>p &lt; 0.02</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td></td>
<td>53.2</td>
<td>±7.0</td>
<td></td>
</tr>
</tbody>
</table>
nerves of the involved and uninvolved extremities were compared in both groups. In the group with central sensory impairment, significantly lower MCV values were noted in the involved sides as compared to the uninvolved sides, as shown in Table 5. There was also a tendency for ulnar MCV to be lower in the involved extremities in the group without central sensory impairment. No significant difference was noted in the comparison of the same sides (involved, uninvolved) in each group.

(7) Relationship of Muscle Atrophy to Ulnar MCV of the Involved and Uninvolved Extremities

Patients were divided into three groups, according to the criteria in the previous paper:1 a group without muscle atrophy, a group with +1 muscle atrophy, and a group with +2 atrophy. As shown in Table 6, only in the first

Table 6

<table>
<thead>
<tr>
<th>Degree of atrophy</th>
<th>Extremity</th>
<th>No. of patients</th>
<th>Mean</th>
<th>S.D.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Healthy</td>
<td>20</td>
<td>56.4</td>
<td>±5.5</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td></td>
<td>51.5</td>
<td>±7.2</td>
<td></td>
</tr>
<tr>
<td>+</td>
<td>Healthy</td>
<td>26</td>
<td>56.0</td>
<td>±7.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td></td>
<td>52.4</td>
<td>±8.9</td>
<td></td>
</tr>
<tr>
<td>++</td>
<td>Healthy</td>
<td>8</td>
<td>56.3</td>
<td>±5.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td></td>
<td>52.2</td>
<td>±5.8</td>
<td></td>
</tr>
</tbody>
</table>

group were statistically significant lower MCV values found. There was no significant value noted in comparing each group of involved sides and in comparing each group of uninvolved sides.

(8) Relationship of Side of Occurrence of Lesion to Ulnar MCV of the Involved and Uninvolved Extremities

Patients were divided into two groups: those with right hemiparesis, and those with left hemiparesis. In each of the groups, the ulnar MCV values were significantly lower in the involved extremities than in the uninvolved extremities, as shown in Table 7 [(P<0.02), right hemiparesis group, and (P<0.01), left hemiparesis group]. No significant differences were noted in comparison of each group of involved sides and in comparison of each group of uninvolved sides. All patients examined were right-handed.
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Table 7
Ulnar MCV in relation to side of occurrence of lesion

<table>
<thead>
<tr>
<th>Side of occurrence</th>
<th>Extremity</th>
<th>No of patients</th>
<th>Mean</th>
<th>S.D.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right hemisphere</td>
<td>Healthy</td>
<td>32</td>
<td>56.9</td>
<td>±7.4</td>
<td>p &lt; 0.02</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td>&quot;</td>
<td>52.2</td>
<td>±7.8</td>
<td></td>
</tr>
<tr>
<td>Left hemisphere</td>
<td>Healthy</td>
<td>25</td>
<td>56.7</td>
<td>±5.5</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td>&quot;</td>
<td>51.0</td>
<td>±7.5</td>
<td></td>
</tr>
</tbody>
</table>

(9) Relationship of Degree of Muscle Tonus to Ulnar MCV of the Involved and Uninvolved Extremities

Patients were divided into three groups: rigidospasticity, normotonicity, and flaccidity.

In both the rigidospasticity and normotonicity groups, significantly lower ulnar MCV's were noted in the involved extremities, as shown in Table 8

Table 8
Ulnar MCV in relation to degree of muscle tonus

<table>
<thead>
<tr>
<th>Degree of muscle tonus</th>
<th>Extremity</th>
<th>No. of patients</th>
<th>Mean</th>
<th>S.D.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigidospasticity</td>
<td>Healthy</td>
<td>26</td>
<td>56.8</td>
<td>±5.5</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td>&quot;</td>
<td>51.5</td>
<td>±8.2</td>
<td></td>
</tr>
<tr>
<td>Normotonicity</td>
<td>Healthy</td>
<td>26</td>
<td>55.8</td>
<td>±6.6</td>
<td>p &lt; 0.02</td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td>&quot;</td>
<td>50.2</td>
<td>±8.7</td>
<td></td>
</tr>
<tr>
<td>Flaccidity</td>
<td>Healthy</td>
<td>17</td>
<td>55.6</td>
<td>±5.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Involved</td>
<td>&quot;</td>
<td>52.1</td>
<td>±6.4</td>
<td></td>
</tr>
</tbody>
</table>

[(P<0.01) in the rigidospasticity group, and (P<0.02) in the normotonicity group]. However, no significant difference was noted in ulnar MCV between involved and uninvolved extremities in the flaccidity group. In comparing involved sides of all three groups, no significant difference in ulnar MCV was found. The same statement is true of the comparison of uninvolved sides, also.

(10) Relationship of Groups With and Without Skin Temperature Differences to the Ulnar MCV of the Involved and Uninvolved Extremities

As described in a previous paper,¹ patients were divided into two groups: those with a lower skin temperature in the involved extremity than in the uninvolved extremity, and those with no skin temperature differences between both
upper extremities. In the former group, significantly lower MCV values were obtained from the ulnar nerve in the involved sides, as shown in Table 9 (P<0.01). In the latter group, no significant differences were found between involved and uninvolved sides. There was no significant difference obtained in comparing the involved sides of each group to each other, nor in comparing the uninvolved sides of both groups to each other. However, ulnar MCV in the involved extremities tended to be lower in the group with low skin temperature in the involved side as compared to the group with no skin temperature differences between both upper extremities. As described by some authors,13-18 artificially controlled tissue temperature has a notable effect on MCV. Therefore, among those groups which were characterized by low skin temperature in the involved side, the significant lowering of ulnar MCV could be explained in part by this known temperature effect. To further examine the temperature effect on ulnar MCV in this part of the study, the next procedure was carried out.

(11) Effects of Artificially Controlled Skin Temperature On the Ulnar MCV of the Involved and Uninvolved Extremities

The methods and equipment used have been described previously.1 During this temperature study, the MCV's of the involved sides were measured before hot packs and were compared to MCV values obtained during hot packs. In the same manner, ulnar MCV's of the uninvolved sides were taken before and during hot packs, and the results were compared to each other.

From the comparison of the 15 cases studies in this manner, the average increase in velocity obtained during hot pack application was 3.57 m/sec in the involved extremity. An average increase in velocity of 4.63 m/sec was obtained in the uninvolved side.

As shown in Table 10, each of the two sides showed a statistically significant increase in ulnar MCV by application of hot packs. However, the average increase in velocity of the 15 cases was approximately the same in both sides, with no statistically significant difference noted. In only one case in which a
lower MCV in the involved side was noted before hot packs were MCV's of the same value found in both extremities after raising the skin temperature in the before-described manner. No other patients had the same MCV values for both extremities, even though both arm temperatures were raised at the same time, to the same degree of temperature.

**COMMENT**

In a previous paper, the author suggested the etiology of hemiplegic amyotrophy to be, in addition to the vasomotor theory, a probable loss of control from the central trophic system of the muscle.\(^1\) The possibility of denervation atrophy and its possible mechanism, caused by cerebrovascular disease, was also described.\(^1\) As shown in this study, MCV values of the ulnar nerves were significantly lower in the involved extremities as a whole. A statistically significant lower ulnar MCV was obtained in the group without muscle atrophy, while no significant lower value of ulnar MCV in the involved upper extremity was found in the group with muscle atrophy.

According to Critchly,\(^12\) appearance of muscle atrophy in hemiplegic patients is usually seen within two weeks after a stroke episode. But as shown in this study, lowered MCV of the ulnar nerve was significantly seen after four months from onset of stroke. A preliminary needle EMG study of hemiplegics showed that a high incidence of low amplitude voltage with short duration pattern was found in the involved wasting muscle of the upper extremity, as compared to the healthy side. Neurogenic disturbances, which have been reported by Goldkamp\(^3\) and Noterman,\(^8\) were not characteristic findings in the involved upper extremities in this study.

Therefore, all these results make it appear doubtful that hemiplegic amyotrophy is the main result of denervation atrophy. The author interpreted the decreased ulnar MCV as representing a more distal motor neuron lesion, whereas neurogenic findings in needle EMG (such as giant spike potential) might repre-
sent a more proximal motor neuron lesion, in close proximity to anterior horn 
cells. The author's needle EMG findings will be presented in a future paper.

To further investigate the lower values of MCV in the involved extremities, 
the author compared the relationship of these values to clinical findings and data, 
the summary of which follows.

1) Motor conduction velocity of the ulnar nerve was significantly lower 
in the involved side of the hemiplegic patient. Fifty-eight per cent of the 86 
patients showed a lower MCV in the involved side as compared to the uninvolved 
side.

2) There was a tendency for ulnar MCV to be lower in the involved ex 
tremity in the groups below 50 years of age and 50-60 years of age; and there 
was a statistically significant lowering of ulnar MCV found in the group over 
60 years of age. In a comparison of involved sides and in a similar comparison 
of uninvolved sides to each other, a significantly higher ulnar MCV in both the 
involved and uninvolved extremities was noted in the below-50 age group, as 
compared to the 50-60 age group and to the over-60 age group. In the same 
comparison mentioned above, no significant difference in ulnar MCV in either 
the involved or the uninvolved extremities was noted in comparing the 50-60 
age group to the over-60 group.

3) No statistical relationship was found between either the sex of the 
patient, or the clinical diagnosis, and the ulnar MCV values of the involved and 
uninvolved extremities.

4) A significantly lower MCV in the involved extremities was found in 
each of the three groups of over four months duration of lesion.

5) There was no statistical significance found between ulnar MCV of the 
involved and uninvolved sides in comparison to degree of motor impairment.

6) A significantly lower ulnar MCV in the involved extremity was found 
in both the group with dominant hemispheric lesions and in the group with non-
dominant hemispheric lesions.

7) A significantly lower ulnar MCV was noted in the involved extremity 
in relation to the presence of central sensory impairment. Even though no 
statistically significant evidence was obtained, there was a tendency for ulnar 
MCV in the involved extremity to be lower in the group without central sensory 
involveent, also.

8) A significantly lower ulnar MCV was noted in both the rigidospasticity 
and normotonicity groups, but was not found in the flaccidity group.

9) In the group with skin temperature differences in both upper extremi-
ties, ulnar MCV in the involved side was significantly lower than in the unin-
The measurement of conduction velocity of peripheral nerves has been shown to be of diagnostic value in diseases of the peripheral nerves. There are several well-known important factors which affect the conduction velocity of peripheral nerves in normal subjects. These are age, sex, handedness, temperature of the extremities, and axonal diameter. Other factors which have been reported are the EMG machine stimulators themselves and the various examiners using them. In the present study, out of the factors mentioned above, age and temperature of the extremities played an important role in the interpretation of the data obtained.

The author and others have reported the effect of aging on ulnar MCV in normal subjects. The results of that study showed a significantly lower ulnar MCV in an over-50 age group as compared to a 30-50 age group. Wagman and Lesse measured ulnar MCV of subjects ranging in age from 35 to 82, and reported a significantly lower ulnar MCV in the group over 60 years of age. In a study of hemiplegic patients, Panin et al reported no significant ulnar MCV changes in relation to the age factor.

In the present study, a significant difference in ulnar MCV due to aging was found in both healthy and involved sides in comparing the below-50 age group to the 50-60 age group and to the over-60 group, as shown in Table 2. Therefore, the twelve subjects below 50 years of age had to be excluded from the study due to the aging factor before further investigation could be carried out.

Panin et al and Sutton et al did not find any significant difference between ulnar MCV and duration of lesion. In this study, as mentioned before, the MCV of the ulnar nerve was significantly lower after four months following stroke episodes. Therefore, seven patients with a below-four months duration of lesion from onset had to be dropped from the study.

Temperature effect on conduction velocity of peripheral nerves has been the subject of many experimental studies. Gasser has reported a decrease in MCV of 7 m/sec with every 3°C decrease in temperature. Henriksen
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has reported in an artificially controlled temperature study a 2.4 m/sec change with every 1°C difference in temperature. In his study, forearm muscle temperature ranged from 28°C to 38°C. However, in this paper, this temperature effect on conduction velocity of peripheral nerves is not a subject of discussion. As mentioned before, the author did not find temperature differences to be responsible for lowering of ulnar MCV at the time of examination.

Panin and Paul et al. have reported that statistically significant lower values of ulnar MCV were found in involved extremities as compared to uninvolved extremities in 50 hemiplegic patients. But Sutton et al. and Goldkamp have reported that no significant differences in ulnar conduction velocities of involved and uninvolved extremities were found in their patients with residual hemiparesis.

Cowley et al. found a significant difference in conduction velocity between the peroneal nerves of the affected and unaffected sides in hemiplegics, but no differences in the post-tibial nerves of the two sides were found. All these results are still subjects of controversy, with no conclusions reached as yet. In the present study, results showed that a significantly lower ulnar MCV was found in the involved sides of hemiplegic patients in 86 cases.

There are various possibilities which could explain the etiology of a lower MCV in the involved side of the hemiplegic patient. One is nerve compression or traction, and another is lower motor neuron denervation caused by vasomotor dysfunction.

Nerve traction, or the compression theory, was introduced to explain neurogenic disturbances in the hemiplegic's extremities. Cowley also explained lower peroneal MCV with the compression theory. In the author's group study, MCV decreases were more often seen after four months from onset of stroke, which may suggest that a lower motor neuron lesion had had time to develop and to reduce conduction velocity of the ulnar nerve during that time. The author does not consider that any patient stays immobile and in a poor arm position long enough to induce compression neuropathy. Also, the patients' past histories and the author's own observations did not reveal any noticeable pain, numbness, or tingling sensation, which would suggest radiculoneuropathy.

In addition, the fact that ulnar MCV in the involved extremity was not related to degree of severity of motor impairment would seem to indicate that the possibilities of compression or traction, and also vasomotor dysfunction due to motor impairment, do not play important roles in the lower ulnar MCV in the involved side.

As mentioned before, temperature of the extremity does not play an im-
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important role in conduction velocity of peripheral nerves. Studies under artificially controlled temperature conditions revealed that effect of skin temperature difference was not an important factor on the whole in lowering ulnar MCV in the involved side.

Discrepancies seen between ulnar MCV of involved and uninvolved extremities before hot packs have also been observed to a similar extent during artificially controlled temperature studies, even though MCV values in both extremities increased with temperature increase. Therefore, there exist the possibilities which are listed below.

1) In those groups studied, there is the possibility that the lowering of ulnar MCV in the involved extremity could be a result of vasomotor dysfunction (originating centrally) which has already induced organic changes in the lower motor neuron at the time of measurement of ulnar MCV.

2) The second possibility suggests that the central vasomotor system is closely related functionally to the central trophic system of the peripheral nerves.

3) However, the author believes that the co-relation of the first and second possibilities also exists.

There is another possibility which could explain the etiology of a lower MCV in the involved side of the hemiplegic patient. Anterior horn cell changes in CVD were observed by Charcot and others\(^2\); peripheral nerve lesions were observed by Dejerine.\(^2\) As cited by Bhala\(^9\) "...experimental and clinical study of several works indicate that the upper motor neuron exerts a definite yet unknown influence on anatomical and physiological existence of its lower motor neuron," as this study also would seem to indicate.

However, in the present study, a lower MCV had no relationship to the severity of motor impairment; and, as described before, a preliminary EMG study showed no neurogenic disturbances in the involved upper extremities in relation to hemiplegia. These facts suggest that upper motor neuron lesions do not play an especially important role in lowering ulnar MCV in the involved extremity.

Nyberg—Hansen et al\(^2\) found corticospinal fiber degeneration following various lesions in the cortical somesthetic areas in cats. Baranek et al\(^2\) observed that transection of the spinal cord in rabbits reduced the rate of regeneration of motor fibers. They called the influence of one nerve cell upon another connected with it as transsynaptic trophic influence. It is also known that the central somesthetic system has a neurophysiological association with the corticospinal tract.

In this study, ulnar MCV in the involved side, as compared to the unin-
volved side, was found to be significantly lower in groups with central sensory involvement. In groups without central sensory involvement, a tendency was found for ulnar MCV of the involved side to be lower, also. These facts suggest that lowering of ulnar MCV is not completely related to presence or absence of sensory impairment. From these results, the central somesthetic system seems to have little influence on the lowering of motor conduction velocities of ulnar nerves in hemiplegic patients.

In addition to the second theory dealing with vasomotor dysfunction, the author considers that the other most probable explanation for lowering of ulnar MCV in the hemiplegic's involved side seems to be the involvement of the central trophic system of lower motor neurons, as hemiplegic amyotrophy was explained by the central trophic system of the muscles.

In an explanation of peripheral nerve lesions caused by loss of central nervous system control, Panin et al. have introduced and given references for the phenomenon of diachisis and the concept of parabiosis, both of which suggest a close interrelationship between physiological processes of the central nervous system and the peripheral nervous system. They also discussed and gave references for the hypothesis that "alteration of central nervous system control produced significant alteration of physiologic function in the peripheral nervous system as well."

From this study's data, the author puts forward a theory that the lower MCV in the peripheral nerve could be explained by the existence of a possible trophic center of the peripheral nervous system (including lower motor neurons), which might be interrelated with the vasomotor system. This similar relationship could be responsible for the physiological changes in the lower motor neurons, and also for the amyotrophy seen in the hemiplegic patient.

SUMMARY

(1) MCV of the ulnar nerve was measured to investigate the effects of CVD on peripheral nerves.

(2) MCV of the ulnar nerve was found to be significantly lower in the involved extremities of hemiplegic patients.

(3) No relationship was found between hemiplegic amyotrophy and decrease in ulnar MCV.

(4) Correlation of the MCV of the ulnar nerve with clinical findings was made.

(5) The possible factors causing lowered MCV of the ulnar nerve in hemi-
plegic patients were commented upon.

6. The author's hypotheses as to the etiology of hemiplegic amyotrophy and decrease in ulnar MCV in the involved extremity of the hemiplegic patient were offered.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the advice and assistance of Prof. T. Aizawa, Prof. J. Gomi, Prof. Y. Goto, Prof. F. Gotoh, Dr. T. Hasegawa, Dr. M. Kato, Dr. H. Wakamatsu, and Mrs. S. Shigeno in preparing this paper.

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