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Diagnostic sensitivity of motor nerve conduction studies in ulnar neuropathy at the elbow.

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Abstract

Seventy-six patients with ulnar neuropathy at the elbow were divided into 3 classes (Grades I, II, and III) according to their clinical features and the maximal motor nerve conduction velocity (MCV), and the amplitude ratios at the across-elbow segment were retrospectively analyzed. To determine the criteria for abnormality, a control study was conducted on 150 healthy volunteers ranging in age from 20 to 89 years (6 age groups). The normal value for MCV could be set for two age groups: those under 60 and those over 60 years old. The 95% confidence limit was 54m/s for the former and 50m/s for the latter. There was no statistically significant difference in the amplitude ratio among the age groups. The confidence limit was set uniformly at 0.82 (above elbow/below elbow). An abnormality in either MCV or the amplitude ratio was found in 66.7% of Grade I (recent and mild symptoms), 89.7% of Grade II (persistent symptoms), and 100% of Grade III cases (marked intrinsic muscle atrophy). Evaluation using the combination of MCV and the amplitude ratio, considering the age-related normal value, appeared to be useful in establishing a differential diagnosis of ulnar neuropathy at the elbow.

KEYWORDS: entrapment neuropathy, ulnar nerve, electrodiagnosis, M-wave

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Diagnostic Sensitivity of Motor Nerve Conduction Studies in Ulnar Neuropathy at the Elbow

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Seventy-six patients with ulnar neuropathy at the elbow were divided into 3 classes (Grades I, II, and III) according to their clinical features and the maximal motor nerve conduction velocity (MCV), and the amplitude ratios at the across-elbow segment were retrospectively analyzed. To determine the criteria for abnormality, a control study was conducted on 150 healthy volunteers ranging in age from 20 to 89 years (6 age groups). The normal value for MCV could be set for two age groups: those under 60 and those over 60 years old. The 95% confidence limit was 54 m/s for the former and 50 m/s for the latter. There was no statistically significant difference in the amplitude ratio among the age groups. The confidence limit was set uniformly at 0.82 (above elbow/below elbow). An abnormality in either MCV or the amplitude ratio was found in 66.7% of Grade I (recent and mild symptoms), 89.7% of Grade II (persistent symptoms), and 100% of Grade III cases (marked intrinsic muscle atrophy). Evaluation using the combination of MCV and the amplitude ratio, considering the age-related normal value, appeared to be useful in establishing a differential diagnosis of ulnar neuropathy at the elbow.

Key words: entrapment neuropathy, ulnar nerve, electrodiagnosis, M-wave

For motor nerve conduction studies of ulnar neuropathy at the elbow, evaluating the M-wave by the inching technique (1) has been attracting attention recently. For a screening test to diagnose this clinical entity, a rapid determination can be made by merely finding the maximal motor nerve conduction velocity (MCV) and the changes in amplitude between 2 stimulus points across the elbow. Since the report by Simpson in 1956 (2), there have been many studies on abnormal MCV at the elbow segment but few take age-related changes into consideration in the determination. Furthermore, the evaluation of the amplitude at the across-elbow segment and the diagnostic criteria are not well established. We set the normal lower limit in relation to age prior to the determination and conducted a retrospective study to investigate the clinical efficacy of the parameters.

Materials and Methods

We tested 150 healthy volunteers between the ages of 20 and 89 years to determine the normal values for each of the 6 age groups. The 76 patients comprising the subjects of the retrospective study were outpatients who visited our clinic from 1987 to 1991. They were diagnosed with ulnar neuropathy at the elbow based on Tinel's sign and other clinical findings, and they suffered from the symptoms for over 1 month. Their ages ranged from 13 to 82 years (mean, 53.6 years) and the group included 58 men and 18 women. The affected side was the right in 45, the left in 25, and both in 3. The duration of illness ranged from 1 month to 16 years (mean, 2 years and 5 months). The causes were determined as follows: idiopathic (34 cases), osteoarthritis of the elbow (18 cases), and cubitus valgus (9 cases). Two patients developed the neuropathy due to compression in bed, which was caused during general anesthesia in association with a surgical procedure (Table 1).

Patients were grouped by McGowan's classification (3) by clinical symptoms: 18 cases of Grade I (minimal lesions with no detectable motor weakness of the hand),

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Table 1 Lesions causing ulnar neuropathy at the elbow

	No. of cases	Total (%)
Idiopathic	34	44.7
Osteoarthritis	18	23.7
Cubitus valgus	9	11.8
Rheumatoid arthritis	3	3.9
Tumor	3	3.9
Trauma	2	2.6
Compression in bed	2	2.6
Recurrent dislocation of ulnar nerve	2	2.6
Others	3	3.9
Total	76	100

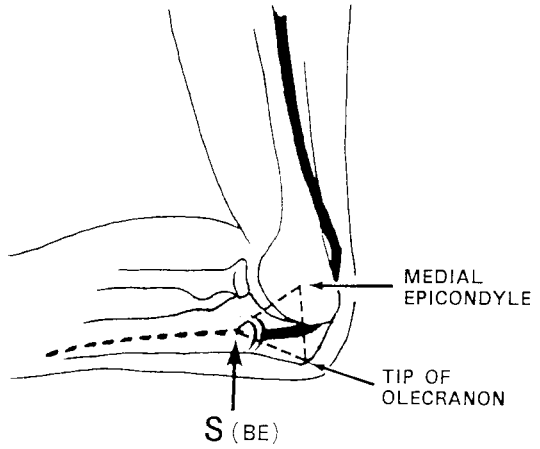

Fig. 1 Stimulus point below the elbow. The humero-ulnar arcade lays from 3 to 20 mm distal to the medial epicondyle (From ref. 4). The stimulus point below the elbow was located 3 to 4 cm from the medial epicondyle. Therefore, it is assumed that the arcade exists proximally from the stimulus point.
S, stimulation; BE, below elbow.

43 of Grade II (intermediate lesions), and 15 of Grade III (severe lesions with paralysis of one or more of the ulnar intrinsic muscles). The motor conduction studies performed at the initial examination were evaluated retrospectively.

The motor conduction study was initiated after the subjects had rested on a bed in an air-conditioned room for approximately 15 min. Silver disc electrodes were attached by adhesive tape over the abductor digiti quinti according to the belly-tendon method, and the stimulus was increased gradually to a supramaximal level. The ulnar nerve was stimulated at the following 3 points: wrist, below-elbow (BE), and above-elbow (AE). The BE stimulus point was set at the summit of an equilateral triangle, the base of which was formed by connecting the olecranon and the medial humeral epicondyle. This stimulus point was intended to correspond at a distal point from Osborne's ligament (Fig. 1) (4). Above the elbow, the stimulus point was kept at least 15 cm from the BE point. The distance at the across-elbow segment was measured using a flexible tape with the elbow flexed to 110 degrees. Maximal MCV and the amplitude ratio (proximal/distal) were determined at the 2 segments (from the wrist to BE and across the elbow). The hand temperature, determined using a surface thermistor over the midpalm, was found to be 33°C or higher in all subjects.

Results

Controls. The age-related normal values across the elbow for the 6 age groups (from 20 to 89 years) were determined. In comparison with the neighboring groups, MCV showed a statistically significant difference ($P < 0.01$) only between the 6th and 7th decades and none between contiguous decades under or over 60 years of age. For the amplitude ratio, there were no significant

Table 2 Control study

Age (years)	No.	Segment	MCV (m/sec)	Amplitude ratio (proximal/distal)
20-39	25	W-BE	62.1 ± 3.0	0.91 ± 0.06
		BE-AE	63.1 ± 3.6	0.94 ± 0.05
40-49	25	W-BE	62.4 ± 4.4	0.90 ± 0.08
		BE-AE	62.6 ± 4.6	0.94 ± 0.06
50-59	25	W-BE	62.6 ± 3.1	0.95 ± 0.06
		BE-AE	61.8 ± 4.1	0.94 ± 0.05
60-69	25	W-BE	58.4 ± 4.9*	0.93 ± 0.06
		BE-AE	56.9 ± 4.2*	0.93 ± 0.05
70-79	25	W-BE	58.5 ± 3.9	0.92 ± 0.06
		BE-AE	56.8 ± 2.7	0.91 ± 0.09
80-89	25	W-BE	57.9 ± 3.1	0.92 ± 0.07
		BE-AE	57.3 ± 3.6	0.92 ± 0.07

MCV, maximal motor conduction velocity; W, wrist; BE, below elbow; AE, above elbow. Values are mean ± 1 standard deviation of healthy age-group.
*Significantly different ($P < 0.01$) from the adjacent younger group.

differences between adjacent decades (Table 2). Therefore, the criterion for marginal value across the elbow with a 95 % confidence limit was made as follows: two groups separated by age (< 60 and ≧ 60 years) for MCV and no age distinction at all for the amplitude ratios (Table 3).

Patients. The M-wave was detected in 18 patients (100 %) with Grade I, 39 (90.7 %) with Grade II and 7 (46.7 %) with Grade III, indicating that MCV across the elbow decreased as the disease progressed. The amplitude ratio across the elbow was lowest in Grade II (Table 4).

The frequencies of abnormal MCV, determined at BE-AE in contrast with the normal value for each age group, were 61.1 %, 84.6 % and 100 % in Grades I, II and III, respectively. Abnormal appearance of the amplitude ratio was highest for Grade II at both the W-BE and BE-AE segments (Table 5).

Table 3 Criteria of marginal value

	< 60 years	≧ 60 years
MCV (m/sec)		
W-BE	55.0	51.0
BE-AE	54.0	50.0
Amplitude ratio		
BE/W	0.81	
AE/BE	0.82	

MCV, maximal motor conduction velocity; W, wrist; BE, below elbow; AE, above elbow. Each value indicates lower 95% confidence limit in healthy subjects.

Table 4 Results of patients in whom M-waves could be detected

	Grade I (n = 18)	Grade II (n = 39)	Grade III (n = 7)
MCV (m/sec)			
W-BE	58.9 ± 6.3	50.5 ± 10.2	42.7 ± 7.5
BE-AE	48.5 ± 10.4	36.2 ± 10.5	29.3 ± 13.4
Amplitude ratio			
BE/W	0.87 ± 0.11	0.77 ± 0.20	0.83 ± 0.27
AE/BE	0.89 ± 0.18	0.80 ± 0.22	0.84 ± 0.30

MCV, maximal motor conduction velocity; W, wrist; BE, below elbow; AE, above elbow. Values indicate mean ± 1 standard deviation in each disease group.

Table 5 Percentage of abnormal appearance in MCV and amplitude ratio

	Grade I (n = 18)	Grade II (n = 39)	Grade III (n = 7)
MCV			
W-BE	11.1	53.8	85.7
BE-AE	61.1	84.6	100
Amplitude ratio			
BE/W	22.2	48.7	42.9
AE/BE	16.7	38.5	28.6

MCV, maximal motor conduction velocity; W, wrist; BE, below elbow; AE, above elbow.

An abnormality in either MCV or the amplitude ratio at the BE-AE segment was found in 66.7 %, 89.7 % and 100 % in Grades I, II and III, respectively.

Discussion

Several systems of nomenclature have been used to describe entrapment neuropathy of the ulnar nerve at the elbow. The term tardy ulnar nerve palsy has gradually fallen into disuse except to describe the condition caused by cubitus valgus associated with lateral condylar fracture during early childhood. At present, "cubital tunnel syndrome" is used mainly for compression of the flexor arcade and retrocondylar compression at the ulnar groove (5).

Of the causative factors, idiopathy was the most prevalent cause among our patients (44.7 %), which generally agreed with the results reported in the literature [30 % by Chan *et al.* (6) and up to 50 % by Macnicol (7)]. Osteoarthritis was cited as the cause in 23.7 %, showing the second highest frequency, which was followed by cubitus valgus (11.8 %). Payan (8) reported that compression during unconsciousness was the most frequent cause among his subjects. However, we found only two patients in whom general anesthesia was considered to be the cause.

For electrophysiological diagnosis, our first choice was the M-wave examination, combined with the determination of sensory conduction velocity and needle electromyography if necessary. The inching technique (1), a recently developed method, is superior in terms of precisely localizing the site of nerve entrapment but it is time-consuming

and is technically complex. We resort to the inching technique only when an abnormality is found in the screening test.

In reviewing the literature concerning examination of M-wave across the elbow, few give a clear description of the site of the stimulus point. Eisen (9) stated that the distance should be 10 cm or more but he did not specify the stimulus point. McLeod (10) applied stimuli 3 to 4 cm below the elbow and above the medial epicondyle, and Bhala (11) 5 to 7 cm distal and just proximal to the medial epicondyle. We used the top of an equilateral triangle, with its base connecting the olecranon and medial humeral epicondyle, for the stimulus point below the elbow, and the intermuscular septum of the brachial muscle 15 cm proximal to the stimulus point below the elbow for the stimulus point above the elbow. The flexor arcade, one of the entrapment points at the elbow, is located at least 2 cm distal to the medial humeral epicondyle. Therefore, the stimulus point that we selected below the elbow is supposed to be distal to the flexor arcade.

MCV across the elbow. Simpson (2) reported initially on the application of motor conduction study for the diagnosis of entrapment neuropathy (carpal tunnel syndrome and tardy ulnar nerve palsy in his study), while a report by Thomas and Gilliatt (12) is one of the first to prove the delay in MCV across the elbow. In the majority of studies conducted to date, however, the criteria for clinical data are based on those of age-matched controls for patients. It is well-known that the normal values of MCV decrease in the elderly. Mayer (13) and many others also reported age-related changes in the ulnar nerve, but most of them were observed between the elbow and the wrist. To our knowledge, there are only 2 studies which address the age-related changes in MCV across the elbow: one is a study by Payan (8) comparing two age groups, in which no statistically significant differences were noted, and another was a report by Krogness (14) who compared the MCV in the sulcus of the ulnar nerve in 55 subjects under 50 years of age, with 21 subjects who were 50 or older.

For the criterion to determine abnormality of MCV across the elbow, Jebsen (15) set the normal lower limit at 41 m/s and Bhala (11) at 45 m/s. It should be noted, however, that they were based on age-matched controls. In the present study, we conducted a comparative examination of normal values among 6 groups, divided by age into decades. Consequently, independent criteria to determine abnormalities were established for 2 groups: those under 60 and those over 60 years of age.

There are few reports on the percentage detection of MCV abnormalities in cases of ulnar neuropathy at the elbow. Eisen (9) stated that slowing of MCV at the across-elbow segment was found in only 19.7 % of 56 patients with mild lesions and in 53.0 % of 34 patients with severe lesions of the ulnar nerve. It should be noted, however, that his data were derived based on a comparison with the MCV of the forearm. Bhala (11) reported abnormalities in 40 of 78 patients (51.3 %). Nevertheless, it was the result of a comparison with age-matched controls. Among the 64 patients in whom we were able to detect M-wave in the present study, the rate of abnormality at the across-elbow segment was 61.1 %, 84.6 % and 100 % for Grades I, II and III, respectively. We found that the percentage increased as the disease progressed.

The mean MCV (W-BE) in Grade III, that is 42.7 m/s, represented abnormality. It is postulated that the nerve damage may extend to axons, resulting in Wallerian degeneration.

Amplitude ratio of the across-elbow segment. It is well known that in some patients with local demyelination of the peripheral nerves, the M-wave amplitude following proximal stimulation is reduced in comparison with that following distal stimulation. Even with normal peripheral nerves, the amplitude and duration of two M-waves produced by two stimulus points on a single nerve trunk are not identical. Those variations are often evident in peripheral nerve diseases, which is explained by the temporal dispersion of compound muscle action potentials caused by conduction delay of the damaged nerve fibers. These variations may be used to ascertain the presence of the peripheral nerve lesion even when no MCV abnormality is detected. Bawens (16) was one of the first to recognize such temporal dispersion; he described changes in the M-wave amplitude evoked by proximal stimulation of a lesion in compression neuropathy and suggested the possible clinical application of this phenomenon. For the diagnostic criterion for local demyelinative lesions, Miller (17) maintained that the reduction in amplitude consequent to the proximal stimulation, in comparison with the distal stimulation of the cubital tunnel, was 40 % or more. His report was followed by those of Pickett and Coleman (18), Feasby *et al.* (19), and Kincaid *et al.* (20), all of whom stated that the criteria of abnormality for amplitude reduction ranged from 10.5 % to 25 %. As for the subject of age-related changes in the amplitude ratio at the across-elbow seg-

ment, the only known study is one by Konishi (21). As the result compared healthy volunteers in the 3rd decade with those in the 9th decade, he stated that the mean decrease ratio in the latter was 5.7 %.

One of the purposes of this study was to determine whether or not there are age-related changes in the amplitude ratio (proximal/distal) across the elbow. To accomplish this, we determined the normal value for 6 groups divided into decades by age. We found no statistical significance between any pair of groups. Therefore, we set normal lower limits of 0.82 (AE/BE) and 0.81 (BE/W) regardless of age. Because of the lack of evident age-related changes such as those found in MCV, we think there might be an extension of localized degeneration to axons through age-related exaggeration of anatomical entrapment.

In patients where M-waves could be detected, the frequency of abnormal findings in the amplitude ratio at the across-elbow segment was 16.7 %, 38.5 % and 28.6 % in Grades I, II and III, respectively. The lower percentage in Grade III in comparison with Grade II suggests that the neural damage of the former is composed mainly of axonal degeneration. When the partial neural damage caused by local demyelination remains, the proximal M-wave amplitude might be smaller than the distal one. However, when the neural damage extends to the axon, the amplitude change will not be found because of Wallerian degeneration. Abnormality of either the amplitude ratio or MCV occurred in 89.7 % of Grade II cases and 100 % of Grade III.

The abnormal change in the M-wave amplitude between 2 stimulus points might reflect the presence of a local demyelinative lesion. Combined with MCV, M-wave amplitude seems to improve not only the detection of abnormalities but also makes it easier to determine whether the main lesions involve the myelin or the axon.

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