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ORIGINAL ARTICLE
Preoperative diagnosis of the responsible level in CCM using CMAPs: comparison with SCEPs

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Study design: A retrospective study.

Objective: To elucidate the correlation between compound muscle action potentials (CMAPs) amplitudes and responsible level of compressive cervical myelopathy (CCM), and the accuracy of level diagnosis by using CMAPs.

Setting: This study was conducted at the Department of Orthopedic surgery, Yamaguchi University Graduate School of Medicine, Japan.

Method: A total of 28 patients with CCM were investigated in this study. Erb's point-stimulated CMAPs were measured from deltoid, biceps, triceps in all patients as compared with 88 healthy subjects. We performed a level diagnosis on the basis of CMAPs amplitudes. We performed a level diagnosis on the basis of CMAPs amplitudes and using an index that measures the deviation of CMAPs amplitudes between triceps and deltoid or biceps.

Results: Significant correlations between the mean CMAPs amplitudes and responsible level were showed for deltoid $(6.82 \pm 2.33 \, \text{mV})$ at C3/4 $(P<0.01)$ and biceps $(8.75 \pm 4.42 \, \text{mV})$ at C4/5 $(P=0.015)$. Despite considerable individual variability in CMAP amplitudes, there were correlations among CMAPs amplitudes for deltoid, biceps and triceps in the same individual. The sensitivity was 75.0%, specificity 75.0% in the index for diagnosis of C3/4. The sensitivity was 75.0%, specificity 66.7% in the index for diagnosis of C4/5.

Conclusion: This study showed small CMAPs amplitudes in the deltoid indicated a C3/4 level of myelopathy and in biceps at the C4/5 level and could help exclude clinically silent cord compression and determine the surgical procedure to the suitable level of concern.

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INTRODUCTION

Magnetic resonance imaging (MRI) can be used to demonstrate compression of the spinal cord and has an important role for level diagnosis in cases with compressive myelopathy. However, MRI can show abnormal findings despite clinically asymptomatic presentation and therefore it is difficult to determine the responsible level in patients with multilevel spinal compression, as, for example, in elderly people. Ossification of the posterior longitudinal ligament may also occur at several vertebral levels during spinal cord compression, but not all levels compressed by the ossification of the posterior longitudinal ligament lead to symptomatic spinal cord compression. Spinal cord-evoked potentials (SCEPs) are useful for investigating the functional integrity of the spinal cord, in spite of MRI evidence of compression at several levels.[1,2]

We also reported compound muscle action potential (CMAPs) amplitudes that were lower than normal values indicated the involvement of anterior horns.[3] However, there have so far been no reports that correlated the responsible level of cervical myelopathy (CCM) with CMAPs amplitudes.

We hypothesized that preoperative measurement of CMAPs could be used for level diagnosis of CCM. In the present study, we correlated CMAPs amplitudes with the responsible level in an attempt to provide preoperative level diagnosis.

MATERIALS AND METHODS

Patients

A total of 28 patients with CCM (18 with cervical spondylotic myelopathy and 10 with ossification of the posterior longitudinal ligament) were determined by intraoperative SCEPs to have a single site of conduction abnormalities at the intervertebral level. Eighteen were men and 10 were women and their average age was 70.8 years (range; 48–86). All patients underwent cervical laminoplasty. Written informed consent with the approval of Yamaguchi University Graduate School of medicine was obtained for preoperative MRI investigation and electrophysiological studies in all patients. Those who fulfilled the following criteria were included in the study.

A diagnosis of myelopathy was established based on the presence of hyperreflexia, including a positive Hoffmann sign, upper extremity sensory disturbance and obvious MRI-documented cervical spinal cord compression. Sensory and motor nerve conduction velocities in the peripheral nerves were within normal limits.

Patients who had peripheral neuropathy and concomitant radiculopathy were excluded.

Normative data

Thirty-nine male and forty-nine female subjects (average age 54.3 years, age range 23–91 years) with no history of injury or pathology of the upper limb were studied. They were submitted to a medical examination consisting of a detailed history regarding motor and sensory upper limb symptoms, followed

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by thorough physical examination. Exclusion criteria were a history of upper limb symptoms, glove and stocking sensory symptoms, diabetes mellitus, any form of medication and abnormal tendon reflexes or sensory and motor examination.

Magnetic resonance imaging

All patients underwent MRI with a 1.5-tesla imaging system. Sections were 5-mm thick, with a 2-mm gap between intersections. T1-weighted and T2-weighted sagittal and axial imaging were obtained.

Electrophysiological investigation

Erb's point-stimulated CMAPs. All electrophysiological examinations were performed using a Nicolet Viking 4 instrument. Erb's point-stimulated CMAPs were recorded in the deltoid, biceps brachii (biceps), and triceps brachii (triceps) muscles in all subjects. An 11 mm diameter disc (Dantec 13L 29, Dantec Medical, Skovlunde, Denmark) was placed over the middle of the deltoid as an active electrode, on the acromion as a reference electrode in the deltoid, over the middle of the biceps muscle as an active electrode and on the lateral epicondyle of humerus as a reference electrode in the biceps muscle, and over the middle of the triceps muscle as an active electrode and on the olecranon as a reference electrode in the triceps muscle. The skin was prepared with an abrasive solution to reduce impedance and a ground strap was wrapped around the elbow. The bipolar stimulator probe (Nicolet S403, Natus Medical, San Carlos, CA, USA) provides a pair of bare metal contacts, 3 mm in diameter and with an adjustable inter-electrode distance which was set to 25 mm in our study. The stimulus intensity was gradually increased until it no longer altered the size of the recorded response. Measurement of CMAPs included the negative-peak amplitude from baseline to peak. Average amplitudes for CMAPs were calculated for both sides. The amplitude ratio was calculated by dividing the response from one side by the other and multiplying by 100.

Recording of SCEPs for diagnosis of symptomatic lesion

SCEPs after median nerve stimulation (MN-SCEPs), transcranial electric stimulation (TES-SCEPs), and spinal cord stimulation (Spinal-SCEPs) were recorded intraoperatively. The median nerves were stimulated (square wave pulse, 0.2-ms duration, 3-Hz rate) at the wrist with the cathode placed proximally. The stimulus intensity was set at 1.5 times for producing the thumb twitch in an awakened condition. TES was delivered as square pulses of 0.2 ms duration and at an intensity of 100 mA through needle electrodes (13R25, length 8 mm, diameter 0.8 mm; Dantec, Skovlunde, Denmark) placed on the skull. The anode was placed 7 cm laterally to the right of the vertex on line joining the external auditory meatus. The cathode was placed on the opposite side. Spinal-SCEPs were delivered by an epidural catheter electrode (UKG-100-2PM, diameter 0.8 mm, length 900 mm, Unique Medical Corporation, Kobe, Japan) inserted into the dorsal epidural space from the C7-T1 and T11-T12 interlaminar space. Square wave pulse (0.2 ms duration, 3-Hz rate) was delivered at an intensity of 15–20 mA. Before laminoplasty, all SCEPs were recorded intraoperatively with recording electrodes (13R25) inserted in the ligamentum flavum at each interlaminar space. A reference electrode was inserted into the subcutaneous tissue in the posterior aspect of the neck for the recording of MN-SCEPs and Spinal-SCEPs. A bipolar recording method was used (active proximal and reference distal) for the recording of TES-SCEPs. All SCEPs signals were amplified and filtered with a bandpass of 20 to 3000 Hz using a standard evoked potential/electromyography machine (Nicolet Viking, Natus Medical). Average of 100 to 200 MN-SCEPs, 40–60 TES-SCEPs and 20–30 spinal-SCEPs responses were obtained. Two different averaged responses were superimposed and displayed. In MN-SCEPs, abnormality was determined from the amplitude ratio of spinal responses at each intervertebral level to that recorded at the C6/7 intervertebral level as reported earlier.[4] In TES-SCEPs and Spinal-SCEPs, intervertebral levels with a marked reduction in size of the negative peak (reduction of >50%) were considered as significant (Figure 1).[5]

Preoperative level diagnosis using CMAPs

Studies on the level diagnosis for CCM have shown the C5 motor segment in the spinal cord to be at the level of the C3/4 disc and the C6 motor segment at the level of the C4/5 disc. We have previously reported that C5 and C6 nerve roots are distributed to the deltoid and biceps muscle, with the deltoid predominantly innervated by the C5 nerve root and the biceps by the C6 nerve root.[6,7] We hypothesized the main myotomal distribution was as follows: deltoid in C5 cord segment, biceps in C6 and triceps in C7. If the preoperative CMAPs amplitudes in deltoid were smaller than the normal limits, the responsible level was estimated to be C3/4. This meant that the C5 cord segment was involved. In the same way, if the CMAPs in biceps were smaller, we estimated the responsible level to be C4/5 and this meant the C6 cord segment was involved. We used CMAPs in deltoid and biceps on the affected side and in triceps on the normal side. As described further below, CMAPs amplitudes in triceps correlated with CMAPs amplitudes in the deltoid and biceps. On the basis of this correlation, we designed an index for level diagnosis. When the observed CMAPs amplitudes in the deltoid or biceps were lower than those extrapolated from the CMAPs amplitudes in triceps, this was an indication of C3/4 or C4/5 myelopathy (Table 1).
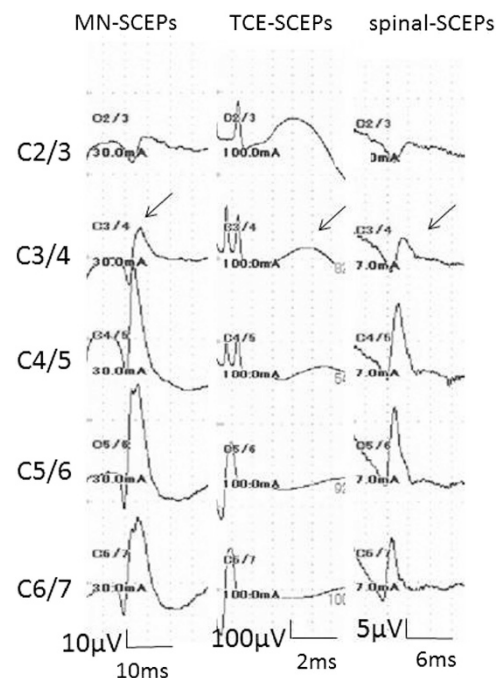
Figure 1 SCEPs obtained from patients with compressive cervical myelopathy. MN-SCEPs demonstrate marked attenuation of amplitude at the C3/4 intervertebral level. TCE-SCEPs also show marked attenuation of amplitude at the C3/4 level. Spinal-SCEPs also show marked attenuation of amplitude at the C3/4 level. The marked attenuation of amplitudes at C3/4 in all SCEPs indicates a conduction block at C3/4. MN-SCEPs, spinal cord-evoked potentials following median nerve stimulation; TCE-SCEPs, spinal cord-evoked potentials following TES; Spinal-SCEPs, spinal cord-evoked potentials following spinal cord stimulation.

Table 1 The index for electrophysiological level diagnosis

Responsible level	Index for level diagnosis
C3/4	(D-CMAPs-3)/T-CMAPs
C4/5	(B-CMAPs-4)/T-CMAPs

Abbreviations: CMAPs, compound muscle action potentials; D-CMAPs, CMAPs amplitudes in deltoid (mV); B-CMAPs, CMAPs amplitudes in biceps (mV); T-CMAPs, CMAPs amplitudes in triceps (mV); D-CMAPs-3 divided T-CMAPs are index for the diagnosis of C3/4 myelopathy; B-CMAPs-4 divided T-CMAPs are index for the diagnosis of C4/5 myelopathy.

Statistical analysis

Descriptive statistics, including the mean and standard deviation (s.d.), were applied to each CMAPs value. Related on sex and age factors in CMAPs amplitudes were analyzed. Regression analysis was used to evaluate the correlation among CMAPs amplitudes for the different muscles. (Dependent variables: CMAPs amplitudes in the deltoid- or biceps-independent variable: CMAPs amplitudes in triceps) The Mann–Whitney U test was used for unpaired data. The cutoff points for CMAPs amplitudes or for the index were selected by receiver-operating characteristic curve analysis. Receiver-operating characteristic curves were also used to calculate the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of the preoperative diagnosis corresponding to each intervertebral level. All P-values <0.05 were regarded as statistically significant. The free software program R version 2.14 (http://www.r-project.org/) was used for statistical analysis.

RESULTS

Normative data

The normal value (mean ± s.d.) for CMAPs in the deltoid muscle was 10.44 ± 2.18 mV amplitude (range 6.17–16.7), in biceps it was 10.83 ± 2.65 mV (4.79–17.18) and in triceps it was 12.59 ± 3.25 mV (4–21.3). Each amplitude showed large variation. Amplitudes in all muscles decreased with advancing age, but these correlations were weak (deltoid: $R^{*2} = 0.13$; biceps: $R^{*2} = 0.05$; triceps; $R^{*2} = 0.01$; where R^{*2} is the coefficient of determination adjusted for degree of freedom). Compared with women (mean age 53 years, $n = 49$),

men (mean age 55 years, $n = 39$) showed significantly higher amplitude in all three muscles (deltoid: 11.5 ± 2.15 mV vs 9.6 ± 1.81 mV, $P < 0.01$; biceps: 12.21 ± 2.65 mV vs 9.73 ± 2.09 mV, $P < 0.01$; triceps: 14.15 ± 3.45 mV vs 11.36 ± 2.49 mV, $P < 0.01$).

The ratio between deltoid and biceps (D/B) amplitude was $99 \pm 18\%$, between biceps and triceps (B/T) $88 \pm 18\%$ and between deltoid and triceps (D/T) $86 \pm 20\%$. These ratios did not show age-related differences (D/B: $R^{*2} = -0.008$; B/T: $R^{*2} = 0.01$; D/T: $R^{*2} = 0.04$) or gender differences (D/B: $P = 0.26$; B/T: $P = 0.78$; D/T: $P = 0.50$). For each muscle, regression analysis was used to express the amplitudes as a correlation coefficient (Figures 2a and b). CMAPs amplitudes in deltoid or biceps could therefore be estimated from CMAPs amplitudes in triceps, regardless of age or gender. Normative data for CMAPs values are summarized in Table 2.

Magnetic resonance imaging

MRI showed multiple compressions in 26 patients (92.8%). Details were shown in Table 4.

CMAPs of patients with CCM

The level of conduction abnormalities was C3/4 in 16 cases and C4/5 in 12 cases by monitoring SCEPs intraoperatively. Table 3 shows the responsible level estimated from SCEPs and CMAPs amplitudes of deltoid, biceps and triceps, whereas Table 4 shows the mean CMAPs amplitude at each responsible level.

In patients with C3/4 myelopathy, the CMAPs amplitudes of deltoid were 6.82 ± 2.33 mV (mean ± s.d.) ($P < 0.0001$) and those
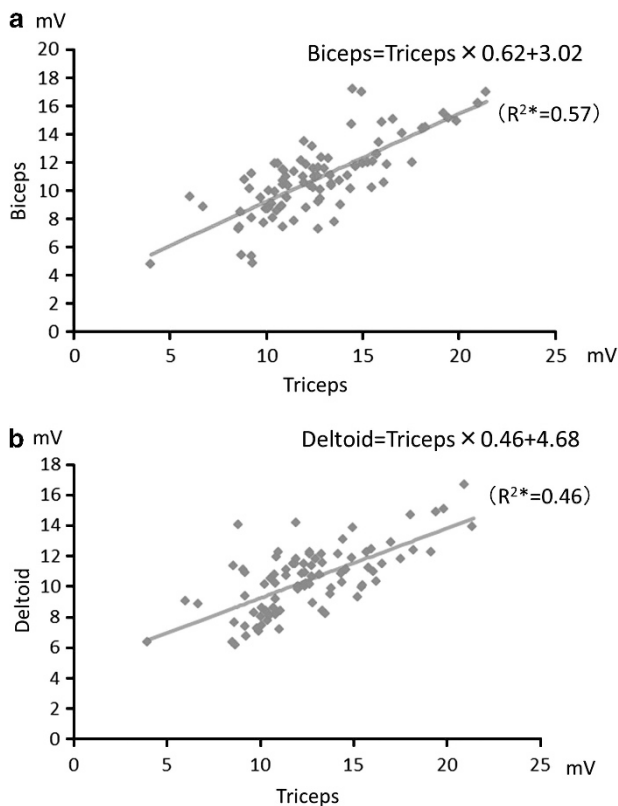
Figure 2 Regression analysis was used to express the amplitudes as a correlation coefficient for deltoid, biceps barchii and triceps brachii. The formulae used for this were: (**a**) biceps brachii amplitude B = triceps brachii amplitude (T) × 0.62 + 3.02 mV ($R^{*2} = 0.57$), (**b**) deltoid amplitude D = T × 0.46 + 4.68 mV ($R^{*2} = 0.46$) (R^{*2}, the coefficient of determination adjusted for degree of freedom).

Table 2 Normative date of CMAPs amplitudes and the ratio among deltoid, biceps and triceps

Muscles	All subjects	CMAPs amplitudes (mV)	
		Men	Women
Deltoid	10.44 ± 2.18	11.50 ± 4.64	9.60 ± 3.26
Biceps brachii	10.83 ± 2.65	12.22 ± 7.05	9.73 ± 4.35
Triceps brachii	12.59 ± 3.25	14.15 ± 11.91	11.36 ± 6.21
	Ratio (%)		
Deltoid/biceps	98.8 ± 17.9	95.99 ± 16.2	101.14 ± 19.0
Biceps/triceps	87.91 ± 18.79	87.88 ± 14.17	87.93 ± 20.1
Deltoid/triceps	85.9 ± 20.09	83.8 ± 17.19	87.57 ± 22.16

Abbreviation: CMAPs, compound muscle action potentials.

Table 3 CMAPs amplitudes with patients of CCM as compared with normal values

CMAPs (mV)	Responsible level		
	All (n = 28)	C3/4 (n = 16)	C4/5 (n = 12)
Deltoid	7.55 ± 2.88	6.82 ± 2.33	8.52 ± 3.34
	$P < 0.01$	$P < 0.0001$	$P = 0.11$
Biceps brachii	9.14 ± 3.55	9.43 ± 2.85	8.75 ± 4.42
	$P < 0.01$	$P = 0.10$	$P = 0.015$
Triceps brachii	12.50 ± 3.54	12.69 ± 3.59	12.51 ± 3.61
	$P = 0.94$	$P = 0.89$	$P = 0.97$

Abbreviations: CMAPs, compound muscle action potentials, CCM, compressive cervical myelopathy.

Table 4 Detail of the 28 patients with cervical compressive myelopathy

| Case	Age	Gender	Disease	The level of conduction abnormalities	CMAPs amplitudes (mV)			MRI (cord indentation and/or deformed cord)			
					Deltoid	Biceps	Triceps	C3/4	C4/5	C5/6	C6/7
1	72	F	OPLL	C3/4	7.6	11.68	9.8	+	+	+	
2	54	M	OPLL	C3/4	8.4	12.3	16.6	+	+	+	+
3	77	M	CSM	C3/4	8.3	13.2	15.8	+			
4	59	M	OPLL	C3/4	5.3	9.1	12.8	+		+	+
5	63	F	OPLL	C3/4	8.73	9.41	12.57	+	+	+	
6	78	F	CSM	C3/4	5.61	9.08	12.91	+	+	+	+
7	70	M	OPLL	C3/4	6.92	10.16	14.05	+		+	
8	82	F	CSM	C3/4	3.19	6.01	9.56	+		+	+
9	71	F	CSM	C3/4	5.51	6	8.85	+		+	+
10	71	F	CSM	C3/4	6.17	6.99	11.35	+	+	+	
11	79	M	CSM	C3/4	2.48	7.61	9.07	+	+	+	
12	82	F	CSM	C3/4	6	5.04	8.52	+		+	+
13	84	M	CSM	C3/4	5.17	7.03	9.3	+	+		
14	68	M	OPLL	C3/4	11.04	11.22	19.29	+	+	+	
15	63	M	OPLL	C3/4	10	14.78	19.5	+	+	+	+
16	86	M	CSM	C3/4	8.64	11.35	13.03	+		+	
17	75	M	OPLL	C4/5	4.1	3.4	8.8		+	+	
18	66	F	CSM	C4/5	12.25	8.62	14.2	+	+	+	
19	48	M	CSM	C4/5	11.4	16.4	17.4		+	+	
20	68	M	CSM	C4/5	10.1	6.6	12.5		+	+	
21	84	F	CSM	C4/5	5.32	4.22	6.12		+		
22	56	M	OPLL	C4/5	9.58	14.25	14.34		+	+	
23	67	M	CSM	C4/5	6.5	7.55	11.99	+	+	+	+
24	70	M	OPLL	C4/5	5.54	7.23	8.62	+	+	+	+
25	69	M	CSM	C4/5	11.32	15.83	18.28		+	+	+
26	85	M	OPLL	C4/5	3.28	4.61	10.04	+	+	+	+
27	70	M	CSM	C4/5	10.6	7.7	13.6	+	+	+	
28	66	F	CSM	C4/5	12.3	8.6	14.2		+	+	

Abbreviations: CMAPs, compound muscle action potentials; CCM, compressive cervical myelopathy; CSM, cervical spondylotic myelopathy; F, female; MRI, magnetic resonance imaging; M, male; OPLL, ossification of the posterior longitudinal ligament.
The level of conduction abnormalities was determined by the spinal cord-evoked potentials.

of biceps were 9.43 ± 2.85 mV ($P = 0.10$). In patients with C4/5 myelopathy, the CMAPs amplitudes of deltoid were 8.52 ± 3.34 mV ($P = 0.11$) and those of biceps were 8.75 ± 4.42 mV ($P = 0.015$). There were no statistically significant differences between the mean CMAPs amplitudes in triceps of C3/4 ($P = 0.89$) or C4/5 ($P = 0.97$) myelopathy patients and the normal values.

The most discriminative cutoff value for CMAPs amplitudes in the deltoid for the diagnosis of C3/4 myelopathy was 8.73 mV, giving an area under the curve value of 0.671 (95% confidence interval, 0.44–0.90). This resulted in a sensitivity of 87.5%, specificity of 57.3%, PPV of 73.2% and NPV of 77.5%. The most discriminative cutoff value using the index for diagnosis of C3/4 myelopathy was 0.52, with an area under the curve value of 0.750 (95% confidence interval, 0.55–0.95) and a sensitivity of 75.0%, specificity of 75.0%, PPV of 80.0% and NPV of 69.2% (Figure 3).

The most discriminative cutoff value for CMAPs amplitudes in biceps for the diagnosis of C4/5 myelopathy was 8.62 mV, giving an area under the curve value of 0.594 (95% confidence interval, 0.35–0.83) and a sensitivity of 62.5%, specificity of 75%, PPV of 73.2% and NPV of 77.5%. The most discriminative cutoff value using the index for diagnosis of C4/5 myelopathy was 0.325, with an area
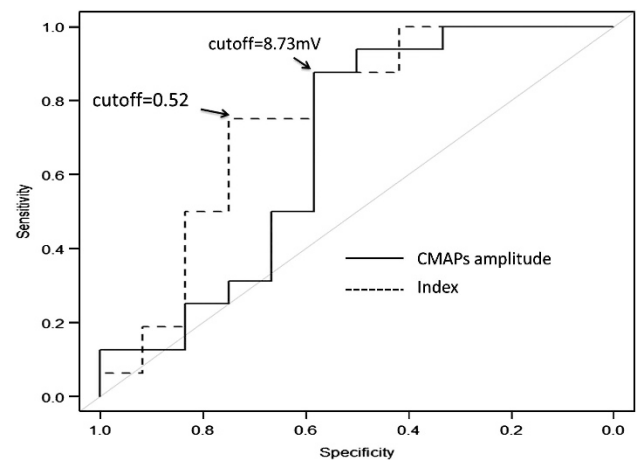
Figure 3 The receiver-operating characteristic (ROC) analysis was performed on the patients with C3/4 myelopathy yielded 0.75 (95% confidence interval (CI), 0.55–0.95) for an area under the curve (AUC) value for the index. (The sensitivity is 75.0% and specificity is 75.0%). CMAPs amplitude in the deltoid had 0.67 (95% CI, 0.44–0.90) for an AUC. (The sensitivity is 87.5% and specificity is 57.3%).
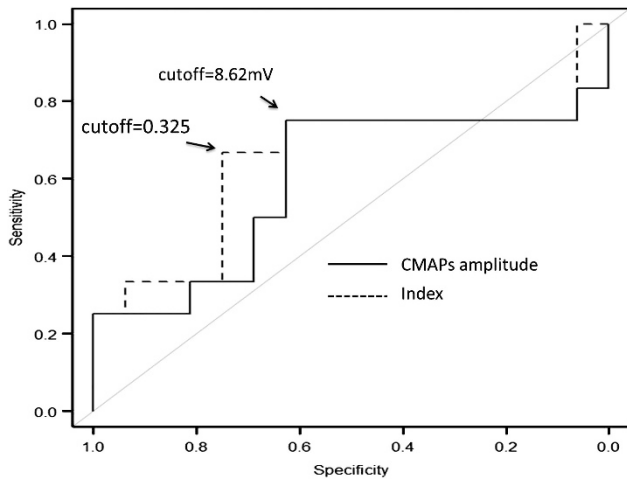
Figure 4 The ROC analysis was performed on the patients with C4/5 myelopathy yielded 0.65 (95% CI, 0.41–0.88) for an AUC for the index. (The sensitivity is 75.0% and specificity is 66.7%). CMAPs in biceps had 0.59 (95% CI, 0.35–0.83) for an AUC. (The sensitivity is 62.5% and specificity is 75%).

under the curve value of 0.646 (95% confidence interval,0.41–0.88) and a sensitivity of 75.0%, specificity of 66.7%, PPV of 62.8% and NPV of 78.1% (Figure 4).

DISCUSSION

CMAPs amplitudes obtained by stimulating below the lesion after injury determine the degree of axonal loss and thus allow for an accurate assessment of prognosis.[8] However, we reported that small CMAP amplitudes indicated not only the involvement of ventral nerve roots but also that of anterior horns with proximal-type cervical spondylotic amyotrophy.[3] Ito et al.[9] reported a common pattern for lesion progression in cervical spondylotic myelopathy that involved initial atrophy and neuronal loss in the anterior horn and intermediate zone, followed by degeneration of the lateral and posterior funiculus. MN-SCEPs are mediated by the lateral part of posterior columns, TES-SCEPs by the lateral corticospinal tract and spinal-SCEPs by medial parts of the posterior columns.[10] In the current patient series all SCEPs showed abnormalities, thus indicating the involvement of anterior horns. Small CMAPs amplitudes corresponding to compressed cord segments (deltoid, C3/4 and biceps, C4/5) also showed involvement of the anterior horns, but could not detect the involvement of the long tract. We confirmed that CMAPs amplitudes were better suited for assessing involvement of the anterior horns.

Level diagnosis for CCM is performed by investigating the muscle weakness, deep tendon reflex and sensory disturbance. The sensitivity of muscle weakness tends to be low, but its specificity is high,[11] such that muscle weakness is not detected in mild cases. Cadaver dissection has revealed a close correlation between anterior horns and vertebral bodies;[12] however, the anatomical features make it difficult to give a level diagnosis for CCM. In this respect, muscle weakness resulting from involvement of the anterior horn would be more accurate than sensory disturbance from the posterior horn. The accuracy of level diagnosis using CMAPs was about 70% and it is equivalent to the result of previous reports.[11] However, we confirm that deltoid and biceps are innervated by both C5 and C6 motor segments

and these have dominance to innervate muscles, it is difficult to clearly discriminate the nerve domination of C5 and C6. Therefore, it would also be difficult to clearly discriminate between C3/4 myelopathy and C4/5 myelopathy through the monitoring of CMAPs amplitudes. This point is included as the limitations of our study.

Sharrard[13] reported from a study of cadavers with poliomyelitis that more than 40% of anterior horn cells maintained normal muscle strength. If more than 60% of the anterior horn cells were involved this lead to muscle weakness. Patients with a single responsible level of myelopathy do not show clinical muscle weakness because multiple anterior horns innervate the muscle. Small CMAPs amplitudes could indicate subclinical muscle weakness and implicate the involvement of anterior horns in a quantitative manner.

Wee[14] reported that there are good correlation between the CMAPs amplitudes and the muscle bulk in biceps. Therefore, CMAPs amplitudes show considerable individual variation as well as gender and age differences. However, side to side differences in the same individual are much smaller.[15] The distribution of muscle volume in the upper limb was highly conserved across normal subjects, as assessed by MRI.[16] The conserved distribution of muscle volume probably accounts for the correlation of CMAPs amplitudes among the muscles of the upper extremity. The correlations among CMAPs amplitudes for deltoid, biceps and triceps in the same individual may be explained as follows. When CMAPs amplitudes are higher or lower than normal values in patients with large or small muscle volumes, they would be determined as false negative or false positive. The index we designed was therefore more accurate than CMAPs amplitudes, regardless of patient age or gender.

With advancing age, MRI tends to show multiple compression but the responsible level shifts from C5/6 to C3/4 or C4/5.[17] Elderly patients with cervical spondylotic myelopathy show multiple cord compression on MRI, but SCEPs usually showed a single level of conduction block and 95% of focal conduction block at the C3/4 or C4/5 level.[18] Azuma et al.[19] reported that 78% of patients with cervical ossification of the posterior longitudinal ligament were determined by SCEPs to have a single site of conduction abnormalities and in about 70% the level was C3/4 or C4/5; however, they found multiple cord compression. These reports indicate multiple compression of the spinal cord on radiographic findings can include clinically silent compression. In our series, however, we evaluated only those patients with a single site of conduction abnormalities in the C3/4 and C4/5, as this has the most clinical relevance.

CONCLUSION

We have investigated 28 patients with CCM at the C3/4 and C4/5 intervertebral levels as determined by SCEPs. We suggest that small CMAPs amplitudes in the deltoid indicate a C3/4 level of myelopathy and in biceps at the C4/5 level. This study could help exclude clinically silent cord compression and determine the surgical procedure to the suitable level of concern.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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