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Evaluation of cervical spondylotic myelopathy using somatosensory-evoked potentials

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Abstract Fourteen patients who had cervical spine surgery for cervical spondylotic myelopathy with median-nerve short-latency somatosensory-evoked potentials (SSEP) were followed preoperatively and until six months postoperatively. We evaluated the N18 latency and compared it with the JOA score recovery rate for each period. Seven patients demonstrated improvement in the N18 latency immediately following the operation and showed improvement of upper- as well as lower-extremity function 12 weeks postoperatively. We found a statistically significant correlation between improvement in the SSEP during the early decompression period and a good surgical outcome at 12 weeks postoperatively. We conclude that evaluating the median nerve SSEP is useful for prediction of the prognosis in patients with cervical spondylotic myelopathy treated surgically.

Résumé Quatorze malades opérés pour myélopathie cervicale arthrosique ont été suivis avec l'étude des potentiels évoqués somesthésiques du nerf médian de la période préopératoire jusqu'à 6 mois postopératoires. Pour chaque période nous avons évalué la latence électrique et l'avons comparé au score de récupération de la JOA. Sept malades ont démontré l'amélioration de l'état électrique immédiatement après l'opération et ont montré l'amélioration de la fonction du membre supérieur aussi bien que du membre inférieur à 12 semaines postopératoires. Nous avons trouvé une corrélation statistiquement significative entre l'amé-

lioration dans la mesure des potentiels évoqués précocément après la décompression et un bon résultat chirurgical à 12 semaines postopératoires. Nous concluons que l'évaluation des potentiels évoqués du nerf médian est utile pour évaluer le pronostic chez les malades avec une myélopathie cervicale arthrosique traitée chirurgicalement.

Introduction

Cervical spondylosis is an important and frequent cause of cervical myelopathy in patients over the age of 50 years, and the incidence of symptomatic cervical spondylosis increases with age. The thickening of bony and ligamentous structures as well as protrusions of intervertebral disc material associated with cervical spine degenerative disease produce spinal canal narrowing. Under such conditions, spinal cord injury may occur due to mechanical compression and vascular compromise, with resultant lesions in the dorsal and lateral columns and degeneration of the ascending and descending tracts. Clinical manifestations of cervical spondylotic myelopathy (CSM) include gait disturbance, clumsiness and paresthesia of the hand, and signs of pyramidal and posterior column dysfunction. The diagnosis of CSM is based on typical clinical signs and radiological findings. Magnetic resonance imaging (MRI) is the preferred radiological diagnostic tool that not only anatomically depicts how the spinal cord is compressed but also reflects the pathological changes in the spinal cord. An accurate assessment of patients with CSM is important. However, it is difficult to make an objective clinical assessment of CSM based on radiological findings alone.

Many authors have reported somatosensory-evoked potentials (SSEPs) to be a useful neurophysiological study for detecting an objective functional abnormality of the spinal cord. When the clinical presentations of CSM are equivocal, neurophysiological investigations, such as SSEPs, may be useful to establish a clinical diagnosis. However, the prognostic value of these investigations has rarely been examined in detail. The purpose of this prospective study was to evaluate the efficacy of analysing the median-nerve

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short-latency SSEPs in order to predict the postoperative prognosis in CSM patients.

Patients and methods

We prospectively studied 14 consecutive CSM patients (seven men and seven women ; mean age 68.1 years, range 44–78 years) who needed cervical spine surgery (11 open-door laminoplasty and three anterior spinal fusion). One surgeon performed all the operations. The patients presented with the following clinical manifestations: three had cervical compression due to herniated cervical discs, eight had cervical spondylosis, and three had ossification of the posterior longitudinal ligament (OPLL) (Table 1). Both Institutional Review Board approval and informed consent were obtained from all patients.

Neurological examinations

Clinical assessments were done based on the Japan Orthopaedic Association (JOA) score for CSM patients. Both upper- and lower-extremity functions were evaluated in this study. All patients were clinically evaluated before the operation and re-evaluated at 12 weeks postoperatively. The surgical outcome was represented by the JOA score recovery rate as calculated by the formula of Hirabayashi et al [6].

Somatosensory-evoked potentials

The electrophysiological monitoring system (MEB-9102, Neuropacki, NIHON KOHDEN, Japan) was used to elicit and record SSEPs. SSEPs of the arm were recorded using surface electrodes on the scalp overlying the primary sen-

sory area in the parietal lobe contralateral to the stimulated limb (2 cm behind the 10–20 system C3 or C4 locations) (N18). Impedances were reduced to less than 5000 Ω . The median nerve was stimulated at each wrist by square-wave electrostimulation at 5 Hz and with 0.2 ms duration. Stimulus intensity was adjusted to produce a visible twitch in the abductor pollicis brevis muscle without causing any discomfort. To confirm the reproducibility of the SSEP, each measurement was carried out at least three times. Data from the SSEP were obtained before operation and at one week, two weeks, four weeks, 12 weeks, and 24 weeks postoperatively except for two patients (one died and one was lost to the follow-up before 24 weeks), and we evaluated the N18 latency in these patients for each period.

Statistical analyses

The correlation between any changes in the SSEP and an improvement in the JOA score during the 12-week postoperative period were analysed statistically. Statistical analysis was done using the Mann–Whitney U test (a value of $P < 0.05$ was considered to be significant).

Results

Neurological examinations

Neurological examination findings of the JOA score recovery rate are presented in Table 2. Thirteen of the 14 patients showed a gradual improvement in the JOA score during the 12-week postoperative period. Seven of the 14 showed an improvement in upper-extremity function, and 12 showed an improvement in lower-extremity function postoperatively. Patients who demonstrated an improvement in upper-extremity function also showed good improvement in lower-extremity function.

Somatosensory-evoked potentials

Median-nerve SSEP (N18) data are presented in Table 2. Seven of the 14 patients showed an improvement in the N18 latency at one week postoperatively. After surgery, the N18 latency of all patients gradually improved over the 24-week postoperative period (Fig. 1).

Statistical analysis

Patients who showed improved median-nerve SSEP also showed an improvement postoperatively, not only in the upper extremity function but also in the lower extremity function. A statistically significant correlation was observed between improvement in the median nerve SSEP and the 12-week postoperative JOA score recovery rate ($P = 0.0019$). A significant correlation was also observed between improvements in the SSEP and postoperative

Table 1 Diagnosis and surgical characteristics of the study population

Case no.	Age	Diagnosis	Type of Surgery
1	76	Cervical OPLL	Laminoplasty
2	70	Cervical spondylosis	Laminoplasty
3	72	Herniated cervical disc	Anterior spinal fusion
4	44	Cervical spondylosis	Laminoplasty
5	76	Cervical spondylosis	Laminoplasty
6	72	Cervical spondylosis	Laminoplasty
7	77	Cervical OPLL	Laminoplasty
8	76	Cervical spondylosis	Laminoplasty
9	59	Herniated cervical disc	Anterior spinal fusion
10	55	Cervical spondylosis	Laminoplasty
11	75	Herniated cervical disc	Anterior spinal fusion
12	66	Cervical spondylosis	Laminoplasty
13	57	Cervical OPLL	Laminoplasty
14	78	Cervical spondylosis	Laminoplasty

OPLL ossified posterior longitudinal ligament

Table 2 JOA score recovery rate at postoperative 12 weeks and the median nerve short-latency somatosensory-evoked potentials (SSEPs) for each period

	JOA score recovery rate (%)			N18 latencies (ms)					
	Total	Upper extremity	Lower extremity	Preoperation	1 week	2 weeks	4 weeks	12 weeks	24 weeks
1	50.0	50.0	66.7	20.1	20.1	19.3	20.2	19.7	19.7
2	30.0	25.0	25.0	26.6	24.4	24.9	24.3	23.2	23.0
3	15.0	00.0	00.0	19.1	19.7	19.9	19.4	19.4	19.5
4	66.7	100	100	20.2	19.7	19.6	20.3	9.6	—
5	50.0	33.3	50.0	24.0	22.5	20.2	21.6	21.9	—
6	14.3	00.0	33.3	19.2	19.4	18.6	18.4	19.3	19.4
7	11.1	00.0	25.0	22.7	24.1	24.5	25.6	22.2	22.1
8	20.0	00.0	33.3	21.6	21.7	22.1	22.3	21.1	21.3
9	33.3	50.0	33.3	20.4	20.1	20.2	20.1	19.6	19.4
10	16.7	00.0	50.0	20.2	21.8	21.8	20.5	20.7	20.1
11	42.9	33.3	66.7	22.2	21.1	21.3	21.6	21.0	20.7
12	50.0	66.7	50.0	20.8	20.1	20.2	20.2	19.8	20.2
13	00.0	00.0	00.0	18.9	18.9	19.5	20.0	19.5	19.2
14	25.0	00.0	33.3	19.7	19.8	19.7	19.3	19.3	18.8

recovery of both the upper and lower extremity functions ($P=0.0067$, $P=0.0454$, respectively) (Fig. 2).

Discussion

There have been many reports regarding the utility of SSEPs in CSM patients. Several authors have reported tibial SSEPs to be the most sensitive test for CSM [10, 16]; others claim that ulnar potentials are more sensitive than tibial SSEPs [15] or found no difference between the arm and the leg [4, 7]. Although many studies have shown evoked potentials to be useful in detecting myelopathy in CSM, the prognostic value of these tests has so far rarely been examined in detail. Rustuccia et al [11] found clinical recovery to be accompanied by an improvement in SSEPs and that such an improvement was more pronounced in patients with an isolated loss of N13. Lyu et al [7] found normal median SSEPs to correlate with a good surgical outcome. We demonstrated a significant correlation between improvement in the median-nerve SSEP (N18) in the early decompression period and a good surgical outcome at 12 weeks postoperatively.

Fig. 1 Median-nerve N18 latencies improved gradually over the 24-week postoperative period

There is evidence that symptoms of spinal cord compression appear after the cord has been reduced either by 30% in size or to a transverse area of less than 60 mm² [1, 9]. Ogino et al. also observed that the severity of the pathological changes in the spine of patients with CSM correlated significantly with the extent of compression [8]. However, the transverse area of the spinal cord did not correlate well with the preoperative neurological status. The transverse area of the spinal cord was found to be the most significant factor in determining the response to surgery [3].

Many authors have reported the spinal cord to be supplied almost exclusively by the anterior spinal cord artery and that a dysfunction of this artery causes spinal cord failure [13, 14]. The combined effects of spinal cord compression and spinal cord ischemia in CSM patients have been reported by several authors [2, 5, 12].

In our study, there were two groups of patients, one showing improvement, the other no improvement in median-nerve N18 latency at 1 week postoperatively. In the

Fig. 2 Correlation between improvement in the somatosensory-evoked potentials (SSEPs) and postoperative neurological function

group that showed improved N18 latency, all patients demonstrated good improvement in neurological function at 12 weeks postoperatively. Finally, N18 latency in all patients improved gradually during the 24-week postoperative period; however, the group that showed no improvement in N18 latency in the early decompression period showed a poor surgical outcome. This group seemed to have severe degeneration in the artery that provides nutrition to the spinal cord, such as hyalinization or thickening of the vessel wall due to long-term and severe mechanical stresses, so it would appear that the blood supply did not improve in this group. Based on these results, we consider that improvement of postoperative SSEP in CSM patients seems to reflect improvement of spinal cord function due to restoration of blood supply in the spinal cord. Finally, our results suggest that median-nerve SSEPs seem to be useful for predicting postoperative prognosis in CSM patients.

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