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Clinical Study

Tibial somatosensory evoked potential can prognosticate for ambulatory function in subacute hemiplegic stroke

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ABSTRACT

Early prediction of expected recovery in stroke can help in planning appropriate medical and rehabilitation interventions. Recovery of ambulation is one of the essential endpoints in stroke rehabilitation. However, the correlation of somatosensory evoked potentials (SSEP) with clinical parameters and their predictive significance are not clearly defined. We aimed to examine the association between tibial nerve SSEP and ambulatory outcomes in subacute hemiplegic stroke patients. We reviewed medical records for hemiplegic patients with first-ever stroke who received inpatient rehabilitation from January 2009 to May 2013. We excluded patients with diabetes mellitus, quadriplegia, bilateral lesions, brainstem lesions, those aged over 80 years, and those with severe musculoskeletal problems. Tibial nerve SSEP were performed when they were transferred to the rehabilitation department. SSEP findings were divided into three groups; normal, abnormal and absent response. Berg balance scale and functional ambulation category (FAC) at discharge were compared with initial tibial SSEP findings using one-way analysis of variance. Thirty-one hemiplegic patients were included. Berg balance scale and FAC were significantly different according to the SSEP ($P < 0.001$). *Post hoc* analysis showed a significant difference between normal and absent response in Berg balance scale ($P < 0.001$) and FAC ($P < 0.001$), and between abnormal and absent response in Berg balance scale ($P = 0.012$) and FAC ($P = 0.019$). Functional outcomes of the normal response group were better than the abnormal response group, but there was no statistical significance. These findings suggest that initial tibial nerve SSEP may be a useful biomarker for prognosticating functional outcomes in hemiplegic patients.

1. Introduction

Early prediction of expected recovery in stroke can help in planning appropriate medical and rehabilitation interventions. Recovery of ambulation is one of the essential endpoints in overall functional improvement, as independent walking is a primary determinant of independence [1,2]. Most studies, however, focus on motor and/or functional recovery of the arm [2].

Prediction of motor recovery has long been based on clinical examination. The degree of motor deficit at onset has been found to be the strongest predictor of motor and functional recovery [1,2]. Muscle tone changes, disturbances of deep sensation and disturbances of consciousness in the acute phase are also considered important predictors [3].

The measurement of somatosensory evoked potentials (SSEP) is an objective method of assessing the integrity of sensory and motor pathways and areas of the central nervous system. The prevailing opinion is that they contribute to prediction of functional recovery [4]. However, most SSEP studies are performed late, even months after the onset of stroke and thus do not contribute to early functional prognosis and decision-making [5]. The correlation of SSEP with clinical parameters and their predictive significance is not clearly defined.

Few authors have performed comparative or selective assessment of lower limb function by measuring SSEP. Tzvetanov et al. studied the possibility of predicting recovery of muscle strength and the degree of independence in activities of daily living (ADL) of the patients with acute stroke using median and tibial SSEP [6]. SSEP parameters were compared to motor and functional ability (Barthel index) followed up at 1, 3, 6 and 12 months. The authors used the amplitude of SSEP as the standard with which to classify patients into normal, abnormal and absent response groups; therefore the result of study was not significant because the latency of SSEP is generally considered a more valuable measurement [7].

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The aim of this study is to examine the association between the latency value of tibial nerve SSEP and ambulatory outcomes in hemiplegic patients and to evaluate the prognostic potential of SSEP.

2. Methods

2.1. Subjects

A total of 113 patients who were admitted to the rehabilitation department with the diagnosis of stroke and discharged after rehabilitation from January 2009 to May 2013 were retrospectively studied by reviewing their medical records. The diagnosis of stroke was based on clinical history and examination and confirmed by CT scan or MRI. From these cases, patients with first-ever stroke, hemiplegic stroke and a supratentorial lesion were enrolled. The patients with quadriplegia or bilateral lesions, previous stroke, brainstem lesions or polyneuropathy were excluded, as were patients in stupor, coma or acute confusional states or those with other disorders of consciousness that precluded active cooperation.

Thirty-one patients met these criteria (20 men and 11 women) ranging in age between 39 and 79 years with a mean age of 61.2 ± standard deviation (SD) 13.2 years. Ten patients had a stroke with a cerebral cortical lesion and 21 patients had a stroke with a subcortical lesion. Fourteen patients had lesions in the left hemisphere, whereas 17 patients had lesions in right hemisphere. The demographic characteristics of patients who participated in this study are shown in Table 1.

2.2. Electrophysiological evaluation

Tibial nerve SSEP were performed when the patients were transferred to the rehabilitation department at a mean of 10.47 ± SD 6.80 days from onset. The Electro Synergy 10 channel (VIASYS Healthcare; San Diego, CA, USA) was used for SSEP measurement. A bar electrode was used to stimulate the posterior tibial nerve, while a cathode was located in the middle site between the medial border of the Achilles tendon and medial malleolus posterior border, and stimulated the posterior tibial nerve at 30 mA. The anode was located 3 cm distally from the cathode.

Needle electrodes were used to record results. The reference electrode was placed on Fz, and the active electrode was placed and recorded on Cz, while those on the head were defined using the International 10–20 system [6]. Repetitive stimulation was produced with a frequency of 2.3 per second for 250 pulses and results were averaged. The whole process was repeated twice. Band filter width was set to 20–2000 Hz.

Response was classified as normal if P37 was less than 41.7 ms and abnormal if it was 41.7 ms or longer, and absent if there was no signal [8]. A distorted wave was included in the abnormal group. A total of 31 patients were assigned to three groups based on their SSEP results: 15 patients to the normal response group; 10 patients to the abnormal group; and 11 patients to the absent group. Examples of SSEP graphs and corresponding brain MRI for normal, abnormal and absent response SSEP patients are shown in Figure 1.

Table 1
Demographic and clinical characteristics of stroke subjects (n = 31)

Variable	Mean ± SD
Age (years)	61.2 ± 13.2
Sex (males/females)	20/11
Lesion (cortex/subcortex)	10/21
Stroke (infarction/hemorrhage)	13/18
Side of infarct or haemorrhage (left/right)	14/17
SSEP group (absent/abnormal/normal)	15/10/6
Time from onset of stroke to SSEP (days)	10.47 ± 6.80
Time from onset of stroke to discharge (days)	76.77 ± 37.59

SD = standard deviation, SSEP = somatosensory evoked potentials.

2.3. Clinical evaluation

Functional recovery (independence in activities of motor ability) was assessed using the Berg balance scale (BBS) and the functional ambulation category (FAC) [9–11]. The patients were evaluated with BBS and FAC twice, when they were transferred to the rehabilitation department and when discharged. The functional outcome was assessed by a physical therapist who was blinded to this study and included measurements of impairment and disability.

2.3.1. BBS

The BBS comprises a set of 14 simple balance related tasks, ranging from standing up from a sitting position to standing on one foot. The degree of success in achieving each task is given a score of 0 (unable) to 4 (independent), and the final measure is the sum of all of the scores out of a possible 56 [9,10].

2.3.2. FAC

The FAC is a method for classifying mobility. The FAC has six categories ranging from 0 (non-functional ambulation) to 5 (independent). The intermediary categories quantify levels of requiring assistance, requiring supervision, and independent but limited mobility [11].

2.4. Statistical analysis

The Statistical Package for the Social Sciences version 18.0 (IBM, Armonk, NY, USA) was used for all statistical calculations. Patient groups based on SSEP findings, BBS and FAC were compared using a one way analysis of variance. Additionally, the *post hoc* analysis was performed to verify whether there was a difference in each group using the Tukey method. The statistical significance was set at $P < 0.05$ and values were shown as mean ± SD.

3. Results

3.1. Balance ability

The average value of the initial BBS was 6.73 ± 15.41 in the absent group, 15.4 ± 17.33 in the abnormal group, and 27 ± 19.94 in the normal group. The discharge BBS for each group was 12.6 ± 17.83 in the absent group, 32.9 ± 15.53 in the abnormal group, and 50.7 ± 3.44 in the normal group. The discharge BBS for each group had a statistically significant difference ($F = 14.28$, $P < 0.000$). In a *post hoc* test, the difference was statistically significant between absent and normal groups ($P < 0.000$), and absent and abnormal groups ($P = 0.009$), whereas the difference was not statistically significant between the normal and abnormal response groups ($P = 0.084$).

3.2. Ambulatory function

The average value of the discharge FAC was 1.27 ± 1.44 in the absent group, 2.7 ± 0.95 in the abnormal group, and 4.17 ± 0.41 in the normal group. The discharge FAC for each group was significantly different ($F = 14.24$, $P < 0.000$). In a *post hoc* test, the difference was statistically significant between absent and normal groups ($P < 0.000$), and between absent and abnormal groups