Usefulness of the Median Sensory Nerve for the Evaluation of Median Nerve Injuries

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Abstract. [Purpose] This study compared the results of EMG and a neurometer test and examined the kinds of sensory fibers for which nerve damage may be objectively evaluated in an attempt to provide the basic materials with which to develop an evaluation method incorporating these two tests. [Subjects] The subjects were individuals who visited an EMG laboratory of a general hospital in Busan from January 2010 to December 2011 with the cardinal symptom of hand tingling and who underwent a sensory nerve conduction study and then neurometer CPT. [Method] The present study used sensory NCVs of the finger-wrist and palm-wrist segments. The A-β fiber, A-δ fiber, and C fiber thresholds were measured by sequentially applying stimulation at the frequencies of 2000 Hz, 250 Hz, and 5 Hz, respectively. [Result] The thresholds for nonmyelinated C fibers were higher in the abnormal group than in the normal group. [Conclusion] Testing the neurometer current perception thresholds for nonmyelinated C fibers first is useful in confirming whether a patient with a complaint of hand tingling has nerve fiber abnormalities.

Key words: Median sensory nerve conduction velocity, Median nerve injuries, Current perception threshold

INTRODUCTION

The median nerve is formed by the union of two roots from the lateral (C₃₋₆,₇) and medial (C₈,T₁) cords originating from the brachial plexus. This nerve has no branches in the upper arm and innervates flexor muscles of the anterior compartment of the forearm except the ulnar half of the flexor digitorum profundus and flexor carpi ulnaris muscles. In the hand, the nerve supplies some of the skin and five intrinsic muscles (muscularis propria).

The palmar cutaneous branch arises from the median nerve just proximal to the flexor retinaculum and passes between the tendons of the palmaris longus and flexor carpi radialis muscles and then proceeds superficially to the lateral aspect of the skin of the palm. The sensory fibers of the median nerve innervate the skin of the palmar side of the thumb, the index and middle finger, the lateral half of the ring finger, and half of the distal dorsum of these fingers. Sensory nerves of the median nerve innervate the central palm branch in the carpal tunnel, and the palmar branch of the median nerve passes superficial to the carpel tunnel13). A disturbance resulting from the impairment of sensory fiber function of this nerve triggers diverse symptoms. Abnormality in tactile sensation fibers causes tingling or vibration, and proprioceptive receptor dysfunction leads to pseudo convulsion. Thermal sensory abnormality results in paresthesia, an abnormal feeling of warmth and coldness, and problems with A-delta fibers trigger stinging and pain sensation3).

Ordinarily, such nerve abnormalities are identified by electromyography (EMG). EMG is a useful test for diagnosing diverse diseases such as various neuropathies and myopathies, spinal cord diseases, neuromuscular junction lesions, and neuromyopathy caused by a herniated intervertebral disc. However, examinees undergo severe discomfort and pain during the test. In particular, needle EMG triggers extreme pain in the majority of those who undergo the test3). In addition, measuring sensory nerve conduction velocity (NCV) or somatosensory evoked potential (SEP) may only diagnose whether sensory nerves have been damaged; hypesthesia and hyperesthesia cannot be diagnosed5–7). In order to counteract these disadvantages, neurometers that can objectively measure the pain of a neurodegenerative disorder or nerve damage have been developed and used. A neurometer applies stimulation of a certain frequency to the tested peripheral nerve area, thereby measuring its sensory nerve conduction threshold (NCT); it can quantify the severity of hypesthesia or hyperesthesia. In particular, this test can measure and evaluate nerve fibers differentiated according to their thickness and the existence of myelin sheaths8–10). The neurometer test, which is excellent for diagnosing paresthesia, is based on the scientific principle...
that nerve fibers with different thicknesses react to currents with different traits. Nonmyelinated C fibers and myelinated A-delta fibers, both of which have small diameters, react to 5 Hz and 250 Hz current stimulations, respectively. Myelinated A-beta fibers, which have a large diameter, react to current stimulation of a higher frequency (2000 Hz). The function of nonmyelinated fibers of small diameters may be objectively quantified by measuring the current perception threshold. In this way, the limits of NCV or SEP measuring only thick nerve fibers may be compensated for by measuring the threshold. Moreover, nerve injuries like hypesthesia or hyperesthesia may be differentiated as well. Neurometers are objective, precise, and easy to use. They are used to evaluate synesthesia and nerve abnormalities in different areas.

This study compared the results of EMG and a neurometer test and examined the kinds of sensory fibers for which nerve damage may be objectively evaluated in an attempt to provide the basic materials with which to develop an evaluation method incorporating these two tests.

SUBJECTS AND METHODS

The subjects were individuals who visited an EMG laboratory of a general hospital in Busan from January 2010 to December 2011 with the cardinal symptom of hand tingling and who underwent a sensory nerve conduction study and then neurometer CPT. Patients with a history of diabetic peripheral neuropathy, a complication that is likely to accompany diabetes mellitus, were excluded, and only those with the symptom of hand tingling without any other specific disease were included. The side affected by median nerve abnormality in 52 patients, regardless of whether it was the right or left side, was selected. Of these, 46 cases with ulnar nerve abnormalities found in the nerve conduction study were used for analysis.

EMG is a method used for the differential diagnosis of myopathies and neuropathies. A nerve conduction study that measures NCV is a relatively simple and reliable test for diagnosing peripheral nervous diseases. The NCV test is also recognized as a reliable, objective, and quantitative method to not only diagnose peripheral nervous diseases but also estimate their treatment effects. This study used EMG (MEB-9200 K, Neuropack, Nihon kohden., Tokyo, Japan) to examine the subjects’ median nerves. The sensory nerve conduction study was performed on the median nerves of the affected arms of the patients with a complaint of tingling, and the normality or abnormality of their median sensory nerves was verified.

The period of latency and an action potential are examined for nerve abnormalities. Latency is measured from the stimulation timing to the onset of the negative phase, or from the stimulation timing to the peak of the negative phase. The amplitude of the action potential is very small and is therefore expressed in microvolts. It is measured from the baseline to the peak of the negative phase or as the distance between the peaks of the negative and positive phases. In this study, the method used was the one in which the distance between the peaks of the negative and positive phases was measured.

The sensory perception threshold was quantitatively measured using a neurometer CPT (Neurotron, Incorporated, Baltimore, MD, USA). The CPT can apply stimulation at frequencies of 5, 250, and 2000 Hz. Five hertz, 250 Hz, and 2000 Hz are used to selectively stimulate nonmyelinated C fibers, myelinated A-delta fibers with a small diameter, and myelinated A-beta fibers with a large diameter, respectively.

A median sensory nerve conduction study was performed on four segments—finger-wrist, palm-wrist, wrist-elbow, and elbow-axilla. The sensory NCV of the palm-wrist segment of the palmar surface best reflects the focal changes of demyelination in carpal tunnel syndrome. During the palmar stimulation test, the action potentials of the cutaneous sensory fibers and muscle sensory fibers are recorded, and the latter are the most myelinated nerve fibers with high conduction velocity and are therefore sensitive to demyelination. The palmar-wrist segment is very sensitive to carpal tunnel syndrome relative to the finger-wrist segment. For this reason, the present study used sensory NCVs of the finger-wrist and palm-wrist segments. The normal ranges of NCV in the finger-wrist and palm-wrist segments were 41.26 m/s and 34.05 m/s, respectively.

The median sensory nerve conduction study was performed using the orthodromic method, which stimulates the distal portions and records the nerve action potentials of proximal areas. A stimulation electrode was attached to the index finger, and a reference electrode was put on the wrist. Stimulation was applied to the index finger, and the action potential measured from the wrist was recorded. Thereafter, the stimulation electrode and reference electrode were attached to the palm and the wrist, respectively. Stimulation was applied to the wrist, and the action potential measured from the wrist was recorded.

Two 1-cm coated electrodes were attached to the fourth digit bilaterally dominated by sensory and ulnar nerves at an interval of 3 cm. Stimulation intensity was increased from a minimum of 1 to a maximum of 25 in order to measure the minimum stimulation intensity felt by the subject. The A-beta fiber, A-delta fiber, and C fiber thresholds were measured by sequentially applying stimulation at frequencies of 2000 Hz, 250 Hz, and 5 Hz, respectively. Here, an intensity of 1 refers to 0.01 mA. Nerve abnormalities of the patients were evaluated according to the following standard. Intensity results between 1 and 5, between 6 and 13, or between 17 and 25 meant the patient was sensitive, normal, or insensitive, respectively. The highest number (25) indicates that the patient did not feel any sensation.

This study intended to examine the current perception thresholds that are useful for the diagnosis of nerve injuries under a neurometer threshold test. Based on the median sensory nerve conduction study results, the subjects were divided into a normal and abnormal group. In order to examine whether there were differences in the current perception thresholds between the two groups, an independent samples t-test was performed. SPSS for Windows (Ver 19.0) was used for statistical analysis. A p-value < 0.05 was considered statistically significant.
RESULTS

Based on the median sensory nerve conduction study of the index finger-wrist segment, the subjects were divided into a normal group (23 subjects) and an abnormal group (23 subjects). Then, stimulations at 2000 Hz, 250 Hz, and 5 Hz were applied to stimulate A-beta nerve fibers, A-delta fibers, and C fibers, respectively. The thresholds for stimulation with 2000 Hz and 250 Hz were not significantly different between the two groups, but the thresholds for stimulation with 5 Hz to stimulate C fibers were higher in the abnormal group than in the normal group (p<0.05).

Then, based on the median sensory nerve conduction study of the palm-wrist segment, the subjects were divided into a normal group (29 subjects) and an abnormal group (17 subjects). Thereafter, stimulations were applied at 2000 Hz, 250 Hz, and 5 Hz to stimulate A-beta nerve fibers, A-delta fibers, and C fibers, respectively. Likewise, the thresholds for stimulation with 2000 Hz and 250 Hz were not significantly different between the two groups, but the thresholds for stimulation with 5 Hz to stimulate nonmyelinated C fibers were higher in the abnormal group than in the normal group (p<0.05)(Table 1).

DISCUSSION

The purpose of a nerve conduction study is to determine whether motor and sensory branches of peripheral nerves are abnormal. Electrical stimulation of the peripheral nerves triggers electrolyte exchanges in cell membranes, resulting in action potentials, which move along the nerve axons. The transferred action potentials on a part of the nerves move along the nerve axons, which triggers electrolyte exchanges in cell membranes, resulting in action potentials, which move along the nerve axons. For instance, it was demonstrated that nerve fibers selectively and sensitively reacted to different skin stimulations such as warm and cold, pain, tactile, pressure, and vibratory senses. Warm and cold senses, pain senses, and tactile and pressure senses are delivered by A-δ, C, and A-β fibers, respectively. Test methods applying the above principle have been developed. Among them, the nerveometer selectively stimulates sensory nerves through the following mechanism. Current stimulation at a frequency of 2000 Hz is very fast, and only large myelinated fibers, A-β fibers, are depolarized during the depolarizing phase of a 0.25 pulse duration; therefore, their reactions are triggered. However, in order to induce a reaction from slowly reacting unmyelinated C fibers, depolarization stimulus of up to 10 ms is required. Five-hertz waveforms, whose stimulation is slowly delivered, stimulate small unmyelinated C fibers only. A-beta fibers, whose nerve conduction velocity is swift, adapt quickly, and therefore, they adapt when stimulation with a low frequency at 5 Hz is applied, resulting in no depolarization. Further, for a current perception threshold test, stimulation currents are standardized with continuous alternating currents so that constant currents are maintained all the time and are not affected by changes in tissue resistance. In this way, measured values obtain reliability. Lee (2008) observed that although a neurometer CPT test had a lower positivity rate in diagnosis than a nerve conduction study and had problems with subjectivity in analysis of its results and its testing method, the former caused less discomfort to the examinee than the latter, was able to differentiate small nerve fiber damage, and was simple to apply. Lee (2008) concluded that the neurometer test was useful as an ancillary diagnostic tool or for observation of disease progression when it is difficult to perform a nerve conduction study.

The present study compared the results from a nerve conduction study and a neurometer test with the aim of discovering a simple method for testing nerve abnormalities and found that the neurometer test results were quite similar to the nerve conduction study results. The results of the present study showed that the nerve fibers related with nerve abnormalities in nerve conduction studies were

<table>
<thead>
<tr>
<th>Variable</th>
<th>Normal</th>
<th>Abnormal</th>
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<tbody>
<tr>
<td>M.2F-WSCV 2000Hz</td>
<td>12.91 ± 3.20</td>
<td>11.87 ± 3.20</td>
</tr>
<tr>
<td></td>
<td>12.22 ± 1.99</td>
<td>12.96 ± 2.12</td>
</tr>
<tr>
<td>5Hz</td>
<td>12.48 ± 2.31</td>
<td>14.13 ± 2.49</td>
</tr>
<tr>
<td>M.P-WSCV 2000Hz</td>
<td>12.72 ± 3.31</td>
<td>11.82 ± 3.05</td>
</tr>
<tr>
<td>250Hz</td>
<td>12.41 ± 2.11</td>
<td>12.88 ± 2.03</td>
</tr>
<tr>
<td>5Hz</td>
<td>12.69 ± 2.48</td>
<td>14.35 ± 2.29</td>
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(Unit: m/s) M.2F-WSCV: Sensory nerve conduction velocity of the median nerve from the 2nd finger to the wrist. M.P-WSCV: Sensory nerve conduction velocity of the median nerve from the palm to the wrist. Mean±SD. *Independent samples t-test (p<0.05)
nonmyelinated C fibers with a small diameter and no myelin sheaths. When there were abnormalities in nerve conduction studies of the median nerve, the thresholds of nonmyelinated C fibers in the abnormal group were higher than those in the normal group in the test results (p<0.05). This result shows that although the methods to verify whether there are abnormalities in the median nerve using a neurometer and by applying current stimulation at a frequency of 5 Hz to nonmyelinated C fibers are different, they may be used complementarily. Therefore, the discomfort and economic burden of patients will decrease if the process of confirming abnormalities using a nerve conduction study is preceded by a simple and inexpensive neurometer test in which the thresholds of nonmyelinated C fibers are beyond the normal ranges.

This study concerned only the median nerve and was performed with a small number of patients, and therefore it is difficult to generalize the results. Future research should be performed on other nerves and with a larger number of patients to verify the results of this study.

REFERENCES