Normal median near nerve potential

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Abstract

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In routine studies of sensory nerve conduction, only fibers ≥ 7 µm in diameter are analyzed. The late components which originate from thinner fibers are not detected. This explains why a normal sensory action potential (SAP) may be recorded in patients with peripheral neuropathies and sensory loss. In the present study we investigated the late component of the median SAP with a near nerve needle electrode technique in 14 normal volunteers (7 men and 7 women), aged 34.5 ± 14.8 years. The stimulus consisted of rectangular pulses of 0.2-ms duration at a frequency of 1 Hz with an intensity at least 6 times greater than the threshold value for the main component. Five hundred to 2000 sweep averagings were performed. The duration of analysis was 40 or 50 ms and the wave analysis frequency was 200 (-6 dB/oct) to 3000 Hz (-12 dB/oct). We used an apparatus with a two-channel amplifier system, 200 MΩ or more of entry impedance and a noise level of 0.7 µVrms or less. The main component mean amplitude, conduction velocity and latency and the late component mean amplitude, conduction velocity and latency were respectively (mean ± SD): 26.5 ± 5.42 µV, 56.8 ± 5.42 m/s, 3.01 ± 0.31 ms, 0.12 ± 0.04 µV, 16.4 ± 2.95 m/s and 10.6 ± 2.48 ms. More sophisticated equipment has an internal noise of 0.6 µVrms. These data demonstrate that the technique can now be employed to study thin fiber neuropathies, like in leprosy, using commercial electromyographs, even in non-academic practices.

Introduction

The compound sensory action potential (SAP) represents the time-space summation of the action potentials in each of the myelinic and amyelinic fibers comprising a nerve and is a measure of their function (1). Ideally, all the components constituting the SAP should be analyzed in clinical neurophysiology since different fiber populations may be selectively involved in peripheral neuropathies (2,3). However, in routine studies of sensory nerve conduction, only fibers of 7 µm or more in diameter, that generate the main component of this potential, are analyzed. The late components, which originate from Aα fibers of smaller diameters, Aδ and C fibers, are hidden in the noise (4); this explains why many patients with peripheral neuropathies and with clinical evidence of sensory involvement present a normal SAP (3,5).

In 1966, Buchthal and Rosenfalck (6) developed a method to record potentials from fibers as small as 3 to 4 µm in diameter. The main feature of this method is the improvement of the signal-to-noise ratio (5,6), achieved by 1) the use of needle electrodes 0.7 mm in diameter, insulated up to 3 mm (active electrode) or 5 mm (reference electrode) from the tip; 2) reducing the impedance of the electrodes by passing an alter-

nating current; 3) positioning the needle electrodes close to the nerve; 4) using a frequency band analysis of 200 to 4000 Hz; 5) using an analysis duration of 40 or 50 ms; 6) employing an apparatus with an internal noise of 0.6 µVrms or less; 7) using a stimulus intensity sufficient to stimulate the finest fibers, and 8) making a large number of sweep averages.

The objective of the present study was to investigate the late component of the median SAP in normal volunteers. Certain modifications were required to facilitate recording with our equipment, and we evaluated the effect of these alterations on the data.

Material and Methods

Recordings were obtained from 14 median nerves of 14 normal volunteers (7 men and 7 women; mean age (± SD), 34.5 ± 14.8 years; range, 18-64 years) who gave informed consent to participate in the study. The protocol was approved by the Hospital Ethics Committee. The neurophysiological examination was preceded by a screening questionnaire regarding peripheral neuropathies, particularly those more frequent in our city and region (alcoholic, nutritional, diabetic and inflammatory) (7), neurological examination and blood glucose analysis.

Stimulation was performed with ring electrodes previously immersed in saline solu-

tion. The cathode was positioned proximally on the distal region of the middle phalanx of the third finger, and the anode on the distal phalanx of the same finger about 2 cm from the negative electrode. The stimulus consisted of 0.2-ms rectangular pulses at a frequency of 1 Hz. Intensity was at least 6 times higher than the threshold value required to record the main component of the median nerve SAP. The maximum intensity of stimulation was limited by the sensation of pain reported by the subject.

Recordings were made using Dantec model 13L60 and 13L61 needle electrodes. Immediately before insertion, the recording electrodes were subjected to alternating currents (10 mA/mm^2) for 30 s. The insertion site of the needle electrode was established by subliminal stimulation: a line rostral to the proximal fold of the wrist was traced and stimulated point by point until the subject defined the site at which a submaximal current of constant intensity triggered the strongest response. This site was noted and the same procedure was applied to record the compound muscle action potential of the abductor pollicis brevis muscle. The reference electrode was positioned 3 to 4 cm medially to the active electrode so as to provide a unipolar recording method. For optimization of the final position of the active electrode near the nerve, this electrode was transformed into a cathode and, after recording the motor response in the thenar region, the position was adjusted until the motor threshold was between 0.5 and 1.0 mA. The temperature was kept above 33ºC.

Five hundred to 2000 sweep averagings in two or three series were performed. The duration of analysis was 40 to 50 ms and the wave analysis frequency was 200 (-6 dB/oct) to 3000 Hz (-12 dB/oct). The latency and amplitude of the main component were measured with a sensitivity of 5 to 20 µV/div. The late component was studied with a sensitivity of 5 V/div and the gain ranged from 0.31 µV to 0.07 µV/div. The latencies were measured from the stimulus artifact to the first positive

Figure 1 - A near nerve recording from volunteer 5. The arrowhead shows the late component. The main component is not visible because of the high gain. The number of averagings is 400, 800 and 1200 from upper trace.
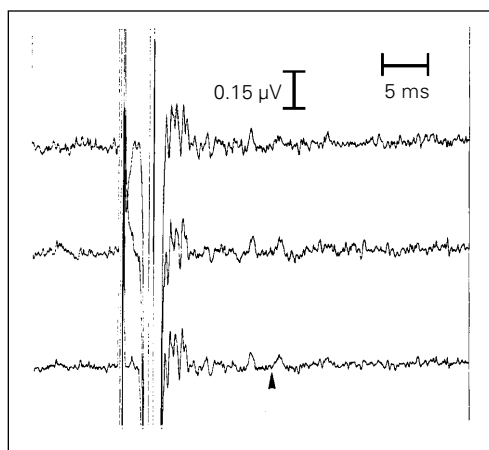
deflection of the respective potential. The amplitudes were measured from the first positive peak to the negative peak.

Stimulation and recording were performed using a Nihon Koden® Neuropack MEB71AO/K electromyograph with a two-channel amplifier system, 200 MΩ or more of entry impedance and a noise level of 0.7 µVrms or less (1 to 10 Hz). The measuring device was equipped with an 8-bit x 2-channel A/D converter and a measurement memory of 24 bits x 512 points x 2 channels. To be accepted as a late component the potential should satisfy the following criteria (2,5,8): 1) to be clearly distinct from the background noise; 2) to become sharper with an increased number of averagings; 3) averaging replication should reproduce the findings, and 4) the amplitude should be at least twice that of the baseline noise level. Recurrent potentials (8), defined as a potential of prolonged latency (>26 ms) not preceded by other temporally close biological potentials,

were not considered. Recordings with significant stimulation artifacts, excessive background noise, or excessive baseline oscillation were excluded from analysis.

Since several components usually follow the main potential (Figure 1), the late component was defined as the last component visualized that satisfied the above criteria.

Data were analyzed statistically using a *t*-test to compare sample means, followed by the nonparametric Wilcoxon test for result correction. Since much of the data exhibited marked inequality of variance, they were also analyzed at the 80% limit of confidence level. The lower limit for the normal amplitude of the main component was stipulated as half the mean amplitude of the potentials for normal individuals (9).

Results

The results are presented below and in Table 1.

Amplitude of the main component. The mean amplitude was 26.5 µV (SD = 5.42) with a median of 26.05. The lower normal limit was established as 13.25 µV.

Conduction velocity of the main component. The mean conduction velocity was 56.8 m/s (SD = 5.42) with a median of 56.5. The tolerance limit ranged from 49.2 to 64.0 m/s.

Latency of the main component. The mean latency was 3.01 ms (SD = 0.31) with a median of 3.05. The tolerance limit ranged from 2.5 to 3.7 ms.

Amplitude of the late component. The mean amplitude was 0.12 µV (SD = 0.04) and the median 0.11, ranging from 0.07 to 0.2 µV.

Conduction velocity of the late component. The mean conduction velocity was 16.4 m/s (SD = 2.95) with a median of 15.6. The confidence interval ranged from 11.3 to 20.9 m/s.

Latency of the late component. The mean latency was 10.6 ms (SD = 2.48) with a median of 3.05. The tolerance limit ranged from 7.1 to 17.1 ms.

Table 1 - Median near nerve sensory action potential in 14 normal volunteers.

AM, Amplitude (µV) of the main component; VM, conduction velocity (m/s) of the main component; LM, latency (ms) of the main component; AL, amplitude (µV) of the late component; VL, conduction velocity (m/s) of the late component; LL, latency (ms) of the late component.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
AM	26.4	14.7	15.2	25.7	40.2	35.3	17.5	23.0	36.6	27.8	27.6	17.7	41.0	22.4
VM	51.8	49.2	53.1	61.4	58.8	55.0	51.5	53.2	63.5	61.8	64.0	58.1	63.6	50.0
LM	2.8	3.7	2.8	2.9	3.3	3.0	3.3	3.1	2.6	2.8	2.5	3.1	2.8	3.1
AL	0.16	0.08	0.07	0.12	0.11	0.10	0.10	0.13	0.13	0.20	0.11	0.10	0.09	0.16
VL	15.6	19.5	15.6	16.5	11.3	14.5	14.9	20.6	19.6	14.0	13.7	14.0	20.9	18.2
LL	9.3	8.7	10.8	10.8	17.1	11.4	11.4	7.1	8.6	12.4	11.7	11.7	8.5	8.5

Discussion

According to Oh (10), the technique for recording the near nerve sensory action potential provides information that cannot be obtained with surface electrodes. This technique is fundamental when recordings obtained from electrodes positioned on the skin fail to demonstrate abnormalities in individuals clinically suspected to present peripheral neuropathy, or when there is insufficient discrimination to record the sensory potential. The technique can also contribute to studies of peripheral neuropathies.

The main SAP component represents the sum of potentials of sensory fibers larger than 7 μm in diameter, and the main peak is a measure of the properties of fibers of more than 9 μm in diameter (11). The biological factors that determine the amplitude are the number, or more precisely, the density of nerve fibers, their diameter and their relative conduction velocities (1). Latency and conduction velocity are determined by the fiber diameter and the characteristics of the myelin sheath (1).

Buchthal and Rosenfalck (12) reported normal conduction velocity values of 56.1 ± 1.2 m/s and 53.5 ± 1.4 m/s in subjects ranging in age from 18 to 21 and 40 to 60 years, respectively. Both of these velocities are close to the mean conduction velocity of 56.8 m/s obtained in the present study. The mean amplitude of 26.5 μV obtained in this study and that reported by the investigators cited above (26.0 μV) were very similar.

Near nerve needle electrodes 0.6 to 0.7 mm in diameter, low noise amplifier and 500 to 2000 sweep averagings are required to detect the late SAP components (12). Under these conditions, a significant number of small fibers must be present for a 0.08-μV potential to be distinguished from the background noise. In contrast, only 40 fibers of 7 μm are necessary to visualize the corresponding potential. This is because the amplitude of the potential is proportional to the sec-

tional area of the fiber, so that a much larger number of small fibers are necessary to visualize a given potential compared to the number of larger fibers. Under normal conditions, the late component detected by the near nerve technique is determined by fibers of approximately 4 μm in diameter according to Buchthal et al. (11), with an estimated conduction velocity of 15 m/s. This is similar to our own data (16.4 m/s, SD = 2.95) and to Buchthal et al.'s data (16 m/s) (13) who analyzed the late component of 56 patients. These values differ from those of Tackmann and Minkenberg (4), who evaluated 37 nerves, reporting a value of 20.6 m/s (SD = 3.1). However, these investigators used a maximum of 1000 measurements and only studied potentials with an amplitude of 0.1 μV or more, parameters that exclude components of lower amplitude and velocity from analysis. As also reported by Buchthal et al. (11), potentials of less than 0.1 μV were analyzed in the present study and more than 1000 sweep averagings were performed in some nerves to better define the potentials originating from small fibers.

Thus, our findings are similar to those reported in the literature, although the technique employed was not exactly the same. More sophisticated equipment has an internal noise of 0.6 μVrms, while the apparatus used here has an internal noise of 0.7 μVrms (1 to 10 Hz). Although this higher noise level may have rendered the examination more difficult by requiring a larger number of averagings, the detection and recording of late potentials were not affected.

The frequency analysis used in the present study was 200 Hz (-6 dB/oct) to 3000 Hz (-12 dB/oct). Buchthal and Rosenfalck (12) used 20 or 200 to 4000 Hz (3 dB) while Shefner et al. (5) used 200 to 4000 (3 dB). A high-pass filter (low frequency filter) is used to reduce the amplitude of the slow waves without attenuating the fast waves. The elevation from 20 to 200 Hz permits the attenuation of slow fluctuations without im-

pairing the signals (2). According to Buchthal and Rosenfalck (12), the reduction in the low-pass filter (high frequency filter) from 5000 to 2000 Hz reduces the amplitude of a potential recorded on the wrist by only 15% and prolongs the passage from the positive to the negative phase by no more than 0.1 ms. Thus, when the amplitude of the potential is less than 2 μV and there is no evidence for a fast component, the reduction in frequency is advantageous.

The number of sweep averagings appears to influence the last detected component significantly, although we have not specifically studied this aspect. Increasing this parameter causes smaller potentials with amplitudes as low as 0.08 μV to become clearly distinct from the background noise. This is probably the best explanation for the fact that, while the conduction velocities of the last component detected by Shefner et al. (5) and that recorded here are similar, both are different from the value obtained by Tackmann and Minkenberg (4).

In conclusion, the present method proved to be technically reproducible and thus is applicable in the clinical evaluation of peripheral neuropathies, especially those that affect small fibers, such as leprosy. The modifications introduced to allow recording with commercial equipment did not significantly affect the results, although the examination may have become more time consuming and more uncomfortable for the patient. The number of sweep averagings should be large enough to permit the good definition of the late component.

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