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ORIGINAL ARTICLE

Comparison of Three Filter Configurations and Their Effect on Muscle and Sensory Action Potential in a Colombian Population: Descriptive Study of Cross-Sectional Temporality

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Abstract

Introduction: A common error when performing electrodiagnostic studies is the configuration of the filters, which is rarely reported and is generally unknown.

Objective: To compare three filter configurations and their effect on the sensory and motor action potential of the median nerve in a Colombian population.

Methods: 19 healthy patients (38 hands) were included, performing motor and sensory nerve conduction of the median nerve on three occasions with a different filter configuration. The preset configuration of two commercial equipment Cadwell (C) and Nikon Hoken (NK) was used, and the filter configuration recommended by AANEM (A). The three groups were compared, using the ANOVA test of variance and post hoc analysis.

Results: Sensory and motor nerve conduction of the median nerve were performed in 38 hands. Statistically significant differences ($P < 0.01$) were found in compound muscle action potential amplitude and duration, and in sensory action potential amplitude, when using filter A versus filter NK and C. No significant differences were found in neither motor nor sensory latency when comparing the three configurations.

Conclusion: The configuration of the filters influences the components of the compound muscle action potential and the sensory action potential in the nerve conductions of the median nerve. Statistically significant differences in amplitude and duration were found between the three filter configurations. Therefore, we recommend that the filter settings should be included in the nerve conduction reports.

Significance: This is the first study to compare three filter configurations and their effect on sensory and motor action potentials, in a South American population.

Keywords

Filters, Nerve conduction, Median nerve, Motor potential, Sensory potential

Acronyms

SNAP: Sensory Nerve Action Potential; CMAP: Compound Motor Action Potential; AANEM: American Association of Neuromuscular & Electrodiagnostic Medicine; NCS: Nerve Conduction Study

Highlights

- The configuration of the filters influences the components of the compound muscle action potential and the sensory action potential in the nerve conductions.
- Statistically significant differences in amplitude and duration were found when comparing three filter configurations.
- The filter settings must be included in the nerve conduction reports.

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Introduction

Nerve conduction studies are a record of the different electrical potentials that are reproduced in the nerves and muscles. After an external electrical stimulus, the generation, propagation and integration of an action potential in these two systems is valued, they are an extension of the neuromuscular clinical examination [1,2]. The measurement of nerve conduction is an expression of the physiological or pathophysiological state of the nerves, therefore it is a diagnostic tool for the study of neuropathy [3].

A filter is an electronic device composed of a variable resistor/capacitor circuit capable of excluding specific frequencies, with the primary objective of attenuating noise or artifacts, allowing the visualization of a specific wave [4]. All the signals recorded during the electrodiagnostic tests are electronically filtered, this process is carried out to improve the visual quality of the tracing and reduce the effects of external interference [5,6].

There are two types of filters, both can vary the shape of the wave in motor and sensory potentials. The first type is high frequency (low pass filter), this attenuates high frequencies and allows low frequencies to pass. The second type is the low frequency (high pass filter), this attenuates the low frequencies and allows the high frequencies to pass; the concomitant use of both filters creates a Band-pass filters [7].

In electrodiagnostic studies, the most common sources of error include: filter settings, amplifiers, tracing speed, electrode separation, temperature, and stimulation [4]. Filter settings can be modified by adjusting high and low frequency filters. There could be errors depending on the initial configuration at the time of carrying out the study, since they have not been standardized in our population; affecting the result and more critically the interpretation of the data.

Currently in Colombia, electrodiagnostic studies are carried out by specialists in Physical Medicine and Rehabilitation and by neurologists, and most of them (approximately 70%) are unaware of the filter configuration they use; according to the results of an informal survey developed by the authors at the III National Congress of Electrodiagnostic Medicine, in the city of Medellin in 2017. The concern about a configuration of the filters arises when identifying that these, in the different brands of electromyographs in the market, have a pre-established default configuration; which varies, and are different from those recommended by the AANEM [8]. Additionally, many of the electrophysiologists do not make changes to this configuration or are unaware of it.

Currently we are not aware of any research publications identifying the impact of changing filter settings. This study aims to compare three filter configurations in the nerve conduction of the median nerve, and the effect on the characteristics of the compound muscle action potential (CMAP), and sensory nerve action potential (SNAP) in a Colombian population.

Materials and Methods

A descriptive cross-sectional study was carried out in a healthy population, in the electrodiagnostic laboratory of the Physical Medicine and Rehabilitation Unit in a high complexity Health Institution in the city of Cali, southwestern Colombia. All participants signed informed consent for participation. This study was endorsed by the Ethics Committee of Hospital Universitario del Valle and Universidad del Valle.

The participants were chosen between June-December 2019; they were working or carrying out educational activities in a high complexity medical center. Subjects aged between 18 and 60 years, absence of any type of peripheral nerve symptom at the time of the study and body mass index between 18.6% and 29.9% were included. Those with a history of peripheral nerve disease, peripheral vascular disease, diabetes mellitus, rheumatoid arthritis, hypothyroidism, chronic kidney disease, heart failure, liver cirrhosis, history of hand and wrist trauma, upper limb amputation at any level, history of surgery on upper limbs, and phobia of electricity were excluded.

Patient evaluation and outcome measures

After verifying that the patients met the inclusion criteria, sociodemographic data were recorded, including age in years, sex and dominance, anthropometric measurements, height, weight and body mass index (BMI) were taken.

Motor and sensory nerve conduction studies of the median nerve were performed, using the technique described in the Buschbacher Manual of Nerve Conduction Studies, capturing with surface electrodes on the abductor pollicis brevis muscle of the thumb with proximal stimulation in the antecubital region and distal in the wrist; 8 cm from the active electrode, and sensory nerve conduction, capturing with ring electrodes on the second finger [9]. The volunteer's position had to be, seated with the shoulder in a neutral position, the elbow flexed at 90°, the forearm supinated, and the hand on a surface that provided support. The temperature had to be between 32-34 °C. The nerve conductions were performed in a Nikhon Kohden Neuropack S1 equipment, by the same evaluator, a physiatrist with more than 20 years of experience in electrodiagnosis.

Motor and sensory NCV of the median nerve were performed three times in the same patient. Each time changing the filter configuration, using the configuration of the high and low frequency filters according to the recommendations of the AANEM (A), and the other two

Table 1: Configuration of the high and low frequency filters.

Filters	Motor Conduction			Sensory Conduction		
	A	C	NK	A	C	NK
High frequency	10 KHz	10 KHz	5 KHz	2 KHz	2 KHz	2 KHz
Low frequency	2 Hz	10 Hz	10 Hz	5 Hz	10 Hz	20 Hz

A: AANEM; NK: Nihon Kohden; C: Cadwell; Hz: Hertz; KHz: Kilohertz

Table 2: Demographic data of study subjects.

Men	9 (47.3%)
Women	10 (52.3%)
Mean Age (years)	29.5 (± 2.1)
Mean height (cm)	168 (± 9.69)
Mean weight (kg)	65 (± 12.1)
Mean BMI (kg/m^2)	23 (± 0.74)
Hand dominance	
Right	16 (84.2%)
Left	3 (15.7%)
Total, subjects	19

BMI: Body Mass Index Mean (SD)

with the factory configurations equipment, the Cadwell (C), Sierra Summit and Nihon Kohden (NK) Neuropack S1 (Table 1).

Sample size

To determine the sample size, the results obtained in the article by Pease, et al. [5] were taken into account. The formula for comparing means with dependent or paired data was used, obtaining a calculated sample size of 32 hands.

Analysis

An exploratory analysis was carried out where the behavior of the data was determined, and the presence of atypical values was evaluated. The measures of central tendency and dispersion in the quantitative variables were calculated, and the frequencies of the qualitative variables were studied. To statistically infer whether the means of a variable were different between their levels or groups, a single-factor ANOVA was used for repeated measures. The level of significance was set at $p \leq 0.05$, where statistically significant differences by group were identified. We performed Bonferroni adjusted pairwise comparisons ($p \leq 0.0167$).

Table 4: ANOVA of sensory and motor action potential components, comparing the three filter configurations.

Variable	P-Value of ANOVA
Latency of CMAP	0.063
Duration of CMAP	< 0.01*†§
Amplitude of CMAP	< 0.01*†§
Latency SNAP	0.119
Amplitude SNAP	< 0.01*†§

SNAP: Sensory Nerve Action Potential; CMAP: Compound Motor Action Potential

Note: Results of post hoc analyses are indicated by the following symbols:

*Significant difference between AANEM vs. Cadwell; †Significant difference between AANEM vs. Nihon Kohden; §No significant difference between Cadwell vs. Nihon Kohden

Results

19 participants (38 hands) were evaluated, 52.3% were women. The mean age was 29.5 years. Table 2 presents the demographic characteristics of the participants.

Table 3 shows the results of the CMAP and SNAP components, and in Table 4 the results of ANOVA and post hoc analysis.

Motor nerve conductions

No statistically significant differences were found in the latency of the CMAP (P 0.063), comparing the parameters of the 3 groups of filters. Statistically

Table 3: Average values of the CMAP and SNAP components comparing the three filter configurations.

	Motor compound muscle action potential			Sensory action potential	
Filters Configuration	**Latency (ms)**	**Amplitude (mV)**	**Duration (ms)**	**Latency (ms)**	**Amplitude (μV)**
AANEM	3.38 (2.7-4.28)	10.47 (5.93-18.47)	6.62 (5.36-8.14)	2.52 (2.04-3.08)	65.5 (33.8-105)
C	3.38 (2.68-4.22)	9.87 (5.67-17.63)	6.32 (5.14-7.58)	2.53 (2.14-3.08)	64.44 (32.5-104.2)
NK	3.34 (2.44-4.12)	9.88 (5.46-17.28)	6.39 (5.22-7.76)	2.51 (2.14-2.98)	63.35 (36.4-101)

SNAP: Sensory Nerve Action Potential; CMAP: Compound Motor Action Potential

Ranges are shown in parentheses.

ms: Milliseconds.; μV: Microvolts; mV: Millivolts.

significant differences (P < 0.01) were found in the duration and amplitude of the CMAP when comparing filters A vs. filters C and NK, being higher when using the parameters of filters A. Increasing by 3.6% (0.23 ms) and 4.7% (0.3 ms) the duration of the CMAP, that was obtained with the NK and C filter settings respectively, and by 6% (0.6 mV) the amplitude of the CMAP for both groups.

Sensory nerve conduction

No statistically significant difference was found in SNAP latency or duration, comparing the three filter groups (P 0.11). A statistically significant difference (P < 0.01) was found in the amplitude. This being greater using the configuration of filters A compared to filters C and NK¨; with an increase of 3.39% (2.15 uV) and 1.6% (1.06 uV) in the amplitude with respect to the average value that was obtained with the NK and C filter configuration, respectively.

Discussion

Previously, the influence of changing the configuration of the electronic filter parameters in nerve conduction studies has been researched, finding significant alterations in the parameters of CMAP and SNAP, for which an optimal configuration of the filter in the nerve conduction study is advisable [5,7]. It is recommended that these parameters remain constant when determining normal values and when performing serial studies [4,8]. Failure to do so could lead to the appearance of false positives or negatives in cases close to normal ranges.

From the three filter configurations compared (Table 1), we can deduce that the widest range of wave frequencies that pass through the filters is offered by filters A (Table 1), followed by the default configuration by equipment C and finally the NK equipment. Furthermore, for configuration A, it is evident that this range is determined almost exclusively by the low-frequency filter in both the motor and sensitive components, since the high-frequency filter is invariable except for the motor component of NK.

Our data reveal that there are statistically significant differences in the duration and amplitude of the CMAP, and in the amplitude of the SNAP. These being greater, using the parameters of the high and low frequency filters recommended by AANEM, with respect to the predetermined ones in the Cadwell and Nihon Kohden equipment. No significant changes in motor or sensory latency were observed when comparing the three filter configurations.

The AANEM recommended filter adjustment range for motor nerve conductions is: high frequency with high setting, and low frequency with low setting. In the CMAP our data evidenced a significant increase in the amplitude of 0.6 mV against the C and NK filters. In sensory nerve conductions, the low-frequency filter has a low configuration, with which reduction in amplitude and prolongation in latency would be expected. On the contrary, our data showed a significant increase in amplitude of 1.06 mV compared to C, and of 2.15 mV compared to NK.

When comparing our results with the reference values of nerve conduction of the upper limbs for a Colombian population published by Esteves and Guio [10], we found that the latencies, duration and amplitude of the CMAP, the latency and amplitude of the SNAP, were within normal ranges. This indicates, that despite the variations, these changes do not generate alteration of the result in the healthy population. However, we do not know their behavior in patients with symptoms or diseases, where a decrease in amplitude can be interpreted as an abnormal finding.

Therefore, electrodiagnostic study reports and research methodology should record the filter parameters used. More studies are needed to determine the appropriate filter range, and to study it in a population with a specific disease and determine the behavior in extreme values to normal.

Within the limitations of the study, we do not have a standardized filter configuration for our population as a reference value.

Conclusions

Statistically significant differences were found in the nerve conduction of the median nerve, in the duration and amplitude of the motor potential and in the amplitude of the sensory potential. These being greater when using the filter parameters recommended by the AANEM, compared to those predetermined in Cadwell and Nihon Kohden equipment.

Given the data obtained in the present study and the variability observed in some components of the sensory and motor responses, according to the configuration of the filters, we could suggest the need to standardize the configuration of the filters in each laboratory and record it in the reports and research studies, to allow reproducibility.

We urge specialists who perform electrodiagnostic studies to know the configuration of filters they use and consider them as a source of error or alteration in potentials.

Authors Contribution

Oscar Castro and Alejandro Molina: Conception and study design, data collection, literature review; Katalina Espinosa and Luz Miriam Leiva: Data analysis, writing of the manuscript, literature review; Enrique Esteves: Conception of the study, supervision, review and final approval.

All authors approve the content of the manuscript.

References

1. O'Bryan R, Kincaid J (2021) Nerve conduction studies: Basic concepts and patterns of abnormalities. Neurol Clin 39: 897-917.
2. Tavee J (2019) Nerve conduction studies: Basic concepts. Handb Clin Neurol 160: 217-224.
3. Oh Shin J (1998) Principles of clinical electromyography: Case studies. Williams & Wilkins.
4. Dumitru D, Walsh NE (1988) Practical instrumentation and common sources of error. Am J Phys Med Rehabil 67: 55-65.
5. Pease WS, Pitzer NL (1990) Electronic filter effects on normal motor and sensory nerve conduction tests. Am J Phys Med Rehabil 69: 28-31.
6. MacCabee PJ, Hassan NF (1992) AAEM minimonograph #39: Digital filtering: Basic concepts and application to evoked potentials. Muscle Nerve 15: 865-875.
7. Tankisi H, Burke D, Cui L, de Carvalho M, Kuwabara S, et al. (2020) Standards of instrumentation of EMG. Clin Neurophysiol 131: 243-258.
8. Gitter AJ, Stolov WC (1995) AAEM minimonograph #16: Instrumentation and measurement in electrodiagnostic medicine-part II. Muscle & Nerve 18: 812-824.
9. Buschbacher RM, Prahlow N (2006) Manual of nerve conduction studies. (2nd edn), Demos Medical Publishing.
10. Esteves EA, Guio SP, de Los Reyes-Guevara CA, Cantor E, Habeych ME, et al. (2020) Reference values of upper extremity nerve conduction studies in a colombian population. Clin Neurophysiol Pract 5: 73-78.