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LATE RESPONSES IN MEDIAN NERVE ENTRAPMENT NEUROPATHY IN THE CARPAL TUNNEL

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Abstract: *This study aims to systematize the late responses' parameters and determine the usefulness of each of them. We studied a total of 325 patients and we evaluated bilateral the median and the ulnar nerve with F wave and A wave parameters. We draw attention to the necessity of the bilateral examination and that of examining of the ipsilateral ulnar nerve, due to the difference in average latency of F waves of the median and ulnar nerve which was the most sensitive parameter studied, modified in almost three quarters of cases. This parameter is included in the composite score along with AAEM recommendations.*

Key words: *late responses, entrapment neuropathy, median nerve, carpal tunnel.*

1. Introduction

The electrodiagnostic study is part of the first line of investigations in the case in which we suspect the existence of a entrapment neuropathy of the median nerve in the carpal tunnel. This may confirm or refute the diagnosis, determine severity, so guiding the patient management and can be performed after surgery to assess the outcome of surgery and determine prognosis. This test can also detect the presence of other associated diseases such as polyneuropathy or cervical radiculopathy [2]. Peripheral nerve's proximal segments can not be investigated using ordinary electro-physiological studies, so the late responses' assessment enable the examiner in obtaining information at this level [5], [14].

There is a common principle of obtaining all types of late responses, it consists in causing an excitation of a nerve in its distal portion, this impulse is propagated proximally to the marrow and then returning to the periphery where it is taken up by surface electrodes [5], [13].

Regarding the F wave, there are some parameters that are usually studied and are recommended to be used in most specialty materials. They are: the average latency of F wave and the persistence, the presence of repetitive F waves or F wave increased amplitude. The parameters that are rarely watched are: the chronodispersion, the proximal velocity, the tacheodispersion, the ratio between wave amplitude F and M. It is desirable to enter into account the latency difference between F and M and F ratio. Simultaneously, can be determined the differences in average latency of right-left F wave and the right-left differences in average velocities of F waves.

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Regarding the A wave there aren't any recommendations regarding its parameters, it should only be mentioned as being present. Given that its presence indicates reinnervation, calculating its parameters: amplitude, latency and latency difference to F wave may provide information on this process. It can also be determined the distance at which the collateral branch occurs in relation to the point of stimulation.

2. Objectives

This study aims to systematize the late responses' parameters and determine the practical utility of each, taking into study a large number of cases and studying even the least used parameters.

Late responses are recorded and their parameters studied based on clinical and electromyographic diagnosis.

3. Material and Methods

We included a total of 325 patients with mean age 58.52 and the female/male ratio 53.85/46.15.

The examination included the bilateral study of the median and ulnar nerves, including the assessment of F and A waves' parameters. Also electromyography of the abductor pollicis brevis and abductor digiti minimi was performed. When appropriate, the number of nerves and muscles has been expanded for an accurate diagnosis.

3.1. Technical examination

The F wave was defined as the second wave occurring after the M response with minimum amplitude of 100 [μV] at supra-maximal stimulation of the motor nerve, recording on the muscle innervated by that nerve. A third wave occuring between M and F wave response is defined as A wave, being differentiated from the F wave by constant morphology, latency and amplitude.

For median nerve stimulation was applied at the wrist, between the tendons of flexor carpi radialis and palmaris longus, with the cathode oriented proximaly. The recording was made with surface electrodes, the active one applied on the muscle belly of abductor pollicis brevis and the reference distal to it at least 3 [cm], examined muscle being relaxed. Ground electrode was placed on the dorsal aspect of the hand. The skin was cleaned with alcohol before placing electrodes.

For the ulnar nerve stimulation was applied at the wrist medial to the flexor carpi ulnaris tendon, with the cathode oriented proximaly. The recording was made with surface electrodes, the active one applied on the muscle belly of abductor digiti minimi and the reference distal to it at least 3 [cm], examined muscle beeing relaxed. Ground electrode was placed on the dorsal aspect of the hand. The skin was cleaned with alcohol before placing electrodes.

To determine the supramaximal current intensity that needs to be applied, the same assembly of electrodes has been used but with the cathode oriented distal and the current intensity was gradually increased to obtain maximum amplitude of the M response. To obtain F waves, a current 30% higher than the above has been used.

Each nerve has been stimulated with the respective intensity of the current with a duration of 0.2[ms], using 10 to 20 consecutive stimulations at a frequency of 1 [Hz].

The surface temperature of the limbs was 32 degrees Celsius.

Screen settings for each examination were 7.5 [ms / div], 1.5 [mV / div], low cut filter 5 [Hz] and high cut 10,000 [Hz].

3.2. Studied parameters

The studied parameters for F wave were:

1) The minimum latency,
2) The average latency,
3) the maximum latency,
4) chronodispersion (defined as the difference between the minimum and maximum latency)
5) The difference between the minimum latency of F wave and the latency of M wave,
6) The difference between the average latency of wave F wave and the latency of M wave,
7) The difference between the maximum latency of wave F wave and the latency of M wave,
8) Proximal maximum velocity calculated by the formula: (the distance from the point of stimulation and C7 or T12) x2 / ((latency F-latency M) - 1msec)
9) Proximal average velocity calculated by the formula: maximum proximal velocity x ((minimum latency of F-1) / (average latency of F-1)),
10) Minimum proximal velocity calculated by the formula: maximum proximal velocity x ((minimum latency of F-1) / (maximum latency of F-1)),
11) tacheodispersion (defined as the difference between the maximum and minimum velocity)
12) The average ratio of amplitudes F / M,
13) The maximum ratio of the amplitudes F / M,
14) The percentage of F waves with high amplitude (greater than 1 mV)
15) F wave persistence,
16) The percentage of repetitive F waves,
17) F ratio calculated using the formula: ((latency F-latency M) -1ms) / (latency Mx2).
18) The right-left difference between the mean latencies of the F-wave of the median nerve,
19) The right-left difference between average velocity of the F-wave of the median nerve,
20) The difference in average latency of F waves for the median nerve and ipsilateral ulnar nerve.

All this was calculated bilaterally for the median and ulnar nerves.

The studied parameters for A wave were:

1) The amplitude,
2) The latency,
3) The latency difference between A wave and F wave,
4) Calculation of the distance from the generating branch to the point of stimulation.

M-wave, F-wave and A-wave latencies were calculated from the deflexion of those waves and the amplitudes were calculated peak-to-peak.

4. Results and Discussions

46.95% of all patients had suspected diagnosis of entrapment neuropathy of the median nerve in the carpal canal. EMG diagnosis of bilateral involvement was found in 72.62% of cases and 27.38% had unilateral involvement. Unilateral right upper limb involvement was present in 21.23% of the total cases, more frequently affected than the left upper limb. 29.23% of cases were associated with a diagnosis of polyneuropathy, 6.77% showed entrapment neuropathy of the ulnar nerve and 6.15% a diagnosis of cervical radicular involvement.

In terms of F waves of the median nerve, minimum latency of this wave was modified at 37.96%, average latency at 39.19% and maximum at 44.29% of cases. Chronodispersion shows changes at 36.41% of patients (Figure 1).

The difference between the minimum latency of F-wave and the latency of M-wave shows changes at 33.98%, the average at 33.89% and the maximum at 40.32% of cases. F ratio had values lower than 0.7 at 55.83% of patients (Figure 2).

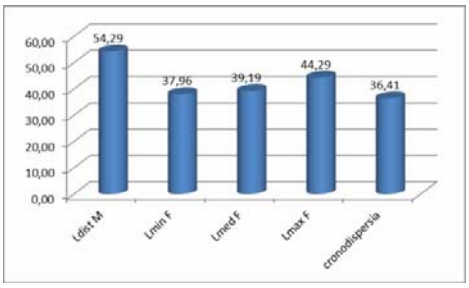

Fig. 1. *F-wave parameters, expressed as a percentage, for the upper limbs*

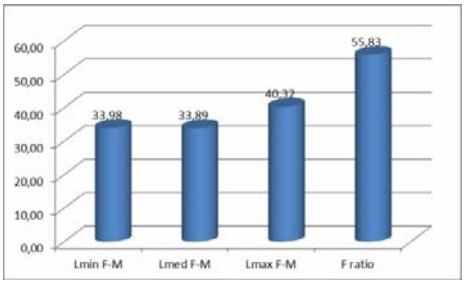

Fig. 2. *F-wave parameters, expressed as a percentage, for the upper limbs (continuation)*

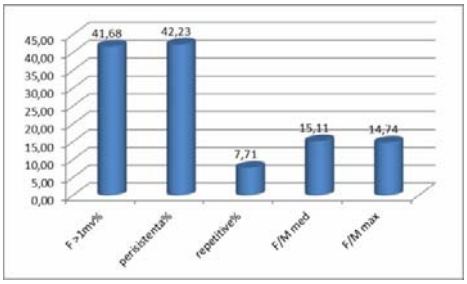

Fig. 3. *F-wave parameters, expressed as a percentage, for the upper limbs (continuation)*

41.68% F-waves with increased amplitude were present, persistence was altered in 42.23%, and 7.71% of patients had an increased number of repetitive F-waves. The F and M waves amplitudes' ratio was altered at 15.11% cases for the average and at 14.74% cases for the maximum (Figure 3).

The maximum proximal velocity was modified at 25.91% of patients, the minimum at 33.21% and the average at 26.44% of cases. Tacheodispersion has presented abnormal values at 45.12% of cases (Figure 4).

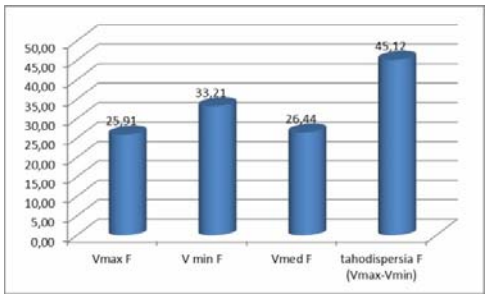

Fig. 4. *F-wave parameters, expressed as a percentage, for the upper limbs (continuation)*

Regarding the right-left differences of the mean latency for the F-waves of the median nerve there were alterations at 44.23% cases and the average velocity for the median nerve at 35.94% cases. The difference of the average latency of F-waves between median and ulnar nerves was altered at 75.57% of patients (Figure 5).

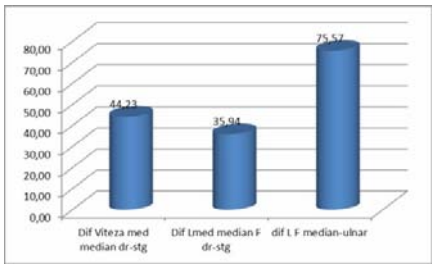

Fig. 5. *Right-left differences of latency and average* velocity *of the F-waves for the median nerve and the difference of the average latency of F-wave versus ipsilateral ulnar nerve*

Analyzing Pearson bivariate correlations we observe that there is a significant positive correlation between age and the minimum,

maximum and average values of F-wave latency and the latency of the motor response. Thus, there is a significant directly proportional correlation between age and the difference in minimum, average and maximum latency between F and M. On the other hand, there is a highly significant positive relationship between motor response latency and minimum, maximum and average latency of F-wave.

Also, there is a significant positive correlation between the chronodispersion and the minimum, average and maximum latency difference between F and M, the maximum, average and minimum latency of the F-wave.

Tacheodispersion values were significantly positively correlated with the minimum, average and maximum proximal velocity. Interestingly, there was a highly significant positive correlation between the presence of a high percentage of repetitive F-waves and presence of increased number of F-wave blocks. In the same way there was a significant positive correlation between the percentage of repetitive F-waves and average and maximum values of the ratio between F and M amplitudes, presence of F-waves with increased amplitude, but also with the minimum, average and maximum velocity of F-waves and the tacheodispersion.

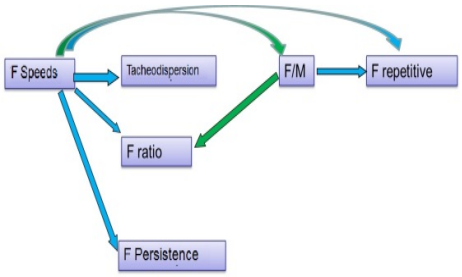

Fig. 6. *Pearson correlations between F wave parameters*

Also, highly significant but negative, was the correlation between the increased percentage of F-waves blocks and tacheodispersion and the values of the minimum, average and maximum velocity.

F-ratio values were significantly positively correlated with the minimum, average and maximum velocity and negative with the ratio of amplitudes (average or maximum) of F-waves and M-waves, with the presence of high amplitude F-waves and F-wave blocks.

The minimum, average and maximum velocity of F-waves and the tacheodispersion were negatively correlated with the presence of high amplitude F-waves and the average, maximum ratio of the amplitudes between F and M (Figure 6).

The A-waves appeared in only 11.08% of patients, half of them having prolonged distal latency of M-wave. The average amplitude was 92.58 [μV] (Figure 7) with an average latency of 20.30 [ms].

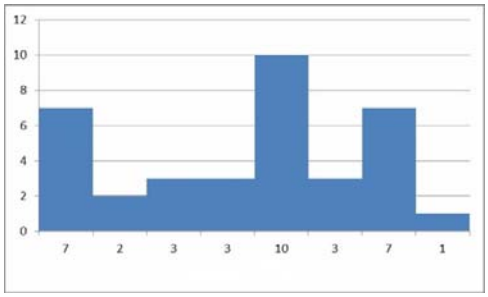

Fig. 7. *A-wave amplitude* [μV]

The average distance where was calculated the occurrence of the generating branch was 44.06 [cm] from the point of stimulation (Figure 8).

There was a significant positive correlation between the patients' age and the distance calculated from the point of stimulation where is the generating branch and highly significant between A-wave latency and the latency of the motor response.

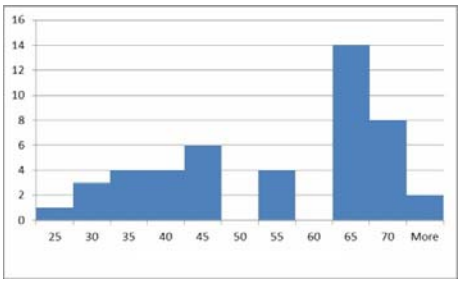

Fig. 8. *The distance of the generating branch from the point of stimulation* [cm]

5. Conclusions

Regarding entrapment neuropathy of the median nerve in the carpal tunnel, we draw attention to the need of bilateral examination due to the presence of a large number of cases with both right and left injuries. Also, the changes in unilateral cases occurred in most cases at the right upper limb [6].

On the other hand, it is necessary to examine ipsilateral ulnar nerve, not only because of the possibility of coexistence of entrapment neuropathies at this level, which occurred in the present study in a small percentage of cases, but because of the necessity of calculating the average latency difference between median nerve F-waves and those of ulnar nerve F waves, as will be discused below.

Although many authors, as Jablecki, Anand and Araujo et al [1], [4], [7], believe that the F-waves study has no role in the diagnosis of focal lesions or has a low sensitivity and specificity, there were authors whose studies reinforce the role of late responses study parameters such as Yazdchi [17] who studied both latencies and persistence of these waves.

In this study, if we take as comparator element the distal latency of the motor response of the median nerve, which was altered in half of the cases, then we can define two types of parameters: the first, in which the changes occurred in a lower percentage and the second, in which they have a similar or higher percentage.

The first category includes F-wave latencies, which are otherwise most recomended parameters of these waves, which were modified in a third of cases, predominantly the maximum, contrary to the recommendations of the Weber's study [15] where the minimum latency is the shown to be specific. In the same category are the differences between the latencies of F and M waves, predominantly the maximum, persistence, chronodispersion, F-waves of increased amplitude, right-left difference of the proximal velocity and average latency of the median nerve.

Tacheodispersion and F-ratio had changes in half the cases, but the most sensitive parameter, changed in nearly three quarters of the cases, was the difference between the average latency of F-wave referred to the ipsilateral ulnar nerve.

Thus, as we discussed above about the importance of the study ipsilateral ulnar nerve, we strengthen this statement demonstrated by this study but also according to previous studies of Kuntzer, Kim, Mehmet, Sulaiman, Menkes et al [8], [9], [10], [11], [12].

However, contrary to the study of Aygul and Kim et al [3], [8] that identifies a role in the diagnosis of carpal tunnel syndrome of the amplitude ratio of M-wave and F-wave and the proximal velocity, in this study those have been altered in a lower percentage of 30% of examinations.

In terms of A-wave, these appeared at 10% of cases, but more than half of these patients had also present a prolongation of motor response distal latency. The amplitude of this wave was approximately 90μV with an average latency of 20 ms, and the distance from the point of stimulation of 44cm.

The patients' age was positively significantly correlated with the distal

latency of the motor response, latencies of F-waves, differences in latency to M wave and the calculated distance at which the A-wave generator branch is located. Thus, the more advanced the age, there is an increase of all these latencies and a more proximal location of the colateral branch.

It is noted a positive correlation between the distal latency and of M-wave and the latency of F-waves. Thus, a prolongation of the former implies one of the latter. Another positive correlation appeared between F wave latencies or chronodispersion and the latency differences between F and M waves, this finding can conclude that a prolongation of F wave latencies will attract an increase of chronodispersion. Wave velocity was positively correlated with tacheodispersion and F-ratio and negatively with the presence of F-wave blocks. Thus, when the velocity will drop we will notice a lower persistence of these waves. Another positive correlation appeared between the amplitude ratio between F and M waves or low persistence with the presence of repetitive F waves and also a negative correlation with the F-ratio, suggesting that an increase in wave amplitude F is associated with an increase in the percentage of F-waves with the same morphology.

In terms of A wave, there was a significant positive correlation between its latency and the latency of the motor response. Thus, when the latter increases we will notice an increase in the latency of A wave.

The composite Score:

Associated with the recommendations of AAEM in the examination of patients with entrapment neuropathy of the median nerve in the carpal tunnel [16], [18]:

- Median sensory conduction studies across wrist and if the result is altered, examination of other sensory nerves in the affected limb;
- if the initial test result is normal, comparison with ulnar or radial sensory conduction across the wrist.

It is recommended to assess the difference of the average latency of F waves between the median nerve and ipsilateral ulnar nerve.

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