Arq Neuropsiquiatr 1996;54(3): 393-396

FACIAL NERVE ELECTRONEUROGRAPHY

VARIABILITY IN NORMAL SUBJECTS

JOVANY LUIS ALVES DE MEDEIROS, JOÃO ANTONIO MACIEL NOBREGA*, LUIZ AUGUSTO FRANCO DE ANDRADE*, YARA JULIANO***

SUMMARY - Twenty normal individuals were submitted to facial nerve electroneurography using different techniques in order to determine the most accurate to obtain the latencies and amplitudes of the compound muscle action potentials (CMAP) of the facial muscles. First of all it was determined in which muscle or muscle group highest amplitude CMAP could be recorded with the lowest variability between sides and in test-retest. Different techniques were studied in order to determine which could give the best results. This was shown to be an arrangement of bipolar surface electrodes fixed to a plastic bar. The records with higher amplitude where obtained from the nasolabial fold muscles. Therefore 65 normal volunteers were examined using this technique and recording the potentials obtained over the nasolabial fold muscles. Normal values were determined (latency lower than 4.5 ms and amplitude larger than 2 mV - 95% confidence limits).

KEY WORDS: facial nerve, eletroneurography.

Eletroneurografia do nervo facial: variabilidade em indivíduos normais

RESUMO - Vinte voluntários normais foram submetidos a eletroneurografia do nervo facial utilizando-se diferentes técnicas para a determinação da mais acurada para a obtenção das latências e amplitudes do potencial de ação muscular composto (CMAP) dos músculos faciais. Inicialmente determinou-se em qual músculo ou grupo muscular registra-se CMAP com maior amplitude e menor variabilidade entre lados e entre testes, assim como determinou-se qual técnica proporcionou melhores resultados. A que mostrou melhores resultados foi realizada com eletrodos de superfície bipolares de discos fixos em barra de plástico e os melhores registros foram obtidos nos músculos do sulco nasolabial. A seguir 65 voluntários normais foram estudados com esta técnica registrando-se os potenciais nos músculos do sulco nasolabial e foram determinados os valores normais para a latência (menor que 4,5 ms) e amplitude (acima de 2 mV).

PALAVRAS-CHAVE: nervo facial, eletroneurografia.

Since Desmedt's[4] description of compound muscle action potential (CMAP) in facial muscles, many electrophysiological techniques have been described aiming to establish an early prognosis for facial nerve palsy. Most of these techniques are based on comparative analysis between the CMAP obtained by the stimulation of the normal and damaged facial nerves. Another method is to compare the amplitude of the CMAP obtained by the stimulation of the damaged facial nerve with values obtained from a normal group of subjects, which is particulary helpful in patients with bilateral facial palsy. Fisch[6] and Esslen[7] considered that the percentage of reduction of the CMAP obtained on the paralyzed side is proportional to the number of affected nerve fibers. Many techniques have been described analyzing CMAPs of different facial muscles obtained with different stimuli and recording conditions[10,12-14,16,18,20]. To validate these techniques it must be assumed that normal subjects have small variability in CMAP amplitude between sides and in successive examinations (test-

Clinical Neurophysiology Laboratory, Federal University of São Paulo - Escola Paulista de Medicina: * MD, PhD; ** PhD. Aceite: 20-março-1996.

Dr. João A.M. Nobrega - Rua Prof. Artur Ramos 183 conj.12 - 01454-011 São Paulo SP - Brasil.

retest). Conflicting results have been reported by various authors, some report a mean variation of the CMAP amplitudes of 3% between sides and 5% in test-retest of normal subjects[6,7] while others report variations of up to 50% between sides and 20% in test-retest[2,18]. As the CMAP amplitude values in normal subjects have a great variability, the statistical methods used in the majority of the studies, i.e., parametric analysis, is questionable. A typical example is found in Gavilan et al.[12] report, where the average CMAP amplitude obtained at the nasolabial fold muscles (NFM) was 1177 uV with the standard deviation of 518 uV. This means that if a variation of 2 standard deviations is applied, a potential of 171 uV should be considered normal and if the average plus 2.5 standard deviations is used a negative amplitude should be considered normal.

The goals of the present study are to determine the best muscle or muscles to be analyzed, the best recording technique to obtain the CMAP with the highest amplitude and the lowest variability between sides and in the test-retest, and to determine values of CMAP amplitude, latency and amplitude variation between sides and in test-retest in a normal group of subjects.

MATERIAL AND METHODS

Experiment 1: Twenty normal volunteers were examined to compare recording techniques, 10 men and 10 women with ages ranging from 18 to 48 years, average 25 years and median 22 years. The CMAP of the frontalis, orbicularis oculi and the nasolabial fold muscles were recorded bilaterally in all subjects on two different days using three techniques, A, B and C. Technique A was characterized by the use of bipolar surface electrodes (felt pads soaked in saline solution fixed to a plastic bar with an interelectrode distance of 2.5 cm). Techniques B and C were characterized by the use of 8 mm diameter silver/silver chloride electrodes taped to the skin and filled with electrode conducting gel. For techniques B and C the reference electrode was placed on the tip of the nose and on the contralateral ear lobe, respectively. The recording electrode was placed at the same position for all three techniques according to a previous study[19]: at the frontalis muscle, 2.5 cm above the center of the eyebrow and 0.5 cm towards the medial line; at the orbicularis oculi muscle, 0.5 cm laterally and 0.5 cm below the external palpebral commissure, and at the nasolabial fold muscle just lateral to the ala nasi. The ground electrode was fixed to the right wrist.

Experiment 2: 65 normal volunteers, 34 women and 31 men, with ages ranging from 14 to 66 years were examined using technique A and recording the CMAP over the nasolabial fold muscles. In 25 individuals of this group a retest was performed on the next day without knowledge of the results of previous examination.

The examinations were carried out using an electromyography equipment ATI 900. Filters were set at 3 Khz and 25 Hz. Time base was set at 5 ms/div for the first experiment and 2 ms/div for the second. The facial nerve was stimulated with the cathode located in front of the ear lobe according to a technique previously described[19].

Statistical analysis: analysis of variance was done to compare techniques and muscles and when significant differences were obtained, the analysis was complemented with Tukey's test. Wilcoxon's test was used to compare the CMAP amplitudes and latencies in the test-retest and between sides. Kolmogarov-Smirnov's test was used to study the distribution of the latency and amplitude values[17].

RESULTS

Experiment 1: the amplitude values of the CMAP obtained in the test-retest of the frontalis, orbicularis oculi and nasolabial fold muscles did not show significant differences. Therefore, the averages of these values were used to compare techniques and muscles and to determine the variability of the amplitudes on both sides. The amplitudes of the CMAP recorded at the NFM were significantly higher than the amplitudes obtained in the frontalis and orbicularis oculi muscles ($p<0.05$). There was a great variability of amplitudes between sides and in the test-retest when results were compared individually, however, no significant difference was found when overall amplitudes were compared. The three techniques were equivalent when the CMAP were recorded at the NFM (Table 1).

After comparing the techniques, latency, amplitude and CMAP amplitude variability were determined between sides and in the test retest in a group of 65 normal subjects (experiment 2). As

Table 1. Minimal (Min) maximal (Max), average (x) and median (Md) amplitude values in millivolts recorded bilaterally at the frontalis, orbicularis oculi and nasolabial fold muscles in 20 normal subjects using techniques A, B and C.

	frontalis			orbicularis oculi			nasolabial fold muscles		
values	A	B	C	A	B	C	A	B	C
Min	0.43	0.55	0.55	1.15	0.70	0.70	1.60	1.50	1.40
Max	2.40	3.10	2.00	3.15	4.50	4.50	5.35	5.80	6.20
x	0.87	1.50	1.63	1.97	2.20	2.42	2.83	2.62	2.74
Md	0.83	1.40	1.23	1.83	1.80	1.75	2.50	2.50	2.5

Table 2. Normal limits of the CMAP latency and amplitude values, amplitude variation between sides and in the test-retest obtained from 65 normals subjects.

Latency	less than 4.5 ms (x + 2SD)
Amplitude	greater than 2.0 mV (percentile 95)
Amplitude	(between sides): < 35% (95th percentile)
Amplitude	(between tests): < 40% (95th percentile)

the latency values were normally distributed, the mean plus 2 standard deviations was used to calculate the normal limits. As the amplitude related measures were significantly different from the normal curve ($p<0.05$) the 95th percentile was used to establish the normal limits (Table 2).

DISCUSSION

CMAP amplitude obtained with techniques B and C in the frontalis muscle were significantly higher than those recorded with technique A. This observation is probably due to the fact that, in technique A, both surface electrodes were placed over the same muscle.

The highest CMAP amplitude was obtained at the NFM muscles, in agreement with the observations of Esslen[6] and Thomander and Stalberg[23], and is probably due to the high amount of muscle fibers innervated by the facial nerve in this region. The thickest branches of the facial nerves (zigomatic and the buccal branches) innervate the paranasal muscles which generate the CMAP recorded over this region.

The exclusive use of bipolar surface electrodes fixed to a bar[6,9,10] seems not to be justified when registering on the nasolabial fold muscles, since no significant difference was detected in the CMAP amplitudes obtained in this muscle comparing the three techniques.

We can conclude that if one muscle group is to be selected for recording, this should be the NFM group. However the adoption of a particular recording technique may be dictated by technical conveniences of each laboratory, provided it is used consistently.

No overall significant difference was detected in the CMAP amplitudes between sides or in the test-retest in any of the muscles or techniques used. This result was also reported by Kartush et al.[16] and Raslan et al.[20] who compared the techniques using bar fixed or disc electrodes.

As the CMAP amplitudes obtained from the nasolabial fold muscles were significantly higher than those recorded at the frontalis and orbicularis oculi muscles and no significant difference was

found in the CMAP amplitudes registered in the nasolabial fold muscles in any of the three techniques, we decided to use technique A to determine the latency, amplitude and the variability of these parameters between sides and in the test-retest.

The CMAP latency upper limit detected in our sample (4.5 ms) is similar to the results reported by many authors[3,22,24,25]. Latency values between 6 and 8 ms as reported by Joachims et al.[15],Gavilan et al.[12] and Gavilan and Gavilan[11] in normal subjects were not observed in our sample. A wide intersubject and intrasubject variation of the CMAP amplitude was detected. This phenomenon was also reported by several authors[1,5,10-14,16,18,20,21]. The data of the CMAP amplitudes in the test-retest and between sides found in the literature shows a great variability and has limitations when compared to the data obtained in our own study, probably because most authors express these results as averages of differences in percentage, whereas we used the 96th percentile. As percentages usually are not distributed normally it is difficult to interpret average or standard deviation from such values.

The CMAP recorded in the electroneurography at the NFM is a contribution of several muscles located laterally to the ala nasi. Slight changes in the position of the recording electrodes modifies the morphology and polarity of the recorded potential. This fact is probably related to the complex spatial orientation of the different muscle fibers in this region.

Stimulating electrode placement is another important aspect. The best point for stimulating the facial nerve was with the cathode located in front of the ear lobe. This position allows for maximal CMAP amplitudes with minimal stimulation intensity[19].

Acknowledgment - The authors thank Dr Gilberto M Manzano for reviewing the manuscript.

REFERENCES

1. Adour KK, Wingerd J. Idiopathic facial paralysis (Bell's palsy): factors affecting severity and outcome in 446 patients. Neurology 1974;24:1112-1116.
2. Adour KK, Sheldon MI, Khan ZM. Comparative prognostic value of maximal nerve excitability testing (NET) versus neuromyography (NMG) in patients with facial paralysis. Trans Pacific Coast Otoophtalmol 1977;58:29-42
3. Brown E, Arno MA, Twedt DC. Bell's palsy: nerve conduction and recovery time. Phys Ther 1970;50:799-806.
4. Desmedt JE. Methods of studying the neuromuscular function in man. Acta Neurol Belg 1958;58:1007-1010.
5. Eavey RD, Herrman BS, Joseph JJ, Thornton AR. Clinical experience with electroneurography in the pediatric patient. Arch Otolaryngol Head Neck Surg 1989;115:600-607.
6. Esslen E. The acute facial palsies. Berlin: Springer Verlag, 1977.
7. Esslen E, Fisch U. Zur Lokalisation der Nervenschadigung bei der idiopathischen Facialisparese und zur Frage der Dekompression. Schweiz Med Wschr 1971;101:386-387.
8. Fisch U. Total facial nerve decompression and electroneuronography. In neurological surgery of the ear. Silverstein H, Norrel H (eds) Neurological surgery of the ear. Birmingham, USA: Aesculapius, 1977:21-33
9. Fisch U. Maximal nerve excitability testing vs electroneuronography. Arch Otolaryngol 1980;106:352-357.
10. Gantz BJ, Gmuer AA, Holliday M, Fisch U. Electroneurographic evaluation of the facial nerve method and technical problems. Ann Otol Rhinol Laryngol 1984;93:394-397.
11. Gavilan J, Gavilan C. Electroneurography, statistical study of amplitude and latency in normal subjects. Rev Laryngol 1986;107:57-59.
12. Gavilan J, Gavilan C, Sarria MJ. Facial electroneurography results on normal humans. J Laryngol Otol 1985,99:1085-1088.
13. Hughes GB, Josey AF, Glasscock ME, Jackson CG, Ray WA, Sismanis A. Clinical electroneurography: statistical analysis of controlled measurements in twenty two normal subjects. Laryngoscope 1981;91:1834-1846.
14. Hughes GB, Nodar RH, Williams GW. Analysis if test-retest variability in facial electroneurography. Otolaryngol Head Neck Surg 1983;91:290-293.
15. Joachims HZ, Bialik V, Eliachar I. Early diagnosis in Bell's palsy: a nerve conduction study. Laryngoscope 1980;90:1705-1708.
16. Kartush JM, Lilly DJ, Kemink JL. Facial electroneurography: clinical and experimental investigations. Otolaryngol Head Neck Surg 1985;93:516-523.
17. Levin J. Estatística aplicada a ciências humanas Ed 2. São Paulo: Harper & Row do Brasil, 1987.
18. May M, Klein SR, Blumental F. Evoked electromyography and idiophatic facial paralysis. Otolaryngol Head Neck Surg 1983;91:678-685.
19. Medeiros JLA, Nobrega JAM, Novo NF. Eletroneurografia do nervo facial. Arq Neuropsiquiatr 1992;50:168-172.
20. Raslan WF, Wiet R, Zealear DL. A statistical study of ENG test error. Laryngoscope 1988;98:891-893.
21 Redhead J, Mugliston T. Facial electroneuronography: action potential amplitude and latency studies in 50 normal subjects. J Laryngol Otol 1985;99:369-372.
22 Taverner,D. Electrodiagnosis in facial palsy. Arch Otolaryngol 1965;81:470-477.
23. Thomander L, Stalberg E. Electroneurography in the prognostication of Bell's palsy. Arch Otolaryngol 1981;92:221-237.
24. Waylonis G, Johnson EW. Facial nerve conduction delay. Arch Phys Med Rehab 1964;45:539-547.
25. Yanagihara N, Kishimoto M. Electrodianosis in facial palsy. Arch Otolaryngol 1972;95:376-382.