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Facial electroneurography:
results on normal humans

by

J. GAVILÁN, M.D., C. GAVILÁN, M.D. and MARÍA J. SARRIÁ, M.D. (Madrid, Spain)

Introduction

In recent years, facial electroneurography (ENoG) has become one of the most widely used electric tests to assess the prognosis of intratemporal facial paralysis. The clinical applications of this technique began with the studies of Esslen (1973) and Fisch (1973), and it consists of the registration and measurement of the compound muscle action potential (CAP) generated by the synchronous firing of many motor units. The response on the paralyzed side is compared to that on the healthy side and a percentage is derived which is presumed to be proportional to the number of degenerated fibres. In this manner, an objective quantification of facial nerve function is obtained which has predictive value and which has been used to ascertain the need or not to undertake surgical treatment.

The most frequent measurement is the amplitude of the CAP peak-to-peak in microvolts. Nonetheless, the latency and area of the CAP have also been evaluated by certain authors.

The majority of the bibliography concerning ENoG has studied directly the results obtained on abnormal facial nerves, and only a few in-depth studies have been carried out on normal subjects (Hughes *et al.*, 1981; Hughes *et al.*, 1983). Our intention in this article is to present the results obtained in a study of 24 normal subjects, giving special attention to data regarding amplitude and latency.

Material and methods

Twenty-four adults, selected from among volunteer hospital personnel, served as subjects. Eleven were male and 13 female, with ages ranging from 16 to 65 years (average 32 years). Previous facial nerve disorders were excluded by routine examination.

The test was carried out with the subject comfortably seated and in only one session. In half the cases the right side was stimulated first, and in the other half the left side.

The skin was prepared in such a manner that its resistance did not exceed 5,000 ohms in any case. Resistance at both recording and stimulating points was measured. The inter-electrode resistance at corresponding points of the face was always less than 2,000 ohms.

Bipolar surface electrodes fixed in an isolated chassis were used for stimulation, with an intercenter electrode distance of 3 cm. Silver chloride electrodes 10 mm in diameter filled with electrode paste were used for recording, with an intercenter electrode distance of 2 cm. The recording electrode was placed just lateral to the ala nasi. The reference electrode was fixed along the naso-labial fold. The two poles of the stimulating electrode were set between the tip of the mastoid and the condylar process of the mandible (ground electrode), and in front of the tragus (stimulating electrode).

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The surface bipolar recording electrodes were attached to the amplifiers of a Nicolet Med-80 computer. Filters were set to pass frequencies from 15 to 3,000 Hz. For stimulation a constant-voltage stimulator was used (Cibertek CS-220) to deliver square wave pulses with a duration of 0.2 ms, and a manually chosen frequency of less than 1 per second. Electrical stimulation in volts was increased until supramaximal stimulation was achieved (10 per cent above that producing a maximal CAP). This output represented the test level for both sides of the face.

A total of 25 stimuli were delivered, but only the first 5 responses (F-CAP) and the last 5 responses (L-CAP) were recorded. The procedure was repeated on the opposite side of the face at the same intensity.

CAP amplitude and latency were evaluated. Amplitude was measured peak-to-peak. Latency was measured between the stimulus and the first peak of the CAP. The CAP amplitudes and latencies of each side of the face were compared, as were those from the F-CAP and the L-CAP within each side.

The 560 readings so obtained were studied statistically on an IBM 4341/1 computer utilizing the UCLA statistical package (BMDP). Inter-subject and intra-subject results were evaluated. All statistical tests had the same level of significance of 0.05.

Results

1. *Amplitude*

Inter-subject results show great variations in the amplitude of the CAP from one subject to another (Table I), though significant overall differences between the amplitudes of the right and left sides of the face were not detected (Table I). Likewise there were no significant differences between the five F-CAP and the five L-CAP on each side (Table I).

Since these data are not very useful from a practical standpoint, we studied the intra-subject differences between the amplitude on the right side and that on the left side, expressed as a percentage of the CAP of greater amplitude (Table II). The mean intra-subject interface difference is the average difference between right and left halves of the face within each subject, expressed as a percentage. This difference is 25.15 ± 2.38 per cent (Table II). Differences over 35 per cent were found in 5 subjects. No significant intra-subject differences were found between the F-CAP and the L-CAP.

As amplitude test-retest variability did not fit a normal distribution, it was defined as the median intra-subject coefficient of variation of repeated testing. Test-retest variability was 3.15 per cent, ranging from 0.9 to 10.5 per cent. Only one subject had a test-retest variability greater than 10 per cent.

2. *Latency*

Inter-subject latencies show variations slightly smaller than those of the amplitude (Table III). No significant inter-subject differences were found between the latency of the CAP on the right and left sides of the face, nor between the F-CAP and the L-CAP on either side (Table III). Average inter-subject latency was 4.94 ± 0.08 ms, ranging from 3.2 to 8.5 ms (Table III).

Intra-subject latency test-retest variability was 1.9 per cent (range 0–7 per cent). The

TABLE I

INTER-SUBJECT AMPLITUDE IN MICROVOLTS. (CV=COEFFICIENT OF VARIATION. F-CAP=FIRST 5 CAP. L-CAP=LAST 5 CAP AFTER 25 CONSECUTIVE STIMULI).

		Mean	SD	CV	Range
NS	Right	1177	518	43%	180–2108
	Left	1129	461	40%	154–1980
NS	F-CAP	1167	487	38%	160–2032
	L-CAP	1140	492	40%	154–2108
	Total	1153	479	41%	154–2108

TABLE II

INTRA-SUBJECT RIGHT-LEFT DIFFERENCES OF AMPLITUDE AND LATENCY. AMPLITUDE IS EXPRESSED AS A PERCENTAGE OF THE CAP OF GREATER AMPLITUDE. (CV=COEFFICIENT OF VARIATION. TRV=TEST-RETEST VARIABILITY.)

	Amplitude	Latency
Mean	25.15%	0.5 ms
SD	11.4	0.4
CV	63%	88%
Range	2–50%	0–1.7 ms
TRV	3.15%	1.9%

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TABLE III

INTER-SUBJECT LATENCY IN MILLISECONDS. (CV=COEFFICIENT OF VARIATION. F-CAP=FIRST 5 CAPS. L-CAP=LAST 5 CAPS AFTER 25 CONSECUTIVE STIMULI.)

		Mean	SD	CV	Range
NS	Right	4.94	0.98	34%	3.6–8.2
	Left	4.94	0.90	31%	3.2–8.5
NS	F-CAP	4.93	0.89	30%	3.4–8.2
	L-CAP	4.95	0.99	34%	3.2–8.5
	Total	4.94	0.94	32%	3.2–8.5

mean intra-subject right-left difference in milliseconds was 0.5 ± 0.09 ms, ranging from 0 to 1.7 ms (Table II). No significant intra-subject differences exist between latencies of the five F-CAP and the five L-CAP.

Discussion

The absence of right-left differences in the inter-subject study, already mentioned by Hughes *et al.*, (1981), is a misleading result since it does not reflect the reality of the phenomenon which we are facing. As can be seen from our results, despite the fact that these differences in inter-individual evaluations do not exist, the average variation shown by the intra-individual CAPs between both sides of the face is 25 per cent. This intra-subject difference can be as high as 50 per cent (Table II). Nevertheless, differences over 35 per cent are most probably due to technical deficiencies, as was proved in three cases in our study in which great right-left differences appeared in the first test, but in which subsequent tests revealed that these differences had a technical origin. This is despite the great experience of the persons carrying out the tests, who have examined more than 500 patients by means of ENoG. Thus the great importance of frequent, repeated testing, and the need for an extremely careful exploration to assess prognosis for recovery from facial paralysis.

The most important clinical application of these differences in normal subjects is that differences of less than 25 per cent between one side and the other of the face in a facial paralysis do not have any pathological value. This right-left difference in normal subjects accords well with the levels of asymmetry mentioned by Thomander and Stalberg (1981), but is in contradiction with the hypothesis which affirms that in facial paralysis the percentage decrease on the paralyzed side reflects the percentage of nerve fibres that have undergone Wallerian degeneration. If so, we would have to accept that, in normal subjects, Wallerian degeneration is present in an average of 25 per cent of fibres in one or other facial nerve.

The test-retest variability of our study is quite satisfactory if we compare it to the 10 per cent reported by Fisch (1980), or even the 6.2 per cent of Hughes *et al.*, (1983). We feel that test-restest variability does not depend, as has been suggested on occasions (Fisch, 1980; Esslen, 1977a) on the desynchronization of the motor unit volley. The absence of differences between the first and last five CAPs obtained after 25 successive stimuli supports our affirmation. In the light of our results we feel that the repetition of at least 20 stimuli before registering the definitive CAP (Fisch, 1980) is not justified. Also, our low test-retest variability suggests that computer averaging of responses is not necessary.

The latency of the CAP, measured between the beginning of the stimulus and the onset of the CAP, or between the beginning of the stimulus and the first peak of the CAP, has been generally less studied than the amplitude. Esslen (1977b) affirms that, although the values of the latency increase statistically with higher degrees of degeneration, in the individual case the latency is not a useful measure. Inter-subject variability of the latency is great and similar to that of the amplitude. Yet, if we are to compare the latencies obtained on each side of the face of the same subject, we should be interested in the intra-subject variability; here the results show much less dispersion (test-retest variability of 1.9 per cent, right-left differences of 0.5 ms). In any case, the practical usefulness of latency measurements in evaluating the prognosis of facial paralysis remains doubtful.

Summary

Electroneurography (ENoG) is one of the tests recently introduced for the clinical analysis of facial paralysis. Right-left facial differences, test-retest variability and differences

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between the first and the last CAPs after 25 consecutive stimuli were studied in 24 normal subjects. Significant inter-subject right-left differences were not found. Intra-subject results show an average variation of 25 per cent in the amplitude between either side of the face. Test-retest variability is minimal both for the amplitude and for the latency (3.15 per cent and 1.9 per cent respectively). No differences in amplitude or in latency were found between the first and last compound action potentials gathered after 25 consecutive stimuli.

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Address for correspondence:
Dr Javier Gavilán,
Las Viñas, 2, 4°D,
Urbanizacion Baymar,
Majadahonda (Madrid),
Spain

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