Hilger Facial Nerve Stimulator: A 25-Year Update

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Percutaneous nerve excitability testing using the Hilger facial nerve stimulator was introduced about 25 years ago. The test is reliable, easy to use, and inexpensive; it continues to be the most frequently used method for predicting prognosis of facial nerve disorders. Between 1966 and 1974, we recorded 10,243 nerve excitability tests on 865 patients with a mean of 3.29 tests for each peripheral branch and 3.43 for the trunk. Using a multiple regression model, we determined the effect on nerve stimulus values of age, sex, race, diabetes, hypertension, partial or complete clinical paralysis, diagnosis of herpes zoster, year of testing, and eventual facial paralysis recovery profile. We discuss statistical reliability, provide a table of interpretive results, and offer "tips and traps" invaluable to the practitioner. A prospective study of 25 patients with residual facial paralysis was evaluated by two separate otolaryngologists to determine intertester reliability.

INTRODUCTION

Percutaneous electrical stimulation of the facial nerve to evaluate facial paralysis was first described by Duchenne in 1872.1

In 1954, Campbell, et al.2 popularized a form of the nerve excitability test. The stimulator used was cumbersome, nonportable, and sometimes painful. In 1963, the Hilger facial nerve stimulator (W/R Medical Electronics Co., St. Paul, Minn.) was presented as a new instrument at the Sixty-Eighth Annual Session of the American Academy of Ophthalmology and Otolaryngology.3 It was compact and easy to use, and it quickly became the standard instrument for performing nerve excitability tests.

Initially, minimal nerve excitability testing (NET) of the trunk at the stylomastoid foramen was advocated.4 However, the lack of intertester reliability, poor patient tolerance of the procedure due to pain, and the trigeminal nerve artifact restricted its applicability.

In the interim 25 years, maximal nerve excitability testing (MST), electromyography (EMG), and electromyography (EMG) have evolved.5 Although various authors have advocated each method, a nationwide investigation in Japan in 1988 revealed that NET was by far the most-used system in 28 major medical facilities.6 The authors suggest this may result from the great expense and complicated technique of the EMG apparatus. The EMG requires placement of needle electrodes and is not helpful in patients with recent onset of Bell's palsy. In the United States, NET has been replaced by MST; however, the instrumentation remains the same.7

The main purpose of electrodiagnostic testing in patients with facial paralysis is to determine the physiological extent of nerve damage to predict prognosis. In previous studies, we had concluded that MST is a more accurate assessment of total nerve function and prognosis than NET and ENoG because the test stimulates each of the peripheral branches.8,9 However, normal values for minimal stimulation of the peripheral branches of the facial nerve using the Hilger nerve stimulator have not been standardized. In this study, we determined mean values for each peripheral branch, examined factors affecting these values, and analyzed intertester reliability of measurements. Establishing these normal ranges for minimal peripheral nerve excitability is essential to performing the MST.

MATERIALS AND METHODS

Between 1966 and 1974, we performed and recorded 10,243 percutaneous NETs on 865 patients. The population included all patients over 10 years of age with Bell's palsy or herpes zoster facial paralysis with no history of previous or bilateral paralysis and at least one reading on the unaffected side.

Percutaneous facial NET and MST are simple procedures, although some experience is required to determine...
the location of the trunk and peripheral branches. The facial nerve trunk is tested by applying the probe of the stimulator over the area of the stylomastoid foramen in front of the mastoid tip and behind the ascending ramus of the mandible. The branch to the frontalis muscle is usually found approximately 1 inch posterior to the outer canthus of the eye. The branch to the orbicularis oculi is usually located anterior to the notch where the facial artery traverses the mandible. It may be necessary to move the stimulating probe to determine the point of maximal response because the facial nerve branches in many directions beyond the stylomastoid foramen.

Good electrical contact with the skin is essential. The indifferent (ground) electrode is moistened with a conducting paste, placed on the back of the patient's hand, and held by the patient. The observer is in a position to see both sides of the face simultaneously. The testing (stimulating) probe is applied to the nerve branch to be tested, and the current intensity is adjusted to produce a barely visible muscle twitch. When twitching is first observed, the area is explored to find the most sensitive point (i.e., where muscle motion is maximal). In this fashion, minimal nerve excitability is determined.

In Part 1 of the study, values for minimal nerve stimulation of the trunk and peripheral branches of the facial nerve were recorded using the Hilger nerve stimulator; models 2 and 2R. The mean and standard deviations for the minimal stimulation level of the forehead, eye, mouth, and trunk were analyzed on the unaffected, normal side. Multiple regression analysis was performed to determine the effect of age, sex, race, diabetes, obesity, and hypertension on nerve stimulation values.

In Part 2, a prospective study involved 25 patients with recovered facial paralysis, constituting a full spectrum of facial dysfunction. For all patients, at least 6 months had passed since the onset of paralysis. Individuals having bilateral disease with residual dysfunction were included.

Minimal and maximal nerve excitability tests using the Hilger model 2R facial nerve stimulator were performed on both the affected and unaffected sides by two otolaryngologists during the same clinic visit. The measurements were analyzed statistically to compare intertester reliability on both the affected and unaffected sides. Statistical analysis of the MST will be discussed in a future paper.

**RESULTS**

In Part 1, mean patient age was 38.8 years. Fifty-two percent were men, 33% were nonwhite, 13% were hypertensive, 10% were diabetic, 8% were obese, and 15% had herpes zoster infections. All patients received repeated measurements on follow-up visits. The mean number of tests was 3.29 for each peripheral branch and 3.43 for the trunk. Minimal nerve excitability thresholds for each site tested are shown in Table I.

Multiple regression analysis revealed a linear rise in minimum threshold stimulus required at all sites with respect to increasing age ($P < 0.001$) (Table II). Men revealed a higher threshold that was statistically significant ($P < 0.001$) at all sites except the forehead. Nonwhites also revealed higher thresholds ($P < 0.05$) for all peripheral branches, but no statistically significant difference for trunk measurements. Hypertension, diabetes, and obesity also exhibited statistically significant elevation in the mean minimal thresholds.

In Part 2, of the 25 patients with residual facial dysfunction, two were unable to tolerate any stimulation on either the affected or unaffected side. Thus, 23 patients were included. Three patients had histories of bilateral Bell's palsy; 16 had right and 4 had left facial paralysis. The average patient age was 51 years (25 to 69 years). Participants included 8 men and 15 women; 10 were white and 13 were nonwhite.

Pain became an important factor in patients' tolerance during nerve stimulation at the various positions. On the unaffected side, patient intolerance was 3% (4/138) on stimulating the peripheral branches; however, stimulation of the trunk was not tolerated in 28% (13/46). On the affected side, patients were unable to tolerate 5% (27/46) of the trunk stimulation and only 14% (20/138) of the peripheral branches because of pain. Patients were eight times more likely to tolerate peripheral nerve stimulation than trunk stimulation.

There was excellent agreement between testers on both the affected and unaffected sides at the forehead and mouth positions (Table III). Variation between testers at the eye position averaged .26 mA on the affected side and .24 mA on the unaffected side. Trunk measurements revealed the most variation.
between examiners: .34 mA on the unaffected side and .27 mA on the affected side. Neither examiner recorded consistently higher or lower readings than the other.

**DISCUSSION**

Electroprognostic methods to determine function of the facial nerve include NET, MST, ENoG, and EMG. Each test has its advantages and deficiencies. Percutaneous minimal and maximal NETs are easy to perform, but have the disadvantage of relying on visual endpoints. Electroneurography has the advantage of possessing a recorded and often reproducible endpoint; however, it requires elaborate, expensive equipment and a trained technician. Electrodermography also requires elaborate, expensive equipment and a needle electrode, and it may show no muscle action potential even when the nerve is neuropraxic. Further, degeneration reflected as fibrillation potentials does not occur for 2 to 3 weeks. Electrodermography is of little benefit in the acute stages of Bell’s palsy. Currently, the most effective and economical method of clinical evaluation is with the Hilger nerve stimulator.

In 1968, the model 2R Hilger nerve stimulator was re-engineered to produce a linear output and allow direct reading of the stimulus output in mA, vastly improving its accuracy. However, normal values were never standardized.

One intent of this study was to establish normal values for minimum nerve excitability thresholds of the peripheral branches. Statistical analysis of stimulation values of the unaffected side were consistent for each branch. Although minimum nerve excitability threshold testing of peripheral branches is not used as a prognostic tool, we believe it is important in establishing the MST.

Pain was a limiting factor in obtaining satisfactory results using MST and NET on the affected and unaffected sides. Stimulation of the facial nerve trunk was poorly tolerated; therefore, it is no longer used in our clinic. Stimulation of the unaffected peripheral nerves revealed excellent tolerance. However, 15% of patients were unable to tolerate minimal peripheral nerve stimulation on the affected side. Several authors have suggested MST using 5 to 20 mA, but such levels would further decrease patient cooperation. Reducing the required maximum stimulation should improve patient cooperation. Determining the minimum threshold at the peripheral branches, then increasing the current by 2 mA, allowed us to achieve improved tolerance to maximal nerve excitability.

The average minimum stimulation thresholds of the peripheral branches compare reasonably well with those reported by Gates. In our study, the mean minimal thresholds in nonwhite, elderly, hypertensive, diabetic, or obese men were elevated to a statistically significant degree. Therefore, each patient's unaffected side must be used to determine the minimal stimulation levels to correct these variables.

When the same Hilger nerve stimulator was used by different examiners, agreement of measurements on both the affected and unaffected sides was excellent. A small variation of .06 mA was noted at the eye. Experts consider 2 mA at the nerve trunk to be a clinically significant difference when comparing the affected versus unaffected sides of the face; thus, a variation of .26 mA is not meaningful.

Mean minimal nerve stimulation levels of each peripheral branch were consistently higher in the retrospective Part 1 of the study versus the prospective Part 2 (Table IV). However, the patient population in Part 2 was, on the average, 12 years older and included more nonwhites than in Part 1. Both factors cause a clinically significant increase in minimum threshold values.

The prognostic value, accuracy, and limitations of MST have been discussed in detail in other articles. The findings from MST must be correlated with the clinical and pathological process causing the paralysis. If the nerve has been severed, regeneration cannot be expected unless repair is undertaken. For the two most common causes of facial paralysis (cranial polynymuritis and temporal bone fracture, which account for 95% of all cases in which the facial nerve is intact), regeneration can be expected and is predictable. If MST indicates equal response on both sides of the face, the patient can be expected to have complete return of facial function in 3 to 6 weeks without complication of faulty nerve regeneration. If there is minimal, moderate,
TABLE V.

Prediction of Prognosis of Facial Paralysis Based on Maximal Nerve Excitability Tests.

<table>
<thead>
<tr>
<th>Degree of Denervation</th>
<th>Recovery Time (weeks after onset)</th>
<th>Recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>3 to 6</td>
<td>100</td>
</tr>
<tr>
<td>Minimal</td>
<td>4 to 8</td>
<td>75 to 100</td>
</tr>
<tr>
<td>Moderate</td>
<td>4 to 12</td>
<td>75</td>
</tr>
<tr>
<td>Severe</td>
<td>8 to 12</td>
<td>50 to 75</td>
</tr>
<tr>
<td>Complete</td>
<td>12+</td>
<td>50</td>
</tr>
</tbody>
</table>

CONCLUSION

The Hilger facial nerve stimulator has proved to be an accurate, efficient, economical, and easy method of evaluating facial nerve function. This study reveals that the stimulator is reliable in the hands of different observers and that it is affected by such factors as age, sex, race, obesity, hypertension, and diabetes.

The major shortcoming of the nerve stimulator is the inability of patients to tolerate the stimulus. Determining minimum stimulation levels of the peripheral nerve branches is essential to increasing patient tolerance. It is not necessary to increase the stimulus more than 2 mA above the minimum stimulation level to produce a supramaximal response.

BIBLIOGRAPHY


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