Utility of EMLA in the Relief of Pain Associated with Electroneurography

Amiel Levine*
L. Clarke Cox*
C. Bruce MacDonald*

Abstract

Electroneurography (ENoG) is an electrodiagnostic procedure used to evaluate facial nerve deficit. A problem with application, however, is pain. Several studies have demonstrated that topical application of the eutectic mixture of lidocaine and prilocaine has an anesthetic effect on superficial and deep tissues. The present study was intended to determine if successful anesthesia of the trigeminal nerve could be achieved without altering the impulse transmission on the facial nerve. ENoG responses were measured at stimulation levels of 8, 16, 24, and 30 to 40 ma before and after Eutectic Mixture of Local Anesthetic (EMLA) application. A significant reduction in pain sensation was observed at stimulation levels of 8 and 16 ma while the amplitude of the response was not significantly changed. At the higher stimulation levels, namely, 24 and 30 to 40 ma, no significant reduction in pain or amplitude was observed. We concluded that, at moderate stimulation levels (<16 ma), EMLA reduces the pain associated with ENoG testing without affecting the amplitude of the muscular response.

Key Words: Electroneurography, EMLA, facial paralysis, Visual Analogue Scale

Abbreviations: CAP = compound action potential, EMG = electromyography, EMLA = Eutectic Mixture of Local Anesthetic, ENoG = electroneurography, VAS = Visual Analogue Scale

The etiology of facial nerve paralysis is quite varied. The anatomical location and tortuous path through the bony canal exposes the facial nerve to acute paresis and paralysis due to trauma, tumor, inflammation, degeneration, and meningioma (Beck and Benecke, 1993).

Electroneurography (ENoG) is one of several electrodiagnostic tests used by clinicians to evaluate facial nerve function. ENoG is generally considered a key clinical tool in identifying the presence and extent of facial nerve integrity (Hughes, 1990) and, as such, can assist in determining possible treatments and prognosis. Because ENoG can document and predict recovery from facial paralysis, it can also assist in selecting candidates for surgery (Graham et al, 1987). The favorable characteristics of ENoG are its speed of operation, noninvasiveness, cost effectiveness, ease of use, high efficiency, and reliability (Beck and Benecke, 1993). Figure 1 illustrates a typical ENoG response.

The typical ENoG test uses stimuli in the 7- to 20-ma range to elicit a supramaximal response (Coker, 1992). In cases of extensive facial nerve injury, high stimulation currents (25–40 ma) may be required to elicit a response. At high current levels, the patient may decline further testing due to pain. It was assumed for the present study that the pain associated with ENoG testing originates from stimulation of sensory branches of the trigeminal nerve. We hypothesized that if the trigeminal nerve were anesthetized, there would be a reduction in pain during ENoG testing.

The protocols and procedures used in ENoG testing may not be familiar to many audiologists. The facial nerve, however, certainly should be as it provides innervation for the stapedius muscle, which is frequently assessed with acoustic immittance testing. We will not take the time to review the basics of ENoG testing but the interested reader may wish to read the excellent...
Eutectic Mixture of Local Anesthetic (EMLA, Astra pharmaceuticals) cream is a 1:1 oil/water emulsion of lidocaine and prilocaine. This topical anesthetic is used to reduce pain during procedures such as intravenous and arterial cannulations in children and adults (Evers et al, 1985). Other clinical applications include removal of molluscum contagiosum and tattoos, separation of preputial adhesion, heel lancing, and superficial surgery. It is also used for manipulation of a fractured nose and management of otitis externa pain (Evers et al, 1985). Lamarche et al (1992) showed that EMLA is effective in easing the painful procedure of pricking the skin and underlying muscle with needles during electromyography (EMG). These authors did not, however, discuss whether EMLA affected the EMG response. Nielsen et al (1992) showed that a 30-minute application of EMLA to the facial skin (forehead) was sufficient to produce adequate analgesia for performing electromyography.

In the present study, we evaluated the analgesic effects of EMLA on the facial skin prior to ENoG. We formulated three questions: (1) Can EMLA reduce the discomfort associated with ENoG at typical stimulation levels? (2) Does EMLA application affect ENoG response amplitude? and (3) Can a high-stimulus current be applied after application of EMLA without significantly increasing pain?

METHOD AND MATERIALS

Subjects

Twenty-one healthy individuals volunteered to participate in the study: thirteen females (mean age 30 years, range 20–48 years) and nine males (mean age 29 years, range 23–39 years).

EMLA Cream/Placebo

EMLA cream is an oil/water emulsion. The oily phase consists of a eutectic mixture of lidocaine (25 mg/ml) and prilocaine (25 mg/ml). Two and a half grams of EMLA were applied to an ellipsoid area surrounding the location of the stimulating electrode at the stylomastoid foramen. This area was about 19 cm². The cream was then covered with a clear, impermeable plastic patch for a period of 45 minutes. Five minutes elapsed between the removal of EMLA and the initiation of stimulation. On the contralateral side, electrode cream that was similar in color and consistency to the EMLA was applied as a placebo.

Instrumentation and Stimuli

Testing was performed with a Bio-logic Navigator. Test stimuli consisted of a single sweep, variable current (8–40 ma), 200-msec pulse. Analysis time was 20 msec, filter setting was from 5 to 1500 Hz, and preamplifier gain was 1000. Silver/Silver chloride patch electrodes were attached to the forehead (ground), ipsilateral nasolabial fold (noninverting), and contralateral nasolabial fold (inverting). Responses were measured at current levels of 8, 16, and 24 ma and at the maximum tolerated current with an upper limit of 40 ma. The current was preset at each level using a saline solution soaked pad. Figure 2 documents the changes in amplitude with increasing current levels.

Visual Analogue Scale

The Visual Analogue Scale (VAS) is a self-reporting device that is used to measure subjective phenomena. Selection of the VAS was based on its simplicity and ease of use. Furthermore, it is easily understood by most people from diverse cultural groups (Harms-Ringdahl, 1986). The VAS uses a line of predetermined length (100 mm) that separates the extreme boundaries of the phenomenon: no pain at all
Illustration of ENoG response at stimulation levels of 8, 16, 24 & 40 ma

Latency 2.00 msec/div

Figure 2  ENoG response illustrating changes in amplitude with changes in stimulation current.

Illustration of VAS response at stimulation levels of 8 & 40 ma

No pain at all | Pain as bad as it could be

The subject entered a slash mark between the two extremes to indicate his/her pain. The VAS is simple and easy to score, and the subject can mark fine increments of the stimulus. Maxwell (1978) and others (Scott and Husjjson, 1976; Gift, 1989) have reported on characteristics that increase the reliability and validity of a VAS. These authors suggest that there be an interval of less than 1 hour between the two tests, the patient have access to the previous rating, and using a 100-mm vs 50-mm marking line, which tends to produce less error. To maximize our VAS reliability, we adhered to the above factors in the present study.

Protocol

Subjects were introduced to the objective and the procedures of the study (i.e., ENoG and VAS). The site that produced the maximal muscular twitch of the angular facial muscles was searched for by moving the bipolar stimulation electrode on the skin surface near the stylomastoid foramen. This location was marked with a ballpoint pen and served as the stimulation site during the testing. Both right and left sides were tested. At each of the three current levels, 8, 16, and 24 ma, two recordings were measured and the mean response was calculated. The subjects rated their sensation of pain on the VAS after each stimulation, while being blinded to the level of stimulation. The order of the stimulated side and the level of stimulation was counterbalanced to control for order effects.

Upon subject agreement, the final event was the maximal stimulation test. Only one side was stimulated at the maximum level as we did not want to unduly “punish” our volunteers. This test was performed only on the side designated for EMLA application. Maximum stimulation level was determined by increasing the current level while the simulator was in contact with the skin. Maximum level was noted when the volunteer signaled to stop or when the current level reached the output limits of the equipment (40 ma).

Statistical Analysis

Data were analyzed with a paired t-test. Statistical significance was set at an alpha-error probability level of .05. The critical t-value at p < .05 and 20 degrees freedom is 2.086. The amplitude of the response was measured before and after EMLA application to determine if EMLA reduced or enhanced the muscular response. Similarly, the VAS measurements
Table 1: Amplitude of the Muscular Response from Electrical Stimulation Pre and Post EMLA/Placebo Application

<table>
<thead>
<tr>
<th>Stimulation (ma)</th>
<th>Pre (mv)</th>
<th>Post (mv)</th>
<th>t</th>
<th>Pre (mv)</th>
<th>Post (mv)</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>401</td>
<td>398</td>
<td>0.07</td>
<td>348</td>
<td>346</td>
<td>0.06</td>
</tr>
<tr>
<td>16</td>
<td>777</td>
<td>762</td>
<td>0.36</td>
<td>741</td>
<td>860</td>
<td>-1.74</td>
</tr>
<tr>
<td>24</td>
<td>1332</td>
<td>1306</td>
<td>0.52</td>
<td>1159</td>
<td>1176</td>
<td>-0.28</td>
</tr>
<tr>
<td>Maximum (30-40)</td>
<td>1871</td>
<td>2044</td>
<td>-0.87</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

RESULTS

Amplitude of Muscular Response

The measured responses of the entire population were grouped according to stimulation level, with males and females grouped together. The mean amplitudes at 8, 16, 24, and 30 to 40 ma before and after EMLA application were not significantly different, as shown in Table 1. These data suggest that EMLA application has no measurable effect on the amplitude of the ENoG response. The placebo data document that application of the electrode cream produced no change in response amplitude.

Change in Pain Sensation

The VAS data associated with ENoG stimulation and pain perception are shown in Table 2. At a stimulation level of 8 ma, EMLA application reduced the mean perception of pain from 15.4 mm to 8.2 mm. At 16 ma, the mean pain sensation was reduced from 19.8 mm to 14.6 mm. Both outcomes represent a significant reduction of pain (p < .05). At 24 ma, we observed a decrease in pain sensation from 24.3 mm to 22.5 mm, while at maximal stimulation the reduction was from 62.8 mm to 59.6 mm. When measurements were taken from the side of the face to which the placebo was applied, changes in sensation of pain did not reach statistical significance for any level of stimulation.

DISCUSSION

Evaluation of facial nerve paralysis involves case history, physical examination, ENoG, and modern imaging techniques. Electroneurography is the most important electrodiagnostic test in predicting facial nerve outcome (Fisch, 1980; Arendt-Nielsen and Bjerring, 1985). The value of ENoG is greater during the first 14 days of paralysis, when the nerve has not completely degenerated and when the prognostic information obtained can help determine whether surgical intervention is indicated (Selesnick and Patwardhan, 1994). Practitioners are well aware of the pain and discomfort that is associated with electroneurography. An attempt to alleviate this discomfort has not been reported in the literature.

The present study was aimed at evaluating the effect of EMLA application on the fifth and...
seventh cranial nerves. We anticipated that EMLA application might reduce the cutaneous pain associated with ENoG through trigeminal analgesia. We were concerned, however, that EMLA might reduce the amplitude of the muscular response via facial nerve analgesia. The data noted no significant differences in amplitudes between the pre- and post-EMLA application at any stimulation level. Analysis of the perceived pain revealed a significant reduction at current levels of 8 and 16 ma. These data indicate that EMLA succeeded in anesthetizing the trigeminal nerve, thus reducing the pain sensation while having no significant effect on the function of the facial nerve. At higher stimulation levels (24 and 30–40 ma), however, the drug was not effective in reducing pain. On this basis, we approximate the efficacious range of the anesthesia under the described conditions to be as high as 20 ma. This range corresponds to Coker’s (1992) study in which it was shown that the current necessary to elicit a supramaximal response lies within the 7- to 20-ma range. We, therefore, suggest that clinicians who perform ENoG tests with current levels in the 7- to 20-ma range consider using EMLA to reduce the pain of the procedure.

Arendt-Nielsen and Bjerring (1985) and Bjerring and Arendt-Nielsen (1990) found that, after the removal of EMLA cream from the skin surface, the analgesia progressed further into the deeper layers of the skin and caused delayed maximal depth analgesia. The maximal depth analgesia occurred 30 minutes after a 90-minute application. In the present study, EMLA was applied, after which there was a 45-minute wait before removal followed by a 5-minute pause before the second stimulation test. We speculate that a longer delay would increase trigeminal anesthesia. It would appear that an interval of 20 to 30 minutes should elapse after EMLA removal to allow further diffusion and better analgesia of the trigeminal nerve. This increased time may alleviate the associated pain even at higher stimulation levels, which would be most beneficial in patients who have a low threshold for pain. The clinician must also remember that high current stimulation is associated with more than just pain. The patient experiences a reflex to the electrical stimulation that causes their head to move. When the patient moves the head with respect to the stimulating electrodes, the pressure of the electrodes on the skin may change, reducing the measured compound action potential (CAP). Furthermore, since subjects have different tolerance levels to the intensity of electrical stimulation, anticipation of pain from stimulation may further influence CAP results because of voluntary or "involuntary" facial and masseter musculature tensing (Hughes et al, 1981; Coker, 1992). Use of EMLA would help control for this problem in everyday ENoG testing.

Selesnick and Patwardhan (1994) reported the disadvantage of discomfort, cost, and test–retest variability of ENoG. According to Selesnick and Patwardhan, the primary source of test–retest variability (that varies from 6.2–11.2%) is the positioning of the recording electrodes. Thomander and Stalberg (1981) have shown that small changes in the electrodes' position can alter the recording to ENoG. We have controlled for the factor of retest by marking the stimulation site and by repeating the stimulation at that site. Other sources of variability include variable skin resistance caused by perspiration and lubrication, skin thickness (fat pad), and inconsistent pressure applied by the stimulating apparatus on the face. Coker (1992) found that the amplitude response differs according to the methodology, site, and gender. We have controlled for the first two by following a set protocol and by stimulating at the same site. Coker had shown that the mean amplitude values for the male subjects were significantly larger than those of the female subjects. This can be explained on the basis of quantity and distribution of muscle mass. The repeated measure design of our study (the patient serves as his own control) controlled for this difference as well.

The reduction in pain sensation while evaluating facial paralysis could be applied in several other clinical cases. For example, ENoG is an important clinical tool in the diagnosis of neurogenic fecal incontinence and a pudendal anal syndrome. Electroneurography of the pudendal nerve is a painful procedure and the patient frequently becomes "tense." The increased myogenic activity associated with being tense causes high artifact and affects the ability to make an accurate diagnosis (Jost and Schimrigk, 1994). Hence, reducing the pain sensation not only spares the discomfort but also improves the diagnostic evaluation.

Chang et al (1994) suggest that 1 to 2 grams of cream should be applied to an area of 10 cm², with a maximum of 10 gm recommended for use at any one application. The maximum application dose is 2 gm for children below the age of 1 year. In the present study, 2.5 gm of EMLA were applied to an area of approximately 19 cm². Several studies suggest a somewhat different amount. Nielsen et al (1992) applied
2.5 gm of EMLA to an encircled area of approximately 7 cm². Bjerring and Arendt-Nielsen (1990) applied 5 gm to a circular area of 12 cm². It is apparent that further studies should investigate the effect of higher amounts of EMLA (i.e., 5 gm) to the area of stimulation.

Two studies (Chang et al., 1994; Nilsson et al., 1994) compared the effectiveness of EMLA cream vs EMLA patch. These authors found no difference between EMLA cream and EMLA patch in terms of either analgesic effectiveness or local reaction. The process of EMLA application in the clinic, as well as in this study, suggests a preference for a patch application rather than a cream for several reasons. First, EMLA patch simplifies the application procedure. Second, a patch prevents the dispersion of the drug during facial movements and enhances the equal spread of the drug across the anesthetized area. Finally, patch application controls for an accurate measurement of the applied amount.

CONCLUSION

The present study formulated three questions to govern the research. The first question was whether or not EMLA could reduce the discomfort associated with ENoG testing at typical stimulation levels. The data suggest that, indeed, it can. The second question asked whether EMLA application had an affect on the ENoG response amplitude. The results show that it did not. The third question asked if the pain associated with stimulation at high current levels could be significantly reduced with EMLA. Unfortunately, the data do not indicate that a reduction in pain occurs. The various uses of EMLA in the clinic and the ample array of clinicians who use ENoG highlight the importance and significance of this study. EMLA application can reduce the pain sensation associated with electromyography at current levels that are sufficient to elicit a supramaximal response.

Acknowledgment. Portions of this paper were presented at the annual AAA Meeting, April 1997, Fort Lauderdale, FL.

REFERENCES


