INTRODUCTION

Neck stiffness due to irritation of the trigeminal nerve endings innervating the cranial meninges is a well-known clinical sign of meningusmus. This sign suggests that there exists a connection between the trigeminal nerve and the posterior neck muscles. The trigeminal system is involved in a number of reflexes such as the blink, jaw, head retraction, defense and orienting reactions, which require connections between the face and the neck motoneurones (1-4). Pinching and rubbing the skin of the face, or electrical stimulation of the trigeminal nerve, causes contraction of the neck muscles in experimental animals (1,5,6). Thus, the existence of the trigemino-cervical reflex was first described in animals (1,6) and later confirmed in humans by Broser et al. (7).

There are only few reports on the trigemino-cervical reflex in humans and there is debate over the best method of reflex examination. The aim of this study was, comparing different methods, to provide a reproducible method for evaluating the trigemino-cervical reflex. The trigemino-cervical reflex was studied in 32 healthy volunteers. The stimulation was applied to the supraorbital, infraorbital or mental nerve. Recordings were performed bilaterally from the sternocleidomastoid and trapezius muscles at rest. The reflex was also examined during maximal voluntary contraction of the sternocleidomastoid muscle after supraorbital nerve stimulation. It presented as a two-component reflex if recorded from a tonically active muscle and as a one-component reflex if recorded from a relaxed muscle. The most reproducible reflex responses were obtained from the resting sternocleidomastoid muscle after stimulation of the supraorbital nerve. In conclusion, the trigemino-cervical reflex may be most easily obtained from the relaxed sternocleidomastoid muscle after supraorbital nerve stimulation.

KEY WORDS: Electromyography, normal subjects, reflex, trigemino-cervical.

THE TRIGEMINO-CERVICAL REFLEX IN NORMAL SUBJECTS

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or mental branches of the trigeminal nerve in order to obtain better reflex recording (8-10,12). The site for reflex recording is also debated.

The aim of this study was to provide a reproducible method for evaluation of the trigemino-cervical reflex, comparing the various methods that have been proposed.

MATERIALS AND METHODS

The trigemino-cervical reflex was studied in 32 healthy volunteers (17 females and 15 males; mean age 36.5 ± 12.2 years). The local ethics committee approved the study and all the subjects gave their informed consent. The stimulation was applied to the supraorbital, infraorbital or mental branches of the trigeminal nerve. Recordings were made bilaterally from the sternocleidomastoid and trapezius muscles at rest. The electromyographic activity was recorded, by means of surface electrodes, from symmetrical sites on the upper half of each sternocleidomastoid muscle, 8 cm above the reference electrode on the clavicle. In the case of the trapezius muscle, the active electrode was located on the muscle belly with the reference electrode on the acromion. Electrical stimuli of 0.5 ms duration were applied to each trigeminal branch via surface electrodes fixed near the point of nerve exit from the skull bilaterally. The intensity was adjusted to reach 3 times the perception threshold and was felt to be strong but not painful. The stimulation rate was 3 Hz.

In all the subjects, we also studied the reflex during maximal voluntary contraction of the sternocleidomastoid muscle after supraorbital nerve stimulation. The subjects were instructed to maintain a maximal voluntary contraction of the sternocleidomastoid muscle by rotating their head forcibly against a resistance offered by the experimenter’s hand (12). The voluntary contraction lasted no more than 1 minute in order to avoid fatigue. The EMG was averaged from 20 msec before to 80 msec after the stimulus.

The onset latency, duration, amplitude and area of the reflex responses were measured. Amplitudes were measured peak-to-peak.

MANOVA and one-way ANOVA with post-hoc Newman-Keuls analysis were used to compare the data from the electromyographic examination. The differences were considered significant if p was less than 0.01.

RESULTS

Bilateral, one-component reflex responses were obtained regularly from all the muscles tested at rest.

Recording from the sternocleidomastoid muscle at rest after supraorbital nerve stimulation elicited the reflex with the shortest latency and the highest (although variable) amplitude (Fig. 1). After infraorbital stimulation the mean reflex latency was longer (p<0.01), while the reflex amplitude and area were reduced (Table I, see over). After mental nerve stimulation the mean reflex latency was further prolonged and the reflex amplitude and area were further reduced.

Recording from the trapezius muscle at rest after supraorbital, infraorbital and mental nerve stimulation elicited a poorly defined reflex, with a longer (p<0.01) latency and lower amplitude in comparison with recordings from the sternocleidomastoid muscle.

A bilateral, two-component reflex response was obtained when recording from the sternocleidomastoid muscle during maximal voluntary contraction (Fig. 2).

No significant (p>0.1) side-to-side differences in the reflex latency and size were found once all the stimulations had been performed.

DISCUSSION

Two main differences exist between the published methods for recording the trigemino-cervical reflex. Some studies have identified the reflex...
by recording the activity in relaxed muscle (8,9). They reported only one-component reflex responses with similar latencies to the one obtained in this study (Table II, see over). Using the same method we also obtained a trigemino-cervical reflex that consisted of only one late component.

Other authors have studied the trigemino-cervical reflex by averaging the response in tonically active muscle (10,12,13). In such cases an early reflex response appeared and the reflex presented as a two-component reflex. In the absence of background muscle activation, the early reflex response was inconsistent, and was enhanced by reinforcement maneuvers (9). Enhanced synaptic plasticity also facilitated the reflex response and evoked a double-component reflex (14). The size of the reflex responses has been found to depend on the degree of background muscle contraction, the stimulus intensity and the stimulus rate (10). It is known that the size of all reflex responses is graded more or less in line with the background muscle activity (15). The muscle activity is related to increased motoneurone activity and decreased onset reflex latency. The latency of the late reflex response obtained from active muscle was shorter than that obtained from relaxed muscle. We supposed that the late component in tonically active sternocleidomastoid muscle is the same trigemino-cervical reflex that we observed at rest but with a shorter latency. The early component latency in this study is compatible with the findings of Di Lazzaro et al. (10) and was evident only during ongoing muscle activity. This method is not easily reproducible as the level of muscle contraction is not easy to control, and the motoneurone activity is not constant. Thus, the reflex latencies will be not stable.
It is not clear which is the best site for stimulation and recording in order to obtain the clearest and most reproducible reflex response. It has been supposed that stimulation of the supraorbital (8) or infraorbital (10) nerve and recording from the trapezius and sternocleidomastoid (8) or semispinalis capitis (9) muscles allows the best reflex evaluation. According to our results the clearest and most reproducible reflex responses are obtained in the resting sternocleidomastoid muscle after stimulation of the supraorbital nerve. Responses to stimulation of the infraorbital and mental nerves showed slightly prolonged latencies, reduced amplitudes and areas but no differences in duration.

The trigemino-cervical reflex is part of a head withdrawal reflex involving the trigemino-cervical system (5). The exteroceptive and nociceptive inputs are probably transmitted through a polysynaptic route that includes the spinal trigeminal nuclei, and reach the cervical motoneurones to produce the trigemino-cervical response. The afferent pathway of the trigemino-cervical reflex involves the trigeminal fibres from the spinal tract, which are connected to the descending spinal nucleus of the trigeminal nerve (4,6). The trigeminal projections on the neck muscle motoneurones are both crossed and uncrossed (8). The input to neck motoneurones are mediated by neural networks in the lower brain stem (10). The efferent pathway follows the motor nerves of the first 3-4 cervical segments (16). The trigeminal afferent projections to neck motoneurones in cats were found to be organised in a reciprocal manner (inhibitory/facilitatory) in relation to flexor and extensor neck muscles (17). They are facilitatory to the dorsal extensor neck muscles and inhibitory to the flexor neck muscles (17). The early reflex response is probably disynaptic or oligosynaptic, resembling the early blink reflex response (9). The early reflex response is missing, except in cases involving active muscle. The late reflex response is probably an exteroceptive, polysynaptic withdrawal nociceptive reflex and could be compared with the R2 of the blink reflex (8,9). The early and late reflex responses suppress each other (9).

The trigemino-cervical reflex may be useful for detecting lesions of the caudal region of the trigeminal nucleus or the corresponding lower brain stem interneurones (11,18). It is more sensitive as a means of disclosing brain stem lesions than the R2 component of the blink reflex (10).

### Table I - Parameters of the trigemino-cervical reflex

<table>
<thead>
<tr>
<th>Recording muscle</th>
<th>Muscle activity</th>
<th>Stimulation nerve</th>
<th>Early component</th>
<th>Late component</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>latency</td>
<td>duration</td>
<td>amplitude (mV)</td>
</tr>
<tr>
<td>Sternocleidomastoid</td>
<td>Rest</td>
<td>Supraorbital</td>
<td>49.8</td>
<td>SD 7.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Infraorbital</td>
<td>51.2</td>
<td>SD 6.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mental</td>
<td>54.8</td>
<td>SD 6.0</td>
</tr>
<tr>
<td>Trapezius</td>
<td>Rest</td>
<td>Supraorbital</td>
<td>51.5</td>
<td>SD 6.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Infraorbital</td>
<td>52.8</td>
<td>SD 7.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mental</td>
<td>52.8</td>
<td>SD 7.3</td>
</tr>
<tr>
<td>Sternocleidomastoid</td>
<td>Active</td>
<td>Supraorbital</td>
<td>11.5</td>
<td>SD 5.7</td>
</tr>
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</table>
It may also be useful for evaluating lesions of the corresponding motoneurones, anterior roots and peripheral nerves (8). Schoenen et al. reported decreased excitability of brain stem inhibitory interneurones as revealed by the exteroceptive suppression of temporalis muscle activity in patients with tension-type headache (19-21). The alterations of brain stem inhibitory interneurones may be a crucial element in tension-type headache. The trigemino-cervical reflex and the exteroceptive suppression share the same afferent nerve, but the extent to which they share the same interneuronal networks is not known (9,12,22). The trigemino-cervical reflexes may constitute a further opportunity for examining the brain stem interneuronal networks and their central control.

In conclusion, the trigemino-cervical reflex may be most easily obtained from the relaxed sternocleidomastoid muscle after supraorbital nerve stimulation.

REFERENCES


<table>
<thead>
<tr>
<th>Table II - Data review of brain stem reflexes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflex</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Exteroceptive suppression</td>
</tr>
<tr>
<td>Trigemino-cervical</td>
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