Dental Pain and Sleep. Experimental Study on Guinea Pigs
(Cavia porcellus)

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The relationship between pain and sleep was studied by using electrocorticograms (ECoG) taken from guinea pigs submitted to noxious stimulation (NS) of the dental pulp of the upper incisors, after local application of serotonin (5-IT) to the obex (a brain region inductive to sleep). The results showed that the dental electrical stimulation of the sleepy animal was capable of keeping this animal in a state of vigilance and excitation, suggesting that the trigeminal system probably acts on the sleep regulating centers.

Key Words: pain, sleep, serotonin, obex, electrocorticogram.

Introduction

In spite of being a common symptom in dental practice, pain remains a very complex problem by its essentially subjective nature. Dental literature reports that toothache plays one of the most, if not the most, important role in the phenomenon of attention and vigilance. Clinical experiments have shown that it is very difficult to describe or quantify a painful sensation caused by dental caries or pulp exposition, but it is well known that an individual suffering from such pain stays alert, in a state of utmost excitation.

Until recently, most of the information about pain came from studies in humans. However, important results from neurophysiological experiments in animals have shown that the stimuli which evoked pain in humans also provoked pain in animals. Thus, pain became just a behavioral phenomenon and could be evaluated by its response to a noxious stimulus.

There are a number of relatively simple methods to measure painful sensations in animals (Shigenaga et al., 1976; Toda and Iriki, 1979; Dickenson et al., 1980; Brentegani and Lico, 1982), and evidence exists that the activation of afferent nerves of the dental pulp and adjacent structures is related to pain (Greenwood et al., 1972; Sessle, 1979; Hayashi, 1980; Toda et al., 1981; Engström et al., 1983).

The purpose of the present investigation was to study pain and its relationship to sleep, by means of local applications of serotonin (5-hydroxytryptamine, 5-IT), a recognized
synchronizing substance) to the obex (a region of the brain inductive to sleep, localized at the caudal vertex of the lozenge of the floor of the IV ventricle), and to evaluate its effect through electrocorticograms (ECoG) taken from guinea pigs submitted to noxious stimulation (NS) of the dental pulp of the upper incisors.

Material and Methods

Fifteen male guinea pigs (*Cavia porcellus*), weighing 300-500 g, were used. After superficial anesthesia, electrodes were implanted in the upper incisors for the noxious stimulation. The animals were immobilized on a stereotaxic device, and their dorsal bulbar region surgically exposed in order to fit electrodes on the cortical surface to register the ECoG.

The chemical activation of the obex was performed with 30 μg/μl of serotonin (creatinine sulfate complex, Sigma), diluted in 0.9% sodium chloride solution. The serotonin solution was topically applied with a piece of cotton-wool at the caudal angle of the IV ventricle for 10 min. The exact localization was monitored with a stereoscopical microscope (Zeiss, model OP Mi 1).

The noxious stimulus had a frequency of 5 Hz, duration of 5 ms and voltage of 5V. Records were made before stimulation (control), after application of the 5-HT and after the electrical stimulation of the teeth.

The electrocortical waves were registered with a polygraph, using silver spiral surface electrodes fixed at the brain hemisphere. The waves were processed with an analyzer, where the frequencies of the ECoG were separated by using electronic filters. The resultant tracing displayed the amplitude (in μV) of the delta, theta, alpha, beta 1 and beta 2 waves. The amplitude of the waves was quantitatively evaluated through the direct measurement (mm) of the deflection, which was indicated by the frequency analyzer.

Statistical comparisons between the numerical data were accomplished by the non-parametric Friedman’s test, and a 1% level of significance was chosen for the null hypothesis.

Results

The ECoG (Figure 1) shows that the application of serotonin on the floor of the IV ventricle produced an increase in the frequency of the slow waves (delta and theta), e.g., it drove the animal to a state characteristic of slowsleep. The mean values expressed in Table 1 reveal a statistically significant increase (P < 0.01) of the slow waves - delta and theta waves - (means, 12.82 mm and 15.06 mm), in relation to the controls (means, 5.52 mm and 6.00 mm). Table 1 shows that the values of the rapid waves (beta 1 and beta 2) are decreased (means, 2.29 mm and 2.54 mm) when compared to the controls (means, 5.16 mm and 5.25 mm).
When the animals were submitted to noxious stimulus (electrical stimulation of the dental pulp), they showed a state of extreme vigilance and excitation, as shown in Figure 1, where the rapid waves were predominant. According to the mean values shown in Table 1, there was a reversion of the anterior situation, and a significant increase to 1% of the frequency of rapid waves - beta 1 and beta 2 - (means, 11.28 mm and 11.78 mm) in relation to the controls (5.16 mm and 5.25 mm). The waves which initially presented great amplitude (delta and theta) decreased after the electrical stimulation of the dental pulp (means, 1.30 mm and 1.42 mm) when compared to the controls (means, 5.52 mm and 6.00 mm).

Table 1 - Means (in mm) of the deflection of the quantity of energy in the frequency of the delta, theta, alpha, beta 1 and beta 2 waves obtained from the electrocorticograms, resulting from the action of 5-HT topically applied on the obex, with subsequent application of noxious stimulus (NS) to the pulp of guinea pig incisors (n = 15).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Delta</th>
<th>Theta</th>
<th>Alpha</th>
<th>Beta 1</th>
<th>Beta 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>5.52</td>
<td>6.00</td>
<td>7.54</td>
<td>5.16</td>
<td>5.25</td>
</tr>
<tr>
<td>5-HT</td>
<td>12.82</td>
<td>15.06</td>
<td>7.38</td>
<td>2.29</td>
<td>2.54</td>
</tr>
<tr>
<td>NS</td>
<td>1.30</td>
<td>1.42</td>
<td>7.27</td>
<td>11.28</td>
<td>11.78</td>
</tr>
</tbody>
</table>
The after waves presented no statistical difference, when controls (mean, 7.54 mm) were compared either to the 5-HT group (mean, 7.38 mm) or the NS group (mean, 7.27 mm).

Discussion

Both clinical and experimental research have established that under normal conditions the levels of consciousness and activity in superior mammals present several states within the sleep-wake continuum. Thus, during vigilance, the electrocorticogram of the neocortex appears desynchronized, exhibiting waves of high frequency and low amplitude (beta 1 and beta 2), as well as high muscular tonus. Synchronized sleep, or slow sleep, exhibits a synchronized activity, with waves of low frequency and great amplitude (delta and theta), which may be observed as “slow waves” and/or fuses, and moderate muscular tonus. The results of the present investigation show that 5-HT, when locally applied to the floor of the IV ventricle, promotes the immediate synchronization of the ECoG (sleep), an alteration observed mainly on the components of low frequency and great amplitude, confirming the findings of Koeilia and Czicman (1966), Bronzino et al. (1972), and Yamazaki and Lico (1981).

There is classical experimental evidence - and more data are progressively accumulating - on the intimate relationship between the mechanism of pain and the control of the rest-activity cycles. The role played by the reticular system in the process of cerebral activation is well known, as well as the importance of the sensorial afferent nerves, particularly pain nerves, as stimulators of the reticular activating system, which is the effector of the alert reaction (Moruzzi, 1972).

Taking into consideration that noxious stimulus is the fundamental effector of the electroencephalographic desynchronization, the results of the present investigation show that dental electrical stimulation of a sleepy animal is capable of keeping this animal in a vigilant state, suggesting that the trigeminal system may act on the sleep regulating centers.

Although many restrictions do exist, the extrapolation of these facts from animals to human may lead one to understand the complaints of patients when they report sleepless and excited nights as a consequence of pain caused by dental abscesses, pulpitis, or even simple dental caries.

References

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