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Analogies and Differences Between Reserpine PGO Wave Discharges and Oculomotor Phasic Activity During Paradoxical Sleep in the Cat *

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In the present study the analogies and differences between phasic PGO activity of parodoxical sleep and the reserpine induced PGO waves were investigated.

The oculomotor phasic activities in chronic cats were studied. It appeared that the intrinsic organisation of latencies and the appearance of phasic waves in the four structures studied were common to both experimental situations. However the sequential patterns of discharges were different in PS and under reserpine treatment.

The phasic ponto-geniculo-occipital activities (PGO waves) during paradoxical sleep (PS) have been well described (1, 5, 8). On the other hand the drug reserpine produces a depletion of transmitter in the monoaminergic neurons (4) and creates a continuous discharge of phasic waves (called reserpine PGO waves) dissociating them from the other signs of PS (7, 8). The organisation and latencies of the PGO in the oculomotor system during PS were described (5). Posteriorly a slightly different organisation was found in the reserpine-PGO in the oculomotor system (3). Other authors found that there were no measurable latencies between the phasic activities of PS, and that they resembled the PGO-Reserpine waves (2). Therefore we thought to study systematically the phasic waves (PGO) in the pontine oculomotor nuclei (abducens nuclei) and the concomitant phasic activity in the lateral rectus muscle of the eye (PALRE) during PS and after reserpine injections in the same chronic cats. We hope this study will clarify some of the

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discrepancies found in the literature between the phasic phenomena of these two experimental situations.

Materials and Methods

Seven adult cats were used in this study. Under Nembutal anesthesia (30 mg/kg I.P.) bipolar electrodes were implanted bilaterally in the VI nuclei of the pons. Two nichrome wires (0.1 mm in diameter) were placed bilaterally in the lateral rectus muscles of the eyes. Cortical epidural electrodes were placed over the lateral gyrus. Neck muscle electrodes completed the preparation. The cats were placed in a sound-proof room and the paradoxical sleep phases were monitored on an 8 channel Grass polygraph. The phasic activities were simultaneously stored on magnetic tape for ulterior statistical analysis with a PDP-12 computer. The phasic waves were displayed in a Tektronix 502A oscilloscope and filmed with a Grass C-4 camera for calculating the latencies. Statistical computer analysis of PGO waves consisted of autocorrelation studies of the intervals between the phasic waves. After a week of control sessions reserpine (Serpasil-Ciba) was intraperitoneally (0.5 mg/kg) and the animals were studied chronically in the same conditions as in the control experiments. After killing the animals with an overdose of Nembutal, histological control confirmed the accurate electrode placement in the VI nuclei.

Results

Paradoxical sleep (PGO waves). During this phase there were phasic activities bilaterally in both VI nuclei and in both lateral rectus muscles of the eyes. Cortical EEG was desynchronized (fig. 1). Records with high paper speed showed the appearance of phasic waves in the four

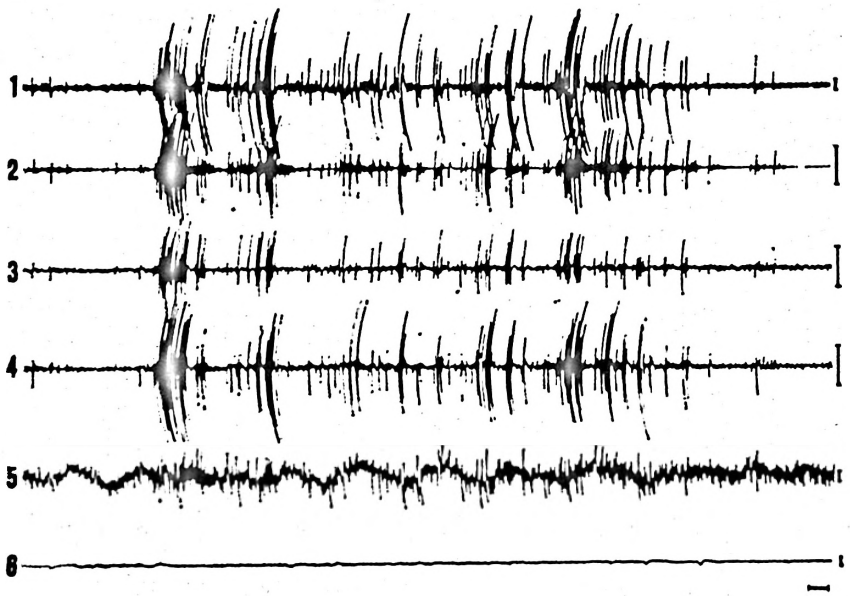

Fig. 1. *The EEG record during paradoxical sleep in a cat.*
1. Phasic discharges in the right lateral rectus muscle of the eye; 2. Left lateral rectus muscle; 3. PGO in the right VI nucleus; 4. PGO in the left VI nucleus; 5. Cortical EEG (occipital region); 6. EMG of neck muscles. Calibrations: 2 seconds, 50 μV.

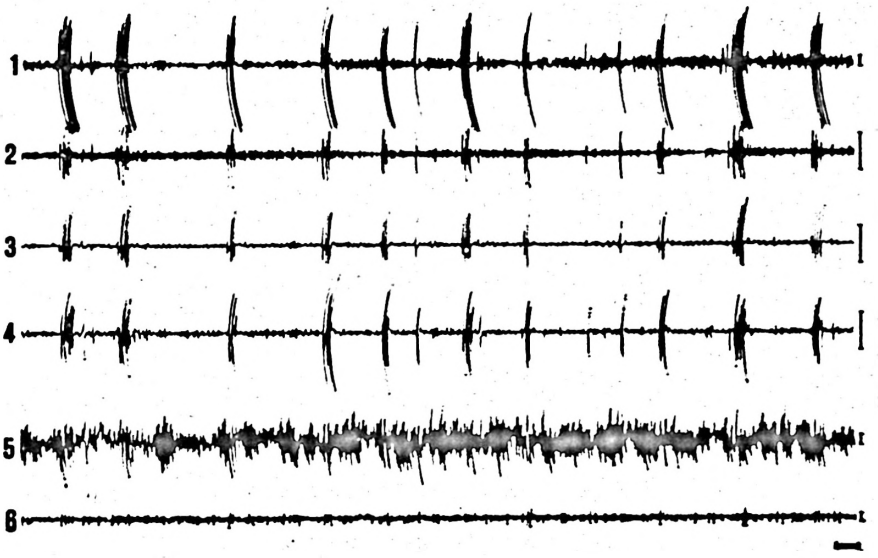

Fig. 2. *The EEG record after Reserpine treatment in a cat.*
Same cat as in figure 1. Notice the regular pattern of phasic discharges as compared with those of paradoxical sleep, and the modifications of EEG cortical activity. 1-6, same denominations as in figure 1. Same calibrations.

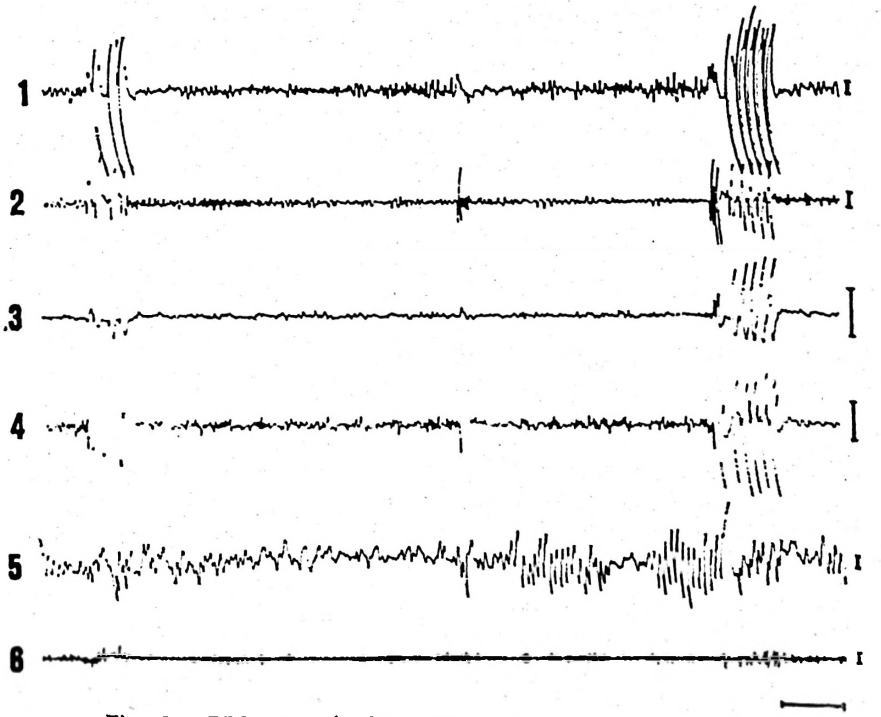

Fig. 3. *EEG record after Reserpine treatment in a cat.*
Notice with this higher paper speed, the details of the concomitant phasic discharges in both VI nuclei and in both lateral rectus muscles of the eyes. Calibrations: 1 second, 50 μV.

structures mentioned. The oscillographic study disclosed two different types of latencies (4 msec. and 24 msec.) with the phasic discharges in the eye muscles (fig. 5-A). Autocorrelation studies show (fig. 5-C) that the PGO waves during paradoxical sleep present a random character and that there are no particular intervals which appear predominantly.

Reserpine Treatment (Reserpine PGO waves). During the fully reserpinized syndrome (12 hours after the injection) phasic PGO-Reserpine waves were recorded bilaterally in both VI nuclei and concomitant phasic activities in both lateral rectus muscles of the eyes (fig. 2). Cortical EEG presented a modified pattern as compared with PS. Records taken at higher speed (fig. 4) objectivized this appearance of phasic waves in the four structures studied. Oscilloscope studies showed that during Reserpine there are also two types of PGO waves in the VI nuclei (fig. 5-B) and that they also have two different types of latencies. However, the main difference with the PS discharges consisted of the regular discharge of PGO-Reserpine waves (figs. 2 and 4). They were grouped in bursts of waves regularly spaced.

Autocorrelation studies (fig. 5-D) showed that the phasic discharges were not distributed at random any more and objectivized the recurrent appearance of particular intervals.

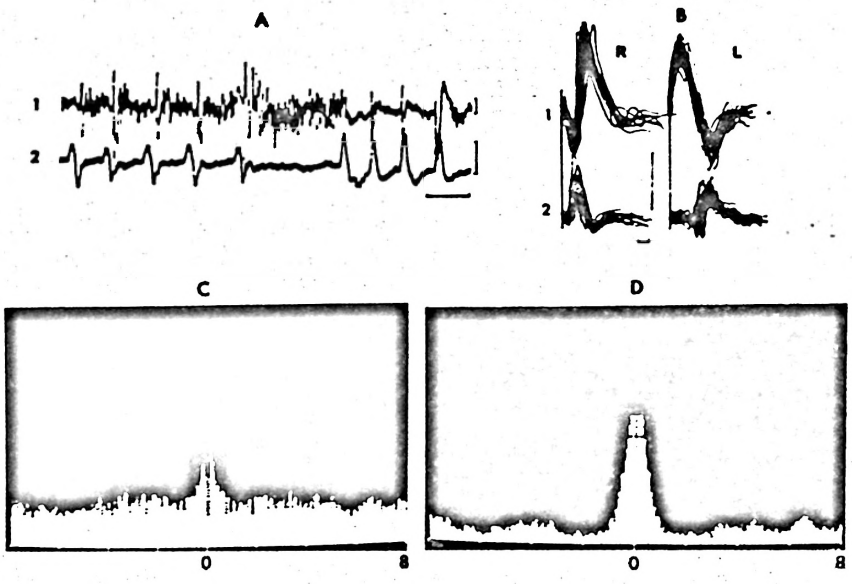

Fig. 4. *Latencies and computer analysis of PGO during paradoxical sleep and after Reserpine.*

A: Record during paradoxical sleep of phasic activity in the lateral rectus muscle 1 and PGO in the homolateral VI nucleus 2. Calibrations: 200 msec, 100 μV. Notice the 2 different types of PGO in the VI nucleus and the 2 different latencies with the phasic discharges in the muscles. B: PGO waves under Reserpine in the VI nucleus 1 and phasic activity in the homolateral lateral rectus muscles 2 in the right (R) and left (L) sides. Calibrations: 10 msec, 100 μV. Notice the 2 different latencies and the 2 different forms of PGO-VI similar to those of paradoxical sleep. C: Autocorrelation of intervals between PGO wave discharges in the VI nucleus during paradoxical sleep in a cat. Analysis time 8 seconds. O = origin. D: Autocorrelation of Reserpine PGO intervals in the same cat as in C. Notice the periodicities present now. Analysis time 8 seconds. O = origin.

Discussion

This study indicates that the PGO-waves during PS have some common characteristics with the Reserpine induced waves but that they are not similar phenomena as was previously advanced (2). Organisation of PGO waves and the sequential order of discharges of the phasic activities in the oculomotor and visual system were described (5). Posteriorly other authors (3) advanced that there was no phasic activity in both lateral rectus muscles during reserpine studies and extrapolated their results to interpret a model of PGO organization applying also to PS.

They used acute animals and probably other recording methods in the rectus muscles but the present results confirm that in the chronic cats there are phasic activities in both rectus muscles in PS and under reserpine. Moreover the latencies between the rectus muscles discharges, and the two types of PGO waves in the VI nuclei were the same in both experimental situations. But perhaps the most striking differences remain in the two different patterns of phasic discharges.

This different temporal sequential discharge indicate that the mode of generation of PGO waves during paradoxical sleep and during reserpine treatment is not the same. In addition the pharmacological spikes are not accompanied by the other behavioral and physiological signs of paradoxical sleep. During drug induced spikes the monaminergic structures of the lateral pontine tegmentum (locus ceruleus) (8) control directly the release of phasic waves in the oculomotor system. During paradoxical sleep other structures such as the vestibular nuclei (11) seemed to have an important role to play in phasic PGO waves and contributed to their modulation. The organisation of PGO waves is created in the premotor area (10) of the pontine reticular formation from where, through crossed and uncrossed pathways of the vestibulo-oculomotor system (9), the PGO appear in the effector sites (VI nuclei and lateral rectus muscles). This study stress therefore the paramount importance of the difference in the temporal sequential patterns in both situations which do not allow pharmacological studies (6) of drug interrelations with reserpine (or parachlorophenylalanine PCPA), to be extrapolate to other situations (paradoxical sleep) in order to discriminate the transmitter mechanisms involved in this particular phase of the sleep-wakefulness cycle.

Resumen

Se estudian las analogías y diferencias entre las actividades fásicas PGO del sueño paradójico y las ondas PGO inducidas por la reserpina, así como las actividades fásicas del sistema oculomotor en gatos crónicos. La organización intrínseca de las latencias y la aparición de las ondas fásicas en las cuatro estructuras estudiadas, son comunes a ambas situaciones experimentales. Sin embargo, las pautas secuenciales de las descargas son diferentes en el sueño paradójico y bajo tratamiento con reserpina.

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