Spinal Reflexes in Normal Unrestrained Cats During Sleep and Wakefulness

It is known that the muscular tone and particularly that of the nuchal muscles is reduced during light sleep with synchronized EEG activity and abolished when the desynchronized phase of sleep (deep sleep) occurs[1]. Moreover, it was shown that the spinal reflexes recorded from synergic muscles were abolished during deep sleep[2]. The aim of our investigation was to study (a) the behaviour of monosynaptic (MR) and polysynaptic (PR) reflexes, (b) the threshold variations of MR and PR and (c) changes in post-tetanic potentiation in normal unrestrained cats with chronic implanted electrodes during the different phases of sleep and wakefulness.

Bipolar stimulating electrodes were chronically implanted in the vertebral bone and applied to L_7 dorsal root. Bipolar recording electrodes were placed around the sciatic nerve of the same side where the dorsal root was stimulated. The EEG (from the frontoparietal cortex of each side), the EMG (from nuchal muscles) and ocular movements were recorded on an inkwriter electroencephalograph. The MR and PR were seen on an oscilloscope. The MR and PR were integrated on a CAT 400 Mnemotron apparatus in order to have an averaging of their amplitude during *attentive wakefulness*, *relaxed wakefulness or light sleep and deep sleep*. The following results were obtained:

(1) A single shock of 0.01–0.05 msec duration delivered every second to L_7 dorsal root with an intensity (0.10 mA) just liminar for group Ia muscle afferent fibres evoked in the sciatic nerve a 'direct' response with 2 msec latency, followed by a monosynaptic reflex which generally appeared after a constant latency of 5 msec.

When the animal was *awake* and *alert* the MR usually appeared to be very inconstant in amplitude. The amplitude of 'direct' response was instead constantly the same indicating that the stimulating and recording conditions remained unmodified. Normally, during the phase of attentive wakefulness, good activity was spontaneously present on the sciatic nerve.

(2) When the signs of *light sleep* appeared on the EEG and EMG the MR became somewhat more stable. An integration of a hundred or more responses showed only a slight reduction of 15% as compared with wakefulness.

(3) As the animal went into an episode of *deep sleep* (with desynchronized EEG activity, flattening of nuchal EMG and ocular movements) the amplitude of MR was dramatically reduced and soon disappeared. Usually this phenomenon appeared synchronously with the desynchronization of the EEG but a few seconds before the tone of the nuchal muscles went to zero. It was paralleled by an abolition of spontaneous activity in the sciatic nerve. Sometimes, however, a small MR reappeared on the sweep during deep sleep. An integration of a hundred or more responses during this phase of sleep showed a complete absence of MR or a marked reduction of its amplitude up to 90% of the amplitude of an equal number of responses integrated during wakefulness. Also during all phases of sleep, the 'direct' response was unmodified indicating that stimulation and recording conditions were the same.

(4) The threshold of Ia muscle fibres for evoking a MR was, during wakefulness, only slightly lower (about $^1/_6$) than the threshold observed in light sleep. During deep sleep the same threshold rapidly increased up to 2.8–3 times the value of the wakefulness. Such an intensity of stimulation usually aroused the animal, possibly through an excitation of fibres other than that of group Ia.

(5) Dorsal root excitation with stimuli above threshold for group Ia afferent fibres evoked on the sciatic nerve a polysynaptic reflex with a latency of 15–20 msec. The amplitude of PR during *wakefulness* was rather inconstant although always evoked by the stimulus. In *light sleep* the PR became slightly more stable. As the phase of *deep sleep* appeared, the PR disappeared completely and never reappeared again for the entire period of desynchronized sleep.

(6) Tetanic stimulation of dorsal root for 7 sec at 300/sec strongly potentiated the MR for 60–100 sec during both wakefulness and light sleep. In deep sleep post-tetanic potentiation was completely abolished even for intensity of stimulation up to 1.8 times the threshold used in wakefulness and light sleep.

(7) Complete transection of the spinal cord at T_9 definitely abolished the fluctuation of MR and PR during attentive wakefulness and light sleep. In these experimental conditions the spinal reflexes remained unchanged during the episodes of deep sleep and post-tetanic potentiation of MR was easily produced regardless of the phase in which it was tried.

The results briefly reported above allow some conclusions: (a) The activity of spinal motoneurons and interneurons are under a tonic supraspinal control which fluctuates amply during attentive wakefulness and becomes more stable during relaxed wakefulness and light sleep. (b) The complete abolition or marked reduction of MR and PR during deep sleep may be due either to a withdrawal of facilitatory influences or to a tonic barrage of inhibitory impulses which inpinges upon spinal neurons. Recent results[3] would suggest the latter interpretation. (c) The disappearance of spinal reflexes before the tone of nuchal muscles is abolished would indicate that the proprioceptive activity from the neck does not play an important role in the abolition of spinal reflexes during deep sleep. (d) The occasional reappearance of MR during deep sleep would suggest a somewhat fluctuating inhibitory control by supraspinal structures on spinal neurons even during this phase of sleep. (e) Increase of threshold of Ia afferent fibres for the MR and abolition of post-tetanic potentiation during deep sleep indicates that the excitability of spinal structures which take part in the proprioceptive reflex and its potentiation is markedly depressed during that phase of sleep.

Our results do not allow any fair inference as to the site (whether presynaptic or postsynaptic) and to the origin of supraspinal descending influences responsible for the phenomena observed.

Riassunto. I riflessi spinali monosinaptico (MR) e polisinaptico (PR) variano in ampiezza ma sono sempre presenti nella veglia e sonno leggero. Nel sonno profondo il MR e PR sono aboliti; la soglia del MR è innalzata e la potenziazione post-tetanica abolita.

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