Segmental reflex responses of the lumbosacral region of the spinal cord to stimulation of peripheral afferents were studied in immobilized decerebrate cats before and after application of D-tubocurarine or bicuculline to the superior cervical segments, potentiating the scratch reflex, and also during fictitious scratching evoked by mechanical stimulation of the ear. Application of these substances led to inhibition of the N1-component of the dorsal cord potential, the dorsal root potential, and polysynaptic responses in efferent nerves. The appearance of fictitious scratching was accompanied by additional tonic inhibition of these responses, against the background of which modulation of the amplitudes of the responses was observed depending on the phase of fictitious scratching. Modulation of amplitudes of monosynaptic reflexes also developed during fictitious scratching. Against the background of these results the mechanisms and physiological role of reorganization of segmental responses during activation of the spinal scratching generator are discussed.

INTRODUCTION

It was shown previously [1] that application of tubocurarine or bicuculline to the superior cervical segments, facilitating the appearance of fictitious scratching, causes lasting primary afferent depolarization (PAD) of the lumbosacral enlargement. The appearance of fictitious scratching in response to mechanical stimulation of the ear is accompanied by additional tonic depolarization of afferent endings, against the background of which periodic changes in the rhythm of efferent activity take place. Under these circumstances the maximum of the periodic changes in PAD occurs at the end of the "induction phase" and at the beginning of the "scratching phase" [1, 3]. Stable depolarization evoked by application of the drugs and tonic depolarization during fictitious scratching were observed in terminals of all groups of afferent fibers investigated (both cutaneous and muscular, of groups Ia and Ib). Periodic changes were found only in endings of cutaneous fibers and group Ib fibers. It was concluded that the spinal scratching generator modulates the level of depolarization of central terminals of primary afferents.

Modulation of PAD by the spinal scratching generator must evidently be accompanied by corresponding changes in effectiveness of synaptic transmission from afferents to postsynaptic neurons. This, in turn, ought to be reflected in segmental responses evoked by afferent stimuli. The object of the present investigation was to study the reorganization of segmental responses during operation of the spinal scratching generator.

EXPERIMENTAL METHOD

Experiments were carried out on adult cats. The preparatory operation was performed under ether anesthesia. Nerves of the hind limb (n. suralis, n. peroneus superficialis, n. peroneus profundus) and also muscular branches to m. posterior biceps and m. semitendinosus, m. gastrocnemius, and m. flexor digitorum longus were dissected. Sometimes a branch to m. tibialis anterior and a branch to m. extensor digitorum longus were isolated from n. peroneus profundus. After laminectomy in the lumbar and upper cervical regions, decerebration was

Fig. 1. DCP, DRP, and ventral root potential (VRP) evoked by stimulation of n. peroneus superficialis before (a) and 10 min after (b) application of D-tubocurarine to upper cervical segments. Potentials recorded in segment L7. Strength of stimulating current relative to threshold value indicated above traces. Traces in (a) and (b) recorded under identical conditions.

performed at the intercollicular level, the ether anesthesia was stopped, and the animal was fixed in a stereotaxic frame and immobilized with D-tubocurarine. The dorsal root potential (DRP) and the dorsal cord potential (DCP) were recorded in segments L5-L7 by the usual method. Efferent activity was recorded from one or more isolated peripheral nerves or from a filament of ventral root L7. Just as previously [1, 3], a piece of cotton soaked in a solution of D-tubocurarine or bicuculline was applied to segments C1 and C2 to facilitate the appearance of fictitious scratching in response to mechanical stimulation of the ear.

EXPERIMENTAL RESULTS

The effect of application of bicuculline or tubocurarine to the cervical segments usually appeared after 5-10 min; after a time interval of that length fictitious scratching could already be elicited by mechanical stimulation of the ear. This time interval was called the period of tuning of the spinal scratching generator [1]. Examples of changes in responses of the lumbar portion of the spinal cord to stimulation of n. peroneus superficialis, after application of tubocurarine to the upper cervical segments, are given in Fig. 1. Clearly at the end of the tuning period the N1- and P-components of DCP, the dorsal root reflex, DRP, and the polysynaptic response in the ventral root were all reduced. DP~ and the polysynaptic responses to stimulation of muscular afferents underwent similar changes.

This depression of segmental responses toward the end of the tuning period took place parallel with an increase in stable PAD [1]. As pointed out previously [3], the effect of application usually reached a maximum after 30-40 min. Throughout that time a progressive rise of PAD and fall of spinal evoked potentials were observed. After 30-40 min responses evoked by a weak stimulating current (not more than 2 thresholds) could disappear completely. Most responses to stronger stimulation were depressed only to a certain level, but in this case the discharge in the ventral root could disappear completely. Sometimes the response in the ventral root was absent by the end of the tuning period.

Similar effects were observed after application of bicuculline. Usually fictitious scratching became more intensive after this application and the changes in PAD and evoked potentials were more marked.

During fictitious scratching the amplitude of evoked responses was definitely dependent on the phase of activity of the spinal scratching generator. Changes in the N1-component of DCP during fictitious scratching are illustrated in Fig. 2. During the "initial aiming" and the rhythmic "aiming" phases the N1-component of DCP evoked by stimulation of the cutaneous nerve was depressed compared with the amplitude of the control response. At the beginning of the "scratching phase" this component was additionally depressed and, as the results of the previous investigation [1] show, this corresponded in time to the maximum of the negative wave of DRP evoked by activation of the scratching generator (Fig. 2a, b). These changes were manifested most clearly during comparatively weak stimulation of the cutaneous nerves (2-5 thresholds).

Dependence of the amplitude of evoked DRP on the phase of fictitious scratching is shown in Fig. 3. DRPs evoked by low-intensity stimulation of cutaneous or muscular afferents could