On the Function of Corticothalamic Neurons

Abstract: The effect of the synchronous discharge of a large population of corticothalamic neurons on activity within the somatosensory relay nuclei has been studied. Thalamic responses to peripheral nerve stimulation are depressed by activity in corticothalamic neurons. A subconvulsive dose of strychnine, given intravenously, changes this depression to enhancement.

The existence of corticothalamic neurons projecting from the cortical receiving areas to the specific thalamic relay nuclei has been recognized for many years, yet little is known of their physiological significance. In order to study the function of these cells it is necessary to activate them in large numbers and synchronously, yet selectively, without firing the nearby thalamocortical neurons antidromically. This may be achieved through the application of penicillin to the cortex as a means of initiating a repetitive high-voltage cortical discharge, the "penicillin spike." It is the purpose of this communication to describe marked alterations in the amplitude of thalamic-evoked responses elicited after a penicillin spike. Forty-seven cats deeply anesthetized with Nembutal were used in this study.

After stimulation of the somatosensory pathway it is possible to record an evoked response from the ventrobasal thalamus: a brief, initially positive, diphasic spike followed by a small negative and a large, slow positive wave. If this thalamic response is initiated during or after a cortical penicillin spike, the negative and late positive waves are greatly reduced or abolished, provided the penicillin spike was generated in the specific cortical receiving area of the nucleus from which the recording was made. Thus, the application of penicillin to somatosensory cortex I generates penicillin spikes which markedly depress the ventrobasal thalamic responses to stimulation of the sciatic or radial nerve or the medial lemniscus. On the other hand, penicillin spikes generated in the auditory or visual cortex have no effect on the responses evoked in the ventrobasal thalamic nuclei.

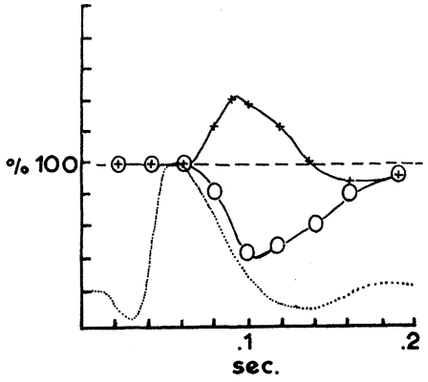

Fig. 1. Effect of the penicillin spike on the ventrobasal thalamic response to stimulation of the medial lemniscus before (circles) and after (crosses) intravenous administration of 0.1 mg of strychnine per kilogram. (Vertical axis) Average amplitude of the late positive wave from 50 thalamic responses represented as a percentage of the control value. (Horizontal axis) The penicillin spike (dotted line) diagrammatically displayed against time.

An important clue to the mechanism by which a cortical discharge may depress thalamic activity is seen in the effect on such activity of a subconvulsive dose of intravenous strychnine. Three to four minutes after intravenous administration of 0.1 mg of strychnine per kilogram, the penicillin spike, rather than depressing the thalamic-evoked response, actually enhances the late positive wave. This is illustrated in Fig. 1. The amplitude of the late positive wave of the ventrobasal thalamic response to medial lemniscal stimulation is represented on the vertical axis as a percentage of the control value. Each point represents the average of 50 responses. On the horizontal axis the cortical penicillin spike in shown diagrammatically (dotted line). It may be seen that before the administration of strychnine the thalamic test response is greatly depressed when it is elicited after the peak of the cortical penicillin spike (circles). Five minutes after the intravenous administration of 0.1 mg of strychnine per kilogram, the depression is abolished and the thalamic response is greater than for the control (crosses). Neither the penicillin spike itself nor the thalamic-evoked response alone is affected by the strychnine.

The possibility that the thalamic depression is caused by activation of the brainstem reticular formation (see *1*) is considered unlikely because of the depth of the anesthesia used. A second possibility, that the thalamic depression is due to antidromic backfiring of thalamocortical neurons, is also considered extremely unlikely because of the action of the strychnine in reversing the depression. Strychnine, in the amount used here, has been shown to be very effective in blocking inhibitory synapses in the spinal cord of the cat (*2*). Since synapses would not be involved in thalamic depression caused by antidromic activation of thalamocortical neurons, it is inferred that the depression is in fact mediated trans-synaptically through corticothalamic neurons. A reasonable hypothesis to explain the above observations is that the penicillin spike activates corticothalamic neurons with both excitatory and inhibitory thalamic synapses, the latter being predominant. The strychnine, in selectively blocking the inhibitory synapses, abolishes the depression of thalamic activity which they cause and permits expression of the previously masked, less potent excitatory activity. It is suggested that the corticothalamic projection system may provide a form of inhibitory sensory feedback which could function to reduce the subliminal fringe about a zone of maximal excitation in the thalamus. This might serve to distinguish the boundaries between one such zone and another and provide a form of sensory "focusing" (*3*).

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References and Notes

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3. This study was supported by a grant from the European Research Office, U.S. Department of the Army.

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Occurrence of Scandium-46 and Cesium-134 in Radioactive Fallout

Abstract. Two hitherto unreported induced radionuclides, scandium-46 and cesium-134, have been detected in fallout material. Identification was made by chemical separation and gamma scintillation spectrometry. While the origin of these materials is not known, possible routes of formation from stable elements are suggested.

Soil samples (*1*) collected a few yards from ground zero by vacuum sweeping after an atomic detonation (balloon shot) in Nevada were sent to the Robert A. Taft Sanitary Engineering Center for radiochemical analyses.

An analysis of the gamma spectrum of an aliquot of the soil was made approximately 60 days after collection. After digestion and leaching of activity presumably fused on the soil, an aliquot of the leach solution was simultaneously analyzed. The gamma spectra are shown in Fig. 1; they indicate the presence of gamma emitters whose energies are near 0.6, 0.8 to 0.9, and 1.1 Mev, respectively. According to data calculated by Hunter and Ballou (*2*), the predominant fission-product contributors to the total activity 60 days after detonation should be Zr^{95}-Nb^{95}, Ce^{141}, Y^{91}, and Sr^{89}. Since none of these nuclides has gamma energies corresponding to the photopeaks observed, analyses of the important fission products for specific radionuclides were performed.

After separation (*3*) of the major fission products—strontium, cesium, zirconium-niobium, and rare earths—we were unable to assign the 0.9 and