REPRESENTATION OF IPSILATERAL-EXTREMITIES IN THE CEREBRAL CORTEX[1]

THE problem of the innervation of the extremities by the ipsilateral cerebral hemisphere has long been a very controversial subject. Recently, in the course of a series of experiments in which the cerebral cortex was stimulated electrically, movement was frequently elicited in the ipsilateral extremities.[2,3] Monkeys, *Macaca mulatta,* were largely used for the present study, although ipsilateral responses were also obtained in a few baboons, *Papio papio,* and chimpanzees, *Pan satyrus.* The "ipsilateral area" was sharply localized in the cerebral cortex. It occupied an area 3–4 mm in diameter about a point in the middle of the superior lip of the superior precentral sulcus. The center of this area was invariably the most excitable and on microscopical examination was always found to lie in the premotor cortex (Area 6 of Brodmann).[4] The entire excitable area, however, although lying largely in Area 6, extended slightly into the anterior part of the true motor cortex (Area 4). The threshold of this area for ipsilateral responses was always somewhat higher than the threshold of the true motor cortex or of the premotor cortex for contralateral responses. The responses elicited in the ipsilateral lower extremity usually consisted of extension at all joints although occasionally flexion, rotation, etc., occurred. Responses in the ipsilateral upper extremity were usually flexor in type and were much less frequently observed and more difficult to elicit than those in the lower extremity. Movement of the upper extremity, when seen, was most commonly obtained from just below the superior precentral sulcus.

In animals with intact spinal cords the ipsilateral responses were almost invariably associated with movements in the contralateral extremities of the opposite type, *i.e.,* extension of the ipsilateral lower extremity was associated with flexion of the contralateral. However, section of the contralateral half of the spinal cord in the mid-dorsal region abolished the response in the contralateral lower extremity without affecting that in the ipsilateral. This demonstrated not only that the two are independent phenomena but that the conducting pathway for the ipsilateral response occupies the ipsilateral half of the spinal cord. The elicitation of the ipsilateral response after removal of Areas 4 and 6, the main cortical motor projection system, of the opposite hemisphere and after section of the corpus callosum demonstrated that the response was not dependent upon the contralateral half of the encephalon.

The use of any of the barbituric acid derivatives as anesthetic agent or of deep ether anesthesia prevented the elicitation of the ipsilateral response. All experiments were, therefore, conducted under very light ether anesthesia.

Isolation of the "ipsilateral area" from the "leg area" of the true motor cortex lying just posterior to it, by an incision of the cortex, extirpation of the "leg" area or the application of novocaine to the "leg area," greatly enhanced the ipsilateral response. This was in accord with somewhat similar experiments of Dusser de Barenne and Marshall.[5]

Ablation experiments were in agreement with the results of stimulation. A remaining motor or premotor area in one hemisphere only is capable of integrating movement in the ipsilateral as well as the contralateral extremities, whereas an animal with the motor and premotor areas removed from both hemispheres is completely incapacitated.

Clinical experience in human cases supports the findings in the monkey. Foerster[6] elicited movement in the ipsilateral thigh by electrical stimulation of the premotor area of the human cerebral cortex, whereas a patient from whom Gardner[7] had removed the greater part of one cerebral hemisphere, including all of the motor and premotor areas, had sufficient use of the extremity contralateral to the extirpation to be able to walk with a cane.

The conclusions from these facts are that the motor and premotor areas of the cerebral cortex of primates are capable of integrating movement in the ipsilateral extremities and that in monkeys the area most excitable, electrically, for ipsilateral responses lies about the superior precentral sulcus in the premotor cortex.

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[3] P. C. Bucy, "Electrical Excitability and Cytoarchitecture of the Premotor Cortex in Monkeys," *Arch. Neurol. and Psychiat.* (In press.)

[4] K. Brodmann, "Vergleichende Localisations lehre der Grosshirnrinde," Leipzig; Barth. 1090. 304 pp.

[5] J. G. Dusser de Barenne and C. S. Marshall, "On a Release Phenomenon in Electrical Stimulation of the 'Motor' Cerebral Cortex," SCIENCE, 73, 213–214, 1931.

[6] O. Foerster, "The Cerebral Cortex in Man." (Unpublished stenographic notes of lectures delivered at University College, London, April, 1931.) Brief résumé, *Lancet,* 2, 309–312, 1931.

[7] W. J. Gardner, "Removal of the Right Cerebral Hemisphere for Infiltrating Glioma," Trans. Phila. Neurol. Soc., *Arch. Neurol. and Psychiat.,* 28, 470, 1932.

BOOKS RECEIVED

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