Thalamic Inhibition of the Myotatic Reflex in Man*

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During the evolution of subcortical surgery in the treatment of parkinsonism, it has become increasingly apparent that some of the most effective therapeutic lesions are those placed in the vicinity of the nucleus ventralis lateralis of the thalamus. Stereotactic techniques of various types have been devised which now provide more than adequate mechanical accuracy. However, similar accuracy in the geographical definition of the subcortical target has not been forthcoming. It is known that the use of bony landmarks as points of reference is highly unreliable. Anatomical studies are now available which demonstrate that greater reliability can be achieved by utilizing the anterior and posterior commissures as the points of reference. But the biological variation from one brain to another has also been shown to be sufficiently great that discrete placement of an electrode in the exact center of a subcortical target such as the nucleus ventralis lateralis (V.L.) is not possible on the basis of stereotactic coordinates alone. These problems of spatial indetermination led Bailey¹ in 1957 to emphasize the importance of finding "physiological methods of checking the point of the needle." Unfortunately, discrete physiological motor functions which can be assigned to V.L. have not been demonstrated until relatively recently.

It is now known that inhibition of the knee jerk² and of the muscle-spindle discharge¹¹ of the hind limb can be evoked by stimulation of the contralateral ventrolateral nucleus of the thalamus in the cat. This inhibition is felt to be a reflection of the inhibition of that fraction of the motor system referred to as the gamma efferent system⁴,⁹,¹¹ which innervates the muscle spindles. This system is schematized in Fig. 1. It will be noted that the muscle spindle is a stretch receptor which lies in parallel with the striated muscle fibers. Each spindle is composed of a central sensory element which is sensitive to stretch and two polar contractile elements which are innervated by the gamma efferent fibers. Activation of these small gamma efferent fibers causes contraction of the polar elements of the spindle increasing the stretch on the equatorial annulo-spiral ending and making it more sensitive to stretch. When sufficient stretch is applied to the entire mass of muscle to activate the annulo-spiral sensing element, a volley of impulses is transmitted back to the cord over fast-conducting fibers in the dorsal root which terminate monosynaptically on the alpha motoneuron in the anterior horn. This feed-back loop appears to play an essential role in motor movement. The spindle registers the difference in length between the main mass of muscle and itself, whereupon the servo loop

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acts to reduce this difference. Steady voluntary or postural contraction is a result of its tonic innervation and consequent facilitation of the alpha motoneuron via this servo loop. When the entire mass of muscle is stretched suddenly, a volley of impulses is transmitted back to the cord exciting the anterior horn cells which in turn produce contraction of the mass of striated muscle. This is the basis of the myotatic reflex of which the knee jerk is an example. Since Stern and Ward have shown that stimulation of V.L. in the cat produced consistently inhibition of the afferent discharge of the contralateral spindle, activation of V.L. in the human should depress or abolish the contralateral knee jerk. This phenomenon might thus be utilized to provide physiological identification that the tip of the stereotactically placed electrode lies within the nucleus ventralis lateralis of the thalamus.

Observations of the effect of stimulation of V.L upon myotatic reflexes in the unanesthetized human would also provide essential physiological data. The experiments of Stern and Ward on cats were carried out using barbiturate anesthesia. Because barbiturates are known to profoundly alter supraspinal mechanisms of motor control, it was feared that the physiological validity of the data reported in the cat might be subject to serious question. Since there are almost insurmountable technical difficulties in studying the gamma system in the unanesthetized animal, confirmation of these findings in the unanesthetized human would be highly desirable. Since we have been placing an electrode into V.L. for several years in the course of operations for parkinsonism, electrical stimulation of this thalamic nucleus is carried out easily. This opportunity has been utilized to study the role of the nucleus ventralis lateralis in modulating the activity of the muscle spindle in unanesthetized humans. It was also hoped that physiological confirmation of the target would result in the production of thalamic lesions which would be more effective in reducing the motor disability in these patients.

Methods

Electrolytic thalamotomy was carried out in a similar fashion in all of the patients included in this study. Following premedication with Phenergan, 25 mg. intramuscularly, trephination was performed in the vicinity of the coronal suture under local anesthesia. The Planisphere, a stereotactic instrument of our own design, was then attached to the skull. The frontal horn of the lateral ventricle was then punctured under stereotactic control and sufficient air was injected to demonstrate the anterior and posterior commissures. From these films taken in the operating room, the necessary simple calculations were made and a unipolar electrode was delivered to the target in the nucleus ventralis lateralis of thalamus based on coordinates obtained from an atlas of the human brain. The electrode was insulated except for 4 mm. at its tip. Stimulation of V.L. was carried out utilizing a Grass stimulator delivering 1 msec. biphasic pulses at a frequency of 60 c./sec. for the observations dealing with modulation of myotatic reflexes. With the electrodes used, the threshold for inducing inhibition of the knee jerk was 3–5 V. and all of the observations reported here were a consequence of stimulation at 3–7 V. At higher voltages, spread of current to adjacent structures is induced. Stimulation of higher voltage (up to 18 V.) was always carried out to provide a crude index of the distance of the stimulating electrode from other structures such as the internal capsule or the nucleus ventralis posterolateralis. Thus, in the dominant hemisphere, a lesion was not carried out if blocking of speech could be obtained at 12 V. even though, at low voltages, apparent physiological confirmation of the position of the electrode in V.L. was obtained. Presumably, under these circumstances, the electrode lay in the lateral portion of V.L. and a spherical lesion could be anticipated to produce damage to adjacent fibers in the capsule.

Observations on myotatic reflexes during stimulation of V.L. were made by observing changes in the knee jerk evoked by a 1/sec. repetitive blow to the patellar tendon which was delivered manually. Only marked reduction or complete inhibition of the knee jerk temporally related to stimulation of V.L. was recorded on the protocol. If minor alterations of amplitude of the knee jerk were to be recorded, it would be necessary to evoke the knee jerk by electromechanical means and record the excursions by gauges of displacement. But this was not considered to be necessary since interest was centered only on obvious and rather dramatic changes in the reflex.

The majority of observations were carried out on patients with parkinsonism although limited data were obtained in patients with a variety of