

axons and terminals of the catecholamine and 5-HT neurons alike, with the exception that a small number of terminals were still observed with the lowest dose. An almost complete recovery occurred 20 h after the administration of the lowest dose. The terminals showed, however, somewhat reduced fluorescence intensity. With the higher dose also, the cell bodies of the catecholamine neurons had a somewhat reduced intensity.

**Zusammenfassung.** Die Zunahme von 5-HT, welche sich im Gehirn der Ratte nach Verabreichung von chemisch sehr verschiedenen Ganglienblockern vollzieht, konnte mit Hilfe einer hochempfindlichen histochemischen Methode auf spezifische 5-HT-Neuronen lokalisiert werden, deren Zellkörper, Axonen und Terminalen schnell ihren Amingehalt vermehren können. Bei den Katecholamin-Neuronen konnten keine deutlichen Veränderungen beobachtet werden. Tetrabenazine verursachen eine schnelle, totale Entleerung der Monoamindepots aller

Teile der monoaminhaltigen Neuronen, gefolgt von einer schnellen Neubildung von Monoaminen<sup>16</sup>.

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### EMG Responses to Capsular Stimulation in the Human

Capsular stimulation is commonly used during stereotactic operations to help in identifying some deep structures and to avoid damage to the cortico-spinal tract<sup>1</sup>. In this paper some observations concerning the latency and the electromyographic (EMG) characteristics of motor responses obtained in man, by stimulating the cortico-spinal tract at capsular level, are reported. The available literature on this subject is very poor<sup>2</sup>.

Our data have been obtained during stereotactic operations performed under local anaesthesia in patients affected by Parkinson's disease, using the stereotactic equipment of TALAIRACH<sup>3</sup>. Capsular stimulations have been performed using the Wyss mono- or bipolar electrode. Stimulation parameters: monophasic square waves; single pulses or with a frequency from 1 to 10 c/s; pulse duration 1 to 5 msec; 1 to 4 V. The muscular responses were recorded by macro-electrodes (needle or surface electrodes) on a two-channel oscilloscope (Poly-scop-Horstfehr): one channel was used to record the stimulus artifact, the other one to record the muscular response.

Stimulation of the internal capsula with single shocks (1–5 msec, 1–4 V) evoked responses localized to the musculature of the contralateral side of the body in the form of violent muscular jerks; responses on the homolateral side of the body have never been obtained. The evoked motor response consisted of contraction of a single muscle or, more often, of many muscles. With stimuli of greater strength, the responses always appeared in complex muscle systems of the two limbs. Because the response generally involved agonist and antagonist muscles, the amplitude of limb movements was generally small and it was very difficult sometimes to identify by clinical observation all the muscles involved. The jerks obtained in a muscle in a state of complete relaxation, using rhythmical stimuli (1 to 4 c/s), seemed, on clinical observation, to be

of the same amplitude; the EMG records, on the contrary, demonstrated small continuous variations of amplitude.

The latency between the beginning of the stimulus and that of the EMG responses was different for the various

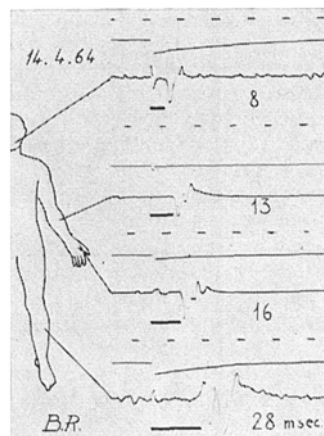


Fig. 1. Capsular stimulation. Parameters: 1 msec, 2 V. Different latency of muscular response in various districts of the body. M. orbicularis oris: 8–9 msec. M. extensor digitorum communis: 13 msec. Thenar: 16 msec. M. tibialis anterior: 27–30 msec.

<sup>1</sup> G. GUIOT, M. SACHS, E. HERTZOG, S. BRION, J. ROUGERIE, J. C. DALLOZ, and F. NAPOLEONE, *Neurochirurgie* 5, 17 (1959). – J. A. GANGLBERGER, *Exc. med. Int. Congr. Ser.* 60, 123 (1963).

<sup>2</sup> R. G. BICKFORD, E. H. LAMBERT, P. F. DONOVAN, E. A. RODIN, and H. J. SVIEN, *Electroenceph. clin. Neurophysiol.* 7, 468 (1955). – V. SKORPIL and V. VLADYKA, *Int. EMG Meeting, Copenhagen* (1963), Abstr. 168.

<sup>3</sup> J. TALAIRACH, M. DAVID, P. TOURNOUX, H. CORREDOR, and T. KVASINA, *Atlas d'anatomie stéréotaxique* (Masson, Paris 1957).

muscular groups, and increased from head to lower limb muscles (Figure 1; Table).

If, during stimulation, the muscle was in a state of voluntary contraction, the amplitude of the provoked response was considerably higher and latency was 1 to 2 msec shorter than in relaxed muscle.

When stimulation was given during muscular voluntary contraction (or postural contraction), after the muscular twitch a period of inhibition of the EMG activity (which could last for 50 to 200 msec) was often

Muscle or muscular group	Latency in msec
M. orbicularis oris	6–9
M. deltoideus	9–12
M. biceps brachii	9–15
M. extensor digitorum communis	13
M. flexores antebrachii superficiales	13
Thenar	16
M. interossei dorsales	19–20
M. quadriceps femoris	20–22
M. semitendineus et semimembraneus	24–30
M. tibialis anterior	26–33
M. extensor digitorum brevis pedis	35

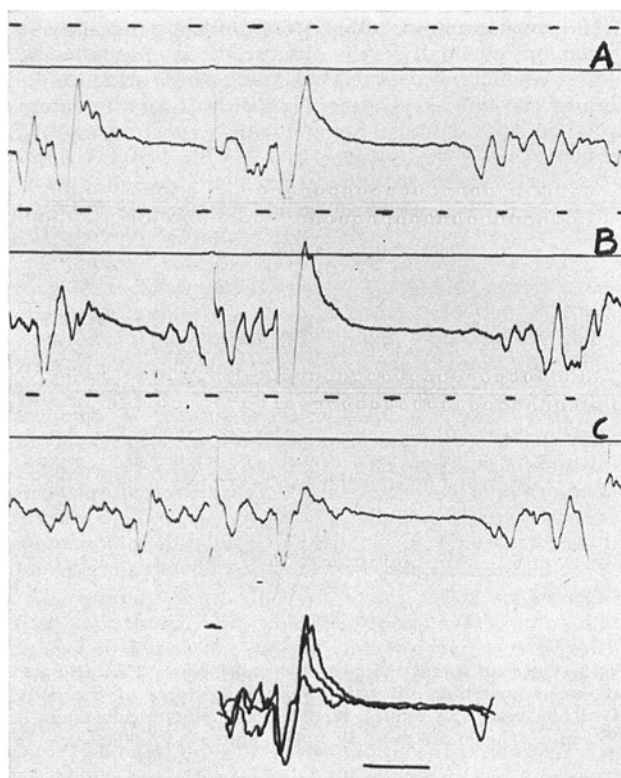


Fig. 2. Stimulation of the thalamo-capsular limit. Parameters: 1.5 msec; 4 c/s. A, B, C: three responses of the M. rectus femoris in a state of slight contraction. A and B: the muscular twitch has a latency of about 22 msec and is followed by a phase of suppression of EMG activity lasting about 50 msec. C: the EMG potential of the muscular jerk is lower than the background activity so that the response seems to consist only of a phase of suppression of EMG activity. In the lower part of the Figure, the 3 responses have been superimposed. Time 20 msec.

seen. After the twitch, a sudden period of muscular relaxation was observed (Figure 2).

Very often, particularly while stimulating in the thalamo-capsular limit, no motor responses could be evoked in completely relaxed muscles. But if stimulation with the same parameters was repeated after voluntary tone had been superimposed in the muscles, a motor response could be observed which seemed to consist only of a short phase of muscular relaxation: the EMG showed suppression of the electrical muscular activity not preceded by any motor response (Figure 3). This suppression phenomenon is observed also during the stretch reflex, which can easily be elicited in Parkinson's disease<sup>4</sup>. This suppression of muscular activity could generally be observed for every stimulus up to 4 c/s; for higher frequencies (8 to 10 c/s) the suppression was only occasionally present. The suppression of the EMG activity with muscular relaxation is probably of the same kind as the so-called 'silent period', which is easily observed following peripheral nerve stimulation or by provoking a muscular reflex<sup>5</sup>.

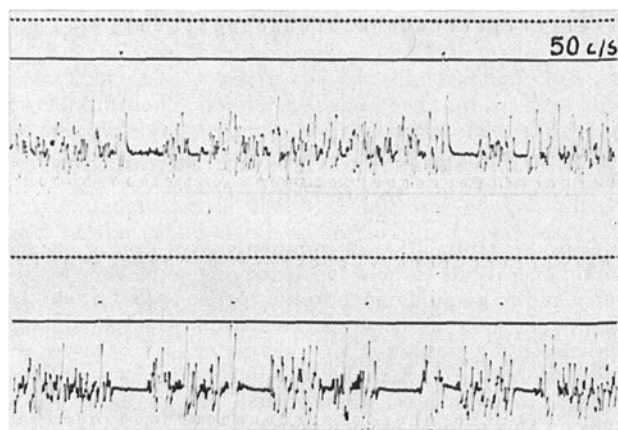


Fig. 3. Stimulation at the thalamo-capsular limit. Parameters: 5 msec, 4 V, 1 c/s (upper) and 2 c/s (lower). Record of M. biceps brachii during strong voluntary contraction. Every stimulus is followed by a phase of suppression of EMG activity lasting 60 to 100 msec.

**Riassunto.** Gli autori studiano la latenza e le caratteristiche elettromiografiche delle risposte muscolari provocate con stimoli capsulari nell'uomo. Le clonie provocate in muscoli in stato di leggera contrazione sono seguite in genere da una fase di rilasciamento muscolare di 50–200 msec di durata.

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<sup>4</sup> H. SHIMAZU, T. HONGO, K. KUBOTA, and H. NARABAYASHI, *Arch. Neurol.* 6, 10 (1962).

<sup>5</sup> P. A. MERTON, *J. Physiol.* 114, 183 (1951). – P. PINELLI, *Boll. Soc. Medico-Chir. Pavia* 55, 877 (1955). – H. J. HUFSCMIDT, *Pflügers Arch. ges. Physiol.* 271, 35 (1960). – E. FERRARI, V. SPADETTA, C. COLUCCI, and G. TEDESCHI, *Riv. Pat. Nerv. Ment.* 83, 56 (1962).