Studies on induced exacerbation of Parkinsonian rigidity

The effect of contralateral voluntary activity

KEIZO MATSUMOTO, FERDINAND ROSSMANN, TUNG HUI LIN, AND IRVING S. COOPER

From the Department of Neurologic Surgery, St. Barnabas Hospital for Chronic Diseases, New York, U.S.A.

Recent increasing interest in surgery of the basal ganglia for tremor and rigidity in Parkinsonism would seem to warrant more critical measures for evaluating these symptoms, not only for the purpose of assessing surgical results but also to elucidate the underlying neurological mechanisms. Parkinsonian symptoms, especially rigidity and tremor, are frequently unstable and may vary with the patient's environment, emotion, stress, and many other factors. Consequently, a clinical evaluation of these symptoms should be made with a method which can yield relatively reliable values as well as reveal the variability of the symptom in each patient.

In our clinic Parkinsonian patients have been examined routinely with different methods of reinforcement to induce accentuation of rigidity and tremor or other symptoms. It was empirically concluded that active movement of the contralateral limbs is a simple and revealing method to elicit or exaggerate Parkinsonian rigidity. The purpose of this paper is to report a clinical and electromyographic study of Parkinsonian rigidity thus augmented.

METHOD

The rigidity was classified in five grades, namely, 0 indicating no rigidity, 1+ slight rigidity, 2+ moderate rigidity, 3+ considerable rigidity, and 4+ very marked rigidity. The wrist joint was used in all cases. From our experience wrist movement seems to be affected more consistently by rigidity than the other parts of the extremities and is more readily examined. Moreover, it shows clear antagonistic features between the flexors and extensors for electromyographical study.

Passive movements of extension and flexion of the wrist were performed continuously and alternately. The amount of rigidity was evaluated both with and without contralateral voluntary movements of the other arm. Two kinds of contralateral movement were used: one was raising and lowering of the whole extended arm and the other was opening and closing of the hand. In either movement, however, there is one strict condition for the contralateral movement. It should be at a different pace and involving a different movement from the passive movement used in testing the wrist.

Electromyographic studies were carried out with a Grass E.E.G. machine model 3 console, with the patient in a comfortable sitting position. Surface electrodes were placed on the flexors and extensors of the wrist of both arms. Discharges, which were evoked by passive stretch of the tested arm and voluntary activity of the opposite arm, were recorded simultaneously. The passive movements of the wrist were performed with care in order not to exert extreme stretching of flexors or extensors. The passive and alternative motions of the examined wrist were also recorded synchronously on recording paper. This was done manually to distinguish the stretch reflexes from voluntary movement (Fig. 1).

RESULTS

CLINICAL OBSERVATIONS A series of 197 patients with Parkinson’s disease who underwent chemothalamectomy in our clinic from January to November 1961 were investigated. Pre-operatively for 82% of the patients rigidity was exaggerated by contralateral movement. This test not only exacerbated existing rigidity but also produced rigidity in patients who had shown only tremor on ordinary clinical examination. There was no inhibition or decreasing of rigidity in any patient. For the remainder there was no evident increase in rigidity or enforcement through contralateral movement. This included several patients with marked (4+) rigidity.

For the post-operative evaluation, patients who had any transient evidence of pyramidal tract sign, motor weakness, pseudobulbar sign, or hyperkinesia were excluded. Thus, 165 patients were investigated at the time of discharge about two weeks after surgery. Excellent results in alleviation of rigidity were

1 Assisted by grants from the Allen P. and Josephine B. Green Foundation and from the John A. Hartford Foundation, Inc.
CONTRALATERAL VOLUNTARY MOVEMENTS

EXTENSORS STRETCH
wrist down

FLEXORS STRETCH
wrist up

L. EXT.
L. FLEX.
R. EXT.
R. FLEX.

CVM

FIG. 1. Diagram of recording technique.
Studies on induced exacerbation of Parkinsonian rigidity

achieved in 152 patients. However, among this group, 30 patients showed noticeable rigidity with enforcement.

Electromyographic observations

Twenty normal persons served as a control group. In 19, no stretch response was evoked with or without reinforcement. In one case minimal stretch evoked discharges which were observed at random, probably due to extreme stretching of wrist muscles. Therefore, it was concluded that stretch responses of the forearm cannot be recorded by the test with gentle alternating flexion and extension of the wrist in a normal person.

Forty-nine consecutive patients with Parkinson's disease were selected pre-operatively for electromyographic analysis. There were always clear-cut stretch-evoked discharges, which were exaggerated markedly by the contralateral movements. When the rigidity was not detected by ordinary clinical methods minimum stretch responses were revealed by electromyography and they were apparently increased by movements of the contralateral limbs.

The cogwheel phenomenon was recognized as an abrupt high amplitude burst in the stretch-evoked discharge. This also was markedly exaggerated by contralateral movement. With slight or moderate rigidity the cogwheel phenomenon became more evident with higher amplitude (Fig. 2). In the case of a prominent cogwheel phenomenon associated with marked rigidity, the discharge tended to become a more continuous, high-amplitude burst during the manoeuvre (Fig. 3).

During the procedure of chemothalamectomy the stretch-evoked discharges were slightly reduced when the tip of the cannula reached the thalamic target. The discharges disappeared completely within two or three minutes after the inflation of the balloon in the area of the ventrolateral nucleus of the thalamus

![FIG. 2. Pre-operative electromyogram of moderate rigidity.](https://example.com/image1)

![FIG. 3. Electromyogram of marked rigidity. Marked cogwheel phenomenon associated with considerable rigidity of the right extensor blended into a strong continuous stretch response influenced by the contralateral movements of the left arm.](https://example.com/image2)
FIG. 4. (a) An E.M.G. during operation at the moment of insertion of a cannula and inflation of a balloon in the area of the ventrolateral nucleus of the thalamus. Notice the decrement of stretch response of the right extensor after inflation of the balloon which reappeared with reinforcement. (b) Two minutes after inflation of the balloon the stretch responses at the right wrist can still be elicited in the trace. (c) Four minutes later the stretch responses could no longer be elicited by contralateral movement.

(Fig. 4a). Thereafter, even with contralateral reinforcement, the stretch response could not be elicited (Fig. 4b).

Post-operative electromyographic studies were performed on 37 patients. Of these, rigidity was completely alleviated in the limbs contralateral to the side of brain surgery in 24 patients. In those instances, no rigidity was disclosed with movement of contralateral limbs. Moreover, electromyograms showed no evidence of stretch-evoked discharges with or without enforcement (Fig. 5).

In 13 patients the rigidity was thought to be alleviated completely but the manoeuvre of contralateral voluntary movements showed slight rigidity on clinical examination. When electromyograms were taken clear-cut, stretch-evoked discharges were produced by the contralateral manoeuvre (Fig. 6).

COMMENT

Rushworth (1960) stated that the Parkinsonian rigid muscles show exaggerated stretch reflexes in both extensors and flexors. Thus, there is resistance to passive movement of the limb in any direction whether it be passive flexion or passive extension, and these features are reflected in the electromyogram. In our investigation, stretch-evoked discharges were clearly recorded by passive gentle movements of extension and flexion of the wrist in Parkinsonian patients but not in normals. The amplitude of
Studies on induced exacerbation of Parkinsonian rigidity

FIG. 5. Electromyogram on a long-range follow-up patient with complete alleviation of rigidity in the left arm. No stretch responses of the left wrist muscles could be elicited by contralateral movement of the right arm.

FIG. 6. Electromyogram of a patient with a good clinical result. Mild stretch responses of left wrist muscles were still elicited by contralateral movements of the right arm.

stretch response is not always greater in the patient showing greater rigidity, although there was gross correlation between intensity of rigidity and stretch response. However, there was always an increase in amplitude, frequency, or duration of stretch response whenever there was an exaggeration of rigidity by the manoeuvre. These observations seem to suggest that there is a close relationship between rigidity and stretch response.

There have been few previous references to the exacerbation of Parkinsonian rigidity by enforcement. Granger (1961) described and classified these exacerbations into three groups: those occurring by withdrawal of the patient's drug, by various forms of stress, and by ingestion of alcohol or other drugs. In our series mental stress induced tremor as well as rigidity in most cases (Fig. 7). It is interesting to note that the elicited tremor usually appeared a few seconds after the stimulation. Mental stress seems to exert diffuse exaggerating effects on the neural mechanism of Parkinsonian symptoms. On the other hand, it appears that the contralateral movements selectively increase only rigidity. Moreover, there was not a single case which showed a decrease of rigidity by this manoeuvre. The clinical incidence of increased rigidity was 82%. It thus appears that Parkinsonian rigidity can easily be elicited and exaggerated with enforcement. The rigidity of early Parkinsonism, as well as the state of the post-operative patient with latent rigidity, which cannot be detected by routine clinical methods, can now be disclosed.

Recent research has revealed that the gamma system in muscle spindle plays a major role in
Parkinsonian rigidity. There are, however, two opposite opinions about the pathogenetic state of the gamma system in rigidity. Hassler (1956), Granit and Kaada (1952), and Stern and Ward (1960) postulated hypoactivity of this system, whereas Barraquer-Bordas (1958) and Matthews and Rushworth (1957) postulated hyperactivity. The latter authors utilized procaine block in their experiments on the gamma efferent fibre or spindle in Parkinsonian rigidity. In either case, the fact that contralateral movements increase Parkinsonian rigidity seems to suggest that this manipulation influences the gamma system augmentation of the stretch reflex.

**SUMMARY**

One hundred and ninety-seven patients with Parkinson's disease were investigated for rigidity by clinical examinations with and without asynkinetic contralateral movement. A marked exaggeration of rigidity was observed in 82%. The latent rigidity of patients with early Parkinson's disease and of patients post-operatively may be disclosed by this clinical reinforcement test.

Electromyographic investigation of 49 patients with Parkinson's disease and 20 normal controls shows that in normal persons no stretch discharge was elicited by passive wrist motion with or without contralateral reinforcement; pre-operatively all patients with Parkinson's disease showed clear-cut, stretch-evoked discharges which were exaggerated markedly by contralateral movements; post-operatively the stretch responses could not be elicited in patients with completely alleviated rigidity but in cases of incomplete arrest of rigidity stretch responses were readily demonstrated by contralateral reinforcement.

The pathophysiological mechanism of this phenomenon is probably related to activity of the gamma system. However, the precise role of the gamma system in reinforcement of rigidity by the contralateral manoeuvre is not yet certain.

We wish to acknowledge with thanks the assistance of Miss Chirlaine Dupree, B.A., chief E.E.G. technician at St. Barnabas Hospital, Bronx, New York.

**REFERENCES**