Ratio of maximum H reflex to maximum M response as a measure of spasticity

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The clinical investigation of the nature and treatment of spasticity has been greatly impeded by the lack of any simple and precise method of measurement of the increased resistance to passive movement of the limbs, most investigators relying on arbitrary clinical grading of severity. Elaborate methods of measurement are still in an experimental stage and are not universally available (Timberlake, 1965; Erdman and Heather, 1965). Angel and Hofmann (1963) therefore explored the possibility of using the ratio between the maximum H reflex and the maximum M response as a simple and precise method of measurement. The M response (Magladery and McDougal, 1950) is simply the response of a muscle as recorded electromyographically (E.M.G.) to stimulation of the motor nerve. The H reflex was first described by Hoffmann (1918) and its general characteristics have been reviewed in detail by Mayer and Mawdsley (1965). There is general agreement that the major component is a monosynaptic reflex elicited by submaximal stimulation of a mixed motor and sensory nerve and, in a normal adult, it can usually only be elicited in the triceps surae from stimulation of the medial popliteal nerve. In many respects the reflex resembles the ankle jerk with the important difference that the peripheral receptor organs are not involved, fast-conducting afferent fibres being stimulated directly. The H reflex is usually increased in a spastic lower limb while the M response is unaffected. Both responses can be elicited using the same stimulating and recording electrodes and, for purposes of comparison, it is essential that they should be so. Pinelli and Valle (1960) had found the relationship between the height of the two responses at different stimulus strengths and between different individuals to be so variable that they rejected the H/M ratio as a measure of spasticity. Angel and Hofmann (1963) hoped that by using the ratio between the height of the maximum H reflex and that of the maximum M response the effect of such factors as electrode placement, thickness of skin and, in particular, stimulus strength, might be excluded. They did not, in fact, demonstrate that with different electrode placements a

constant ratio could be obtained during the period of the experiment, nor did they clearly establish that an investigation of purely monosynaptic reflex stimulation of the motor pool could provide a valid index of the complex phenomenon of spasticity. Nevertheless, the method was simple and ingenious and might well have proved a notable advance.

In the course of investigating the effects of a phenothiazine drug, chlorproethazine (Matthews, 1965) and diazepam (unpublished observations), voluntary power, response to slow stretch, the ankle jerk, H reflex, and M response were recorded in a number of patients. The maximum M response was used both as an indication that the electrodes had not moved during the experiment and also to exclude neuromuscular block as a cause of relief of spasticity. The value of recording this response was not recognized at the beginning of the investigation so that the number of recordings relevant to this report is much less than the number of experiments performed.

METHOD

The patients lay prone with the feet hanging freely over the edge of the couch without any tension on the calf muscles. Recordings were taken from surface electrodes 1 cm. in diameter and 5 cm. apart over the soleus muscle. It was not possible to place one of the electrodes over the Achilles tendon, as in the method employed by Angel and Hofmann (1963), as the ankle jerk was also recorded. The medial popliteal nerve was stimulated by a similar 1 cm. diameter cathode, with a larger plate anode over the patella. At least 15 seconds were allowed to elapse between the elicitation of H reflexes. This is a shorter interval than that recommended by Mayer and Mawdsley (1965) but consistent responses were obtained. The strength of the stimulus was adjusted to obtain the largest possible H wave and at this strength some M response was also visible. After the maximum reflex response had been recorded the strength of the stimulus was increased to be supramaximal for motor fibres and the M response recorded. That the reflex recorded was mainly or entirely an H reflex and not the small and variable F response sometimes obtainable with strong stimuli (Magladery and McDougal, 1950) was confirmed by the disappearance of the response on increasing the stimulus strength. The

stimulator provided an approximately rectangular pulse 100 microseconds in duration and locked to the oscilloscope sweep.

The ankle jerk was elicited by allowing a hammer to fall a set distance on the tendon, the blow triggering the oscilloscope sweep. Slow stretch was applied manually and the resulting E.M.G. response was recorded from the same electrodes. Voluntary action was tested by maximum plantar flexion against resistance and the interference pattern was photographed. Similar recordings were made before and after the injection of the drugs. The entire experiment could be completed in less than 30 minutes so that discomfort to the patient was not an important factor in the results.

RESULTS

In sufficient dosage both chlorproethazine (5-50 mg.) and diazepam (5-10 mg.) by intravenous injection

will reduce or abolish spasticity as assessed by resistance to passive movement. This is accompanied by great reduction or abolition of the recordable response to slow stretch and also of the interference pattern recorded during maximal voluntary effort. The ankle jerk is usually also greatly diminished but the H reflex proved much more resistant and on occasion was unaffected even when the ankle jerk was abolished. The implications of this finding have been discussed by Matthews (1965). The M response was not altered except when electrode placements had obviously been disturbed and such recordings are naturally not included in the present study.

A total of 10 spastic limbs fulfilled the criteria which allowed valid comparison of the H/M ratio before and after injection. Clinical spasticity, the

FIG. 1. Recordings in a patient with disseminated sclerosis before and after intravenous injection of 50 mg. of chlorproethazine. 1 Voluntary action. 2 Slow stretch (not well recorded in this case and partially obscured by artifact). 3 Ankle jerk (note that the amplification after injection is increased $\times 10$). 4 Maximum H. 5 Maximum M: H/M ratio reduced from 0.47 to 0.41. Clinical spasticity abolished.

FIG. 2. Recordings from the left leg in a patient with left hemiplegia following a stroke before and after intravenous injection of 10 mg. of diazepam. 1 Voluntary action. 2 Slow stretch. 3 Ankle jerk, only slightly reduced in this case. 4 Maximum H. 5 Maximum M: H/M ratio reduced from 0.19 to 0.17. Clinical spasticity greatly reduced.

electrical response to slow stretch, and the ankle jerk were reduced or abolished following injection, while the M response was unchanged and consistent H reflexes could be obtained. At least five maximum H reflexes were recorded before and after injection and, although there was little variation in each series, the largest deflection was always used for purposes of comparison. The results are shown in Table I. It

can be seen that in four limbs, despite obvious reduction of spasticity as defined, there was no change in the H/M ratio. In four further examples the ratio was slightly lowered and in only two was there a marked reduction. The range, 0.19-0.67, and mean, 0.35, can be compared with those found by Angel and Hofmann (1963) in six spastic limbs (range 0.15-0.94, mean, 0.45). The figures after treatment, range 0.16-0.67, mean 0.30, are rather higher than those found by these authors in six normal limbs. Typical findings are shown in Figures 1 and 2.

TABLE I
H/M RATIO BEFORE AND AFTER REDUCTION OF SPASTICITY BY THE INTRAVENOUS INJECTION OF CHLORPROETHAZINE OR DIAZEPAM

Drug	Before	After
Chlorproethazine	0.39	0.17
Chlorproethazine	0.47	0.41
Chlorproethazine	0.36	0.36
Chlorproethazine	0.67	0.67
Diazepam	0.26	0.16
Diazepam	0.32	0.27
Diazepam	0.22	0.22
Diazepam	0.37	0.32
Diazepam	0.24	0.24
Diazepam	0.19	0.17
Mean	0.35	0.30

DISCUSSION

Considerable doubt has been thrown on the validity of using the H reflex in any form of precise measurement because of its acknowledged variability (Rushworth, 1964). Paillard (1955) laid down very rigid criteria for the production of consistent results as he found that the reflex was greatly influenced by the patient's comfort and peace of mind and by the degree of tension in the muscle and its synergists.

Comfort and ease of mind are not, in any case, susceptible of measurement, and if random fluctuations in the height of the H reflex had been found, these imponderable factors might well be held to have invalidated the results. Since in the present investigation the H reflex varied little or not at all during the majority of the experiments it may reasonably be assumed that these factors had no great effect on the result. The matter of fixation of the limb so as to maintain the calf muscles at constant length and tension is of much greater importance. It will, however, be obvious that in an experiment involving the acute reduction or abolition of spasticity fixation of the limb introduces an uncontrollable variable. Abolition of spasticity with the calf muscle at constant length causes a great reduction in tension in the muscle. Any attempt at keeping the muscle at constant tension, if it were possible at all after the abolition of spasticity, inevitably implies a considerable increase in the length of the muscle. It was therefore decided to let the foot hang free before and after the injection of the drug. The fact that in most instances the H reflex was little altered suggests that this method was appropriate to the circumstances of these acute experiments. Similar methods were used by Gassel and Diamantopoulos (1964) in their study of the H reflex following procaine nerve block.

The recorded response to slow stretch could not, unfortunately, be accompanied by a recording of the speed of stretch. However, these recordings were simply graphic illustrations of the obvious reduction of resistance to passive movement and, in fact, after an effective dose of either drug it was usually impossible to produce any recordable response to stretch at any speed short of that required to produce a tendon jerk.

The H reflex is normally best recorded from electrodes over the soleus muscle just below the bellies of the gastrocnemius, and such placings were used in this investigation. If the H/M ratio is to be of any value as a clinical investigation the precise electrode placings should not be critical as no such precision could be obtained in, for example, the prolonged investigation from week to week of the effects of a drug given orally.

The H/M ratio is usually higher in the spastic leg of a patient with hemiplegia than on the normal side.

Angel and Hofmann (1963), however, observed a considerable overlap of the values in spastic and normal limbs in different patients and the test is therefore of limited diagnostic value. The present investigation shows that in some patients spasticity may be abolished without change in the ratio, and the hope that the measurement could be used as a simple index of spasticity when assessing treatment cannot be sustained.

SUMMARY AND CONCLUSION

The acute reduction of spasticity following the intravenous injection of drugs may not be accompanied by any alteration of the ratio of maximum H reflex to maximum M response. Thus the measurement of this ratio is unhelpful in the assessment of the results of treatment.

A generous gift of chlorprothazine was presented by Messrs May and Baker, and of diazepam for injection by Roche Ltd. I wish to thank Mrs. Christine Clarke for technical assistance.

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