of the mouth and visual impairment, while others had drowsiness and depression. Orthostatic collapse occurred in one subject. Three persons refused to collaborate on the third day.

Results and Discussion

The results are summarized in the Table. The changes were computed, making each patient his own control, and those induced by the drugs were compared with those produced by atropine and propranolol. These differences in change of heart rate proved significant only for both doses of reserpine ($P < 0.01$) which caused a pronounced decrease in heart rate, whereas, for the other compounds, the only possibly significant finding was

Intrinsic and Control Heart Rates

	No. of Cases	Intrinsic Heart Rate after Atropine and Propranolol	Control Rate	Change in Rate
<i>Series 1</i>				
Control	15	103.7 (± 14.2)	77.9 (± 12.2)	25.9 (± 11.3)
Methyldopa 2 $\times$ 750 mg.	14	99.2 (± 12.2)	73.0 (± 9.2)	26.2 (± 14.1)
Debrisoquine 2 $\times$ 40 mg.	15	101.1 (± 13.7)	68.9 (± 11.0)	32.3 (± 12.3)
Reserpine 2 $\times$ 2.5 mg.	14	85.7 (± 13.3)	72.0 (± 8.2)	13.7 (± 12.4)
<i>Series 2</i>				
Control	13	106.5 (± 10.0)	77.3 (± 8.3)	29.2 (± 12.5)
Methyldopa 2 $\times$ 2000 mg.	12	109.5 (± 13.8)	63.8 (± 11.3)	45.8 (± 19.9)
Debrisoquine 2 $\times$ 180 mg.	11	105.9 (± 15.6)	69.1 (± 9.6)	36.8 (± 19.0)
Reserpine 2 $\times$ 0.75 mg.	12	91.3 (± 10.0)	74.4 (± 8.0)	16.9 (± 10.3)

The standard deviation is given in parentheses after each mean.

a decrease in heart rate caused by a higher dose of methyldopa. The two 0.75-mg. doses of reserpine produced much the same effect as the two 2.5-mg. doses. Contrary to expectation the

bradycardia produced by reserpine, without giving atropine and propranolol, proved to be slight; in several cases the intrinsic heart rate even increased.

The individual values of the patients are given in Figs. 1, 2, and 3. The lines are drawn at 45° to show the increase or decrease in intrinsic heart rate values compared with those in the self-controls.

As regards the mechanism of the decreasing effect of reserpine on the intrinsic heart rate we are compelled to speculate. The decrease of the catecholamine content of the sinus node has been suggested as a possibility by Dornhorst (Jose, 1966). It is well established, however, that the noradrenaline content of the heart decreases after giving adrenergic neurone-blocking agents and also after methyldopa, though perhaps by different mechanisms, because these compounds do not change the intrinsic heart rate (Figs. 2 and 3). In the normal subject reserpine has little effect on heart rate (see Table), yet it has a strong slowing effect on the impulse centre of the heart, which is apparent after total autonomic blockade. Hence reserpine may have a more complex action than is generally assumed and probably affects autonomic nerves as well as the heart itself.

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Great-toe Extensor Reflexes in the Diagnosis of Lumbar Disc Disorder

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Summary: The tendon reflexes obtainable from the extensors of the great toe require practice to elicit, but have been found particularly valuable in the assessment of lesions affecting the fifth lumbar nerve root, especially compression radiculopathy from disc prolapse.

Introduction

Professor G. A. Ransome (1958) described a new deep tendon reflex which he termed the "great-toe jerk," and drew attention to its diagnostic value in a variety of conditions which affect the central and peripheral nervous systems. He ascribed the reflex to the fourth and fifth lumbar segments, and mentioned its merit as an objective sign in radiculopathy secondary to lumbar disc prolapse. Indeed, experience over nine years has shown this to be a reliable physical sign in assessment of the patient with disc disease, but as it was found hard to convince

colleagues of its value, primarily because of the difficulty they experienced in demonstrating the jerk, alternative methods of eliciting a tendon reflex mediated by the fifth lumbar root were sought. The purpose of the present paper is to describe these methods, which have also stood the test of time, and to draw attention to their distinct worth in the examination of the patient with lumbar intervertebral disc disorder.

Deep Tendon Reflexes Associated with Extensor Apparatus of the Great Toe

Great-toe Jerk

The great-toe jerk, as described by Ransome, is elicited from the hallux with a tendon hammer by striking an index finger which depresses the digit so as to put slight "elastic" stretch on the tendons of the extensors hallucis longus and brevis. The foot is placed in plantar flexion and slight inversion. The reflex contraction is felt rather than seen, though the latter may be the case when the response is exaggerated. In this context Ransome suggested an alternative name for the reflex, the

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"great-toe dorsal spring reflex." Ransome placed stress on the need to follow through with the tendon hammer by using wrist movement rather than to "tap" the index finger. If the latter method is used, the chance of success will be comparable to that of the golfer, tennis player, or fly fisherman who fails to complete his stroke.

We have found that this jerk is sometimes more easily obtained by the uninitiated if the index finger is placed over the distal end of the proximal phalanx of the hallux (Fig. 1) rather than over the base of the distal phalanx, and Ransome (personal communication, 1968) observed that occasionally a student can learn to obtain this reflex more readily by the substitution of a wooden spatula for the index finger. We agree with Ransome that it is crucial both not to depress the hallux too far and to use the weight of the hammer to the best advantage. Certainly, many of the tendon hammers available on the market are quite ineffectual. The hammer shown in Fig. 1 has been found to be satisfactory for the toe reflexes, the essential feature being that it is easier to use with precision on the narrow extensor tendons than some of the larger hammers currently popular with neurologists.

FIG. 1.—Photograph demonstrating the method of eliciting the great-toe jerk. The hallux is slightly depressed by the index finger placed over the distal end of the proximal phalanx. Note the radially deviated position of the examiner's wrist, which implies the movement to be used, and also the type of tendon hammer employed.

Extensor Hallucis Longus Reflex

The tendon of the extensor hallucis longus emerges from between the tendons of the tibialis anterior and the extensor digitorum longus muscles just proximal to the ankle joint (Fig. 2), and this has been found the point where the reflex is most

FIG. 2.—Photograph indicating the optimum sites for eliciting the tendon reflexes of the extensor hallucis longus (EHL) and the extensor hallucis brevis (EHB). The foot is plantar flexed and slightly inverted.

readily obtained. The tendon, which is subject to minor variations in its position, is identified by having the patient dorsiflex the great toe against resistance. The jerk is then produced by utilizing the principles of wrist movement and follow-through mentioned above. Again the foot should be plantar flexed and slightly inverted. The reflex manifests itself as dorsiflexion of the hallux at the metatarsophalangeal joint without a separate excursion at the interphalangeal joint. One needs to strike the tendon accurately, as it is not large, and it is useful to mark the skin first when initially attempting to demonstrate the reflex. In the patient with hyperreactive reflexes "overflow" with reflex contraction of the peroneal group may be observed, or occasionally a flexor response from the posterior calf musculature may be seen. Overenthusiastic use of the tendon hammer is to be avoided, as repeated poorly aimed blows in this region, particularly with a tendon hammer constructed of hard vulcanized rubber, will afford the patient sharp discomfort.

Extensor Digitorum Brevis Reflex

The short extensor of the great toe separates from the other short-toe extensors with which it shares a common origin on the upper surface of the calcaneum and the deep surface of the inferior retinaculum and inserts into the base of the proximal phalanx of the great toe. Again the tendon is identified, though not as easily as that of the long extensor, by having the patient dorsiflex the great toe. The reflex is obtained best just immediately distal to the musculotendinous junction (Fig. 2). Because of the relative weakness of the short extensor, as compared with the long extensor, reflex contraction of the muscle results in extension of the proximal phalanx at the metatarsophalangeal joint, but the interphalangeal joint flexes slightly owing to a tenodesis effect by the powerful flexor hallucis longus.

Experience

Judgement on the grading of the three reflexes comes with experience, as it does with examination of all other deep tendon reflexes. Initially it is advisable to start learning to demonstrate the reflexes by trying to elicit them in patients with hyperreflexia. The last two reflexes are judged visually, whereas the first is felt, though it may also be seen.

It was thought that it would be of some interest and value to see how long it would take a final-year medical student (M.W.) to learn and to interpret these physical signs with comparable facility to a physician (T.K.F.T.) who had used them consistently for nine years. Accordingly an attempt was made to elicit the reflexes in the majority of patients examined during the course of an orthopaedic clerkship. The first two weeks saw little progress, but by the end of a month an adequate degree of expertise had been achieved. Both of us then separately examined the deep tendon reflexes in the lower limbs of 64 patients and the results were compared. Activity was graded on the conventional + to ++++ system. The patients examined, whose ages ranged from 2½ to 80 years, had a wide variety of primary diagnoses, and included a number of subjects with conditions in which hyperreflexia was present—cerebral palsy, quadriplegia, paraplegia, disseminated sclerosis, etc. For most patients the examiners had identical findings, and when there was a difference in an evaluation of a reflex, it was usually in the order of half a grade, and rarely a whole grade. Re-examination nearly always resulted in concurrence of opinion.

Discussion

More often than not the clinical diagnosis of lumbar disc prolapse is on tenuous grounds in the absence of root symptoms and signs, and root pain may be mimicked by referred pain

not of discal origin. Moreover, sensory findings and weakness can be extremely difficult to place in the correct perspective in an apprehensive patient with functional overlay, even if there is a clear history of sciatica. In general great reliance is placed on changes in the deep tendon reflexes as objective signs of compression radiculopathy, and an observed loss of a deep tendon reflex is a significant diagnostic event.

Last (1954) greatly facilitated the comprehension of the apparently complex innervation patterns in the lower limbs by focusing attention on the orderly segmental innervation of the various joint movements. Last gives the following values:

Knee	Flexion	L 5 and S 1
	Extension	L 3 and 4
Ankle	Dorsiflexion	L 4 and 5
	Plantarflexion	S 1 and 2
Foot	Inversion	L 4
	Eversion	L 5 and S 1

In clinical practice the knee jerk is depressed with lesions involving the fourth lumbar root and the ankle jerk in the first sacral radiculopathy. The respective contributions from L 3 and S 2 to the reflexes are not major but in keeping with the concept put forward by Last that most joint motions are controlled from two cord segments; the L 3 component of the knee jerk appears to be greater than that of S 2 to the ankle jerk. A pure L 5 lesion will not alter either reflex, though not infrequently a large disc prolapse at any level in the lumbar spine will involve more than one root, and so a L 4-5 prolapse may be associated with either a depressed ankle or knee jerk. The combination of L 5 and S 1 signs is suggestive, but not diagnostic, of a prolapse emanating from the fourth lumbar interspace.

So far as we are aware extension of the great toe has not been ascribed a segmental value (Last, personal communication, 1968), but isolated weakness of great-toe extension and depression or absence of the toe extensor reflexes are consistent findings in pure L 5 radiculopathy from disc prolapse. Frequently loss of toe extensor power is the only paresis detectable on close clinical examination (Spurling, 1953). The situation, however, frequently may be further clarified if other L 5 innervated musculature, particularly the peroneals (L 5 and S 1), is sufficiently fatigued by repetitive testing against strong resistance. Ransome gave toe extension the root value of L 4 and L 5, but we are of the opinion, based on the available clinical evidence, that dorsiflexion of the great toe is overwhelmingly an L 5 movement. In patients with a significant L 5 root compression all three extensor reflexes are usually altered, but experience has led us to place reliance primarily on the reflex from the long extensor. Though the three reflexes have the same segmental value (muscles showing a common action on a joint have the same segmental value), they do not always behave in an identical fashion in L 5 radiculopathy. Not infrequently the jerk from the short-toe extensor will be unimpaired, while that from the long extensor is depressed, and much less often vice versa. It is to be emphasized that the changes in these reflexes are often subtle but readily demonstrable to the satisfaction of an experienced examiner.

Inasmuch as Spurling (1953) has stated that "the only reflex change with lesions at the fourth interspace is loss of the posterior tibial tendon reflex, which is difficult to elicit consistently even in normal subjects," the value of the great-toe extensor reflexes is obvious. We agree that the tibialis posterior reflex is not easy to obtain, and the resulting movement, plantar flexion and inversion, is a coarse one which is hard to judge

accurately let alone compare with the contralateral reflex. It has not been found reliable enough to warrant confidence diagnostically.

Apparent weakness of toe extension may be difficult to interpret if during the manoeuvre the patient experiences pain which itself can produce reflex muscle inhibition. Muscle tone and atrophy in the extensor hallucis longus cannot be estimated with any degree of precision, since its belly lies deep in the anterior tibial compartment. By contrast, the muscle belly of the short extensor of the great toe is superficial, and here loss of muscle bulk and tone is readily appreciated and is a most valuable physical sign in long-standing root compression. The short extensors of the lateral four toes have, as judged by clinical evidence, innervation from the S 1 segment. The hallux (L 5) is on the preaxial side of the foot, secondary to the internal rotation involved in the extension of the lower limb during development, and as one moves across to the lateral or postaxial border of the foot a change in the segmental value of the short extensor apparatus is an expected finding. Because of its availability the extensor digitorum brevis muscle is often explored for evidence of denervation in electromyographic examination, and positive findings are common in conditions affecting the first sacral root.

As would be expected, the toe extensor reflexes behave in a comparable fashion to the other lower limb deep tendon reflexes in compression radiculopathy. If absent they may never reappear, and if depressed may remain so indefinitely, even after the responsible episode of disc prolapse has abated. The likely reason for this behaviour is that the compression occurs proximal to the dorsal root ganglion, which lies in the intervertebral foramina, and secondary irreversible degenerative changes may occur in neural tissue within the reflex arc. Ransome was of the opinion that the extensor muscles in the lower limbs react more readily to noxious stimuli than do the flexors, and accordingly that the great-toe jerk is more sensitive than the ankle jerk. Since our experience with these reflexes is primarily in patients with disc disorder and affections of the contributing roots distal to the intervertebral foramina, we are unable to put forward authoritative comment on this contention. Ransome places great stock by the great-toe jerk in the early diagnosis of the peripheral neuritis associated with typhoid fever, diphtheria, and diabetes mellitus. We have not observed, as Ransome records, disappearance of the extensor reflexes before the onset of sciatic pain in disc prolapse.

The probable reason why the great-toe jerk has not yet gained widespread acceptance in clinical practice is the need for diligent practice before one can use and interpret the physical sign satisfactorily. We are in close agreement with Ransome on this point, as well as on the need to use a well-designed tendon hammer. Ransome cautioned his reader in these respects, supporting his arguments with a succinct though eloquent description of the chequered history of the introduction of the deep tendon reflexes as part of the routine examination of the nervous system. He was of the opinion that the great-toe jerk would in time become routine in the physical examination of the nervous system. We concur and have found that the tendon reflexes described here are particularly valuable in the evaluation of the patient with lumbar disc prolapse.

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