A CRITICAL EVALUATION OF THE TENDON REFLEX MEASUREMENT AS AN INDEX OF THYROID FUNCTION

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IT IS now accepted that the tendon reflex is prolonged in patients with hypothyroidism. Chaney (1924) was the first worker to record the Achilles tendon reflex and prove what had previously been detected clinically. Since then several systems have been devised for recording the ankle jerk (Lambert, Underdahl, Beckett, and Mederos, 1951; Lawson, 1958; Gilson, 1959; Sharpe, 1961; Smart and Robson, 1963; Mouloupoulos, Koutras, and Kralios, 1964). Two of these methods, the Photomotograph (Gilson, 1959) and the Kinemometer (Larson, 1958) are available commercially and are widely used in the United States.

Although many authors have confirmed Chaney's original findings in adults (Lambert and colleagues, 1951; Lawson, 1958; Mann, 1963; Sherman, Goldberg and Lawson, 1963) and in children (Bowers, Gordon and Segaloff, 1959), the value of measuring the Achilles tendon reflex as an index of thyroid function is still in doubt. Measurement of the tendon reflex is a test which can be performed rapidly and which causes the patient little inconvenience. The result is available immediately and is not invalidated by the administration of thyroid replacement therapy or antithyroid drugs. The test would therefore be potentially useful if it were found to be reliable and diagnostic. In this paper an attempt is made to assess the reliability and usefulness of the test in patients suspected of being hypothyroid or who were thyrotoxic. Results obtained over a period of more than three years are summarised.

Methods

Tendon reflexes were elicited and recorded using the method described by Smart and Robson (1963). In all cases reflexes were elicited with the patient kneeling and, if possible, were obtained from the right leg. An interval of at least 15 seconds was allowed between successive reflexes. Although the duration of the tendon reflex was unrelated to the

strength of stimulus used to elicit it, tendon reflex time was calculated from the mean of six satisfactory tracings, the result being expressed to the nearest five milliseconds.

A normal range of results, using the 95% confidence limits, was calculated from a series of 200 normal subjects who had no clinical evidence of thyroid disease. Half were hospital patients and the remainder members of the hospital staff and visitors to hospital. The age range of the normal subjects was from 14 to 84 years and there were equal numbers of men and women.

Tracings were recorded from 223 patients (Table 1). Twenty-six of these patients were known to be thyrotoxic and were selected so that the effect of thyrotoxicosis on the tendon reflex could be studied. The remaining 197 patients were referred by several physicians for measurement of their tendon reflexes before the state of their thyroid function was ascertained. All patients referred for measurement of their tendon reflexes are included in this series with the exception of those receiving antithyroid drugs or thyroid hormone.

The patient's thyroid status was assessed clinically and confirmed by investigations which included ^{131}I uptake by the thyroid, protein-bound iodine estimations, resin uptake of ^{131}I -labelled triiodothyronine (Clark, 1963), serum cholesterol, electrocardiography, basal metabolic rate and antithyroid antibodies, but each of these investigations was not performed on every patient.

Results

Analysis of tracings

Typical tracings obtained from normal, hypothyroid and hyperthyroid subjects are shown in Fig. 1 and a diagrammatic representation of a typical tracing is shown in Figure 2. The initial upright deflection, produced by the stimulus of the tendon hammer stretching the muscle, is followed by a much larger deflection resulting from contraction and relaxation of the muscle during the reflex.

We have measured the time taken from the onset of contraction to the end of relaxation (distance B-D in Fig. 2) and have called this the Achilles tendon reflex duration (A.T.R.D.).

TABLE 1			
SUBJECTS INVESTIGATED IN THIS STUDY			
Normal subjects			200
Patients with absent ankle jerks			4
Thyrototics			26
Patients suspected of hypothyroidism			
(a) Hypothyroid			
i) Primary hypothyroidism	90	110	197
ii) Following ¹³¹ I therapy	5		
iii) Following drug ingestion	8		
iv) Other	1		
v) Panhypopituitarism	6	82	5
(b) Euthyroid			
(c) Undiagnosed			
Total			427

Previous workers, using other methods for recording the tendon reflex, found difficulty in determining the end point of relaxation (Lambert and others, 1951; Gilson, 1959). Because of this they measured the time taken from the point of stimulus to the point of half relaxation—distance A-C in Figure 2. Although we have not experienced similar difficulties using our apparatus, we have also measured the “half-relaxation time” from our tracings (see Table 2) and have analysed both sets of measurements.

The distributions of A.T.R.D. and “half-relaxation time” for the normal subjects were markedly skew but when expressed logarithmically, these parameters were distributed normally (Fig. 4). Because of this all analyses were performed after logarithmic transformation but, for clinical convenience, figures used in the text are the antilogarithms of the logarithmic values.

The two parameters produced similar coefficients of variation for the results obtained from the normal subjects (Table 2) and they produced statistically similar degrees of separation between the hypothyroid, hyperthyroid and normal subjects. In practice we found that when trying to differentiate between hypothyroid and euthyroid subjects the “half-relaxation time” produced erroneous results in 18% of cases whereas the A.T.R.D. measurement, in the same patients, was discordant in 15%. In thyrotoxic subjects A.T.R.D. produced 31% of results below the normal range and the equivalent figure for “half-relaxation time” was 38%. In this paper all further results refer to the A.T.R.D. parameter.

Normal subjects

The mean values and 95 percentiles for the normal subjects, calculated from log₁₀ values, are shown in Table 2. Results from the hospital

FIG. 1.—Typical tracing from (a) normal (b) hypothyroid and (c) thyrotoxic subjects. The divisions on the horizontal axes represent 100 millisecond intervals.

patients and the normal volunteers, and from the males and females were analysed separately, but since no statistically significant difference could be shown between these groups they were re-analysed together. No correlation between length of A.T.R.D. and age could be demonstrated in the 200 normal subjects whose ages ranged from 14 to 84 years.

Thyrotoxic subjects

With one exception the A.T.R.D. values for the thyrotoxic subjects fell in the lower normal

TABLE 2

ANALYSIS OF RESULTS FROM THE 200 NORMAL SUBJECTS

PARAMETER	A.T.R.D.	$\frac{1}{2}$ -RELAXATION
Mean value ('logarithmic')	300 milliseconds	275 milliseconds
Upper 95 percentile	390 milliseconds	360 milliseconds
Lower 95 percentile	230 milliseconds	205 milliseconds
Mean value ($\log_{10}$)	2.4784	2.4362
Standard deviation	0.05805	0.06151
Coefficient of variation	2.34%	2.52%

FIG. 2.—Diagrammatic representation of a typical tracing.

range or were lower than normal (Fig. 2). The 'logarithmic' mean for this group (240 milliseconds) was significantly less than that for the normal subjects (301 milliseconds, $P<0.001$) but of the 26 thyrotoxic patients studied, 18 (69%) had results in the normal range. Many thyrotoxic patients show a marked overswing and oscillation at the end of relaxation (Fig. 1) but this was not present in all thyrotoxic subjects and could not be considered a diagnostic feature.

The effect of treatment with antithyroid drugs on the A.T.R.D. was followed in ten thyrotoxic subjects. Tendon reflexes progressively lengthened and when the patient was clinically euthyroid the A.T.R.D. was in the normal range in each instance (Fig. 3). However, estimation of the A.T.R.D. did not contribute to the management of these cases.

Hypothyroid subjects

One hundred and ten of the 197 patients referred for suspected hypothyroidism were subsequently found to be hypothyroid. The A.T.R.D. measurements from this group of

FIG. 3.—The distribution of A.T.R.D. measurements in the 26 thyrotoxic patients and the effect of treatment in ten of these patients. The interrupted lines represent the 95% confidence limits for the normal subjects.

patients varied widely, the extreme values being 250 milliseconds and 3,450 milliseconds. The values are shown in Fig. 4 which compares these results with those from the 200 normal subjects. The 'logarithmic' mean for this group—596 milliseconds—is significantly different from that of the normal subjects (301 milliseconds, $P<0.001$) but 13 (12%) hypothyroid patients had A.T.R.D. values within the normal range.

The aetiology of the hypothyroidism in this group of patients varied (Table 1). Most patients (90) had primary myxoedema; five had been thyrotoxic and had been given ^{131}I therapeutic

FIG. 4.—The distribution of A.T.R.D. for the normal and hypothyroid subjects. One hypothyroid patient with an A.T.R.D. measurement of 3,450 milliseconds is not included in the figure. A.T.R.D. is plotted on a logarithmic scale.

tically; eight had iodide-induced hypothyroidism usually following the ingestion of 'Felsol' powders (Begg and Hall, 1963); one patient was hypothyroid after a thyroidectomy for thyrotoxicosis and six patients had pan-hypopituitarism with evidence of hypothyroidism. We were unable to demonstrate any significant difference in the A.T.R.D. values between the groups of patients with different causes for their hypothyroidism, this finding agreeing with that of Lambert and colleagues (1951).

With treatment of hypothyroidism the patient's A.T.R.D. fell and with adequate therapy it returned to the normal range. In Fig. 5 the results of the A.T.R.D. before and after treatment with L-thyroxine are compared in 38 patients. In every case the tendon reflex duration shortened and in 34 (89%) the result after treatment was within the normal range. In the remaining four cases the A.T.R.D. value after treatment was just above the upper normal 95 percentile, the longest value being 420 milliseconds. In view of our recent experience, we think it is probable that many of these patients' A.T.R.D. values might have fallen into the normal range if the dose of L-thyroxine had been increased further.

In many patients the A.T.R.D. value was estimated at regular intervals after treatment with L-thyroxine was started and typical results from four patients are shown in Fig. 6. In the majority of patients the tendon reflex progressively shortened (patient J.B., Fig. 6), this improvement paralleling the improvement in the patient's general condition. The time

taken for the A.T.R.D. value to regain the normal range varied from three weeks to four months and at this time the patients were clinically euthyroid. Sometimes the A.T.R.D. did not fall progressively with treatment but tended to fluctuate. However, it eventually fell to normal with adequate replacement therapy and remained in the normal range (see B.T. in Fig. 6). Although we have observed this fluctuation in several patients we have never observed a lengthening of the tendon reflex above the pre-treatment level.

Measurement of the A.T.R.D. appears to be a sensitive index of response to treatment. In patient S.R. the dose of thyroid therapy was progressively increased to 0.3 mg. L-thyroxine per day. On this dose the patient's A.T.R.D. hardly altered after six weeks of treatment and the daily dose of L-thyroxine was increased to 0.4 mg. The A.T.R.D. then rapidly fell to the lower normal range in one month and remained at this level. Similarly in patient N.I. a daily dose of 0.3 mg. L-thyroxine was insufficient to reduce the patient's A.T.R.D. to the normal range. Although the patient felt better on this therapy, the dose of L-thyroxine was increased to 0.4 mg. per day because his tendon reflexes were still prolonged. When seen two months later the patient had noticed a marked improvement and his A.T.R.D. had fallen into the normal range.

Euthyroid patients suspected of hypothyroidism

Eighty-two of the patients referred for suspected hypothyroidism were found, on further investigation, to be euthyroid. The remaining five patients could not be allocated to either the euthyroid or hypothyroid groups since there was insufficient information about their thyroid function. Of the 82 euthyroid patients, 16 (20%) had A.T.R.D. values above the normal range (Table 3). In six of these patients the result was either 395 or 400 milliseconds, i.e., just above the normal upper 95 percentile. In five further patients the A.T.R.D. was between 400 milliseconds and 450 milliseconds, whereas in the remaining five patients the tendon reflex prolongation was even more marked. Clinical details of the euthyroid patients with the most markedly prolonged A.T.R.D. values are shown in Table 4.

Discussion

Although Sherman and others (1963) found that the tendon reflex was shorter than normal in 75% of their thyrotoxic subjects and concluded that measurement of the tendon reflex

FIG. 5.—The response of the A.T.R.D. to treatment in 38 hypothyroid patients. The interrupted lines represent the 95% confidence limits for the normal subjects.

was valuable in the diagnosis of thyrotoxicosis, our figures do not support this view. We found that 69% of thyrotoxic subjects had normal A.T.R.D. values and our findings are similar to those of Lambert, Underdahl, Beckett and Mederos (1951), whose equivalent figure was 75%, whereas Sabeh, Sarver, Moses and Danowski (1964) found that only one of their thyrotoxic patients had a shorter than normal reflex. A variety of drugs have been reported to shorten the tendon reflex (Lawson, 1958; Fejer and Kun, 1964) and shortening of the reflex has also been reported after episodes of stress (Fejer and Kun, 1964; West, 1964). We con-

clude, therefore, that measurement of the tendon reflex in thyrotoxicosis is of little diagnostic value.

In hypothyroidism the test produces a greater degree of separation between normal and abnormal subjects. However, 12% of hypothyroid patients had reflex times which fell below the upper 95 percentile for normal subjects. Since several euthyroid subjects had prolonged reflexes it would appear wise not to diagnose hypothyroidism on the basis of this test alone. Although Mann (1963) found prolonged reflexes in all his hypothyroid patients, this is not a universal finding. Most authors agree

FIG. 6.—Detailed response to treatment in four hypothyroid patients. The interrupted lines represent the 95% confidence limits for the normal subjects.

that there is an overlap between normal and hypothyroid subjects. Lawson (1958) found this overlap to be minimal. Sherman and others (1963) found it to be 6%; Lambert and others (1951) 23%; whilst Sabeh and others (1964) found prolonged reflexes in only half the hypothyroid patients investigated. We have found that it is the patients with obvious hypothyroidism who tend to have the longest reflexes and in the mildly hypothyroid patients, in whom there is diagnostic difficulty, the tendon reflexes tend to be in the upper normal range or only slightly prolonged. This limits the diagnostic value of the test although similar criticisms can be applied to many of the tests of thyroid function.

Measurement of the Achilles tendon reflex appears to have considerable value in assessing

the effectiveness of treatment in patients with thyroid disease. In nearly all hypothyroid patients the tendon reflex time fell into the normal range with adequate thyroid replacement therapy and in several patients the test indicated inadequate therapy when there was little clinical evidence of this. In thyrotoxic patients we have found that the A.T.R.D. measurement will indicate overdosage with antithyroid drugs but this is of limited value since such a problem should not occur very often.

Weissbein and Lawson (1960) have demonstrated the lengthening of the hypothyroid reflex shortly after the institution of thyroid replacement therapy. Our failure to observe this phenomenon may have been because we did not record the reflexes as soon after starting

TABLE 3

THE DISTRIBUTION OF THE A.T.R.D. VALUES IN 192 OF THE 197 PATIENTS SUSPECTED OF HYPOTHYROIDISM. Thyroid function in the remaining five patients could not be determined.

The interrupted line represents the upper 95 per cent confidence limit for the normal subjects.

A.T.R.D. RANGE No. OF PATIENTS IN RANGE (milliseconds)

		Hypothyroid	Euthyroid
201 — 250		1	2
251 — 300		0	16
301 — 330		1	13
331 — 360		5	15
361 — 370		0	6
371 — 380		5	4
381 — 390		1	10
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391 — 400		3	6
401 — 410		1	1
411 — 420		3	2
421 — 430		3	1
431 — 440		3	0
441 — 450		4	1
451 — 500		11	1
501 — 600		20	3
601 — 700		17	0
701 — 800		9	0
801 — 900		10	0
901 — 1,000		4	0
1,001 — 2,000		8	1
Above 2,000		1	0
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Total		110	82

treatment as is necessary to demonstrate this paradoxical lengthening.

Approximately 20 of the 82 euthyroid patients who were investigated for hypothyroidism had A.T.R.D. values very close to the normal upper 95 percentile (Table 3). It is possible that several of these patients were mildly hypothyroid and that this was not detected by other tests of thyroid function. This has been observed in one patient who had an A.T.R.D. measurement (380 milliseconds) in the upper normal range. Although investigations at this time failed to confirm the diagnosis of hypothyroidism, she was reviewed one year later when her A.T.R.D. value had lengthened to 425 milliseconds and re-investigation confirmed the suspected diagnosis.

Another explanation for the clustering of many euthyroid results around the normal upper 95 percentile is that several of these patients were thought clinically to have prolonged reflexes and were referred, and investigated, for this reason. It is not surprising that several of these euthyroid subjects had prolonged tendon reflexes. Two and a half per cent of any normal group of patients would be expected to have A.T.R.D. values above the normal upper 95 percentile and this group of

TABLE 4

CLINICAL DETAILS OF THE EUTHYROID PATIENTS WHO HAD MARKED PROLONGATION OF THEIR TENDON REFLEXES.

PATIENT	A.T.R.D. (milliseconds)	CLINICAL DETAILS
S.A.	450	Obesity, Hypertensive, Myocardial Ischaemia
M.F.	500	Diabetes Mellitus—no peripheral neuropathy
H.K.	540	Hypertensive, Arteriosclerosis
A.S.	590	Psoriasis, Obesity, Positive antithyroid antibodies
A.D.	600	Obesity, Hypertensive
E.L.	1,950	Clinically Hypothyroid investigations negative

euthyroid subjects was highly selected since they were suspected of being hypothyroid.

Previous workers have reported prolongation of tendon reflexes in euthyroid patients. Lambert and others (1951) found that obese patients, as a group, had significantly longer reflexes than normal subjects and three of our six euthyroid patients who had marked prolongation of their tendon reflexes were appreciably overweight. One of our euthyroid patients with prolonged reflexes was a diabetic and Bearwood and Schumacher (1964) found that diabetics often had prolongation of their tendon reflexes outside the normal range and as a group, they had a significantly longer reflex time than had normals. The euthyroid patient with the most marked prolongation of her reflexes was diagnosed clinically as being hypothyroid, but investigations failed to confirm this diagnosis. The sixth patient in this group was hypertensive and arteriosclerotic and recently a patient has been reported who had ischaemia of a limb associated with atheroma and hypotension and was found to have prolongation of her tendon reflex (Galpin and O'Brien, 1964). Prolongation of the tendon reflex has also been reported in sarcoidosis (Richards, 1962), neurosyphilis (Simpson, Blair and Nartowicz, 1963a), myasthenia gravis (Simpson and others, 1963b) and in hypokalaemia (Carr, Gill, Henkim and Bartter, 1963).

Although we have pointed out that measurement of the Achilles tendon reflex has distinct limitations, prolongation of the reflex is so simple to measure and can be so striking clinically, that it can often be a most helpful aid in the diagnosis of hypothyroidism.

Summary

Tendon reflexes were recorded from 200 normal subjects, 26 thyrotoxic patients and 197 patients who were thought to be hypothyroid

In the latter group 110 patients were subsequently found to be hypothyroid, 82 to be euthyroid and five patients could not be classified because of inadequate data. The hypothyroid patients, as a group, had significant prolongation of their tendon reflexes irrespective of the cause of the hypothyroidism, but 12% had results below the upper 95 percentile for normal subjects. Twenty-six per cent of the 82 euthyroid patients, referred because of suspected hypothyroidism, had prolonged tendon reflexes and in six of these the reflex was markedly prolonged. Three of this group of patients were obese, one had diabetes mellitus and one was arteriosclerotic, prolonged tendon reflexes previously having been described in each of these conditions. The mean Achilles tendon reflex duration (A.T.R.D.) for the thyrotoxic patients was significantly shorter than that for the normal subjects but 69% of these patients had results in the normal range.

We conclude that measurement of the Achilles tendon reflex is of little value in the diagnosis of thyrotoxicosis. Despite its limitations, the technique can be helpful in the diagnosis of hypothyroidism and it is especially useful in assessing the effect of treatment and in regulating the dosage of thyroid replacement therapy given to hypothyroid patients.

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REFERENCES

- BEARDWOOD, D. M., and SCHUMACHER, L. R. (1964): Delay of the Achilles Reflex in Diabetes Mellitus, *Amer. J. med. Sci.*, **247**, 324.
- BEGG, T. B., and HALL, R. (1963): Iodide Goitre and Hypothyroidism, *Quart. J. Med.*, **32**, 351.
- BOWERS, C. Y., GORDON, D. L., and SEGALOFF, A. (1959): The Myxedema Reflex in Infants and Children with Hypothyroidism, *J. Pediat.*, **54**, 46.
- CARR, A. A., GILL, J. R., JR., HENKIN, R. I., and BARTTER, F. C. (1963): Relationship of Potassium Metabolism to the Achilles Tendon Reflex in Man, *Clin. Res.*, **11**, 215.
- CHANEY, W. C. (1924): Tendon Reflexes in Myxoedema: Valuable Aid in Diagnosis, *J. Amer. med. Ass.*, **82**, 2013.
- CLARK, F. (1963): Resin Uptake of ^{131}I -triiodothyronine: An In-vitro Test of Thyroid Function, *Lancet*, **ii**, 167.
- FEJER, A. G., and KUN, M. (1964): The Achilles Reflex, *Lancet*, **ii**, 695.
- GALPIN, O. P., and O'BRIEN, P. K. (1964): Prolongation of Tendon Reflexes in Ischaemia, *Lancet*, **ii**, 209.
- GILSON, W. E. (1959): Achilles-reflex Recording with a Simple Photomograph, *New Engl. J. Med.*, **260**, 1027.
- LAMBERT, E. H., UNDERDAHL, L. O., BECKETT, S., and MEDEROS, L. O. (1951): Study of Ankle Jerk in Myxoedema, *J. clin. Endocr.*, **11**, 1186.
- LAWSON, J. D. (1958): The Free Achilles Reflex in Hypothyroidism and Hyperthyroidism, *New Engl. J. Med.*, **259**, 761.
- MANN, A. S. (1963): The Value of Kinemography in the Diagnosis of Thyroid Dysfunction, *Amer. J. med. Sci.*, **245**, 317.
- MOULOPOULOS, S. D., KOUTRAS, D. A., and KRALIOS, A. C. (1964): A Simple Inexpensive Method for Recording Achilles Tendon Reflexes, *Lancet*, **i**, 85.
- RICHARDS, A. G. (1962): The "Myxedema Reflex" as a Presenting Sign in Sarcoidosis, *Canad. med. Ass. J.*, **86**, 32.
- SABEH, G., SARVER, M. E., MOSES, C., and DANOWSKI, T. S. (1964): Triiodothyronine Binding to Red Blood Cells and Achilles Tendon Reflex as Thyroid Indices, *Amer. J. med. Sci.*, **248**, 253.
- SHARPE, A. R. (1961): A Simple Isotope Method for Recording the Achilles Tendon Reflex in Myxedema, *J. Lab. clin. Med.*, **57**, 165.
- SHERMAN, L., GOLDBERG, M., and LARSON, F. C. (1963): The Achilles Reflex: A Diagnostic Test of Thyroid Dysfunction, *Lancet*, **i**, 243.
- SIMPSON, G. M., BLAIR, J. H., and NARTOWICZ, G. R. (1963): Prolonged Achilles Reflex in Neurosyphilis Simulating the "Myxedema Reflex". *New Engl. J. Med.*, **268**, 89.
- SIMPSON, G. M., BLAIR, J. H., and NARTOWICZ, G. R. (1963): Diagnostic Limitations of Achilles Tendon Reflex in Thyroid Disease, *N.Y. St. J. Med.*, **63**, 1148.
- SMART, G. A., and ROBSON, A. M. (1963): A Simple Method for Recording Achilles Tendon Reflexes, *Lancet*, **i**, 363.
- WEISSBEIN, A. S., and LAWSON, J. D. (1960): Paradoxical Lengthening of Muscle Contraction Time in Hypothyroid Patients given Small Doses of L-triiodothyronine, Thyroxine and Dessicated Thyroid, *J. clin. Endocr.*, **20**, 429.
- WEST, E. D. (1964): The Achilles Reflex, *Lancet*, **ii**, 861.