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A Fifteen Minute Test of the Rate of Thyroid Trapping of Radio-Iodine

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Over the years a number of reports have been published dealing with early uptake measurements of radioactive iodine by the thyroid gland (1,2,3,4,5,6,7), particularly within the first 60 minutes. In general, the measurements have been more satisfactory in distinguishing hyperthyroidism from euthyroidism than the conventional 24 hour uptake, but of no practical help in diagnosing hypothyroidism (3,6).

These authors used the per cent of administered dose accumulated in the gland as an index of functional capacity. In the test to be described in this paper continuous counts over the thyroid are obtained on a strip chart recorder after an intravenous injection of radioactive iodine in much the same manner as described by Larsson and Johnsson (4), Higgins (3) and Mosier (6). Instead of counting a separate standard and determining a per cent uptake of radioactivity in the gland after a given interval, a simple ratio of the net counts at 15 minutes to that at 5 minutes is obtained (R_{15}). This ratio, called the trapping index (R_{15}), the 24 hour uptake (T_{24}) and the clinical state are compared in 310 patients.

METHODS AND RESULTS

The patient is placed supine and a scintillation detector probe is positioned directly over the thyroid gland. The probe consists of a 20 degree divergent lead collimator associated with a 1.75 x 2 inch scintillation crystal (Baird Atomic Model 815 CL). The crystal-skin distance is 25 cm and at that level the 50 per cent isoresponse diameter is 15 cm. The discriminator is adjusted to the knee of the I^{131} integral spectrum. Counting rates are continuously registered on a strip chart recorder which is run at 0.75 inches per minute. The rate meter is set at a 10K scale and a 10 second time constant.

With the patient in position and instruments set as described above, a background recording is obtained for 1 to 2 minutes. Following this, the patient is given an intravenous injection of about 20 microcuries NaI^{131}. As the bolus of activity passes under the probe an initial spike is observed on the chart which then settles and reflects the accumulation of I^{131} in the thyroid gland.

The background activity, which is determined prior to injection, is subtracted from 2 points on the curve 5 and 15 minutes after the initial rise. The R_{15} is then calculated by dividing the net 15 minute count rate by the net 5 minute count rate. Typical hyperthyroid, euthyroid and hypothyroid curves are illustrated in Figure 1.

The conventional 24 hour uptake is obtained by counting a known standard at a fixed distance and relating it to the dose administered and the net activity in the thyroid gland at the same distance.

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During a 12 month period, approximately 750 patients were tested for thyroid function using both the trapping rate index and the 24 hour uptake. Of these 750 patients, 310 were seen and clinically evaluated by one or more members of the Endocrinology Department of the Montreal General Hospital.

The relationship between R_{15} and T_{24}, for values of R_{15} equal to or greater than 1, in all patients is given by, log R_{15}=0.292 Log T_{24}−0.334 (Fig. 2). The coefficient of correlation is 0.87. This relationship does not hold when R_{15} is less than 1.

Figures 3 and 4 represent histograms of R_{15} versus clinical state, and T_{24} versus clinical state, resp., of the 310 patients clinically evaluated.

R_{15} Versus Clinical State.

Excluding 4 patients with iodine-induced goitres, the upper euthyroid limit of R_{15} is 1.34. The lower hyperthyroid limit of R_{15} is 1.24. Of the 92 hyperthyroid patients, 8 (9%) had an R_{15} in the euthyroid range.

Approximately 95 per cent of the euthyroid patients lie between 1 and 1.3 (Table). 10 out of the 35 hypothyroid patients (28%) lie in this euthyroid range. There were 34 patients with an R_{15} equal to 1; 7 were hypothyroid and 27 were euthyroid, *i.e.*, 74 per cent of those patients with an R_{15} of 1 are euthyroid.

Thirty patients had an R_{15} less than 1. Of these 25 (83%) were classified as hypothyroid. The remaining 5 patients were euthyroid and 3 of these were in congestive heart failure. There were 35 hypothyroids in the study and 25 (71%) had an R_{15} less than 1.

T_{24} Versus Clinical State.

Excluding 1 patient with a 24-hour uptake of 72 per cent with an iodine-induced goiter, the upper euthyroid limit is 52 per cent. The lower hyperthyroid limit is 30 per cent. There were 90 hyperthyroid cases of which 34 (38%) overlapped the euthyroid range.

About 95 percent of the euthyroid patients had a T_{24} between 12 per cent and 46 per cent. 5 out of 34 hypothyroids (15%) lie in this euthyroid range (Table).

	R_{15}	T_{24}
Euthyroid Range*	1.0 to 1.3	12% to 46%
No. of Hyperthyroids in Euthyroid Range	4/92 (4.5%)	17/90 (19%)
No. of Hypothyroids in Euthyroid Range	10/35 (28%)	5/34 (15%)
No. of Hypothyroids below normal Range	25/35 (72%)	29/34 (85%)
R_{15} and T_{24} in Hypothyroid Range		
Clinically Hypothyroid	25/30 (83%)	29/38 (76%)
Clinically Euthyroid	5/30 (17%)†	9/38 (24%)

*Range for 95% of Euthyroid Patients.
†3/5 were in congestive heart failure.

Table. Analysis of the data on 310 patients assuming a euthyroid range of 1 to 1.3 for R_{15}, and a euthyroid range of 12 per cent to 46 per cent for the conventional 24 hour uptake.

Thirty-eight patients had a T_{24} less than 12 per cent. Of these, 29 patients (76%) were classified as hypothyroid. The remaining 9 patients were euthyroid. Eighty-five per cent of the hypothyroid patients had a T_{24} less than 12 per cent.

Effect of Change of Crystal-Skin Distance on R_{15}.

The crystal-skin distance used in these studies to measure R_{15} was 25 cm. It was found that no significant measureable change occurred in the range of 22 to 28 cm. A small increase was noted when the crystal-skin distance was reduced to 15 cm. This is explained by the fact that R_{15} is a ratio of the total neck counts at 15 minutes to 5 minutes, and a change in distance will effect both the numerator and denominator in the same direction. The small change in R_{15} is due to

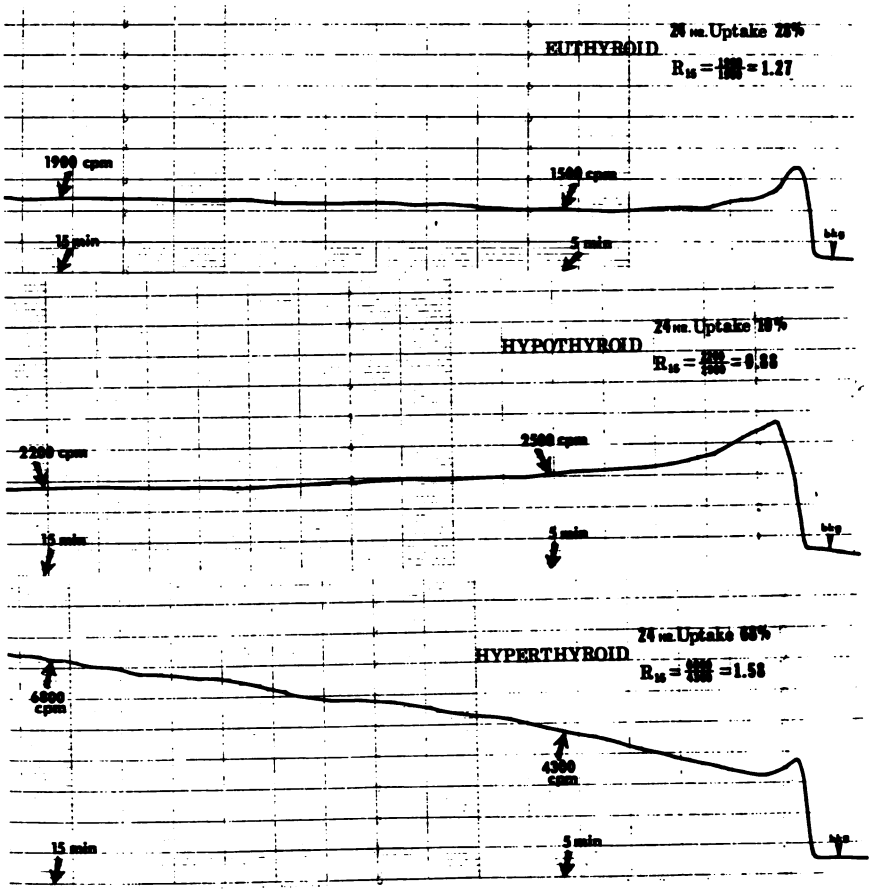

Fig. 1. Typical euthyroid, hypothyroid and hyperthyroid curves.

UPPER—Euthyroid patient with a 24 hour uptake of 28 per cent and an R_{15} of 1.27.

MIDDLE—Hypothyroid patient with a 10 per cent 24 hour uptake and an R_{15} of 0.88.

LOWER—Hyperthyroid patient with a 24 hour uptake of 68 per cent and an R_{15} of 1.58.

the thyroid count rate varying according to the inverse square law whereas the background activity does not.

DISCUSSION

The thyroid trapping index (R_{15}) was superior to the conventional 24 hour uptake (T_{24}) in separating hyperthyroidism from euthyroidism. Nine per cent of the hyperthyroids fell within the normal limits using R_{15} compared to 38 per cent for T_{24}.

The 24-hour uptake had a slight edge in distinguishing euthyroidism from hypothyroidism. When R_{15} is less than 1, the majority (83%) will be hypothyroid, although in the presence of congestive heart failure the result may be misleading.

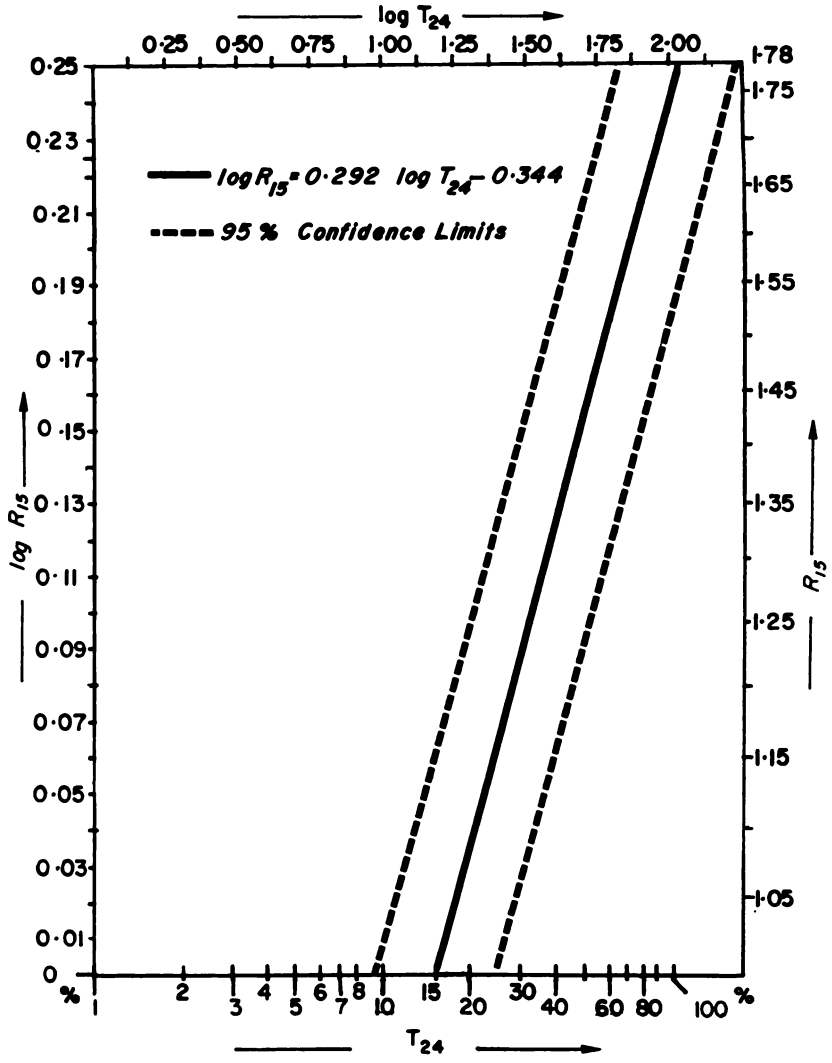

Fig. 2. A Log—log plot of R_{15} versus T_{24} for all patients with an R_{15} equal to or greater than 1.

The major source of error in the test is a partially extravascular injection of radioiodine. This will be reflected in a more steeply rising curve, *i.e.*, a higher R_{15}, because the crystal is seeing both a rising background activity and thyroid uptake. A poor injection can be detected by checking the site of venapuncture with a radiation monitor. Alternatively, a second probe can be placed over the heart and a rising curve will signify an interstitial deposit. (The range of R_{15} for the heart is 0.75 to 0.95).

The procedure is independent of the dose administered and this obviates the necessity of counting a standard—a potential source of error. Small changes in crystal-skin distance, of the order of 3 cm on either side of the 25 cm distance used to evaluate R_{15}, do not effect the result. This 3 cm difference could amount to a 30 per cent error in conventional uptake measurements. The technique possesses the advantages of the other early uptake measurements described in the literature. Within 15 minutes the effect of TSH stimulation or T3 suppression can be determined. It may give a better insight into the pathophysiology of a thyroid defect. For example, 3 out of 4 patients with iodine-induced goitres had

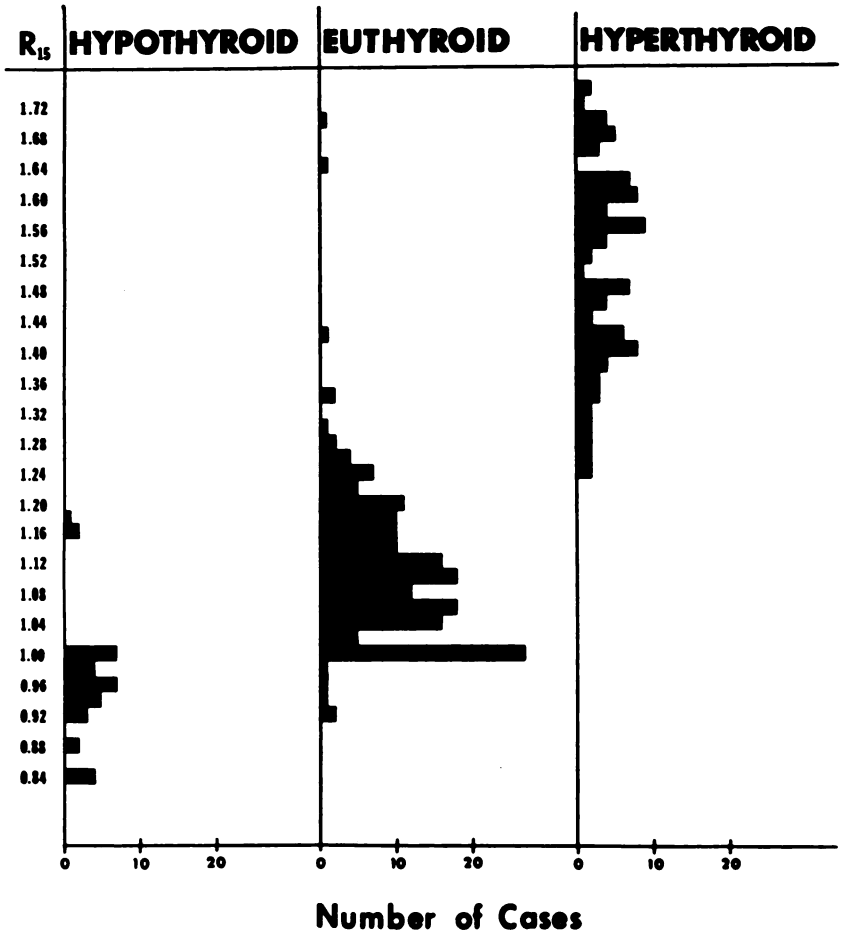

Fig. 3. Histogram of R_{15} versus clinical state.

24 hour uptakes in the euthyroid range but had high trapping rates. The fourth patient had a 72 per cent 24 hour uptake and an R_{15} of 1.7. Two hypothyroid patients had normal trapping rates (1.16 and 1.18) and normal 24 hour uptakes (20% and 22%) with low protein-bound iodines, indicating a block in the release of organified iodine.

Some large non-toxic goitres will show a high uptake at the end of 15 minutes because the amount of parenchymal tissue is increased, but when the R_{15} is calculated it falls in the euthyroid range. On the other hand, small toxic adenomas may show a normal 15 minute total uptake because the functioning tissue volume is small, but a high trapping index in the hyperthyroid range will be obtained. The essential difference between the early uptake measurements reported by other investigators and the R_{15} is that the former measures the amount of activity in the gland in terms of the administered dose as an index of function. The R_{15} is a relative rather than an absolute measurement, and com-

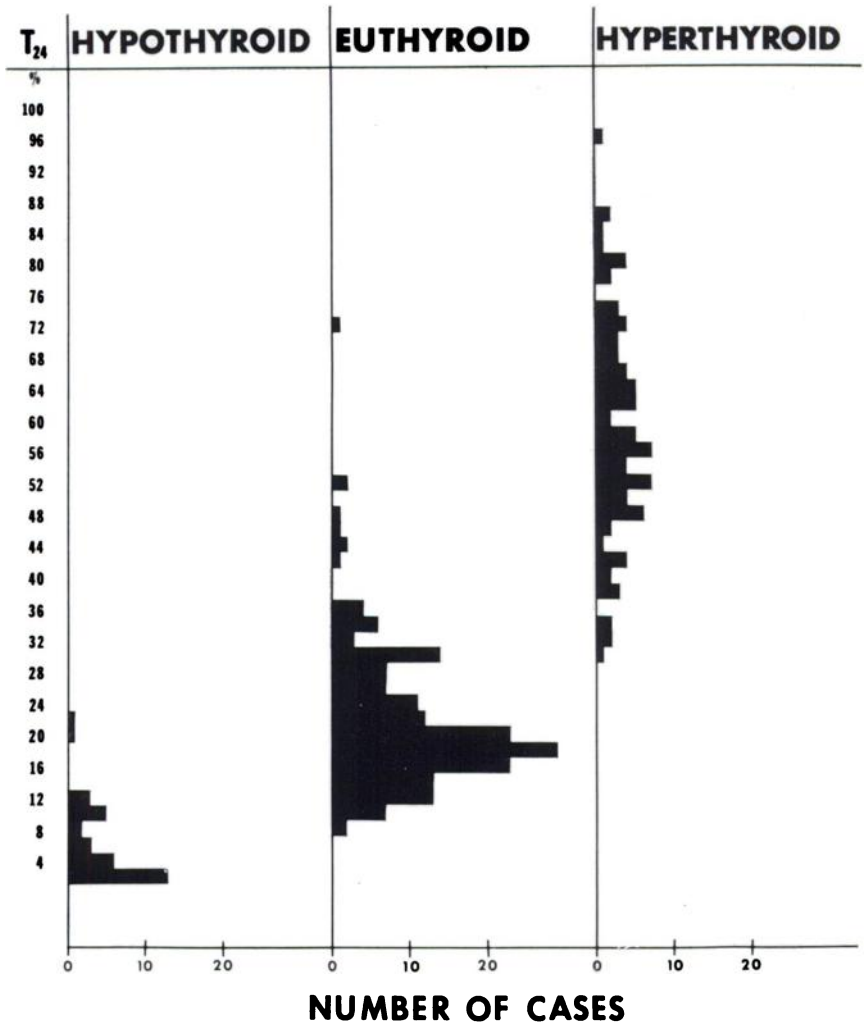

Fig. 4. Histogram of 24 hour uptake (T_{24}) versus clinical state.

pares the amount of activity in the gland in 15 minutes to itself at 5 minutes. A reference point earlier than 5 minutes was avoided because the initial spike on the recording was still descending in some euthyroid patients as late as 3 to 4 minutes after injection. A ratio calculated with an earlier reference point in these patients could have resulted in hypothyroid values.

When 24 hour uptakes or thyroid scans are not required, I^{132} can be used. Its short half-life (2.33 hours) and low radiation dose to the thyroid (about one thirtieth of I^{131}) makes it eminently suitable.

The R_{15} values derived in these studies are valid only for the design of collimator used and at a 25 cm crystal-skin distance. Although correctly timed counts at 5 minutes and 15 minutes will give the same result as continuous recording, the latter will detect changes in geometry and background radioactivity by irregularities in the curve.

SUMMARY AND ACKNOWLEDGEMENTS

A simple 15 minute thyroid function test is described. Continuous recording of radioiodine activity over the thyroid gland following intravenous injection is obtained, and the ratio of the count rate at 15 minutes to 5 minutes is estimated (R_{15}). The relationship of R_{15} to the 24 hour uptake (T_{24}) is given by log $R_{15}=0.292 \log T_{24}-0.334$, with a 0.87 coefficient of correlation. The value of R_{15} is independent of the administered dose and insensitive to small changes in crystal-skin distance.

In 310 clinically evaluated patients the trapping rate index was found to be more sensitive in separating hyperthyroidism from euthyroidism than the conventional 24 hour uptake. The R_{15} and T_{24} were about equally efficient in distinguishing euthyroidism from hypothyroidism. TSH stimulation and T3 suppression can be readily determined and a greater insight into the pathophysiology of the thyroid disorder can be obtained by using this simple 15 minute test.

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