Correlation of Thyroid Uptake with Whole-Body Retention Measurements

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The use of conventional thyroid measurement is not practicable in a number of clinical situations. We investigated the correlation of 48-hr whole-body retention to thyroid uptake results at 4, 24, and 48 hr after administration. The 48-hr count gives the best results, confirmed in studies on 69 patients. Equations computed to fit our data show high levels of confidence with administered doses as low as 50 nCi. The technique can be used in infants, in pregnant women when there is a massive goiter, or in other clinical situations in which a conventional thyroid measurement is contraindicated or technically unsatisfactory.

A number of clinical situations exist in which the use of conventional ^{131}I uptake techniques for thyroid function measurements are neither feasible nor appropriate. Previously Pope *(1)* demonstrated the usefulness of the whole-body counter in the diagnosis of hyperthyroidism, using the peak thyroid uptake count as a standard of comparison. In 1959 Lushbaugh *(2)* and others reported the feasibility of whole-body retention of ^{131}I as a method of studying thyroid function in man. During the past several years our staff has investigated the use of a low-level whole-body counter as an alternative method for testing thyroid function. Our work was specifically directed toward making this technique more generally applicable to any thyroid condition than the conventional thyroid uptake test. It was also aimed at finding the optimum time, after dose administration to a patient, when the relation of ^{131}I thyroid uptake and whole-body retention would be sufficiently accurate and reliable for assessment of thyroid function in the absence of thyroid uptake measurement.

Another objective was to determine the smallest possible dose of ^{131}I that can be used to obtain an accurate appraisal of thyroid function. By using low-level activity in whole-body counting, the technique could be used in clinical studies in which the conventional technique cannot ordinarily be performed.

Objectives and Measurement Methods

First the correlation between the thyroid uptake and the whole-body counting retention was determined at preselected times after dose administration. A standard 5.08 cm (2 x 2 in.) NaI (Tl) crystal was used for probe counting the thyroid gland and compared with results from a low background whole-body counter we developed earlier *(3, 4)*. Our procedure was to make parallel ^{131}I thyroid uptake and whole-body retention measurements at set time intervals after administration of the dose. Results were then compared both graphically and through statistical techniques (linear least squares) to find the interrelating correspondence and its confidence level.

Calculation program. All patient data collected by the conventional thyroid uptake method were converted to net counts and corrected for decay before the thyroid uptake values were calculated. These values were then entered by data cards into an IBM 1800 computer and stored on magnetic tape for future retrieval and computational use.

Data from the whole-body counter were obtained in a spectrum of 200 channels in a 0–2 MeV range and entered by paper tape into the same computer for storage on magnetic tape.

On retrieval of these data, a calibrated optimum window technique *(5)* was used for calculating dose retention values. These whole-body retention values are also stored on magnetic tape.

Once the thyroid uptake and whole-body retention data became available, additional computer programs were developed for data comparison

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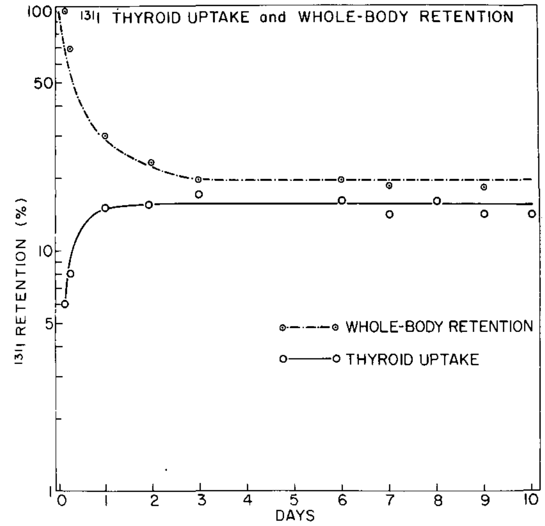

FIG. 1. Whole-body retention and thyroid uptake of ^{131}I in normal patient. Note that slopes of whole-body retention and thyroid uptake curves are nearly parallel after 48 hr.

TABLE 1. Comparison of the Correlation between Thyroid Uptake with 48-Hr Whole-Body Retention

Number of patients	Time of thyroid uptake (hr)	Intercept (%)	Linear slope	Confidence level
75	4	13.94	1.215	0.876
77	24	6.60	1.011	0.966
69	48	4.34	1.081	0.976

and analysis. The first programs were written to find correlations between the two kinds of retention. Earlier studies *(6)* showed that whole-body retention of ^{131}I becomes relatively stable in all patients at or after the 48-hr count (Fig. 1). We therefore used this value as a standard of comparison for each subject against the thyroid uptake values. Whole-body retention measurements at 4 and 24 hr do not correlate well with thyroid uptake measurements due to variable retention of unbound iodine at these times.

The computer was programmed to produce three plots, consisting of a least-squares linear regression fit for the 48-hr whole-body counter data and the 4-, 24-, and 48-hr thyroid uptake data and a calculation of the coefficient of correlation for each.

Results

The comparative data for our whole-body counts at 48 hr and the 4-, 24-, and 48-hr thyroid uptake studies are shown in Table 1 and Figs. 2, 3, and 4. Table 1 lists the linear slope, intercept, and coefficient of correlation for the three best fit lines through the data. The intercepts fall on the positive whole-body retention axis, indicating the percent of whole-body retention that would be expected at these times without any thyroid uptake.

Figure 2 graphs the correlation line between 48-hr whole-body retention and the thyroid uptake count at 4 hr on data from 75 patients. The slope value of 1.215 indicates that greater amounts of unbound ^{131}I are still present in the body than should be if all iodine had been processed through the thyroid. This extrathyroid activity is confirmed by the high intercept value of 13.94% for the correlation at 4 hr. At this time the linear equation of fit has a coefficient of correlation of 0.876, attesting to the variations in patients of unbound, circulating iodine.

In the 24-hr study (Fig. 3) the slope value is 1.011 and the intercept is 6.60%. At this time most of the remaining iodine has become trapped by the thyroid gland and small amounts are now circulating as thyroxine. In addition, there are small amounts of unbound iodine still circulating. The confidence level for this 24-hr study on 77 patients is 0.966, confirming the more narrow spread of data points we see in Fig. 3.

The 48-hr curve of Fig. 4 depicts a slightly increased value in the overall slope value to 1.081, and a continued fall in zero uptake retention to 4.34%. We interpret these values to mean the amount of circulating ^{131}I-thyroxine in the hypothyroid (or near athyroid) individual is very

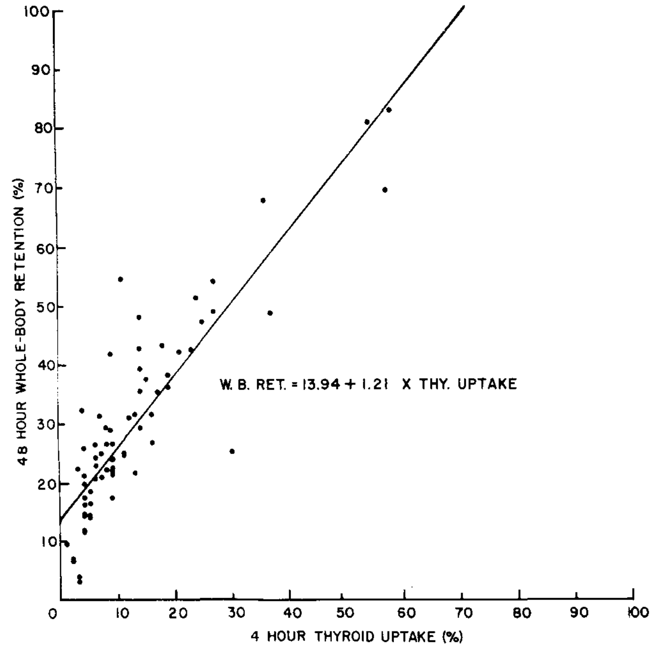

FIG. 2. Plot of 48-hr whole-body retention and 4-hr thyroid uptake of ^{131}I in 77 patients. Coefficient of correlation is 0.876.

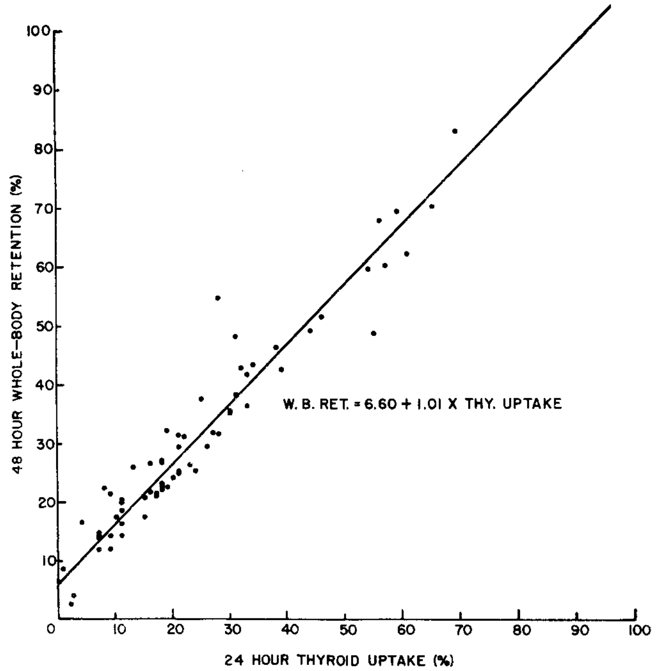

FIG. 3. Plot of 48-hr whole-body retention and 24-hr thyroid uptake of ^{131}I in 77 patients. Coefficient of correlation is 0.966.

low at 48 hr. However, in euthyroid and hyperthyroid individuals the amounts of activity bound to thyroxine are definitely elevated, accounting for more ^{131}I seen in their 48-hr whole-body count. A skewing of our linear fit toward a high whole-body count results and is a change expected from the known physiologic distribution factors. The confidence level for this correlation of the 2-day interval has increased to 0.976.

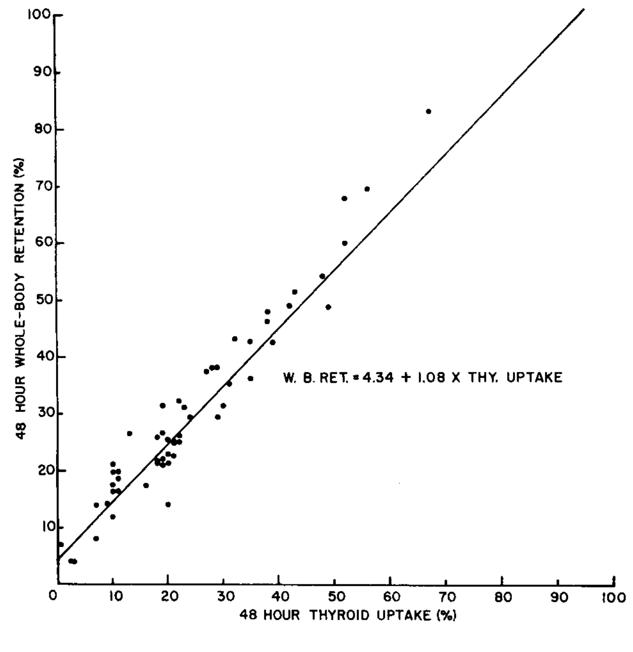

FIG. 4. Plot of 48-hr whole-body retention and 48-hr thyroid uptake of ^{131}I in 69 patients. Coefficient of correlation is 0.976.

Discussion and Conclusions

A linear regression equation, calculated from the values in Table 1 and Fig. 4 and comparing the 48-hr uptake with 48-hr whole-body counts, is one we find increasingly useful and reliable as these studies continue. The form of expression we use in our laboratory for a calculated thyroid uptake is:

$$\text{T. U. } (\%) = 4.34 + 1.081 \times \frac{\text{Patient}_{48}}{\text{Patient}_0} \times \frac{\text{Reference}_0}{\text{Reference}_{48}} \times 100$$

where the subscripts indicate net counts at the time of administration (0) and at the later time of retention (48). Our reference count is made on a small fraction (e.g., 20%) of the patient's dose, drawn from the same stock solution and mixed into a large (8-liter) polyethylene bottle, that is is counted at approximately the same time and position as the patient.

When comparing the whole-body results, calculated using the above equation, with those from conventional uptake measurements, we have found no instance where a hyper-, hypo-, or euthyroid subject has been clinically miscategorized. The variations we have seen in 69 studies have all been too small for a gross error of this nature

We see the following advantages and applications of this technique:

(A) Accurate thyroid uptake values can be obtained using very small doses of radionuclide; viz. 50 nCi of ^{131}I will produce a reliable measurement in our low-level counter *(6)*.

(B) Measurements can be performed in special situations, such as when a massive goiter is present and the field of counting is poorly defined or in a pregnant woman or small children in whom the administered dose must be kept extremely low.

(C) Both the thyroid uptake and circulating thyroxine values can be separated and studied over intervals of several weeks.

(D) Uptake values in animals, even very small ones, can be obtained by this method—where the use of a probe counter would be impractical *(7)*.

Although one emphasis of our work has been on reduction of dose to the patient, we realize that few laboratories possess a low-level whole-body counter and that the dose reduction we can attain is not possible for all. However, this does not preclude the application of the whole-body retention approach to measurement of thyroid uptake.

Simple, inexpensive whole-body counters of the type described by Hodges, et al *(8)* can be used. Use of this approach will minimize errors that can occur when large thyroid glands or pyramidal lobes are present. Such simple whole-body counters can also be applied to other diagnostic radioisotope studies. Since they could completely replace conventional thyroid uptake counting equipment and serve other needs, the investment required should not be beyond the means of most institutions.

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