THYROID-UPTAKE STUDIES USING ^{132}I

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The radioactive-iodine thyroid-uptake determination (RAI) is a valuable measure of thyroid-gland activity, particularly when the results are correlated with clinical findings and other tests of thyroid function. Although ^{131}I (sodium iodide) has become the most commonly used radioisotope of iodine for this test, there is no reason why other radioisotopes of iodine cannot be used if they emit sufficiently energetic gamma photons to permit external detection and if they have suitable half-lives.

Although a number of European investigators (*1–8*) have reported using ^{132}I for thyroid-uptake studies, there have been relatively few reports in the American literature (*9–11*). The principal advantage of using ^{132}I for uptake determinations is that the absorbed radiation dose to the thyroid gland is considerably less than with comparable microcurie quantities of ^{131}I (Table 1). It is the purpose of this paper to present a simple method for performing uptake studies with ^{132}I using conventional counting equipment available in all radioisotope laboratories where ^{131}I uptakes are performed.

In one of the first reports in which ^{132}I was used for thyroid-uptake determinations, Halnan (*12*) described a neck-counting apparatus that consisted of a collar of four G-M tubes and a separate thigh counter. The results were expressed as the ratio of neck-to-thigh counts 2 hr after the administration of the radioiodine. With these measurements he was able to differentiate between hyperthyroid and euthyroid function as well as to demonstrate the thyroid response to suppression and stimulation.

Because of the short physical half-life of ^{132}I (2.33 hr), uptake determinations are usually performed between 1 and 4 hr after administration. To minimize wide variations in uptakes resulting from differences in gastrointestinal absorption of the radioiodine, the 4-hr uptake has generally been preferred. ^{132}I can also be administered by the intravenous route if precautions are taken to assure that the product is sterile and pyrogen-free. At 4 hr, 1–14% of the administered dose is usually within the thyroid and the remaining radioiodine is distributed throughout the intravascular space and in the urine. Thus a significant proportion of counts detected from the neck area at this time represents extrathyroidal radio-

Received June 21, 1968; revision received Nov. 21, 1968.

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TABLE 1. PHYSICAL PROPERTIES OF ^{131}I AND ^{132}I

Isotope	Gamma energies (MeV) with percent occurrence (10)	Max. beta energies (MeV) with percent occurrence (10)	Half-life	Approximate radiation absorbed dose to thyroid*
^{132}I	0.520 (30%) 0.970 (23%) 0.620 (6%) 1.14 (9%) 0.670 (100%) 1.41 (13%) 0.760 (93%) 1.90 (5%) 2.20 (2%) Γ = 12.3R/μCi-hr at 1 cm	0.73 (15%) 0.97 (20%) 1.16 (23%) 1.60 (24%) 2.13 (18%) $\bar{E}_\beta$ = 0.49 MeV	2.33 hr	0.26 rads†
^{131}I	0.080 (2.2%) 0.364 (80%) 0.163 (0.7%) 0.637 (9%) 0.284 (5.3%) 0.722 (3%) Γ = 2.2R/μCi-hr at 1 cm	0.250 (2.8%) 0.335 (9.3%) 0.608 (87.2%) $\bar{E}_\beta$ = 0.188 MeV	8.05 days	10 rads‡

* 10 μCi oral dose (average adult), 20 gm thyroid gland.
† Assume 10% uptake at 4 hr. Effective half-life = physical half-life.
‡ Assume 15% uptake at 24 hr. Effective half-life = 7.6 days (thyroid).

iodine. Stewart and Murray (*13*) and Hilditch *et al* (*14*) have studied the contribution of the extrathyroidal iodine and have stressed the importance of correcting for it, particularly when the uptake determinations are low or are performed early. However, some investigators have ignored the problem and provided no correction for body-background activity. Alexander (*15*) used a 4 × 2-in. lead block placed over the thyroid to obtain a background count. Others have attempted to shield the entire neck except for the immediate region around the thyroid. Both of these methods obviously require that the investigator predict the precise size and location of the gland to provide proper shielding. Others (*16,17*) have compensated for the background with various neck-to-thigh count-ratio techniques.

MATERIALS

The ^{132}I used for the uptake studies reported here was obtained from a ^{132}Te–^{132}I generator system supplied by the Brookhaven National Laboratory as a nonsterile system. Each generator was shipped with approximately 10 mc of the parent radioisotope (^{132}Te half-life—77 hr) adsorbed on the alumina column. Equilibrium of the parent and daughter radioisotopes was reached at 12.4 hr, permitting efficient elution twice a day. The useful life of each generator was approximately 3 weeks, providing sufficient carrier-free ^{132}I for patient use before significant amounts of ^{131}I became apparent. The generator was eluted with 10 ml of 0.01 *N* NH_4OH and the ^{132}I was ready for oral administration after radioactivity assay and radionuclidic purity checks performed on a multichannel analyzer. No significant ^{132}Te breakthrough was observed and only barely detectable amounts of ^{131}I (from ^{131}Te on the column) were found on repeated elutions of the generator. ^{132}I decays with a half-life of 2.33 hr to stable ^{132}Xe. The other physical characteristics of ^{132}I are shown in Table 1.

The counting apparatus consisted of a standard thyroid-uptake system (Nuclear-Chicago Model 4405)—used routinely for performing ^{131}I determinations—which included a 2 × 2 in. NaI(Tl) crystal probe with a flat-field collimator having a 20 deg solid-angle response and a standard analyzer-timer-scaler. The lower-level discriminator of the pulse-height analyzer was arbitrarily set at 660 keV and the upper level discriminator at 760 keV. All counts were performed at a crystal-to-skin distance of 25 cm. An International Atomic Energy Agency (IAEA) plastic phantom was used to hold the 100% standard. When isoresponse curves obtained in air and in tissue-equivalent material using ^{132}I were compared with similar curves obtained with ^{131}I, no significant differences were noted. These characteristics corresponded closely with the recommendations of the IAEA for collimator design (*18*).

METHOD

Patients received no solid food within 3 hr of administration of the oral dose of ^{132}I. Individual doses of 10 μCi of ^{132}I, diluted to 5 ml in plastic syringes, were prepared ahead of time. The entire contents of the syringe and three subsequent rinses of the syringe with water were injected directly into the patient's mouth with, of course, the needle removed. An unused syringe containing an identical dose of ^{132}I was kept as the 100% standard and counted in the IAEA phantom at 4 hr. The patient's neck area was counted at 4 hr followed by counting the right thigh 8 cm above the patella. Both neck and thigh counts were made with the patient in the supine position. Whether or not the patient voided before the thigh count did not have a significant effect on the results. The percent uptake at 4 hr was determined by the following formula:

$$\text{Percent uptake} = \frac{\text{cpm(neck)} - 2.4 \times \text{cpm(thigh)} \times 100}{\text{cpm(standard) at 4 hours}}.$$

The value of 2.4 represents the average neck-to-thigh ratio of counts normally present due to extrathyroidal iodine. This value was arrived at in the following way. Seventeen patients were given a blocking dose of five drops of a saturated solution of potassium iodide three times on the day before and also just before a 10-μCi dose of ^{132}I. Thus by expanding the body pool of iodine several thousand times the total uptake of radioiodine by the thyroid was considered to be negligible, and any radioactivity detected over the neck area should, therefore, represent extrathyroidal ^{132}I.

RESULTS

Table 2 shows the neck-to-thigh ratio in a series of patients ranging in weight from 28 to 260 lb who received blocking doses of stable iodine. Seven repeat determinations in one of these patients are also shown. The average neck-to-thigh ratio was 2.4 with a range of 1.9–3.1 in the patients studied. The results in 13 euthyroid patients and eight hyperthyroid patients are shown in Table 3. All patients were evaluated clinically, and the results of the protein-bound iodine (PBI) are also shown. Serial determinations in two hyperthyroid patients are shown in Table 4.

DISCUSSION

For a number of reasons ^{131}I has become the choice for radioiodine thyroid-uptake studies. It is readily available commercially in precalibrated dose forms, and the relatively long half-life (8 days) permits uptake determinations to be performed at 24, 48 or even 72 hr. The 364-keV gamma emissions from ^{131}I are sufficiently energetic to be unaffected by variations in the amount of soft tissue overlying the thyroid (as opposed to ^{125}I with 27 keV), yet allow external imaging of the gland by scintiphotography. The principal objection to using ^{131}I for repeated uptakes is the associated high absorbed-radiation dose to the thyroid. Table 1 shows an estimated radiation dose of 0.26 rads to the thyroid for ^{132}I assuming 10% uptake of a 10-μCi oral dose composed with 10 rads from a similar dose of ^{131}I with 15% uptake at 24 hr. While the seriousness of this problem has not yet been completely determined, it would appear that every attempt should be made to keep the radiation dose as low as possible, particularly in children and pregnant women.

TABLE 2. NECK-TO-THIGH RATIO IN PATIENTS WITH BLOCKED THYROID UPTAKE OF IODINE

	Arranged in increasing order of size, range 28–260 lb
2.2	
2.0	
2.4	
2.6	
2.5	
2.1	
2.4	
2.5	
2.4	median 2.4 ± 0.29
2.3	
3.1	
2.6	
2.5	
1.9	
2.3	
2.1	
2.0	
serial determinations in the same patient	
2.5	2.4
2.1	2.0
2.5	3.0
3.0	

TABLE 3. COMPARISON OF RAI AND PBI RESULTS

^{132}I RAI (4 hr) (%)	^{131}I RAI (24 hr) (%)*	PBI (μg%)†	Diagnosis
39	44	13.2	hyperthyroidism
43		9.8	hyperthyroidism
46	58	14.3	hyperthyroidism
67		18.0	hyperthyroidism
31	57	14.4	hyperthyroidism
23	88	15.7	hyperthyroidism
40		12.1	hyperthyroidism
33		11.8	hyperthyroidism
1.1	8	4.5	euthyroid
1.7	9	5.0	euthyroid
3.0	9	4.9	euthyroid
3.3	14	5.9	euthyroid
3.6	12	3.6	euthyroid
4.1	12	6.5	euthyroid
5.0	16	4.8	euthyroid
7.0	23	5.1	euthyroid
7.5	14	5.7	euthyroid
8.1	12	5.1	euthyroid
10.1	37	6.4	euthyroid
13.5	24	5.3	euthyroid
13.6	27	5.6	euthyroid

* NIH normal range 10–30%.
† NIH normal range 4–8 μg%.

TABLE 4. SERIAL RAI FOR ^{132}I IN TWO HYPERTHYROID PATIENTS

Date	RAI (%)	Date	RAI (%)
Patient O		Patient T	
4/21	39	7/17	53
4/24	30	7/20	56
4/27	43	7/25	60 *
5/2	35	7/31	35.5
5/4	43	8/3	43.5
5/9	30	8/8	31.4
		8/11	32.1
		8/15	31.0

* Antithyroid drug started.

From our observation of patients with the thyroid uptake of isotope greatly diluted by a large dose of iodide administered before the uptake, we saw that the radiation from areas near the neck could amount to 6% of the administered dose. Previous workers have attempted to correct for this radiation by counting a vascular area in the body, usually the thigh, and expressing the result as a ratio. Besides requiring that the clinician learn a whole new set of normal values which are not clearly related to the usual 24-hr uptake, this method introduces the huge error that comes from dividing a large number, the neck radiation, by a much smaller value, the thigh radiation. Our method has determined a constant, 2.4, by which the thigh radiation is multiplied and the result is subtracted from the neck counts. The uptakes determined by our method are consistent with those expected on a physiological basis.

While ^{132}I has been used fairly extensively abroad for thyroid uptakes, it has never become popular in this country. The fact that the determination cannot be performed at 24 hr and that external imaging of the gland is not possible has probably led to its disfavor. In addition, the requirement of having to maintain another isotope generator system would not appear to make ^{132}I very practical for general use. However, we have found that the cost per dose of ^{132}I compares favorably with ^{131}I if more than 30 doses are used per week. Many investigators have avoided using ^{132}I out of fear that special equipment is required. This probably results from early reports in the literature in which elaborate shielding around crystals was described. Our experience, however, indicates that reproducible results are possible with the equipment ordinarily used for ^{131}I uptake measurements.

There are a number of clinical applications for which ^{132}I can be substituted for ^{131}I with no reduction in reliability, but with a significant reduction in thyroid radiation. It is possible to follow the daily response of thyroid to a variety of situations such as stress or drug administration. For example, investigators at our institution are determining both normal diurnal variations in the thyroid uptake and thyroidal response to stress by repeating the 4-hr uptake twice a day. Hyperthyroid patients are being studied on a twice-weekly basis for a period of several weeks to follow their response to antithyroid drugs. Such studies using ^{131}I would not have been considered safe from the standpoint of thyroid radiation even if small doses of ^{131}I were used. Another area of application is the study of large population groups such as those residing in goitrogenic regions where children are included in the study. We have, however, been reluctant to use ^{132}I exclusively for uptake determinations in our general hospital and outpatient population except where the clinical problem is clearly to determine whether or not the patient is hyperthyroid. This is due to the low range of normal values found at 4 hr which makes differentiation of normal from the hypothyroid state virtually impossible. Nevertheless, the 4-hr uptake correlates well with the PBI and 24-hr ^{131}I uptakes in normal and in hyperthyroid individuals.

SUMMARY

There are a number of clinical situations in which ^{132}I can be substituted for ^{131}I in radioiodine thyroid-uptake determinations. Serial determinations are possible using ^{132}I with a significant reduction in the absorbed thyroid radiation compared with similar administered quantities of ^{131}I. Repeat uptake values are reproducible and correlate well with other measurements of thyroid function in normals and hyperthyroid individuals. No special equipment is required so that ordinarily available counting equipment can be used.

ACKNOWLEDGMENT

The work reported here was done while B. S. Levy was a clinical associate, Laboratory of Clinical Science, National Institute of Mental Health, Bethesda, Md.

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