

Enhancement of Radioiodine Treatment of Small-Pool Hyperthyroidism with Antithyroid Drugs: Kinetics and Dosimetry

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¹³¹I-iodide is the treatment of choice in most cases of hyperthyroidism, with a standard 7,000-cGy (rad) thyroid absorbed dose generally resulting in an incidental blood absorbed dose of less than 10 cGy (rad). However, in ~15% of patients there is a small, rapidly secreted thyroid iodine pool (small-pool patients) and, based on theoretic calculations, an incidental blood absorbed dose of up to 150 cGy (rad) could result. In such small-pool patients, continuing antithyroid drugs (ATDs) at a reduced dosage during ¹³¹I therapy should inhibit the formation of ¹³¹I-labeled levothyroxine and triiodothyronine and thereby reduce the protein-bound ¹³¹I-iodine concentration in blood and the blood absorbed dose. **Methods:** To test this hypothesis, thyroid and blood time-activity data were measured and absorbed doses were calculated for an ¹³¹I tracer administered to small-pool hyperthyroid patients ($n = 9$) not receiving ATDs (off ATDs) and then receiving ATDs (on ATDs). **Results:** The blood absorbed dose (cGy/37 MBq [rad/mCi] administered) was reduced from 2.54 ± 0.91 (mean \pm SD) without ATDs to 1.27 ± 0.54 with ATDs ($P < 0.0001$), whereas the thyroid absorbed dose was unchanged ($1,870 \pm 700$ vs. $2,080 \pm 1,080$). The blood absorbed dose for an administered ¹³¹I activity required to deliver a standard prescribed absorbed dose of 7,000 cGy (rad) to the thyroid therefore was reduced by over 50% with ATDs, from 11.3 ± 6.5 to 4.9 ± 2.8 cGy (rad) ($P < 0.001$). **Conclusion:** Continued administration of ATDs during ¹³¹I therapy thus can effectively reduce extrathyroid radiation in small-pool patients without significantly reducing the target tissue (i.e., thyroid) dose.

Key Words: thyroid; hyperthyroidism; radioiodine; dosimetry; antithyroid drugs

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Optimal radioiodine (¹³¹I-iodide) treatment of hyperthyroidism requires the delivery of an appropriate radiation-absorbed dose to the thyroid gland. Extrathyroid radiation from administered ¹³¹I is inevitable but is assumed to be minimal and inconsequential and is rarely measured any-

more. Common follow-up protocols may examine thyroid function for a limited period of time for signs of hypothyroidism, but even that procedure is considered onerous by busy clinicians who increasingly prefer to deliberately ablate the thyroid and immediately place the patient on thyroid hormone replacement (supplement). Possible other late consequences of incidental whole-body radiation usually are ignored. It is particularly important therefore to administer radioiodine therapy in such a way as to minimize extrathyroid irradiation and the possibility of long-term radiogenic sequelae while still delivering a therapeutically appropriate target tissue (i.e., thyroid) dose.

Besides radioiodine uptake and thyroid mass, the thyroid radiation dose is determined by the residence time (biologic half-time) of the radioiodine within the thyroid gland ($I-3$). In euthyroid individuals, the biologic half-time of radioiodine in the thyroid is ~90 d (range, 60–120 d). In contrast, hyperthyroid patients generally discharge radioiodine more rapidly, with an average biologic half-time of only 30 d (range, 10–40 d). The majority of the radioiodine leaves the thyroid as radiolabeled levothyroxine (T_4) and triiodothyronine (T_3), which bind to serum proteins. They have a prolonged residence time in the circulation and are responsible for as much as 90% of the blood and whole-body radiation-absorbed dose. The levels of circulating radioactive thyroid hormones can be quantified by determining the serum protein-bound ¹³¹I (PB¹³¹I) concentration. As previously reported (4), ~15% of hyperthyroid patients have accelerated thyroid turnover of radioiodine, thought to be attributable to a small thyroid iodine pool (small-pool syndrome) and perhaps reflecting very high levels of thyroid stimulation. As a result, the PB¹³¹I concentration can be markedly elevated, and the absorbed doses to blood and other extrathyroid tissues can be substantially higher than those usually seen. In this study, a small-pool patient was operationally defined as a hyperthyroid patient in whom at least 1 PB¹³¹I measurement when the patient was not receiving antithyroid drugs (ATDs) (off ATDs) was greater than 2% of the administered activity per liter.

In addition, the relatively small thyroid absorbed dose in small-pool patients likely is responsible for at least some

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radioiodine treatment failures whenever the administered radioiodine is based on a standard administered activity or any other method that does not take into account the measured thyroid turnover rate. For example, a standard thyroid absorbed dose of 7,000 cGy requires only 222–259 MBq (6–7 mCi) of ^{131}I in typical hyperthyroid patients but requires ~333 MBq (9 mCi) in small-pool patients. Barandes et al. previously reported a series of 7 small-pool hyperthyroid patients in whom a standard thyroid absorbed dose of 7,000 cGy would require 1,036 MBq (28 mCi) of ^{131}I and theoretically would yield a radiation dose in the blood of 150 cGy (4), a prohibitively high incidental radiation dose for the treatment of a benign disease. In contrast, the usual blood absorbed dose for hyperthyroid patients is less than 10 cGy.

An approach was therefore devised to decrease the release of radiolabeled T_3 and T_4 and thus lower the PB^{131}I concentration by continuing a low dosage of ATDs throughout the period of radioiodine treatment. It is the usual practice in the treatment of hyperthyroid patients receiving ATDs (on ATDs), such as propylthiouracil or methimazole, to discontinue these medications 2–5 d preceding ^{131}I therapy, presumably to avoid interfering with thyroid radioiodine uptake (5). ATDs also have been reported to accelerate radioiodine turnover (6). However, ATDs do not affect the iodine-trapping mechanism (and therefore radioiodine uptake) and do not interfere with the initial binding of iodine to tyrosine residues on thyroglobulin (organification) unless given in large dosages. On the other hand, coupling of 3-monoiodotyrosine and 3,5-diiodotyrosine to form T_4 and T_3 is sensitive to even low concentrations of ATDs (7). In small-pool patients, therefore, continuation of ATDs during radioiodine therapy should reduce the PB^{131}I concentration and the blood radiation dose without significantly reducing the thyroid radiation dose. Potentially, most (i.e., typical) hyperthyroid patients, in whom the ratio of the thyroid absorbed dose to the blood absorbed dose is already quite favorable (especially in uncomplicated Graves' disease), would also benefit from the continuation of ATDs through the maintenance of uninterrupted symptomatic control. Thus, continued administration of ATDs during ^{131}I therapy should markedly reduce extrathyroid radiation in small-pool patients and should maintain symptomatic control without adversely affecting the ratio of the thyroid absorbed dose to the blood absorbed dose. The purpose of this study was to perform a dosimetric analysis of ^{131}I in small-pool hyperthyroid patients off ATDs and on ATDs and thereby to test this hypothesis.

MATERIALS AND METHODS

In our laboratory, hyperthyroid patients are treated with radioiodine according to a prescribed absorbed-dose algorithm, with the following general guidelines for definitive single-dose therapy (1,8): for young patients and those with uncomplicated Graves' disease (i.e., small glands and mild-to-moderate hyperthyroidism), 7,000–8,000 cGy; for patients with complicated Graves' disease

(i.e., larger glands and more severe hyperthyroidism), 10,000–12,000 cGy; and for patients with toxic nodular goiter, 15,000–25,000 cGy. It is important to note that there is substantial evidence that ATDs administered before, with, or after radioiodine therapy induce radioresistance, necessitating an administered activity of radioiodine higher than usual (9). In order to estimate the absorbed dose per unit of administered ^{131}I activity in the thyroid and thus the therapeutic administered activity for the prescribed thyroid dose, all hyperthyroid patients considered for radioiodine treatment in our laboratory were first studied after the oral administration of a 1.11-MBq (30 μCi) ^{131}I tracer. Thyroid uptake and blood activity concentrations (in serum and whole blood and as the PB^{131}I concentration) generally were measured 3 or 4 times from 1 to as late as 7 d after the administration of the radioiodine tracer (1–3). In several instances, however, only 2 PB^{131}I measurements were obtained, with the last measurement at 2 d after administration.

Thyroid uptake (percentage of administered activity) was measured at a skin-to-aperture distance of 30 cm using a "thyroid" uptake probe fitted with an open-bore collimator and set to an ^{131}I photopeak energy window of $364 \text{ keV} \pm 10\%$, subtracting a thigh background counting rate from the gross neck counting rate and comparing the resulting net neck counting rate to the net counting rate for a standard containing a known fraction of the administered ^{131}I activity. The net counting rate for the standard was calculated by subtracting the "room background" counting rate, that is, the counting rate without either the patient or the standard in the room, from the gross counting rate for the standard. Blood and serum activity concentrations were determined from measured volumes of blood and serum, respectively, in a scintillation well counter also set to an ^{131}I photopeak energy window of $364 \text{ keV} \pm 10\%$ and comparing the resulting net blood sample counting rate to the net counting rate for a standard of equal volume and with a known dilution of the administered ^{131}I activity. The PB^{131}I concentration was determined by molecular exclusion column chromatography of a serum sample.

This study, restricted to Graves' disease, included 9 patients found to have small-pool hyperthyroidism, defined on the basis of at least 1 PB^{131}I measurement that was greater than 2% of the administered activity per liter for patients off ATDs (5). Although many of these patients had been treated for prolonged periods with ATDs, none had received ATDs for at least 1 wk preceding the ^{131}I tracer study. ATDs were resumed at a dosage one third to one half the previous maintenance dosage. The patients were reevaluated at 2-wk intervals, and the ATD dosage was adjusted to maintain serum T_3 and T_4 at the upper limit of normal. The ATD dosage required to maintain serum T_3 and T_4 at this level was individually determined for each patient, requiring repeat measurements over at least a 4-wk period. Once this level was achieved, a repeat radioiodine tracer study was performed and radioiodine therapy was administered within 1 wk thereafter. ATDs were maintained at this same dosage throughout the period of the tracer and therapy administrations and for at least 1 wk thereafter. (In nearly all cases, the morning dose of ATD was omitted on the days on which the tracer ^{131}I and the therapy ^{131}I were administered.)

The serial thyroid uptake measurements were fit to a monoexponential function with the numeric module of the SAAM II program (10–12), and the cumulated activity of ^{131}I in the thyroid was calculated by incorporation of physical decay and integration of the resulting function, as follows:

$$\tilde{A}_{thy} = \frac{1.44}{100\%} (A_{thy})_0 T_e, \quad \text{Eq. 1}$$

where \tilde{A}_{thy} is the cumulated activity in the thyroid per unit of administered ^{131}I activity, $(A_{thy})_0$ is the fitted zero-time thyroid uptake (percentage of administered activity), and T_e is the effective half-time of ^{131}I in the thyroid, expressed by the following equation:

$$\frac{T_p T_b}{T_p + T_b}, \quad \text{Eq. 2}$$

where T_b is the fitted biologic half-time of ^{131}I in the thyroid and T_p is the physical half-life of ^{131}I , that is, 8.04 d.

Thyroid absorbed doses then were calculated by use of the MIRD formulation developed by the MIRD Committee of the Society of Nuclear Medicine (2,3). The total thyroid absorbed dose was equated with its self-irradiation absorbed dose (2,3), as follows:

$$\bar{D}(\text{thy}) \approx \bar{D}(\text{thy} \leftarrow \text{thy}) \quad \text{Eq. 3}$$

$$= \tilde{A}_{thy} S(\text{thy} \leftarrow \text{thy}), \quad \text{Eq. 4}$$

where $\bar{D}(\text{thy})$ is the mean absorbed dose in the thyroid per unit of administered ^{131}I activity, $\bar{D}(\text{thy} \leftarrow \text{thy})$ is the mean self-irradiation absorbed dose in the thyroid per unit of administered ^{131}I activity, and $S(\text{thy} \leftarrow \text{thy})$ is the thyroid-to-thyroid S factor, that is, the mean absorbed dose to the thyroid per unit cumulated activity in the thyroid, and given by the following expression (13):

$$\frac{0.406}{m_{thy}} + 0.01014 m_{thy}^{-0.666}, \quad \text{Eq. 5}$$

where m_{thy} is the thyroid mass (g), as estimated by palpation.

The cumulated activity concentration of ^{131}I in the blood was calculated by numeric integration of the serial blood time-activity concentration measurements, with the assumptions of elimination by physical decay only after the last measurement (with analytic integration of this terminal portion) and the incorporation of physical decay (2,14), as follows:

$$[\tilde{A}_{bl}] = \frac{1}{100\%} \times \left\{ \sum_{i=0}^n \left[\frac{e^{-0.693/T_p t_i} \{ [A_{bl}]_i - [e^{-0.693/T_p (t_{i+1}-t_i)} [A_{bl}]_i] \} (t_{i+1} - t_i) }{\ln \left[\frac{[A_{bl}]_i}{[e^{-0.693/T_p (t_{i+1}-t_i)} [A_{bl}]_i]} \right)} \right] + \frac{[A_{bl}]_n e^{-0.693/T_p t_n}}{0.693/T_p} \right\}. \quad \text{Eq. 6}$$

where $[\tilde{A}_{bl}]$ is the cumulated activity concentration in blood per unit of administered ^{131}I activity, $[A_{bl}]_i$ is the activity concentration in blood (percentage of administered ^{131}I activity per milliliter) at time after administration t_i , and $[A_{bl}]_0$ is the zero-time activity concentration in blood (percentage of administered ^{131}I activity per milliliter), which is expressed by the following equation:

$$\frac{100\%}{0.2 m_{tb}}, \quad \text{Eq. 7}$$

where m_{tb} is the total body mass (g).

Blood absorbed doses then were calculated, again by use of the MIRD formulation, as the sum of the blood self-irradiation absorbed dose and the thyroid-to-blood absorbed dose; this strategy assumes, reasonably, that the only significant "non-self" dose contribution to blood arises from the thyroid. The blood self-irradiation absorbed dose was calculated with the assumption of complete local absorption of nonpenetrating radiation (i.e., ^{131}I β -rays) only. The thyroid (thy)-to-blood (bl) absorbed dose was calculated by approximating the thyroid-to-blood S factor (i.e., the mean absorbed dose to the blood per unit cumulated activity in the thyroid) as the Standard Man thyroid (thy)-to-muscle (mus) S factor (i.e., the mean absorbed dose to the muscle per unit cumulated activity in the thyroid) (2,15-17), since both blood and muscle are similarly (i.e., widely) distributed tissues:

$$\bar{D}(\text{bl}) \approx \bar{D}_{np}(\text{bl} \leftarrow \text{bl}) + \bar{D}(\text{bl} \leftarrow \text{thy}) \quad \text{Eq. 8}$$

$$\approx [\tilde{A}_{bl}] \Delta_{np} + \tilde{A}_{thy} S(\text{bl} \leftarrow \text{thy}) \quad \text{Eq. 9}$$

$$\approx [\tilde{A}_{bl}] \Delta_{np} + \tilde{A}_{thy} S(\text{mus} \leftarrow \text{thy}), \quad \text{Eq. 10}$$

where $\bar{D}(\text{bl})$ is the total mean absorbed dose to the blood per unit of administered ^{131}I activity, $\bar{D}_{np}(\text{bl} \leftarrow \text{bl})$ is the mean absorbed dose to blood specifically from nonpenetrating (np) radiations (i.e., β -rays) emitted from ^{131}I in the blood per unit of administered ^{131}I activity, $\bar{D}(\text{bl} \leftarrow \text{thy})$ is the mean absorbed dose to blood from ^{131}I in the thyroid per unit of administered ^{131}I activity, Δ_{np} is the equilibrium dose constant for nonpenetrating radiation for ^{131}I , that is, 0.405 g-Gy/37 kBq-h (g-rad/ μCi -h) (18), and $S(\text{mus} \leftarrow \text{thy})$ is the Standard Man thyroid-to-muscle S factor, that is, 3.8×10^{-6} cGy/37 kBq-h (rad/ μCi -h) (17).

The statistical significance of differences in ^{131}I kinetic and dosimetric parameters between patients who were off ATDs and those who were on ATDs was evaluated by use of the Student paired t test; a P value of 0.05 or less was considered statistically significant (19).

RESULTS

The measured ^{131}I -iodide tracer kinetics and the resulting blood and thyroid radiation dosimetry data for the 9 small-pool hyperthyroid patients in this study are shown in Tables 1 and 2, respectively. These data are also summarized graphically, with the results of statistical testing, in Figures 1-6.

In small-pool hyperthyroid patients, continuation of ATDs during ^{131}I administration markedly reduced the PB ^{131}I concentration (Fig. 1), with little or no effect on thyroid uptake (Fig. 2) but with a small but significant prolongation of the biologic half-time (Fig. 3). As a result, expressed in terms of absorbed dose per unit of administered ^{131}I activity, there was a substantial reduction in the blood absorbed dose (Fig. 4) but no significant change in the thyroid absorbed dose (Fig. 5). Perhaps most importantly, there was likewise a substantial reduction in the blood absorbed dose, ranging from 37% to 68% (Table 2), for the administered ^{131}I activity required to deliver a standard

TABLE 1
¹³¹I-Iodide Tracer Kinetics in Small-Pool Hyperthyroid Patients Off and On ATDs

Patient no.	ATD status	Decay-corrected PB ¹³¹ I (%/L) on day:							Thyroid							Biologic half time (d)
									Decay-corrected uptake (%) on day:							
		1	2	3	4	5	6	7	1	2	3	4	5	6	7	
1	Off	1.88			4.47		5.20		84			52		43		5.0
	On	0.13			1.05		1.53		58			31		22		3.5
2	Off	1.97	3.05						65	39						1.4
	On	1.89	0.81						44	24						2.3
3	Off	1.08			2.05		2.14		79			46		41		4.8
	On	0.13			1.05		1.53		66			39		29		4.1
4	Off	2.27			2.95		2.90		69			44		37		5.3
	On	0.37			0.74		0.75		83			63		59		9.5
5	Off	1.99			2.14			2.34	64			38			28	5.3
	On	1.53	2.02	2.20					83	74	73					10.4
6	Off		2.51					2.29	72	59					40	7.3
	On		0.78	0.42				1.05	80	70					54	11.1
7	Off	2.48	4.02				4.78	4.86	92	79				58	52	8.4
	On	0.47		0.53				0.44	95		82				63	11.8
8	Off	2.43	3.78						62	45		48		39		2.2
	On	0.49	0.85			0.97		1.17	66	51						4.8
9	Off	2.07	2.87		3.85				80	63		48		39		4.7
	On	0.01	0.20						42	34						3.3

prescribed absorbed dose of 7,000 cGy to the thyroid (Fig. 6).

DISCUSSION

The clinical effectiveness of radioiodine treatment of hyperthyroidism is presumably related to the absorbed dose to thyroid follicular cells. However, the most common dose prescription algorithm, a fixed administered activity, entails the administration of a specified activity (at this time, typically on the order of 370 MBq [10 mCi]) to all hyperthyroid patients. If the highly variable individual parameters of thyroid uptake, biologic half-life, and mass, which determine absorbed dose, are ignored, it is unlikely that there will be a correlation between the administered activity and the absorbed dose (2,20). Although up to 85% of patients will eventually be cured (i.e., made euthyroid or hypothyroid) by the administration of single doses of standard amounts of radioiodine (and presumably 100% with repeated administrations) (1,8,21), such an arbitrary approach does not permit individually optimized therapy and would not identify patients, such as small-pool patients, for whom radioiodine therapy may be inappropriate or even hazardous (4,5).

Barandes et al. previously reported a series of 7 small-pool hyperthyroid patients in whom a standard 7,000-cGy absorbed dose would require 1,036 MBq (28 mCi) of ¹³¹I

and theoretically would yield a radiation dose to the blood of 150 cGy (4), a prohibitively high incidental radiation dose for the treatment of a benign disease. Interestingly, the ¹³¹I blood absorbed dose among these small-pool patients, 5.3 cGy/37 MBq, was 2-fold higher than that among the small-pool patients who were off ATDs in the present study, 2.5 cGy/37 MBq; this finding was attributable to a 2-fold difference in the maximum PB¹³¹I concentration between these 2 groups of patients. However, the absence of a significant difference in any kinetic or dosimetric parameter between the “typical” (non-small-pool) patients in the earlier study (4) and the small-pool patients on ATDs in the present study suggests that these 2-fold differences in the PB¹³¹I concentration and the ¹³¹I blood absorbed dose were not related to any methodologic differences between the 2 studies but rather were simply random variations between small groups of patients.

In previously reported attempts to circumvent this problem (4), potassium iodide supplements given before radioiodine treatment decreased the 24-h PB¹³¹I concentration from 4.4%/L to 1.7%/L and increased the biologic half-time of radioiodine in the thyroid from 2.8 to 6.5 d. Although this regimen was successful, problems in logistics and compliance made the regimen difficult to implement. In addition, 1 patient had an exacerbation of hyperthyroidism, with an

TABLE 2
¹³¹I-Iodide Dosimetry in Small-Pool Hyperthyroid Patients Off and On ATDs

Patient no.	ATD status	Absorbed dose			For prescribed thyroid absorbed dose of:			
		cGy/37 MBq (rad/mCi)		Ratio (thyroid to blood)	7,000 cGy (rad)		12,000 cGy (rad)	
		Thyroid	Blood		Administered activity required (37 MBq [mCi])	Associated blood absorbed dose (cGy [rad])	Administered activity required (37 MBq [mCi])	Associated blood absorbed dose (cGy [rad])
1	Off	2,240	3.78	593	3.1	11.8	5.4	20.3
	On	1,300	1.38	942	5.4	7.4	9.2	12.7
2	Off	575	2.06	279	12.2	25.1	20.9	43.0
	On	592	0.99	598	11.8	11.7	20.3	20.1
3	Off	2,050	2.12	967	3.4	7.2	5.9	12.4
	On	1,620	0.55	2,945	4.3	2.4	7.4	4.1
4	Off	1,890	2.74	690	3.7	10.1	6.3	17.4
	On	2,920	1.57	1,860	2.4	3.8	4.1	6.5
5	Off	1,730	2.43	712	4.0	9.8	6.9	16.9
	On	3,030	2.23	1,359	2.3	5.2	4.0	8.8
6	Off	2,210	2.33	948	3.2	7.4	5.4	12.7
	On	3,120	1.54	2,026	2.2	3.5	3.8	5.9
7	Off	3,041	3.28	927	2.3	7.6	3.9	12.9
	On	3,530	1.41	2,504	2.0	2.8	3.4	4.8
8	Off	1,110	2.73	407	6.3	17.2	10.8	29.5
	On	1,670	1.31	1,275	4.2	5.5	7.2	9.4
9	Off	2,010	2.98	674	3.5	10.4	6.0	17.8
	On	921	0.49	1,880	7.6	3.7	13.0	6.4

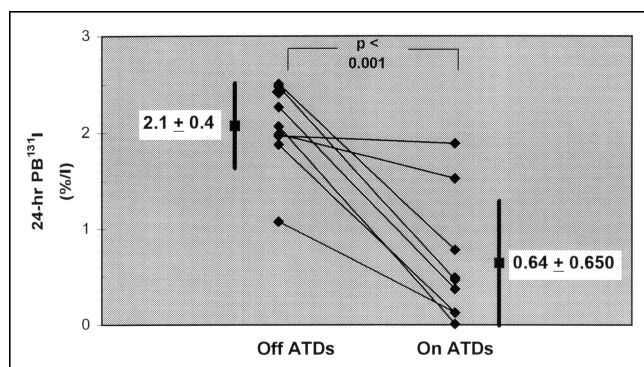


FIGURE 1. Decay-corrected concentration (percentage of administered activity per liter of serum) of PB^{131}I at 24 h after administration of ^{131}I -iodide tracer in 9 small-pool hyperthyroid patients either off or on ATDs at the time of radioiodine administration. Numeric values and errors bars represent mean \pm SD. *P* value represents the result of the Student paired *t* test of the statistical significance of the difference between the 24-h PB^{131}I concentrations in patients off ATDs and on ATDs; difference was statistically significant at a 0.1% significance level.

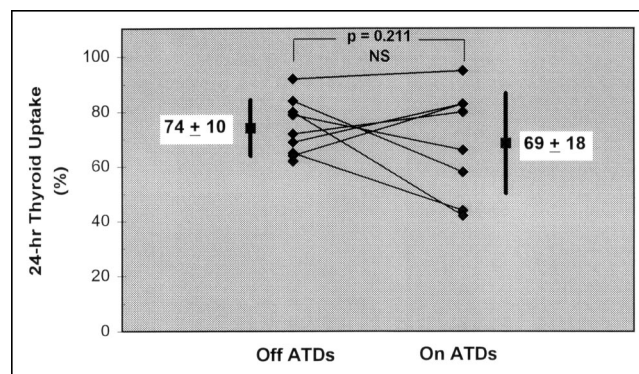


FIGURE 2. Decay-corrected thyroid uptake (percentage of administered activity) at 24 h after administration of ^{131}I -iodide tracer in 9 small-pool hyperthyroid patients either off or on ATDs at the time of radioiodine administration. Numeric values and errors bars represent mean \pm SD. *P* value represents the result of the Student paired *t* test of the statistical significance of the difference between the levels of thyroid uptake at 24 h in patients off ATDs and on ATDs; difference was not statistically significant (NS) at a 5% significance level.

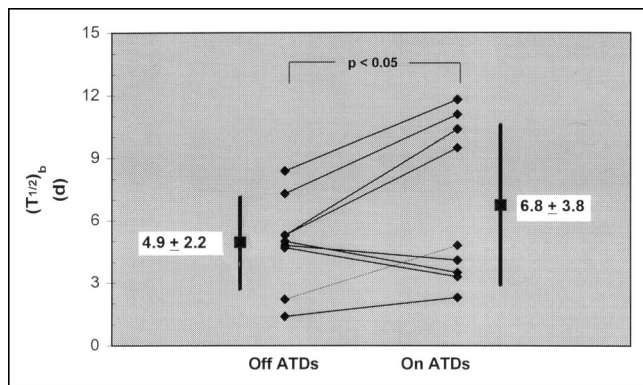


FIGURE 3. Biologic half-time ($T_{1/2}$) in thyroid of ^{131}I -iodide tracer administered to 9 small-pool hyperthyroid patients either off or on ATDs at the time of radioiodine administration. Numeric values and errors bars represent mean \pm SD. P value represents the result of the Student paired t test of the statistical significance of the difference between the biologic half-times in patients off ATDs and on ATDs; difference was statistically significant at a 5% significance level.

impending thyroid storm, and another had a slight increase in symptoms of hyperthyroidism.

The results of this study clearly indicate that continuation of low-dosage ATDs throughout the period of radioiodine treatment substantially reduces (typically by more than 50%) the blood absorbed dose in small-pool patients without a significant reduction in the target tissue (i.e., thyroid) absorbed dose. Consistent with our hypothesis, low-dosage ATDs appear to reduce the secretion of ^{131}I -labeled T_4 and T_3 , as indicated by the substantially reduced 24-h PB^{131}I concentration (Fig. 1). At the same time, ATDs, at least at low dosages, do not appear to affect the uptake of iodine by

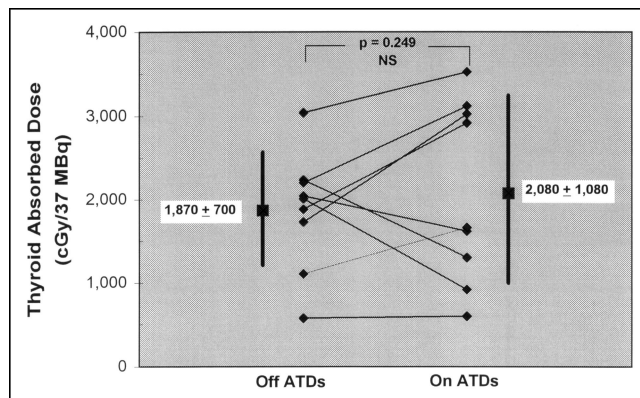


FIGURE 5. Calculated mean absorbed dose to thyroid (cGy/37 MBq [rad/mCi] of administered activity) from ^{131}I -iodide tracer in 9 small-pool hyperthyroid patients either off or on ATDs at the time of radioiodine administration. Numeric values and errors bars represent mean \pm SD. P value represents the result of the Student paired t test of the statistical significance of the difference between the thyroid absorbed doses in patients off ATDs and on ATDs; difference was not statistically significant (NS) at a 5% significance level.

the thyroid, as indicated by the unchanged 24-h thyroid uptake (Fig. 2), and actually result in a slightly longer biologic half-time for radioiodine in the thyroid (Fig. 3). When the administered activity needed to deliver a prescribed radiation-absorbed dose to the thyroid is based on an individualized calculation, an appropriate, curative radiation dose can be delivered.

Although the number of patients in this study, 9, was small, the results are nonetheless compelling, because each patient served as his or her own control. That is, the ^{131}I

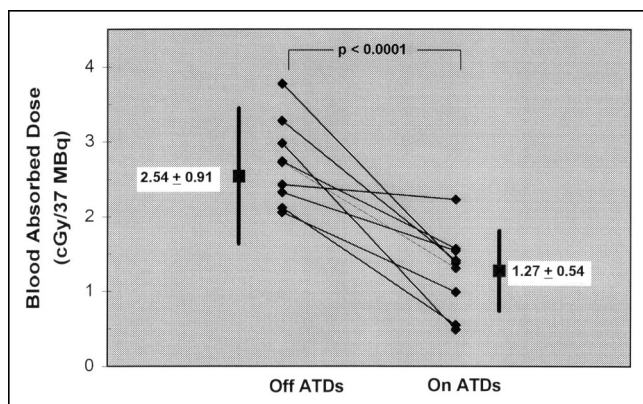


FIGURE 4. Calculated mean absorbed dose to blood (cGy/37 MBq [rad/mCi] of administered activity) from ^{131}I -iodide tracer in 9 small-pool hyperthyroid patients either off or on ATDs at the time of radioiodine administration. Numeric values and errors bars represent mean \pm SD. The P value represents the result of the Student paired t test of the statistical significance of the difference between the blood absorbed doses in patients off ATDs and on ATDs; difference was statistically significant at a 0.01% significance level.

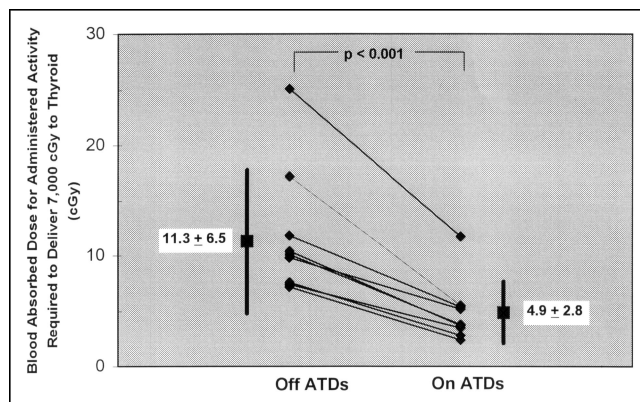


FIGURE 6. Calculated mean absorbed dose to blood for the administered ^{131}I -iodide activity required to deliver a standard prescribed absorbed dose of 7,000 cGy, based on measured tracer kinetics, in 9 small-pool hyperthyroid patients either off or on ATDs at the time of radioiodine administration. Numeric values and errors bars represent mean \pm SD. P value represents the result of the Student paired t test of the statistical significance of the difference between the blood absorbed doses in patients off ATDs and on ATDs; difference was statistically significant at a 0.1% significance level.

tracer kinetics and dosimetry data for each patient on ATDs were compared with those for the same patient off ATDs, and the statistical significance of any changes in kinetic and dosimetric parameters was evaluated by use of the paired *t* test.

CONCLUSION

In summary, continuation of low-dosage ATDs throughout the period of radioiodine treatment substantially reduces the extrathyroid radiation dose in small-pool patients, in whom radioiodine treatment arguably would otherwise be inappropriate on a risk–benefit basis, without a significant reduction in the thyroid absorbed dose. Moreover, continuation of low-dosage ATDs provides the important clinical advantage of uninterrupted symptomatic control.

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