Influence of Dietary Iodine on I^{131} Retention and Distribution in the Chick.* (31406)

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Studies with various species of birds(1-6) have shown wide variations in the time and level of peak thyroidal I^{131} uptake and in the biological half-life of the trapped radioiodine. A possible explanation for these variations in I^{131} metabolism lies in the levels of dietary iodine used by these workers. In support of this suggestion is the work of Rosenberg *et al*(7) who observed a maximal uptake of I^{131} in rats fed a low iodine diet of 52% of the original dose at 6 hours and a half-life of the thyroidal I^{131} of approximately 2.5 days. Rats on an iodide supplemented diet had a maximal uptake of 9% of the original dose at 24 hours and a half-life of the thyroidal I^{131} of approximately 4 days. The purpose of this study was to investigate the influence of the level of dietary iodine on the biological half-life of the I^{131} in the thyroids and on the retention of I^{131} by the chick. The results of studies on the distribution of I^{131} in the chick, as influenced by dietary iodide, are also presented.

Materials and methods. Day-old white Leghorn Cockerels were wing-banded, weighed and placed in electrically heated batteries with raised wire floors. One-half of the birds in each experiment was fed an iodine deficient diet, and the remaining one-half was fed a diet which was adequate in iodine (control diet). The iodine deficient diet consisted of the following in g/kg of diet: Glucose monohydrate, 392.144; soybean meal (44% protein), 480.00; soybean oil, 50.00; mineral premix†, 60.856; vitamin premix‡, 10.00; choline chloride (25%), 6.00; DL methionine, 1.00. This diet was analyzed to contain less than 10 ppb iodine by the dry combustion method of Godfrey *et al*(8) and a slight modification of the catalytic method of Chaney(9).

The control diet was obtained by supplementation of the iodine deficient diet with 3.3 ppm of iodide as a solution of KI. Feed and deionized water were provided *ad libitum*.

Twenty-two and fifteen chicks from each of the 2 treatments were used in Experiments 1 and 2, respectively. On the 15th day of each experiment, each chick was injected intraperitoneally with 3 uc of I^{131} in 0.5 ml of saline. Immediately after injection, the radioactivity present in each chick was determined by counting the chick in a whole-body gamma scintillation detector.§ The retention of the injected I^{131} was determined at 4, 8, 24, 48, 96, 192 and 288 hours post-injection in Exp. 1, and 2, 4, 8, 12, 24, 48, 96, 192 and 288 hours post-injection in Exp. 2.

In Exp. 3, 120 chicks, 60 from each treatment, were injected with I^{131}, and 12 chicks, 6 from each treatment, were sacrificed at 1, 2, 4, 8, 12, 24, 48, 96, 192 and 288 hours post-injection. The birds killed at 1, 2, 4, and 8 hours post-injection had been injected with 0.5 uc of I^{131}, those killed at 12, 24, and 48 hours had been injected with 1 uc of I^{131} and those killed at 96, 192, and 288 hours had been injected with 2 uc of I^{131}. Each bird was counted immediately after injection and again immediately prior to time of sacrifice. The thyroids were removed at time of sacrifice, placed in vials and counted

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† The mineral premix provided the following reagent grade minerals in g/kg of diet: Ca CO_3, 19.10; Ca $(H_2PO_4)_2 \cdot H_2O$, 21.15; K_2HPO_4, 11.20; Na Cl, 6.00; Mg CO_3, 2.50; $MnSO_4 \cdot H_2O$, 0.51; $Fe_2(SO_4)_3$, 0.20; $ZnCO_3$, 0.18; $CuSO_4 \cdot 5H_2O$, 0.015; Na Mo $O_4 \cdot H_2O$, 0.001.

‡ The vitamin premix provided the following units of vitamins per kg of diet: riboflavin, 9 mg; thiamine • HCl, 6 mg; D - calcium pantothenate, 20 mg; niacin, 50 mg; pyridoxine • HCl, 8 mg; folic acid, 2 mg; biotin, 0.3 mg; B_{12}, 20 ug; menadione sodium bisulfite, 2 mg; vit. A, 25,000 USP units; vit. D_3, 1200 ICU; vit. E acetate, 17.6 IU; inositol, 1000 mg.

§ Armac scintillation detector 440, Packard Instrument Co., Inc., Downers Grove, Ill.

TABLE I. Percent Original Dose Retained by Iodine-Deficient and Control Chicks.*

Time after injection (hr)	Exp 1		Exp 2	
	Deficient	Control	Deficient	Control
2			66.47 ± 1.32†	53.25 ± 1.54
4	60.40 ± 1.53†	21.20 ± .95	54.91 ± 2.39†	28.41 ± 1.16
8	52.62 ± 1.40†	9.16 ± .41	48.05 ± 1.96†	14.34 ± .52
12			41.80 ± 1.14†	10.02 ± .38
24	26.77 ± 1.16†	4.98 ± .21	27.14 ± 1.30†	7.18 ± .30
48	11.25 ± .72†	4.06 ± .22	11.67 ± 1.16†	5.64 ± .26
96	3.47 ± .38	2.97 ± .15	3.96 ± .72	4.14 ± .28
192	1.09 ± .10†	1.92 ± .11	1.40 ± .24†	2.50 ± .20
288	.70 ± .06†	1.22 ± .08	.89 ± .10†	1.95 ± .19

* Mean values ± S.E. of mean for 22 chicks/treatment in Exp 1, 15 chicks/treatment in Exp 2.

† Differences between means for iodine-deficient and adequate chick significantly different ($P < .01$).

in a whole-body gamma scintillation detector. After counting the birds at the 48- and 96-hour intervals and prior to time of sacrifice, blood samples were drawn by cardiac puncture with heparinized needles and syringes and the whole blood counted in a well-type, crystal scintillation detector.

The results, after correction for decay, are expressed as per cent of the original dose retained by the whole chick, thyroids and carcass. The t test(10) provides the basis for statements of statistical differences between means.

Results and discussion. The retention of the injected I^{131} by chicks in Exp. 1 and 2 is shown in Table I. As would be expected, the deficient chicks retained significantly higher amounts of I^{131} during the early time intervals as compared with the controls. The loss of I^{131} by the control chicks subsided after approximately the 8th hour, whereas the deficient chicks continued to lose I^{131} from their bodies at a rapid rate (Fig. 1). The amount of radioactivity present in the deficient chicks decreased below that present in the control chicks by approximately 96 hours post-injection in both experiments. By 192 hours post-injection, the deficient chicks had retained significantly less I^{131} than the control chicks.

The rapid loss of I^{131} by the iodine deficient chick apparently resulted from an elevated accumulation and discharge of I^{131} by the thyroids. A rapid turnover of iodinated compounds has been reported by Feldman (11) who observed an elevated thyroidal uptake, increased renal excretion and a high conversion index 2 hours after isotope injection in an iodine deficient rat. The rapid recycling of the small amount of iodine present in the body of the deficient animal exposes it to greater loss than occurs in an animal receiving adequate amounts of dietary iodine. As opposed to that in the deficient animal, much of the I^{131} which was organically bound by the control animal probably remains stored in the thyroid gland and there-

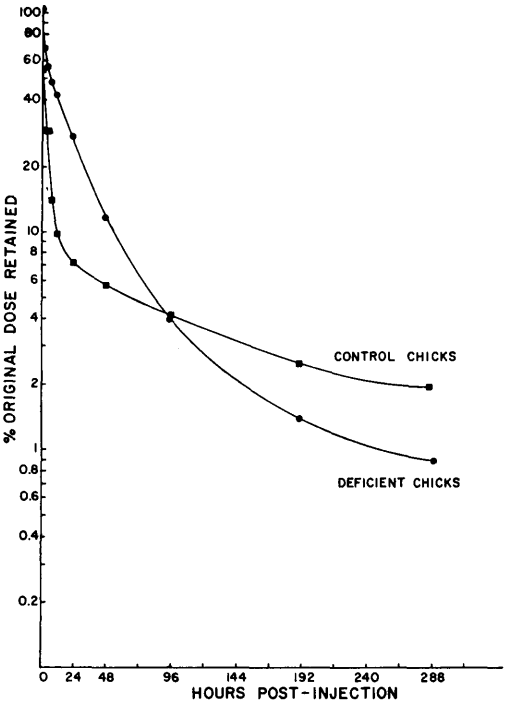

FIG. 1. Retention of injected I^{131} by iodine deficient and control chicks.

TABLE II. Percent Original Dose of I^{131} Retained in Whole Chick, Thyroid and Carcass in Iodine-Deficient and Control Chicks (Exp 3).*

Time after inj, hr	Whole chick		Thyroid		Carcass†	
	Deficient	Control	Deficient	Control	Deficient	Control
1	86.75 ± 3.00	80.12 ± 4.17	23.70 ± 4.17§	2.09 ± .19	63.04 ± 6.10	78.03 ± 4.44
2	76.65 ± 3.60§	55.88 ± 4.04	41.19 ± 3.04§	3.92 ± .47	35.46 ± 3.46‡	51.96 ± 4.06
4	61.60 ± 3.79§	30.88 ± 2.23	33.25 ± 2.20§	4.34 ± .36	28.35 ± 3.08	26.55 ± 2.10
8	49.58 ± 3.69§	13.21 ± 1.12	27.20 ± 3.90§	4.52 ± .42	22.38 ± 4.28‡	8.69 ± .91
12	47.87 ± 2.98§	9.21 ± .51	24.26 ± 1.73§	4.12 ± .39	23.60 ± 2.98§	5.08 ± .22
24	36.49 ± 2.02§	6.22 ± .39	14.87 ± 3.46‡	4.06 ± .39	21.62 ± 2.69§	2.15 ± .12
48	16.06 ± 2.68§	5.93 ± .62	8.71 ± 3.38	4.36 ± .58	7.35 ± .74§	1.57 ± .09
96	4.22 ± .66	3.81 ± .24	1.91 ± .55	2.98 ± .24	2.32 ± .32§	.83 ± .14
192	1.24 ± .51§	2.83 ± .25	.47 ± .13§	2.10 ± .20	.77 ± .09	.73 ± .15
288	.96 ± .18§	3.32 ± .25	.20 ± .03§	2.68 ± .20	.76 ± .27	.64 ± .14

* Mean values for 6 chicks/treatment ± S.E. of mean.
† Carcass values determined by difference between whole chick and thyroid values.
‡ and § Differences between means for iodine-deficient and control chicks significantly different ($P < .05$) and ($P < .01$), respectively.

fore not subject to as great a loss as occurs in the deficient animal.

In Exp. 3, chicks were sacrificed at various intervals following I^{131} injection, and the distribution of I^{131} between the thyroids and the carcass determined (Table II). The I^{131} retention data from the iodine deficient and control chicks in this experiment are in agreement with those of Exp. 1 and 2. The maximal I^{131} concentration in the thyroids of the deficient chicks, 41.19% of the original dose, occurred at 2 hours post-injection. The thyroidal concentration of I^{131} decreased rapidly in deficient chicks killed at subsequent time intervals. The control chicks trapped only about 4% of the original dose, but in contrast to the deficient chicks, retained this amount of radioactivity in the thyroid for more than 48 hours. The thyroidal I^{131} concentration in the deficient chick decreased to a lower concentration than that in the control chicks between the 48- and 96-hour intervals post-injection. By the end of the experiment, 288 hours, the thyroids from the deficient chicks contained only 7.5% as much radioactivity as the thyroids from the control chicks.

Although the thyroids of the deficient chicks killed at 96 hours contained only about two-thirds the activity of the control chicks' thyroids, their carcasses contained approximately 3 times as much activity as compared to the controls. More than 79% of the radioactivity in the deficient birds at 288 hours post-injection was non-thyroidal whereas less than 20% of that in the control chicks at this time was non-thyroidal. These data show that a large amount of the I^{131} in the deficient chick is in circulation and/or the tissues at the later time intervals whereas most of the I^{131} in the control chick remains stored in the thyroid. The radioactivity present in the blood of chicks sacrificed at 48 and 96 hours also demonstrates the greater circulation of I^{131} in the deficient chicks. At 48 hours, $3.18 \pm 0.73 \times 10^{-2}$ and $0.95 \pm 0.10 \times 10^{-2}$% of the original dose were present per ml of blood in the deficient and control chicks, respectively. The values for the 96-hour interval were $0.80 \pm 0.10 \times 10^{-2}$ and $0.23 \pm 0.02 \times 10^{-2}$% of the original dose per ml of blood for the deficient and control chicks, respectively. The differences at both time intervals were statistically significant ($p < .05$).

The influence of dietary iodine on the biological half-life of thyroidal I^{131} observed in this study is in agreement with the work of Rosenberg *et al*(7) with rats. In this study, chicks fed the deficient diet accumulated the maximal thyroidal concentration of I^{131}, 41.19%, at 2 hours and had a biological half-life of about 15 hours whereas the maximal thyroidal I^{131} accumulation in the control chicks, 4.52%, occurred at 8 hours with biological half-life greater than 96 hours. Rosenberg *et al*(5) concluded from their previous studies that intrathyroidal iodination and de-

iodination reactions occur continually and lead to randomization of thyroidal iodine. Such is apparently the explanation for the slow release of I^{131} from the control chicks. Since the deficient chicks possess only a limited amount of thyroidal iodine, extensive use is made of the injected I^{131}.

The results of this study are not in agreement with the suggestion by Rosenberg *et al* (5) that the long retention of thyroidal I^{131} observed in the deficient animals in their studies was due to an adjustment of the thyroxine secretion rate to a minimal level. In our study, deficient chicks exhibited a precipitous decline in thyroidal I^{131}. Rogler *et al*¶ have observed that the protein-bound iodine-131 in the blood of deficient chicks only 1 and 4 hours post-intraperitoneal I^{131} injection was approximately 10 and 100 times higher, respectively, than that in control chicks, indicating a high level of secretory activity of I^{131} labeled thyroid hormone by the deficient thyroid. Rogler *et al*(12) have shown that embryos from hens fed a diet extremely deficient in iodine synthesized and released thyroxine at a much faster rate than embyros from hens fed higher levels of dietary iodine. An extremely rapid turnover and discharge of I^{131} by iodine deficient rats has also been demonstrated by Feldman(11).

The results of this study demonstrate the marked influence which the level of dietary iodine exerts on the maximal uptake, time of maximal uptake, biological half-life in the thyroid and carcass and the thyroid to carcass distribution ratios of injected I^{131}.

¶ Unpublished data by J. C. Rogler, H. E. Parker and F. N. Andrews.

Summary. Chicks fed an iodine deficient ration retained more I^{131} originally than did control chicks. The more rapid loss of I^{131} from the deficient chicks, however, was such that the I^{131} concentration in the deficient chicks was significantly lower than that in the normal chicks by the end of the experiment. Studies of the distribution within the body revealed that the thyroids of deficient chicks trapped a maximum of 41% of the injected dose at 2 hours and had a biological half-life of the thyroidal I^{131} of approximately 15 hours. Control chicks, while trapping a maximum of only 4.5% of the injected dose at 8 hours, exhibited a biological half-life of more than 96 hours. A possible explanation for the rapid disappearance of injected I^{131} in the deficient chicks is discussed.

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