RADIOSURGERY AND UPTAKE OF RADIOACTIVE IODINE BY THE THYROID OF THE OREGON JUNCO

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In recent years numerous advances in the study of the thyroid gland have been made through the use of radioactive iodine. These techniques are possible because the thyroid cells absorb iodine from the blood stream and utilize it in the synthesis of thyroxin. When radioactive iodine is injected or given in food it accumulates in the thyroid in the same manner as stable iodine and in appropriately strong dosages results in complete destruction of the thyroid cells without damaging the parathyroid or surrounding tissues (Goldberg *et al.*, Endocrinology, 46: 72–90, 1950). When used in this manner, radioactive iodine provides a simple technique for physiologically thyroidectomizing an animal and is even capable of destroying small islets of thyroid tissue not associated with the main mass. In smaller dosages no apparent damage to the thyroid cells can be observed, and thus the uptake and retention of radioactive iodine can be used as a means of evaluating thyroid function.

Because several important phenomena, such as molt, feather pigmentation, and fat deposition, are associated with thyroid function, this technique should be useful to ornithologists, especially those working with small birds in which surgical thyroidectomy is difficult or impractical. This paper deals with experiments using iodine-131 for destroying the thyroid cells and on the uptake and retention of a small dose of iodine-131 by the thyroid of the Oregon Junco (*Junco oreganus*).

METHODS

The Oregon Juncos used in these experiments were trapped on the University of California campus, Berkeley, California. They were confined in cages 12 by 18 by 36 inches and provided with ample seed and water. Iodine-131, provided in the form of a carrier-free saline solution, was diluted with 0.85 per cent NaCl to the appropriate strength and administered as a single intraperitoneal injection.

For the radiosurgery three groups of four birds each were injected on February 25, 1952, with 100, 200, and 400 microcuries of iodine-131, respectively. One group of four was kept as controls and one bird was injected with 50 microcuries. One bird from each group was autopsied 7, 18, 43, and 100 days after the injection. The thyroid, parathyroid, and surrounding tissue were removed, fixed in Bouin's fluid, sectioned serially, and stained with hematoxylin and eosin.

To study the uptake and retention of iodine-131, 17 Oregon Juncos were injected with 4.3 microcuries on January 29, 1952. At intervals of 3, 6, 11, 23, 53, 79, 104, and 125 hours after the injection one to three birds were sacrificed and examined. Both thyroid glands of each bird were dissected out, placed in a graduated tube, and dissolved in one-half cc. of 1N NaOH by gentle heating. At the end of the experiment all of the tubes were diluted with distilled water to 5 cc., and in addition two control tubes, containing the equivalent of 4.3 microcuries of the original iodine-131 solution, were prepared. One-half cc. was pipetted from each tube and placed on a copper disk. After the mixture on the disks had been dried under a heat lamp, the amount of radiation was determined with a Geiger counter. From a comparison of the radioactivity of the dissolved thyroid glands with the activity of the control tubes, the percentage of iodine-131 taken up and retained by the thyroids was calculated.

RESULTS: RADIOSURGERY

50 microcuries.—The one bird injected with 50 microcuries of iodine-131 was autopsied at the end of 100 days. The gland appeared normal in gross examination, but microscopic sections showed that the cellular arrangement of the glands had been disturbed. To a large degree the cells were not arranged in follicles, and there were no colloid deposits. In the center of the glands small nests of thyroid cells were located among areas of dense connective tissue, and there were numerous small blood vessels. The cells around the periphery were more normal in appearance, sometimes arranged in follicles but greatly hypertrophied.

100 microcuries.—The thyroids of the birds injected with 100 microcuries were severely damaged. On the 7th day the glands were edematous and swollen. Microscopic sections showed that most of the thyroid cells had been destroyed although a few small cells with pycnotic nuclei and reduced cytoplasm were observed at the periphery. The outlines of the follicles could still be seen in places, but for the most part the interior of the gland was infiltrated by fibrin, numerous blood cells, and macrophages. On the 18th day, a number of healthy thyroid cells was observed at the periphery of the gland. In the center, the outlines of the follicles had disappeared completely, and between the numerous blood sinuses, whorls of new connective tissue infiltrated with leukocytes and fibroblasts appeared.

By the 43rd day the gross appearance of the glands was normal and eventual recovery seemed probable. The number of healthy thyroid cells had increased greatly around the periphery, where they occurred as small nests surrounded by a dense network of distended blood

vessels (fig. 2). These cells were greatly hypertrophied and occasionally mitotic figures could be found. The center of the glands contained fewer blood vessels and more connective tissue than at 18 days. On the 100th day the layer of thyroid cells around the periphery had increased in width and contained many large active cells. Although they were still arranged in small groups somewhat similar to the normal follicles, no true follicles or colloid deposits were seen. The interior of the gland consisted of a diffuse collagenous stroma permeated with a few blood vessels, but with a marked reduction in the number of macrophages and free leukocytes.

200 and 400 microcuries.—The effects of 200 and 400 microcuries were almost identical: in each case the complete destruction of the thyroid cells. The gross and microscopic appearance of the glands went through cycles very similar to that caused by 100 microcuries. At first the glands were swollen and dark red in color. The vesicular arrangement of the cells was destroyed and replaced by a network of blood sinuses interspersed with newly formed connective tissue. 43 days after the injection the thyroid glands were much smaller than normal and were a dark purple color, and the number of large blood vessels and blood sinuses began to decrease. After 100 days the gland was composed of a dense connective tissue infiltrated with macrophages and leukocytes and a few small blood vessels (fig. 3). No normal thyroid cells were found in any of the glands of birds treated with 200 or 400 microcuries.

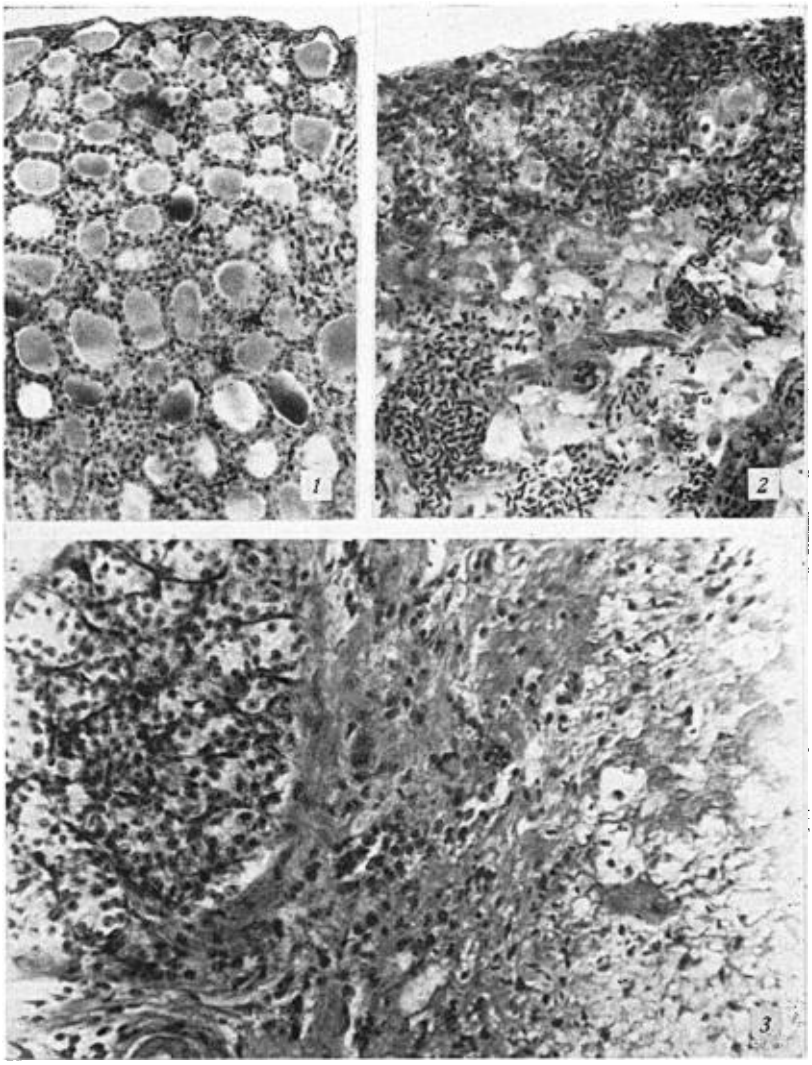
Parathyroid.—No damage to the parathyroid (fig. 3) or other tissues was observed in any of the birds regardless of the dosage or interval after the injection.

Uptake and Retention of Iodine-131

The uptake and retention of a single injection of 4.3 microcuries of iodine-131 is shown in figure 4. The injected iodine-131 was absorbed rapidly by the thyroid cells, and after 53 hours about 80 per cent of the amount administered was found to have accumulated in the glands. The release of the iodine-131 was almost as rapid as the absorption and by the fifth day only about 20 per cent was still present in the thyroid glands.

Discussion

The results of these experiments show that 200 microcuries of iodine-131 is sufficient to destroy the thyroid cells of an Oregon Junco for at least 100 days and that no damage, even with 400 microcuries, is done to the parathyroid or surrounding tissues. The birds weighed approximately 17 grams (range 15.8 to 19.4), and the weight of both thyroids averaged 6.5 milligrams. Thus a minimum effective dose of



THYROID GLANDS OF OREGON JUNCOS

FIGURE 1. Control, showing normal thyroid cells and follicles. × 270.

FIGURE 2. 43 days after a single injection of 100 microcuries of iodine-131. Note that the interior of the gland (bottom) consists of large blood sinuses and whorls of new connective tissue and that several nests of healthy thyroid cells can be seen just under the capsule (top). × 270.

FIGURE 3. 100 days after a single injection of 200 microcuries of iodine-131, showing complete destruction of the thyroid gland (right) and undamaged parathyroid (left). × 291.

200 microcuries is equivalent to 12 microcuries per gram of body weight or about 30 microcuries per milligram of thyroid weight. When estimating the minimum dosage for other birds (or other vertebrates), it is probably more satisfactory to use thyroid weight instead of body weight since the iodine is not diluted equally throughout the body but is concentrated in the thyroid cells. Rough calculations for the rat (based on Goldberg *et al.*, *op. cit.*) indicate that the mini-

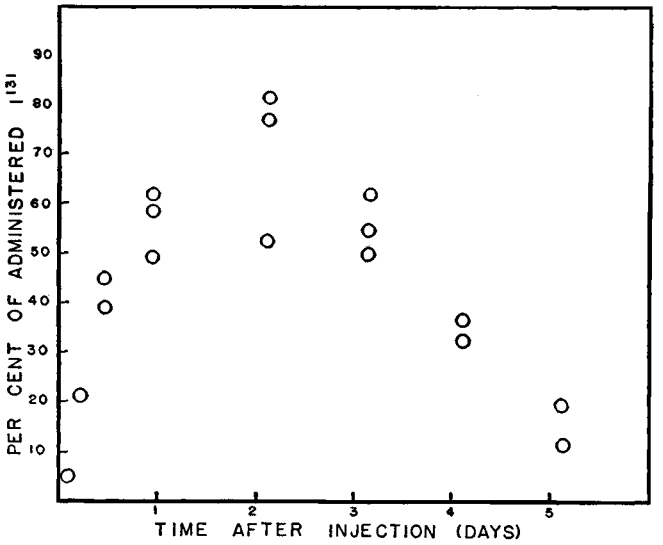


FIGURE 4. The per cent uptake and retention of a single injection of 4.3 microcuries of carrier-free iodine-131 by the thyroid gland of the Oregon Junco.

mum effective dose for this animal is about 35 microcuries per milligram of thyroid tissue, a figure very near that obtained for the Oregon Junco.

The uptake and retention curve in Oregon Juncos of a small dose of iodine-131 is similar to that obtained by Goldberg *et al.* for the rat. The peak of iodine-131 content in the thyroids of Oregon Juncos occurred 48 hours after the single injection, at which time they had accumulated about 80 per cent of the amount administered. The peak for the rat, 60 per cent of the amount administered, occurred 24 hours after the injection; but since no measurements were made at the 48 hour interval, it is possible that more than 60 per cent was actually taken up and that the curve for the rat might be more similar to that of the Oregon Junco than it now appears.

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