Serum Thyrotropin, Thyroxine, and Tri-iodothyronine in Dairy Cows Fed Varying Amounts of Iodine

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ABSTRACT

The objective was to determine whether dairy cows fed supplemental iodine daily at 2.5 or 5.0 mg per kg body weight for 49 wk had altered thyroid status relative to controls fed no supplemental iodine. Average daily dose of iodine was 1.6 and 3.3 g. Iodine as ethylene diamine dihydriodide was fed to Holstein cows beginning at 8 to 10 wk of lactation, for the remainder of that lactation, through the dry period, and into the next lactation. On day 341 after onset of iodine feeding, each cow was injected intravenously with 15 μg thyrotropin releasing hormone per 100 kg body weight. Thyrotropin in jugular blood collected before injection of releasing hormone averaged 7.6, 6.1, and 8.2 ng/ml for cows given 0, 2.5, and 5.0 mg iodine/kg body weight; there were no differences between means. Releasing hormone increased thyrotropin, thyroxine, and tri-iodothyronine in serum of all cows, but increases were not affected by quantity of dietary iodine.

INTRODUCTION

Wallace (12) suspected iodine toxicity in dairy herds in Georgia from physical examination and necropsies which revealed thyroid hypertrophy and adrenal cortical hyperplasia. Average daily intake of iodine in these herds was approximately 100 mg per head. Subsequently, Hillman (unpublished observations) investigated complaints of low milk production and poor health of cattle in 19 Michigan dairy herds and found that iodine was fed at a daily rate of 90 to 235 mg per head. Subsequently we (3) compared thyroid status of lactating cows in dairy herds being fed iodine (mg/head per day) at relatively low (range 11 to 25) or high (range 74 to 402) levels. In that study, quantity of estimated dietary iodine did not affect any parameter of thyroid physiology, but accurate determination of daily iodine intake for individual animals or interval at that intake was impossible. Therefore, we compared thyroid status of lactating dairy cows given measured amounts of supplemental iodine for a known time.

MATERIALS AND METHODS

Fifteen lactating Holstein cows from the University of Tennessee dairy herd were assigned to groups of five to be fed 0, 2.5, or 5.0 mg supplemental iodine per kg body weight daily equal to ≈ 0, 100, and 200 ppm of feed dry matter. Supplemental iodine was from ethylene diamine dihydriodide (EDDI) premixed with dextrose at a ratio of 1:4. Initially the EDDI-dextrose mixture was fed mixed with the pelleted concentrate feed, but as lactation advanced and feed allowances decreased, it was given in a gelatin capsule via balling gun at 1300 daily. Iodine supplementation was initiated when cows were 8 to 12 wk in lactation and pregnant 0 to 1 mo. It was continued for that
lactation, through the dry period, and into the next lactation. Amount of iodine fed was adjusted for change in body weight once at 34 days before TRH (thyrotropin releasing hormone) was given. Average supplemental iodine for each cow is in Table 1.

Cows were fed a pelleted 18% crude-protein concentrate at 1 kg for each 2.5 to 3.0 kg milk up to a maximum of 13.6 kg daily. Roughage was mixed hay plus green chopped summer annual grasses with limited grass pasture when available and corn silage during winter feeding. The concentrate contained .5% trace mineralized salt, which contained .007% iodine. Total iodine concentrations in plasma collected from control cows at ~3 and 1 wk prepartum, parturition, and 1 and 4 wk postpartum averaged 131 ug per liter of plasma. The comparable value for milk collected at 1 and 4 wk postpartum was 108 ug/liter. Based on these values, iodine intake in control cows was estimated at about 5 mg per cow daily. The basal amount of iodine also was consumed by cows fed supplemental iodine.

On day 341 after onset of iodine feeding, each cow was injected intravenously with 15 ug TRH per 100 kg body weight. The TRH was dissolved in .1 M phosphate buffered saline (.85% NaCl) which does not cause changes in serum concentrations of thyrotropin (TSH), thyroxine, or tri-iodothyronine (6, 7). Jugular blood was collected via cannula at 15 min and immediately before TRH then at 10, 15, 20, 25, 30, 60, 120, and 240 min. Concentrations of TSH in serum were determined as in (6). Thyroxine and tri-iodothyronine of serum were assayed by commercial radioimmunoassay reagents 3. Six to eight serum samples from a pool of bovine serum were assayed in each assay. Within and among assay coefficients of variation determined from 12 thyroxine assays were 5.5 and 4.5%. Comparable values for seven triiodothyronine assays were 5.3 and 10.4%. Data in serum for basal hormone (mean of −15 and 0 min samples) were analyzed by one-way analysis of variance (10). Changes in hormone concentration of serum resulting from TRH were analyzed by split-plot analysis of variance appropriate to repeat measurements on the same animals (4).

Samples of serum and milk assayed for iodine were analyzed by an alkaline fusion method adapted from and similar to that for protein bound iodine of plasma (2) without the rinsing steps.

RESULTS

Characteristics of cows in our experiment are in Table 1. Average total daily dose of supplemental iodine during 341 days for cows fed 2.5 and 5.0 mg iodine/kg body weight (bw) averaged 1.9 and 3.1 g (Table 1). Recall that cows in groups fed 2.5 or 5 mg iodine/kg body weight were fed iodine prior to the experiment. For 34 days prior to TRH dosing, average iodine supplements were 1.6 and 3.5 g per day. These doses of iodine resulted in total iodine values of plasma of 2.3 and 5.7 mg/liter on the day TRH was given which were greater (P<.001) than the comparable control value of .18 mg/liter (Table 1).

Concentrations of TSH, thyroxine, and triiodothyronine in serum prior to and following TRH are in Fig. 1, 2, and 3, respectively. Basal hormone concentrations were the average of values for samples taken at 15 min and immediately before TRH. Basal TSH in serum averaged 7.6 ± 1.1 (SE), 6.1 ± .7, and 8.2 ± .6 ng/ml for cows given 0, 2.5, and 5.0 mg iodine/kg bw (Fig. 1), and means were not different (P>.05). Thyrotropin-releasing hormone caused a marked transient increase of three- to six-fold (P<.0005) in TSH concentration of serum in all cows; however, differences in response attributable to dose of iodine were not significant (P>.10). For cows given 0, 2.5, and 5.0 mg iodine/kg bw daily basal thyroxine of serum (Fig. 2) averaged 47 ± 3, 44 ± 2, and 43 ± 2 ng/ml and tri-iodothyronine (Fig. 3) averaged 2.2 ± 1.1, 1.8 ± .1, and 2 ± .1. Comparable means were not different (P>.10). Both thyroxine and triiodothyronine concentrations increased (P<.0005) in serum with time after TRH, however, in neither case was the increase affected by amount of iodine fed (Fig. 2 and 3).

DISCUSSION

Several authors have warned of the possibility of iodism in cattle from routine use of iodine-containing compounds by veterinarians.
### Table 1. Characteristics of experimental cows.

<table>
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<tr>
<th>Supplemental iodine fed daily</th>
<th>Cow no.</th>
<th>Age (year-month)</th>
<th>Body weight (kg)</th>
<th>Days in lactation</th>
<th>Milk yield (kg)</th>
<th>Plasma concentration (mg/liter)</th>
<th>Dose last 34 days (g/day)</th>
<th>Dose overall (g/day)</th>
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<td>Avg ± SE</td>
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<td>.18 ± .08</td>
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<td>80 ± 3.4</td>
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<td>5.7 ± .6</td>
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*a* Cows were nonpregnant except 774 which was 200 days pregnant.

*b* Determined on the day thyrotropin releasing hormone was given, i.e. December 22, 1976.

*c* Average production December 15, 1976 to December 31, 1976.

*d* From November 18, 1976 to December 22, 1976.

*e* Average daily dose of iodine given from onset of iodine feeding to December 22, 1976.
and livestock producers (8, 12). Iodine compounds often are added to concentrates, iodized salt, mineral mixes, liquid protein supplements, and silage topdressing. Diets may contain several of these feedstuffs, and the total amount of iodine ingested would be in marked excess of daily requirements. Potential for feeding toxic amounts of iodine is enhanced additionally by use of iodides in rations as supplements for prevention of footrot, lumpy jaw, respiratory diseases, and mastitis. Chronic ingestion of iodide or iodide-generating organic compounds in amounts of ten or more times the daily requirement for biosynthesis of thyroid hormone can lead to goiter in humans (14). Endemic goiters from excess dietary iodine occur among coast dwellers of Hokkaido, Japan, who daily consume iodine in amounts to 200 mg (11). Whether excess dietary iodine could affect thyroid physiology in cattle similarly, has been questioned (8).

The amount of iodine required to support biosynthesis of thyroid hormone in a 630 kg lactating dairy cow is less than 10 mg daily. Therefore, cows in this experiment that were fed supplemental iodine received approximately 200 to 400 times requirement for 49 wk. Nevertheless, there was no evidence that thyroid physiology was altered in these cows; i.e., basal concentration of TSH and thyroid hormones were similar in control cows and those given supplemental iodine. Similarly, TSH released by TRH was apparently normal in cows fed high concentrations of iodine as was the increase in thyroxine and tri-iodothyronine concentrations of serum that occurred secondary to TSH release. These results confirm our earlier study (3). However, basal concentrations of thyroxine in serum were lower and TSH release by TRH higher in Holstein heifer calves fed 1250 mg iodine daily for 23 days relative to that of control heifers fed no supplemental iodine (7).

Wallace (12) observed hypertrophy of the thyroid in lactating dairy cows fed a calculated average of 107 mg iodine/head per day. Similarly, enlargement of the thyroid has been reported in horses (1), humans (14), and chicks (13) fed excess iodine. However, effects of feeding various amounts of iodine on thyroid weight of dairy calves was variable among trials (9). No gross signs of enlargement of the thyroid accompanied feeding of high iodine in the present study; if altered thyroid size did occur, it was not accompanied by changes in any measures of thyroid physiology.

Estimates of tri-iodothyronine concentra-
tions for lactating cows have not been reported previously. Similar to results with humans (5), tri-iodothyronine of serum is increased following TRH, presumably a result secondary to TSH release. Basal concentrations of tri-iodothyronine were approximately 1/20 those of thyroxine.

In summary, supplemental iodine fed at about 200 to 400 times requirement for 49 wk did not alter basal concentrations of TSH, thyroxine, or tri-iodothyronine nor did it affect amount of TSH released by TRH in lactating cows. In addition, the ability of the thyroid to respond to TSH released by TRH was not affected by dietary iodine.

ACKNOWLEDGMENTS

The authors wish to thank B. McCarthy, West Agro. Chemical Inc., Westwood, KS, for ethylenediamine dihydriodide; S. L. Davis for antithyroid hormone; J. G. Pierce for highly purified TSH for iodination; R. Rippel, Abbott Laboratories, North Chicago, IL, for thyrotropin releasing hormone; and the National Institute of Arthritis, Metabolic, and Digestive Diseases Pituitary Hormone Distribution Program for NIH-TSH-B4 used for standards.

REFERENCES