Epidemiological and Pathological Studies on Congenital Diffuse Hyperplastic Goiter in Calves

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ABSTRACT. Perinatal diseases such as weak calf, stillbirth, or abortion were found in 86 calves from about 600 cows in a farm (A Farm) in 1987 and 1988. Such perinatal diseases were decreased to 36 calves in 1989 and 1990 after an additional supply of seaweed was made to the maternal feeds. From these cases, 23 stillborn and weak calves were pathologically examined. The mean weight with standard deviation of the 18 thyroid glands was 36.3±28.6 g before feeding of the seaweed supplement, and 12 (67%) of the glands showed moderate to marked degree of diffuse hyperplastic goiter in histological criteria. On the other hand, 5 glands weighed 12.0±3.4 g and revealed no such histological lesions after the additional supply. These results suggest that the goiter had been associated with birth of weak calves. Further study was performed on 37 newborn calves affected with Akabane disease in 1986 in A Farm and the neighboring B Farm located. Seven (54%) of 13 thyroid glands from A Farm and 1 (4%) of 24 glands from B Farm showed histologically moderate to marked goitrous lesions. There were dotted “Inugarashi”, Rorippa indica, family Cruciferae in both pastures. The mean iodine contents of the orchard grasses were 87 and 121 μg/kg on dry basis in A and B Farms. Marginal deficiency or lower limit of iodine and possible thiocyanate content of “Inugarashi” may have been responsible for the goiter in the farms. —KEY WORDS: calf, congenital goiter, iodine deficiency, Rorippa indica.


Goiter, a clinical term applicable to any nonmalignant gross enlargement of the thyroid gland, is by far the most frequent disease of the organ [11]. The enlargement may be due to an increase of thyroid tissue which is hyperplasia, or to an increased amount of colloid distending the follicular lumens, or much less commonly to inflammatory proliferation [11]. The occurrence has been reported in endemic areas throughout the world, especially before treatment with iodized salt to animal feeds [12]. Although various domestic mammals can be affected with goiter [1–3, 10, 20, 29], it is common in lambs [6, 13, 31, 32] and calves [14, 19, 28] that goiter is frequently associated with such perinatal diseases as abortion, stillbirth, alopecia, or birth of weak young [1, 16, 22, 31]. Goiter may cause serious loss in reproduction in ruminants raising on intensive grazing systems [33]. In Japan, little attention was made on goiter, but there are several reports on the endemic occurrence in lambs [27], calves [14, 19, 28], and man [26], and on the sporadic cases in calves [25]. The cause remains unknown in domestic animals in Japan, while excessive intake of iodine from seaweed was noted in man [26].

The purpose of the present paper is to describe epidemiological and pathological findings on congenital diffuse hyperplastic goiter observed in calves in a farm (A Farm). Further study was performed for the incidence and etiology of the goiter in newborn calves in A Farm and the neighboring B Farm where the sporadic occurrence of perinatal diseases has been known.

MATERIALS AND METHODS

Pathological examination: Sixteen weak calves and 2 stillborns in 1987 and 1988 and 3 weak calves and 2 stillborns in 1989 and 1990, were examined in A Farm. Additional surveys for the incidence of goiter were performed on 13 newborn calves from A Farm and 24 from B Farm obtained in 1986, which were affected with Akabane disease. All of the examined animals died or were euthanized within 2 weeks of age. At autopsy, specimens of the organs and tissues from the whole body were fixed in 10% neutral formalin solution. Paraffin sections were cut and stained with hematoxylin and eosin (HE) for histological observation. Lesions of the thyroid glands were histologically classified into normal, slight, mild, moderate, and marked mainly based on
the criteria described by Mason [17] and Mason and Laby [18].

**Quantitative analysis of iodine in water and orchard grass**: A total of 3 drinking waters for animals were collected from 3 brooks respectively originated from A and B Farms, and from C Farm where few occurrence of perinatal disease has been known, in August 1990. And a total of 15 orchard grasses were obtained from 5 sites of each pasture in the three farms in October 1990. The iodine contents were examined by neutron activation analysis method by Yuita [34].

**RESULTS**

**Epidemiological history**: A and B Farms are located in the northwest of Iwate Prefecture, Japan, and their lands were covered with the same kind of volcanic ash soil.

In A Farm, about 400 beef cows of Nippon Short Horn breed had been raised in pasture from May to November and in barns from December to the following April. About 300 calves were born during January and April every year. In 1987 and 1988, 86 cows were delivered of weak calf followed by death, stillborn or abortive young. Since May 1988, about 30 g of dried seaweed per cow had been added to their feeds two or three times weekly. In 1989 and 1990, the perinatal diseases were decreased in number to 36 due to pronounced reduction of the weak calves (Table 1).

The weak calves showed difficulty to suck their maternal milk, coarse hair coat, reduced viability, diarrhea, and no response to antibiotics and electrolytes. They died or were euthanatized within two or three weeks of age because of their unfavourable prognosis. Two stillborns in 1987 and 1988 were hairless on the cranial and cervical portions. On the other hand, only 2 or 3 of about 100 cows calved in summer or fall had such perinatal diseases every year. The cows were kept under inferior sanitary environment in the winter and spring, while under good one in summer and fall. The average conception rate was increased from 767 (87.8%) of 874 cows in 1986 and 1987 to 812 (95.5%) of 850 in 1988 and 1989.

In B Farm, Nippon Short Horn cows had been pastured except stall feeding period of the winter and early spring.

**Rorippa indica** Hiern, genus Brassica, family Cruciferae, Japanese name “Inugarashi”, was dotted in both farms (Fig. 1).

C Farm is located in the south of Iwate Prefecture and the land was covered with a different kind of volcanic ash soil from A and B Farms.

**Pathological findings in thyroid gland**: Macroscopically, both lateral lobes and isthmus were uniformly or lobularly enlarged without any nodular lesions nor cystic follicles in the affected gland weighing more than 16 g (Fig. 2). They touched firm and the surfaces as well as the cut surfaces were reddish brown or dark reddish in color. Periglandular tissues of the enlarged gland weighing 40 g or more were edematous. Marked edema was found in the subcutaneous tissues of the neck region in a case having the gland weighing as heavy as 120 g.

The examined glands of 60 calves were classified histologically into 5 criteria from normal to marked goitrous lesions. Eleven glands had normal structure composed of an arrangement of almost same sized

<table>
<thead>
<tr>
<th>Year</th>
<th>Birth of weak calves</th>
<th>Stillbirths or abortions</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>23</td>
<td>20</td>
<td>43</td>
</tr>
<tr>
<td>1988</td>
<td>34</td>
<td>9</td>
<td>43</td>
</tr>
<tr>
<td>1989</td>
<td>3</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>1990</td>
<td>10</td>
<td>8</td>
<td>18</td>
</tr>
</tbody>
</table>

Dried seaweed had been added to the maternal feeds since May 1988.

**Fig. 1.** Scattering yellowish gregariousnesses of *Rorippa indica* Hiern, Japanese name “Inugarashi”, genus Brassica, family Cruciferae, are seen in the pasture. Inset: Close-up view of the plant.
follicles with cuboidal epithelial cells and eosinophilic and homogeneous colloid. The mean weight with standard deviation (SD) was 12.9±2.2 g.

The other 49 glands showed diffuse hyperplastic goiter in various degrees. In the slightly affected 18 glands, several follicles were mildly irregular in shape with slight hyperplasia of the epithelial cells, and the lumens were filled up with eosinophilic and homogeneous colloid. They were weighing 14.8±3.0 g.

In the mildly affected 11 glands, many follicles were irregular in shape with hyperplasia of the columnar epithelial cells forming papillary projections into the lumens. The colloid was still almost normal morphologically, but it had small vacuoles interfacing to epithelial cells in several follicles. The glandular weight was 18.8±5.0 g.

In the moderately affected 13 glands, follicles were increased in number, irregular in shape, and variable in size, showing marked hyperplasia of epithelial cells forming many small or narrow follicles with papillary projections into the lumens. The epithelial cells were columnar, with abundant cytoplasm showing eosinophilic affinity and hyperchromatic nuclei located at the cellular base. Pale epithelial cells lined up the whole margin or a part of several follicles. These cells were hypertrophic and rich in cytoplasm containing vacuoles or liquid-like substances with slightly eosinophilic affinity, and had hyperchromatic nuclei located at the apical part of cells (Fig. 3). The colloid was decreased in amount and eosinophilic affinity. There were many vacuoles of various sizes in the lumens. They were weighing 28.3±14.2 g.

In the markedly affected 7 glands, follicles were more increased in number. The pale follicular epithelial cells were found more frequently (Fig. 4). The colloid was scarce or depleitive in amount and poor in eosinophilic affinity. They were weighing 36.4±35.0 g. Blood capillaries were abundant irrespective of the pathological changes.

Comparison of the thyroidal changes: The weight of 18 glands from A Farm in 1987 and 1988 ranged from 12 to 120 g (36.3±28.6 g). The value of 5 glands ranged 8 to 16 g (12.0±3.4 g) in 1989 and 1990 after the additional supply of dried seaweed. Of the 18 glands in 1987 and 1988, 17 (94%) showed histologically goitrous lesions and 12 (67%) were moderate to marked in the degree. In 1989 and
Table 2. Weight and histological lesions of thyroids

<table>
<thead>
<tr>
<th>Year</th>
<th>Examined number of thyroids</th>
<th>Weight (g)</th>
<th>Number of thyroids with goitrous lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Maximum</td>
<td>Minimum</td>
</tr>
<tr>
<td>A Farm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>13</td>
<td>51</td>
<td>13</td>
</tr>
<tr>
<td>1987-88</td>
<td>18</td>
<td>120</td>
<td>12</td>
</tr>
<tr>
<td>1989-90</td>
<td>5</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>B Farm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>24</td>
<td>23</td>
<td>9</td>
</tr>
</tbody>
</table>

a) SD: Standard deviation.

1990, 3 glands (60%) had slight to mild goitrous lesions in degree.

In cases examined in 1986, the weight of 13 glands from A Farm ranged from 13 to 51 g (21.4±10.7 g), while the value of 24 glands from B Farm ranged 9 to 23 g (14.3±3.8 g). All 13 glands of A Farm showed goitrous lesions histologically and 7 (54%) were moderate to marked in degree. Of the 24 glands from B Farm, 15 (63%) had slight and mild lesions and only 1 (4%) was moderate in degree (Table 2).

Pathological diagnosis in calves of A Farm: Of 18 cases examined in 1987 and 1988, 14 were diagnosed as infectious diseases caused by bacteria or fungi; 2 stillborns had only goitrous lesion histologically marked in degree; one had hydrocephalus with moderate goitrous lesion; and another one was accidental death with slight goitrous lesion. Nine of 14 cases diagnosed as infectious diseases had goitrous lesion moderate to marked in degree and 5 were normal, or possessed slight and mild goitrous lesion. In 1989 and 1990, 2 were infectious diseases and 3 were miscellaneous.

Iodine levels of waters and orchard grasses: The iodine levels of waters from A and B Farms were as low as 0.361 and 0.811 μg/l, respectively. The value was 1.400 μg from C Farm. The mean iodine contents of orchard grasses from A and B Farms were as low as 87±19 and 121±21 μg/kg, respectively, on dry basis, compared with the value of 193±69 μg/kg from C Farm.

DISCUSSION

In A Farm in 1987 and 1988, the perinatal mortality of calves was high and 67% of them possessed diffuse hyperplastic goiter histologically moderate to marked in degree. While, in 1989 and 1990 after treatment with dried seaweed to dams, the mortality of calves was remarkably decreased due to a reduction of the weak calves and no examined cases showed goitrous lesions moderate to marked in degree, though the examined number was as few as 5. These results suggest that the disease had been associated with birth of the weak calf in the farm.

The weak calves in A Farm showed difficulty to suck their maternal milk under inferior sanitary environment, and many of them died of infectious diseases. The infectious diseases may result from complicated factors such as ingestion of insufficient volume of colostrum, inferior sanitary environment, and severe climate conditions in the winter or early spring. The cause of low mortality in the calves in the summer or fall in A Farm was not determined but improvement of several minor conditions recognized in the winter or early spring may have been involved.

Goiter is known to influence on the reproductive disturbances of cattle [9]. The conception rate in A Farm cows was improved after administration of dried seaweed.

Moderate to marked goitrous lesions in histological criteria were shown in 7 (54%) and 1 (4%) glands from A and B Farms in 1986, respectively. These results may reflect the incidence of such degrees of goitrous lesions in many calves born in both farms.

The mean value of the weight of the thyroid glands histologically normal was 12.9 g in the present study, which was heavier than that of 6 to 7 g in the non-endemic areas of goiter [33], although similar to 12.5 g in the endemic areas [16]. The essential histological changes observed in the affected thyroid glands were hyperplasia of the follicular epithelial cells and a decreased amount of
the colloid. The changes were almost the same as those described previously in lambs [17, 18, 21] and calves [14, 19, 28]. The pale follicular epithelial cells observed in the present examination resembled the columnar vacuolated cells showing extreme hyperplasia in the ovine goitreous glands [21].

It is well known that goiter is caused by deficiency [31] or excess intake [2] of iodine, goitrogenic [8, 24] which were classified into thiocyanate and thiouracil types according to Calderbank quoted by Wilson [33], and genetic defects of certain hormonal or enzymatic substances [5, 21–23, 30, 32]. Of these causal factors, deficiencies of iodine and goitrogens of thiocyanate type can be overcome by administration of iodine [4, 18].

The iodine content of water reflects the iodine content of the regional soil and vegetation [9]. In general, the iodine level is said to be less than 2 µg/l in water of iodine-deficient regions [9]. The low level of iodine content of waters in A (0.361 µg/l) and B Farms (0.811 µg/l) may well suggest deficiency of iodine content in the soils of the farms. Wilson [33] described that the mean iodine content of pasture grasses was 200 µg/kg on dry basis in southern Wales and southeastern England, while it was as low as 100 µg in the endemic goiter areas. Hetzel and Maberly [9] cited the result of Hartmans that the iodine levels of pasture grasses in Netherlands ranged from 60 to 140 µg in spite of no reference to prevalence of goiter. Iodine content of 87 µg/kg of pasture grasses in A Farm seems to be marginally deficient, while that of 121 µg/kg in B Farm may be the lower limit within the normal level.

Thiocyanate has been found in many plants but especially in the family Cruciferae [7, 15]. Vegetation of “Imgarashi” was sporadically observed in the farms. The plant would contain the thiocyanate, a goitrogen since it belongs to the family Cruciferae. It is said that marginally deficient iodine and goitrogen may be responsible for development of the goiter [12]. Marginal deficiency of iodine and thiocyanate in A Farm, and thiocyanate intake in B Farm may have been responsible for the disease.

Further studies will be needed for pathogenesis on goiter regarding detailed metabolism or biosynthesis of iodine and associated goitrogens in the thyroid gland.

REFERENCES


