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Diseases of Thyroid in Animals and Their Management

R. Singh and S. A. Beigh

Additional information is available at the end of the chapter

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1. Introduction

Disorders of the thyroid gland are well known in companion animals but less so in livestock. In livestock, nutritional iodine deficiencies have been of greater importance than thyroid-gland diseases, particularly in the iodine-deficient areas. Thyroid hormones have many functions in the body and, in general, regulate growth, differentiation, and the metabolism of lipids, proteins and carbohydrates. The thyroid gland of animals is a bilobed structure that overlays the trachea at a point just below the larynx. Anatomical variations of the gland are quite marked between species and, to some extent, within a given species. The isthmus connecting the two lobes of the thyroid is the region that varies most markedly between species. Humans and the pig have a large discrete isthmus that forms a pyramidal lobe connecting the two lateral lobes. The cow has a fairly wide band of glandular tissue that forms the connecting isthmus. In the horse, sheep, goat, cat, and dog, the isthmus is a narrow remnant of tissue and may be nonexistent. The size of the gland relative to body weight is extremely small in all animals, approximating 0.20% of body weight. Accessory or extrathyroidal tissue is quite commonly seen in the dog, particularly near the thoracic inlet, though it may be found anywhere along the esophagus. This tissue is fully functional physiologically, synthesizes hormone, and can be located by its uptake of radionuclides. The thyroid gland is a highly vascularized tissue with a large blood flow. The functional unit of the thyroid gland is the thyroid follicle, a spherical structure composed of an outer monolayer of follicular cells surrounding an inner core of colloid, the thyroglobulin-hormone complex, which is the storage reservoir of thyroid hormone. The colloid stored in the lumen is a clear, viscous fluid. The individual follicular cells vary from 5 to 10/ μm in height and the entire follicle may vary from 25 to 250/ μm in diameter. The size of the follicles and the height of their cells vary according to the functional state of the gland. The cells may vary from an inactive squamous cell to the highly active, tall columnar cell. Interspersed between the follicles are the thyroid C cells,

the source of calcitonin, the hypocalcemic hormone associated with calcium metabolism. A third type of hormonal tissue, the parathyroid, is embedded within the thyroid or located in close proximity. The parathyroids are the source of parathormone, the hypercalcemic hormone.

Thyroid hormones (T_4 , T_3 , and rT_3) immediately on entering the circulation are bound to transport proteins, mainly to thyroxine binding globulin (TBG) and in lesser amounts to thyroxine binding prealbumin (TBPA) and to albumin. There is a wide spectrum of species variation in hormone binding by serum proteins. TBG is the major binding protein for hormone, but not all species have TBG however, TBPA is present in all species. In the cat, rabbit, rat, mouse, Guinea pig, pigeon, or chicken, TBG is absent and most of the hormone is transported by albumin. In these species without TBG, albumin transports 50-80% of the hormones. T_3 (and likely rT_3) appears to bind to these transport proteins in parallel with T_4 binding.

2. Disorders of thyroid function

2.1. Hypothyroidism

This disorder is most common in dogs but also develops rarely in other species, including cats, horses, and other large domestic animals. Hypothyroidism is most common in dogs 4-10 yr old. It usually affects mid- to large-size breeds and is rare in toy and miniature breeds. Breeds reported to be predisposed include the Golden Retriever, Doberman Pinscher, Irish Setter, Miniature Schnauzer, Dachshund, Cocker Spaniel, and Airedale Terrier. There does not appear to be a sex predilection, but spayed females appear to have a higher risk of developing hypothyroidism than intact females. Clinical Hypothyroidism is usually the result of primary diseases of the thyroid gland, especially idiopathic follicular atrophy also termed "follicular collapse" and lymphocytic thyroiditis. In the adult dog, follicular atrophy is probably the most common cause of hypothyroidism. Hypothyroidism may be secondary to a pituitary insufficiency that prevents the release of either TSH or TRH. Other rare forms of hypothyroidism in dogs include neoplastic destruction of thyroid tissue and congenital (or juvenile-onset) hypothyroidism. Hypothyroidism is an extremely rare disorder in adult cats, iatrogenic hypothyroidism is the most common form congenital or juvenile-onset hypothyroidism does also occur. Hypothyroidism appears to be very rare in adult horses. In foals, congenital hypothyroidism may develop when pregnant mares graze plants that contain goitrogens, nitrate or are fed diets either deficient in or containing excessive amounts of iodine.

Clinical Findings: A deficiency of thyroid hormone affects the function of all organ systems; as a result, clinical signs are diffuse, variable, often nonspecific, and rarely pathognomonic. Slowing of cellular metabolism, results in development of mental dullness, lethargy, intolerance of exercise, and weight gain without a corresponding increase in appetite. Mild to marked obesity develops in some dogs. Difficulty in maintaining body temperature may lead to frank hypothermia; the classic hypothyroid dog is a heat-seeker. Alterations in the skin and coat are

common. Dryness, excessive shedding, and retarded regrowth of hair are usually the earliest dermatologic changes. Nonpruritic hair thinning or alopecia (usually bilaterally symmetric) that may involve the ventral and lateral trunk, the caudal surfaces of the thighs, dorsum of the tail, ventral neck, and the dorsum of the nose occurs in about two-thirds of dogs with hypothyroidism. Alopecia, sometimes associated with hyperpigmentation, often starts over points of wear. Occasionally, secondary pyoderma (which may produce pruritus) is observed.

In moderate to severe cases, thickening of the skin occurs secondary to accumulation of glycosaminoglycans (mostly hyaluronic acid) in the dermis. In such cases, myxedema is most common on the forehead and face, resulting in a puffy appearance and thickened skin folds above the eyes. This puffiness, together with slight drooping of the upper eyelid, gives some dogs a "tragic" facial expression. These changes also have been described in the GI tract, heart, and skeletal muscles.

In intact dogs, hypothyroidism may cause various reproductive disturbances: in females, failure to cycle (anestrus) or sporadic cycling, infertility, abortion, or poor litter survival; and in males, lack of libido, testicular atrophy, hypospermia, or infertility. During the fetal period and in the first few months of postnatal life, thyroid hormones are crucial for growth and development of the skeleton and CNS. Therefore, in addition to the well-recognized signs of adult-onset hypothyroidism, disproportionate dwarfism and impaired mental development (cretinism) are prominent signs of congenital and juvenile-onset hypothyroidism. In primary congenital hypothyroidism, enlargement of the thyroid gland (goiter) also may be detected, depending on the cause of the hypothyroidism. Radiographic signs of epiphyseal dysgenesis (underdeveloped epiphyses throughout the long bones), shortened vertebral bodies, and delayed epiphyseal closure are common.

In dogs with congenital hypopituitarism there may be variable degrees of thyroidal, adrenocortical, and gonadal deficiency, but clinical signs are primarily related to growth hormone deficiency. Signs include proportionate dwarfism, loss of primary guard hairs with retention of the puppy coat, hyperpigmentation of the skin, and bilaterally symmetric alopecia of the trunk.

Clinical characteristics of hypothyroidism in adult horses are poorly defined largely because of the difficulty of confirming the diagnosis and the pharmacological effect of exogenous thyroid hormone. Clinical abnormalities anecdotal attributed to hypothyroidism include exercise intolerance, infertility, weight gain, maldistribution of body fat, agalactia, anhidrosis, and laminitis among others. Congenital hypothyroid foals have a prolonged gestation but are born with a short silky hairs coat, soft pliable ears, difficulty in standing, lax joints and poorly ossified bones. The foals are referred to as dysmature. Characteristic musculoskeletal abnormalities include inferior (mandibular) prognathism, flexural deformities, ruptured common and lateral extensor tendons, and poorly ossified cuboidal bones.

Treatment: Thyroxine (T_4) is the thyroid hormone replacement compound of choice in dogs. With few exceptions, replacement therapy is necessary for the remainder of the dog's life; careful initial diagnosis and tailoring of treatment is essential. The reported replacement

dosages for T_4 in dogs range from a total dose of 0.01-0.02 mg/lb (0.02-0.04 mg/kg), daily, given once or divided bid.

3. Hyperthyroidism

Among domestic animal species, disturbances of growth resulting from the production of excess thyroid hormones is most common in adult cats and often related to adenomas compared to hyperactive follicular cells. These neoplastic cells release both T_4 and T_3 at an uncontrolled rate resulting in the markedly elevated blood levels of both hormones. Cats with hyperthyroidism have elevated levels of total serum thyroxine and triiodothyronine. Normal serum levels of T_4 in cats, as measure by radioimmunoassay, are approximately 1.5 to 4.5 $\mu\text{g}/\text{dl}$ and serum T_3 levels are 60 to 100 ng/dl. In hyperthyroid cats the total levels of T_4 in the serum range from 5.0 to over 50 $\mu\text{g}/\text{dl}$ and total levels of T_3 in the serum range from 100 to 1,000 ng/dl. Hyperthyroidism is associated with weight loss in spite of a normal or increased appetite and with restlessness and increased activity.

Dogs have a very efficient enterohepatic excretory mechanism for thyroid hormones that is difficult to overload, either from endogenous production by a tumor or by exogenous administration of thyroid hormones. Hence, thyroid tumors in the dog only occasionally secrete sufficient amount of thyroid hormone to overload the highly efficient enterohepatic excretory pathways for the thyroid hormones and produce clinical signs of hyperthyroidism. The clinical signs of hyperthyroidism in dogs with functional thyroid tumors include polyuria and polydipsia and weight loss, despite increased appetite and polyphagia, leading to muscle atrophy and weakness. The levels of T_3 and T_4 in the serum of dogs with clinical hyperthyroidism are only mildly elevated: 300-400ng/dl and 5-7 $\mu\text{g}/\text{dl}$, respectively. As compared to dogs, cats are very sensitive to phenols and phenol derivatives. They have a poor ability to conjugate phenolic compounds such as T_4 with glucuronic acid and to excrete the T_4 -glucuronide into bile. In cats the capacity for conjugation of T_3 with sulfate is also limited and can easily be overloaded.

4. Goiter

Goiter is a clinical term for a non-neoplastic and non-inflammatory enlargement of the thyroid gland which develops in mammals, birds and submammalian vertebrate. The major pathogenic mechanism responsible for the development of thyroid hyperplasia include iodine-defeciant diets, goitrogenic compounds that interfere with hormone synthesis, dietary iodide-excess and genetic defects in the biosynthesis of thyroid hormone. All of these seemingly divergent factors result in deficient thyroxine and triiodothyronine synthesis and decreased blood levels of throid hormones. This is sensed by the hypothalamus and pituitary gland and lead to an increased secretion of TSH, which results in hypertrophy and hyperplasia of the follicular cells in the thyroid gland. The following

subtypes of goiters are recognized: diffuse hyperplastic, colloid iodide-excess, multifocal hyperplastic, and congenital dyshormonogenetic.



Figure 1. Goiter in a kid from Jammu region

Diffuse thyroid hyperplasia due to iodine deficiency was common in many goitrogenic areas in India before the widespread supplementation of iodized salt to animal diets. Although outbreaks of iodine-deficient goiter are now sporadic and fewer animals are affected, iodine deficiency is still responsible for most goiters seen in large domestic animals. Marginally iodine-deficient diets containing certain goitrogenic substances may result in severe thyroid hyperplasia and clinical evidence of goiter. Goitrogenic substances include thiouracil, propylthiouracil, sulfonamides, complex anions such as perchlorate (ClO_4^-), pertechnetate (TcO_4^-), perrhenate (ReO_4^-) and tetrafluoroborate (TfO_4^-). In addition, a number of plants from the genus *Brassica* contain thioglycosides which after digestion release thiocyanate and isothiocyanate. A particularly potent thioglycoside, goitrin (L-5-vinyl-2-thiooxazolidone) from plants is excreted in milk. Young animals born to females on iodine-deficient diets are more likely to develop severe thyroid hyperplasia and have clinical signs of hypothyroidism including palpable enlargement of the thyroid gland. Iodine deficiency may be conditioned by other anti-thyroid compounds present in animal feed and in particular situations, these can be responsible for higher incidence of goiter. Hyperplastic goiter in ruminants is associated with prolonged low-level exposure to thiocyanates produced by the ruminal degradation of cyanogenic glucosides of plants such as white clover (*Trifolium*), couch grass and linseed meal, and by degradation of glucosinolates of *Brassica* crops. *Leucaernea leucocephala* and other legumes

of this genus are native or cultivated in many subtropical areas and contain the toxic amino acid mimosine.

Goiter in adult animals is usually of little significance and the general health of the animal is not impaired. However, goiter is of significance as a disease of the newborn, although the drastic losses of animals in endemic area are now controlled by the prophylactic use of iodized salt. Congenital hypothyroidism in domestic animals may be associated with iodine-deficient hyperplastic goiter, even though the dam shows no evidence of thyroid dysfunction. Gestation is often significantly prolonged, particularly for animals with large goiter, and there is increased incidence of dystocia with retention of fetal placenta. Foals affected with iodine-deficient goiter have moderately enlarged thyroids are weak at birth and frequently die within a few days after birth. Calves and kids with goiter are born partially or completely hairless and are either born dead or die soon after birth. Newborn goitrous pigs, goats and lambs frequently have myxedema and hair loss. The mortality rate is high in these species, with majority of offspring born dead or dying within a few hours of birth.

Author details

R. Singh and S. A. Beigh

Division of Veterinary Clinical Medicine & Jurisprudence, Faculty of Veterinary Sciences & A. H., S.K.U.A.S.T.-Jammu, R. S. Pura, Jammu (J&K), India

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