

Thyroid Neoplasia in a Raccoon (*Procyon lotor*)

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ABSTRACT

A 6 year-old female intact captive raccoon (*Procyon lotor*) was presented for a routine annual health evaluation. On physical examination, the raccoon was obese and bilateral ventral cervical masses were palpated. Complete blood count was within normal limits. Serum biochemistry profile revealed an increased alkaline phosphatase activity, increased phosphorus and decreased chloride concentrations. Two-view whole body radiographs were performed and revealed a ventral cervical well-circumscribed soft tissue opacity extending to both sides of the midline, splenomegaly, and a pulmonary nodule. Abdominal ultrasound was performed and was unremarkable. Ultrasonographic examination of the cervical region revealed bilateral cervical soft tissue masses in the area of the thyroid glands. Ultrasound-guided fine needle aspirates of the mass were suggestive of an epithelial neoplasm most likely of thyroid gland origin. When compared to canine references, the total thyroxine values (tT4) and triiodothyronine (T3) values were increased on a thyroid panel performed at Michigan State University. In house tT4 values were also increased, though more significantly than those on outside testing. Given the lack of clinical symptoms related to the pathology, the potential risks of a surgical thyroid procedure and the suspicion of pulmonary metastasis, further diagnostics and treatment were declined. To date, 19 months from the time of the initial presentation, the raccoon is doing clinically well with no obvious clinical signs other than the palpable prominent cervical masses.

Keywords: Thyroid adenoma, thyroid adenocarcinoma, hyperthyroidism, raccoon, *Procyon lotor*.

CASE REPORT

A 6-year-old female intact captive raccoon (*Procyon lotor*) housed at a local zoo was examined by the Exotics and Zoological Medicine Service at Kansas State University for an annual health examination. The raccoon had been doing well at the zoo and the keepers had no concerns at the time of presentation. The raccoon was fed omnivore biscuits (Zupreem omnivore diet, Premium Nutritional Products Inc., Shawnee, KS, USA), weight control dog food (Iams ProActive Health Adult Weight Control, Proctor and

Gamble, Dayton, OH, USA), apples, bananas and grapes as the main staples; feline diet (Nebraska Brand Classic Feline Diet, Central Nebraska Packing, Inc., North Platte, NE, USA) and occasionally lake smelt rotated, as well as other fruits and vegetables. The raccoon was housed with two other raccoons at the zoo that showed no signs of disease other than being chronically overweight.

On presentation, the raccoon was bright, alert, and responsive. The raccoon was hand injected with ketamine hydrochloride (10 mg/kg intramuscularly, Ketalar, JHP

Pharmaceuticals LLC, Parsippany, NJ, USA) and medetomidine (0.035 mg/kg intramuscularly, Domitor, Pfizer Animal Health, Exton, PA, USA) for physical examination. Once sedated, chamber induction of anesthesia was achieved with isoflurane (5%) in oxygen (2L/min). The raccoon was intubated with a 5.0 mm endotracheal tube and maintained under anesthesia with isoflurane (2%) in oxygen (2L/min). An intravenous catheter was placed in the left lateral saphenous vein and the raccoon was given Lactated Ringer's Solution (5 mL/kg/hour, B. Braun Medical Inc., Irvine, CA, USA).

On physical examination the raccoon was overweight (11.2 kg) with a body condition score of 5 out of 5. The raccoon had mild dental tartar, and two 4-6 cm diameter bilateral ventral cervical masses were palpated. A blood sample was obtained from the lateral saphenous vein and submitted for a complete blood count (CBC) and biochemical profile. The results of the CBC were within normal reference limits (1). The results of the biochemistry profile showed a mild increase in phosphorus of 0.47 mmol/L (reference range 0.17-

0.45 mmol/L); a mild decrease in chloride of 101 mmol/L (reference range 103-117 mmol/L); and a mild increase in alkaline phosphatase activity (ALP) of 171 U/L (reference range 21-149 U/L) (1).

The initial differential diagnosis list for the cervical masses included hyperplasia, neoplasia, abscess, or cyst with organs of origin to include salivary gland, lymph node, or thyroid gland. A fine needle aspirate (FNA) of the ventral cervical mass yielded serosanguinous fluid. Following the FNA, an abscess seemed less likely, given the appearance of the fluid.

Two days later the raccoon was brought in for further testing and was immobilized again using the previously described anesthesia protocol. Two-view whole body radiographs were performed and revealed a ventral cervical well circumscribed soft tissue opacity extending to both sides of midline measuring approximately 3.0 cm in diameter, splenomegaly, and a pulmonary nodule, 0.8 cm in diameter (Figure 1).

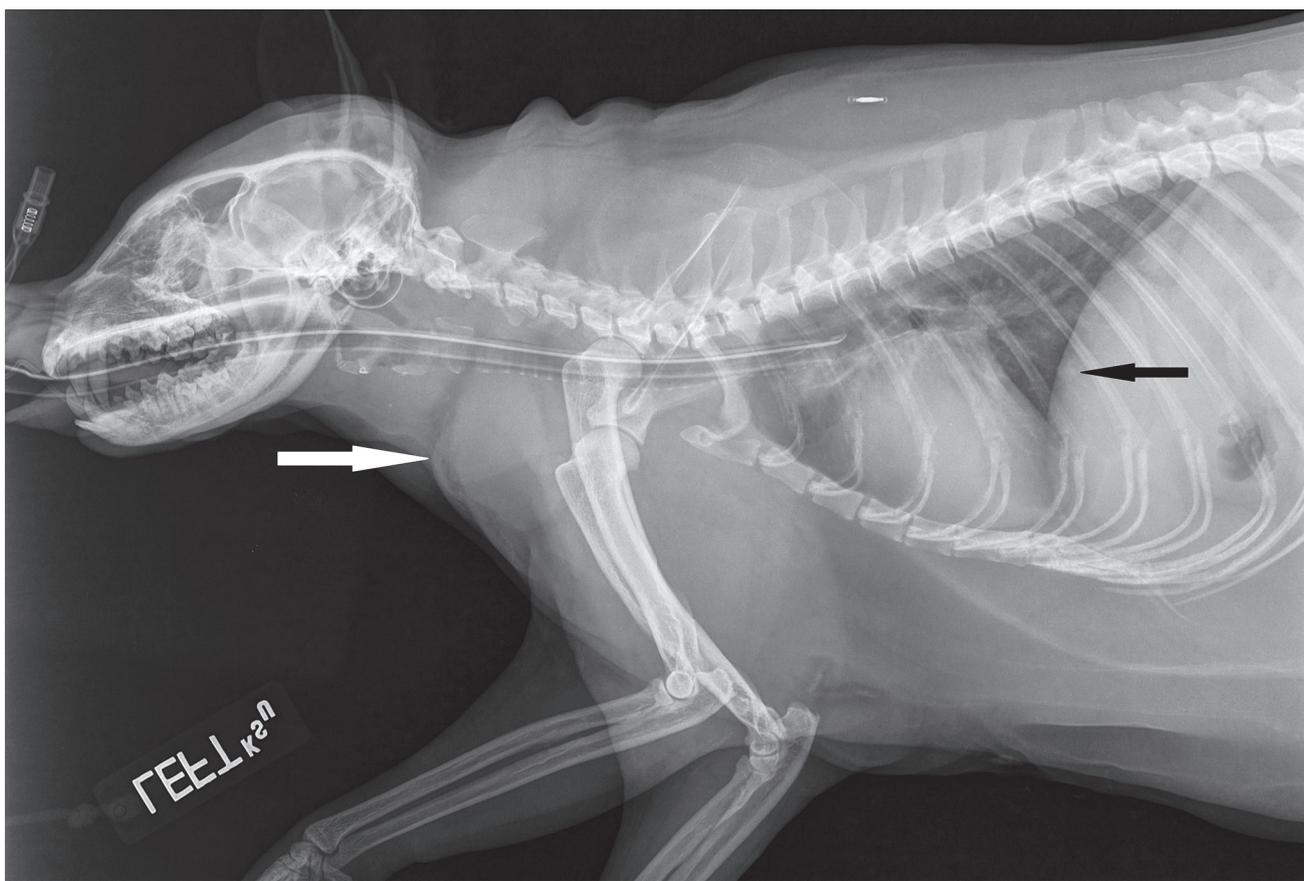


Figure 1: Left lateral cervical and thoracic radiograph of the raccoon.

Notice the ventral cervical soft tissue opacity (white arrow) and pulmonary nodule (black arrow).

An abdominal ultrasonographic examination was performed and was unremarkable. Cervical ultrasonography revealed bilateral cervical soft tissue masses in the area of the thyroid glands. The mass on the right side was heterogeneous and larger than the left, measuring 2.4 cm × 5.3 cm × 5.5 cm. It contained a large anechoic fluid-filled cystic component and a more solid component towards the caudal pole. The left sided mass measured 3 cm × 4.3 cm × 4.1 cm and was heterogeneous in echogenicity. There was extensive blood flow identified via Doppler within and in the periphery of both masses; however, no large vessels were identified to directly invade the mass.

An ultrasound-guided FNA of both cervical masses was performed and the recovered fluid was dark red in color, suggestive of a strong presence of blood in the sample. The cytologic preparations demonstrated high nucleated cellularities, numerous erythrocytes, and pale backgrounds. Nucleated cells consisted primarily of clustered and individualized round, oval, or basaloid epithelial cells with round nuclei containing stippled chromatin patterns and small or indistinct nucleoli (Figure 2). There were moderate amounts of lightly basophilic cytoplasm that often contained variable numbers of dark blue granules most consistent with tyrosine granules. Cell borders were indistinct. Anisocytosis and anisokaryosis were minimal except in rare clusters of pleomorphic cells. Rare binucleated cells were identified. Occasional macrophages, including erythrophages and pigment-laden macrophages most consistent with siderophages, and eo-

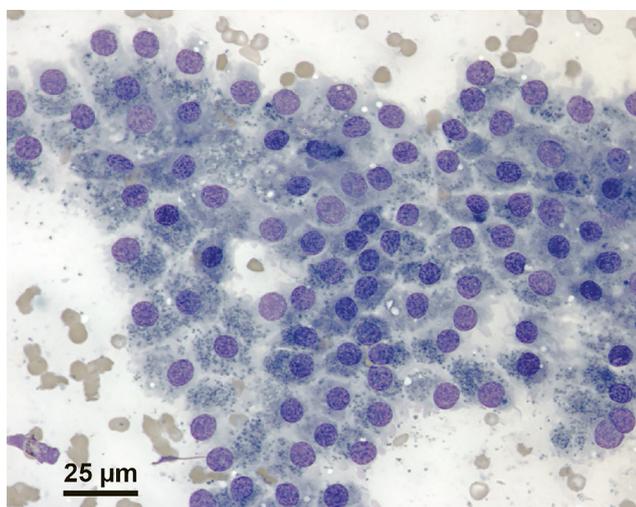


Figure 2: Slide of the fine-needle aspirate showing cytology of the ventral cervical mass in the raccoon. Modified Wright stain, x40 objective.

sinophils were also observed. The cytologic diagnosis given was epithelial neoplasm most likely of thyroid gland origin. The main differential diagnoses following the FNA cytology included a thyroid adenoma, or adenocarcinoma; however, hyperplastic thyroid glands could not be excluded as a differential.

Blood thyroid hormones concentrations were evaluated. The tT4 concentration performed at Kansas State University demonstrated a tT4 of >309 nmol/L (canine reference interval: 10.0-45.5 nmol/L) (Kansas State University, Diagnostic Lab, KS, USA). A thyroid hormones panel performed at Michigan State University revealed a tT4 >156 nmol/L (canine reference interval: 11-60 nmol/L), T3 > 4.7 nmol/L (canine reference interval: 0.8-2.1 nmol/L), free thyroxine concentration by equilibrium dialysis > 128 pmol/L (canine reference interval 6-23 nmol/L), thyroid stimulation hormone 6 mU/L (canine reference interval: 0-30 mU/L), thyroxine autoantibody 7% (canine reference interval: 0-20%), triiodothyronine autoantibody 3% (canine reference interval: 0-10%), and thyroglobulin autoantibody was not detected (canine reference interval: 0-35%) (Michigan State University, Diagnostic Center for Population and Animal Health, USA). These results were highly suggestive of hyperthyroidism when compared to canine reference intervals; however there are no established reference intervals or background data regarding normal thyroid hormones values in raccoons.

With the high suspicion of a functional thyroid neoplasm, incisional biopsy with histopathologic examination of the tissue was recommended as well as potential chemotherapy treatment with Palladia (Toceranib phosphate) (2). Given the lack of clinical symptoms related to the pathology, the potential risks of a complicated surgical thyroid procedure and the suspicion of pulmonary metastasis, further diagnostics and treatment were declined.

On a routine annual examination performed at 19 months from the initial diagnosis, the reported raccoon and its two male cage mates were clinically evaluated. Although not as obese as before (currently 5.4 kg) or when compared to the two other raccoons, this raccoon was still in good body condition (3 out of 5). The thyroid masses on the neck had increased in size and were different in palpation; the left was larger (~8.0 cm) and felt more cystic and the right was smaller (~6.0cm) and more solid to the touch. A blood sample was collected from all three raccoons and analyzed for thyroxine (T4) (VetScan® VS2, Abaxis, Union City, CA, USA), showing an elevated T4

(result >10.0 µg/dL [129 mmol/L]; Abaxis Vetscan canine and feline reference interval: 1.1–4.8 µg/dL [14.2–61.9 mmol/L]). The two other raccoons were within the normal reference interval measuring 2.1 µg/dL and 2.0 µg/dL.

DISCUSSION

This case represents a unique presentation of thyroid pathology in a captive raccoon. Thyroid neoplasms in raccoons have been reported in Europe as well as one report in the United States (3–5). A study in Germany found that 18 of 28 (64%) captive raccoons had thyroid lesions during necropsy, ten of which (38%) were carcinomas (4). Another study in Germany found 31 of 40 (78%) captive raccoons had thyroid lesions during necropsy, 15 of which (38%) were carcinomas and four (10%) were adenomas (6). In both of these studies in Germany, pathology of the thyroid glands was described, but no clinical description of the affected raccoons was given (3, 4). McCain *et al.* described two cases of thyroid neoplasia in older adult spayed female raccoons in the United States (5). Interestingly, the current case was also an older adult female raccoon. One of the cases reported by McCain *et al.* was a unilateral, nonfunctional thyroid adenocarcinoma with eventual pulmonary metastasis and a normal tT4 (20.1 ng/mL (63.9 nmol/L); reference interval: 10–40 ng/mL (31.8–127.2 nmol/L)) when compared to domestic dog and cat reference intervals from the University of Tennessee. The other case described by McCain *et al.* was an obese mature female with no palpable cervical masses, and a lesion described as a bilateral thyroid adenoma with elevated tT4 (80 ng/mL (254.4 nmol/L); reference interval: 10–40 ng/mL (31.8–127.2 nmol/L)) and T3 (1.75 ng/mL (5.57 nmol/L); reference interval: 0.5–1.5 ng/mL (1.59–4.77 nmol/L)) (5). In the current case, the lesions were bilateral, the raccoon was obese with no history of weight loss, and pulmonary metastasis was suspected. Additionally, the tT4 and T3 values were increased, though not as significantly as in the adenoma in the case report from the United States (5).

Since little information is available on thyroid neoplasia in raccoons, the behavior of thyroid tumors was investigated in dogs and cats, where there is a vast array of information available. In dogs, thyroid carcinomas are more common than adenomas (7). Most thyroid carcinomas in dogs are large, unilateral, nonfunctional, invasive, malignant neoplasms (5, 6). Hypothyroidism or hyperthyroidism can occur with ma-

lignant thyroid tumors in dogs (5, 6). In dogs, the metastatic rate can be high with commonly reported sites of metastasis to the lungs, retropharyngeal lymph nodes and the liver (5, 6). Thyroid adenomas are more common in cats than dogs and are often bilateral, functional neoplasms resulting in hyperthyroidism (7). Functional thyroid tumors result in clinical signs of hyperthyroidism as a result of the increased production, secretion, and circulation of active thyroid hormones, thyroxine (T4) and triiodothyronine (T3) (8). The vast majority (98%) of hyperthyroidism cases in cats are a result of benign adenomatous hyperplasia or thyroid adenoma (8). Common abnormalities on CBC in cats with hyperthyroidism include an increased packed cell volume (PCV), macrocytosis, stress leukogram and megathrombocytosis, or the CBC can be unremarkable (8), as was observed in the current case. Common serum biochemistry abnormalities include increased liver enzymes, with mild to moderately increased ALP and/or alanine aminotransferase (ALT), increases in blood urea nitrogen (BUN), and creatinine (8). Increased ALP was also observed in the current case.

The clinical findings of a bilateral, thyroid mass without vascular invasion in the current case might suggest that the lesion is either a hyperplastic thyroid or a thyroid adenoma; however, the pulmonary nodule is suspicious for metastasis, which would be more likely with a thyroid carcinoma. There are few cytologic features that help distinguish between adenoma, carcinoma or hyperplasia. Histopathologic examination of the tissue to look for the presence of a capsule, invasion into surrounding tissue, or compression of adjacent thyroid tissue is required for a definitive diagnosis. In the current case, neoplasia was considered more likely because some of the cells on cytologic examination displayed pleomorphism which is more suggestive of neoplasia than hyperplasia.

Treatment of thyroid carcinoma in the raccoon reported by McCain *et al.* consisted of a unilateral thyroidectomy, with a repeat thyroidectomy when recurrence of the tumor was noted and oral piroxicam and misoprostol following a third recurrence and lung metastasis (5). A third cytoreduction surgery was performed followed by intravenous doxorubicin (5). Anorexia and pancytopenia developed following doxorubicin administration and the raccoon was euthanized (5). The second case reported by McCain *et al.* of a functional thyroid adenoma in a raccoon was treated with total thyroidectomy of one side and partial thyroidectomy of the other side, as well as methimazole gel (5).

Treatment of thyroid carcinoma in dogs involves local treatment with surgery, radiation, or both, or systemic treatment with chemotherapeutic agents (7). Treatment options for thyroid adenoma in cats include thyroidectomy, radioactive iodine (^{131}I) or anti-thyroid drugs such as methimazole (7). The treatment of choice in cats is radioactive iodine (9). The raccoon in this case received no treatments for either its neoplasia or the thyroid hormone imbalance, thus suggesting a different clinical behavior of this pathology in this case. To date, 19 months from the time of the initial presentation, the raccoon is doing well clinically with no obvious clinical signs other than the palpable prominent cervical masses and some weight loss.

This report suggests that thyroid neoplasia is a condition that should be considered when raccoons present with cervical masses. Given the large number of captive raccoons with thyroid pathology described in the studies from Germany, it is probable this condition is more prevalent than the literature suggests at this time (3, 4). It can present as a nonfunctional carcinoma as is most common in dogs, or a functional adenoma as is most common in cats (3)

This case can add to the growing body of literature on this relatively common disease condition in raccoons and can assist clinicians that see similar cases; however, more cases are required to obtain additional information about this condition in raccoons.

REFERENCES

1. International Species Information System (ISIS). 1997. Physiological Data Reference Values. International Species Inventory System. Apple Valley, Wisconsin.
2. London, C., Mathie, T., Stingle, N., Clifford, C., Haney, S., Klein, M.K., Vickery, K., Vail, D.M., Hershey, B., Ettinger, S., Vaughan, A., Alvarez, F., Hillman, L., Kiselow, M., Thamm, D., Higginbotham, M.L., Gauthier, M., Krick, E., Phillips, B., Ladue, T., Jones, P., Bryan, J., Gill, V., Novasad, A., Fulton, L., Carreras, J., McNeill, C., Henry, C. and Gillings, S.: Preliminary evidence for biologic activity of toceranib phosphate (Palladia®) in solid tumours. *Vet. Comp. Oncol.* 10:194-205, 2012.
3. Ippen R., and Henne, D.: Obduktionsbefunde bei baeren (Procyonidae, Ailuridae and Ursidae). *Int. Symp. Verh. Ber. Erkr. Zoot.* 28:89-98, 1986.
4. Wisser, J.: Zum vorkommen von thyreopathien bei waschbaeren (Procyon lotor). *Verh. Ber. Erkr. Zoot.* 37:435-442, 1995.
5. McCain, S. L., Allender, M.C., Bohling, M., Ramsay, E.C., Morandi, F. and Newkirk, K.M.: Thyroid neoplasia in captive raccoons (Procyon lotor). *J. Zoo. Wildl. Med.* 41:121-127, 2010.
6. Liptak, J.M.: Canine thyroid carcinoma. *Clin. Tech. Small Anim. Pract.* 22:75-81, 2007.
7. Scott-Moncrieff, J. C.: Thyroid disorders in the geriatric veterinary patient. *Vet. Clin. Small Anim.* 42:707-725, 2012.
8. Meeking, S.A.: Thyroid disorders in the geriatric patient. *Vet. Clin. Small Anim.* 35:635-653, 2005.
9. Peterson, M. E.: Hyperthyroidism. In: Ettinger, S. J. and Feldman, E. C. (Eds.): *Textbook of Veterinary Internal Medicine*, 5th ed. W. B. Saunders Co., Philadelphia, Pennsylvania. pp. 1400-1419, 2000.