Complications and outcomes associated with unilateral thyroidectomy in dogs with naturally occurring thyroid tumors: 156 cases (2003–2015)

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OBJECTIVE
To describe complications and outcomes of dogs undergoing unilateral thyroidectomy for the treatment of thyroid tumors.

ANIMALS
156 dogs undergoing unilateral thyroidectomy for a naturally occurring thyroid tumor.

PROCEDURES
Dogs that underwent a unilateral thyroidectomy in 2003 through 2015 were included in a multi-institutional retrospective study. For each dog, information gathered through evaluation of electronic and paper records included perioperative complications, short-term outcome (survival to discharge from the hospital vs nonsurvival), and long-term outcome (survival time).

RESULTS
In the perioperative period, complications occurred in 31 of the 156 (19.9%) dogs; hemorrhage was the most common intraoperative complication (12 [7.7%] dogs). Five of 156 (3.2%) dogs received a blood transfusion; these 5 dogs were among the 12 dogs that had hemorrhage listed as an intraoperative complication. Immediately after surgery, the most common complication was aspiration pneumonia (5 [3.2%] dogs). One hundred fifty-three of 156 (98.1%) dogs that underwent unilateral thyroidectomy survived to discharge from the hospital. One hundred-thirteen dogs were lost to follow-up; from the available data, the median survival time was 911 days (95% confidence interval, 704 to 1,466 days).

CONCLUSIONS AND CLINICAL RELEVANCE
Results indicated that unilateral thyroidectomy in dogs with a naturally occurring thyroid tumor was associated with a perioperative mortality rate of 1.9% and a complication rate of 19.9% and that hemorrhage and aspiration pneumonia were the most common complications. Long-term survival of dogs undergoing unilateral thyroidectomy for the treatment of thyroid tumors was not uncommon. (*J Am Vet Med Assoc* 2019;255:926–932)

Thyroid tumors are estimated to represent 1% to 3.8% of all canine neoplasms.[1–4] Unilateral tumors are more common than bilateral tumors; 53% to 75% of thyroid tumors in dogs are unilateral.[1,5] Up to 90% of clinically detectable thyroid tumors are malignant.[3,6] Of the thyroid tumors detected in various pathology- and imaging-based studies,[7–9] a large proportion are adenomas. Nonfunctional thyroid carcinomas have reported metastatic rates ranging from 20% to 80%, depending on tumor size and treatment selection.[1,9] Surgical excision of thyroid tumors is generally considered to be the treatment of choice, when possible; other reported treatment options include radiation therapy and radioactive iodine treatment for tumors that take up radioactive tracer during technetium Tc 99m pertechnetate or iodine I 131 scintigraphy.[1,10–14] Treatment with chemotherapeutants or tyrosine kinase inhibitors has also been used, although its efficacy for this tumor type is not well established.[15–17]

Assessment of the resectability of a unilateral thyroid tumor is often based on the size of the mass as well as the perceived extent of invasion; the best surgical outcomes are associated with masses that are

ABBREVIATIONS
CI Confidence interval

small and freely movable.[1,10,12,13,18] Specifically, it has been recommended that surgical excision of a unilateral thyroid tumor in dogs should be considered when the maximum dimension of the tumor is < 7 cm and the mass is mobile on palpation.[10,11] However, to our knowledge, there is no information regarding the rate of perioperative complications or outcomes associated with surgical excision of unilateral thyroid tumors to support those recommendations.

Given the anatomic location of the thyroid gland, invasion of the trachea, recurrent laryngeal nerves, larynx, esophagus, vagosympathetic trunk, carotid arteries, jugular veins, and surrounding musculature is possible. Thyroid tumors are also highly vascular. Therefore, it is not surprising that possible complications attributable to the presence and surgical treatment of thyroid tumors include hemorrhage, laryngeal paralysis, edema associated with airway obstruction, Horner syndrome, and trauma to surrounding tissues.[5,12,13,19,20]

To date, there are few reports[12,21,22] of studies that have evaluated the perioperative complications and outcomes associated with unilateral thyroidectomy in dogs, and those studies generally did not involve large numbers of dogs. Often, research has been limited in focus to specific procedures (eg, bilateral thyroidectomy) or tumor characteristics (eg, only mobile tumors).[5] The lack of information on complications and outcome for dogs with thyroid tumors that undergo thyroidectomy is surprising, given that surgery is currently the treatment of choice for thyroid tumors determined to be resectable.[1,10–13] The objective of the study reported here was to describe the major and minor complications and short- and long-term outcomes of dogs undergoing unilateral thyroidectomy for the treatment of naturally occurring thyroid tumors. A secondary aim was to describe patient- and tumor-related factors associated with complications and outcome. We hypothesized that the rate of major complications would be low and that hemorrhage would be the most common complication in dogs with naturally occurring thyroid tumors that underwent unilateral thyroidectomy.

Methods and Materials

Case selection criteria

In this multi-institutional retrospective study, medical records were reviewed for dogs that underwent unilateral thyroidectomy for excision of a suspected thyroid tumor between January 1, 2003, and December 31, 2015. The 5 institutions that contributed data were the colleges of veterinary medicine at the University of Illinois, Colorado State University, Purdue University, and University of California-Davis and the Alta Vista Animal Hospital. All dogs that underwent unilateral thyroidectomy in the study period were eligible for inclusion in the study. The inclusion criteria were that results of histologic analysis of the excised tissue confirmed a thyroid tumor and that there was a minimum follow-up interval from surgery to death in the hospital or discharge from the hospital. Exclusion criteria included the presence of bilateral disease recorded at the time of surgery, surgery for nonthyroid tumors (ie, parathyroid tumors), and incomplete data related to complications or outcome at the time of discharge from the hospital after thyroidectomy.

Medical records review

Electronic and paper medical records were reviewed and evaluated for data of interest **(Appendix)**. Data were classified as incomplete when there was lack of availability of the medical record from the time of hospitalization or missing documentation crucial for collection of information about complications (eg, the surgery report, the anesthesia record, or perioperative care notes).

A major complication was defined as a complication that was considered life-threatening and required major medical or surgical intervention (eg, blood transfusion) or injury to the recurrent laryngeal nerve unilaterally that could result in clinically evident laryngeal paralysis in dogs with preexisting contralateral laryngeal hemiparalysis. A minor complication was defined as a complication that was self-limiting or required minimal medical intervention to achieve resolution. Because this was a retrospective study, multiple pathologists evaluated the excised samples at the different clinical centers, and determination of malignancy was based strictly on the final diagnosis made by the pathologist who evaluated each specimen. As such, the specific criteria used for determination of vascular invasion and capsular invasion were not standardized; the presence or absence of vascular invasion and capsular invasion was determined from the primary pathologists' reports. Each dog's age, survival time, progression-free interval, and durations of hospitalization and follow-up period were reported for or calculated from the date that the thyroidectomy was performed. Multiple individuals evaluated the medical records, but interobserver variability was not assessed. The data were compiled by 1 individual (JKR).

Statistical analysis

Descriptive statistics were calculated for each variable of interest. Continuous variables were assessed for normality by analysis of histograms, assessment of skewness and kurtosis, and use of the Shapiro-Wilk test. If the data were normally distributed, mean and SD were calculated; if the data were not normally distributed, the median and range were calculated.

Univariate analysis with logistic regression was performed for assessment of association of factors with overall complications and to allow calculation of ORs and 95% CIs. The variables assessed were duration of hospitalization, presence of concurrent endocrinopathy (yes vs no), tumor characteristics (malignant vs benign, maximum diameter, volume, fixed vs mobile, and gross vascular invasion [present vs absent]

at the time of surgery), anesthesia time, and surgery time. Survival outcomes were evaluated with Kaplan-Meier methods to generate survival curves and calculate the median progression-free interval and survival time along with 95% CIs. The progression-free interval was calculated as the number of days from the date of surgery to the date of first detection of metastases or local recurrence. Survival time was calculated as the number of days from the date of the thyroidectomy to death or euthanasia as a result of any cause. Dogs were censored in the progression-free interval analysis if they did not have documented metastases at the time of last follow-up or at the time of death. Dogs were censored in the survival time analysis if they were alive at the time of last follow-up or at the time that they were lost to follow-up. Additionally, Cox proportional hazards analysis was performed to assess factors for associations with the progression-free interval or survival time. The results were reported as hazard ratios and 95% CIs. Factors assessed for association with both the progression-free interval or survival time included histopathologic factors (capsular invasion, lymphatic invasion, vascular invasion, mitotic index, and margin status), tumor factors (maximal dimension, volume, and fixed vs mobile), intraoperative hemorrhage, and overall perioperative complications. Significance was set at a value of $P < 0.05$, and statistical analyses were performed with commercially available software.[a,b]

Results

During the period of interest, 169 dogs underwent unilateral thyroidectomy for excision of a suspected thyroid tumor. Of the 169 dogs, 156 met the inclusion criteria and none of the exclusion criteria. Among these dogs, there were 71 (45.5%) spayed females, 3 (1.9%) sexually intact females, 71 (45.5%) neutered males, and 10 (6.4%) sexually intact males. The sex of 1 (0.6%) dog was not reported. Most of the 156 dogs were mixed breeds (n = 44 [28.2%]); the other more common breeds were Golden Retrievers (21 [13.5%]), Labrador Retrievers (18 [11.5%]), and Beagles (9 [5.8%]). The median weight of the dogs was 27.9 kg (61.4 lb); weights ranged from 2.4 to 87.7 kg (5.3 to 192.9 lb). The mean ± SD age was 10.1 ± 2.5 years.

History and clinical signs

Among the 156 dogs, the median interval between mass detection and surgery was 58 days (range, < 1 to 1,096 days). Most commonly, the presence of a cervical mass was detected by the owner (86/156 [55.1%] dogs). For some dogs, the mass was an incidental finding during a wellness examination (16 [10.3%] dogs) or during evaluation of a different mass (9 [5.8%] dogs). In other cases, the mass was detected during examination because of weight loss with or without polyphagia (9 [5.8%] dogs) or detection of high circulating thyroid hormone concentrations (7 [4.5%] dogs). Clinical signs associated with hyperthyroidism, including polyuria and polydipsia, polyphagia, and weight loss were noted in 15 of 156 (9.6%) cases. Respiratory changes, coughing, or gagging was noted in the medical records of 8 of the 156 (5.1%) dogs. Clinical signs were marked as none or were missing in 25 (16.0%) and 17 (10.9%) records, respectively. Diagnosis of concurrent or historical neoplasia was recorded for 38 of the 156 (24.4%) dogs. A diagnosis of concurrent endocrinopathy or cardiac disease had been made for 33 (21.2%) and 17 (10.9%) dogs, respectively. Concurrent endocrinopathies included hyperthyroidism (15/156 [9.6%] dogs), hypothyroidism (11/156 [7.1%] dogs), and hyperparathyroidism (3/156 [1.9%] dogs); 1 [0.6%] dog each had hyperadrenocorticism, hypoadrenocorticism, hyperadrenocorticism with hyperparathyroidism, or hyperadrenocorticism with hypothyroidism. Concurrent laryngeal paralysis was noted in 10 of 156 (6.4%) cases.

Physical examination findings and diagnostic test results

On palpation of the 156 masses, 15 (9.6%) were considered fixed and 115 (73.7%) were mobile; this assessment was not documented in the records of 26 (16.7%) dogs. Preoperative laryngeal examination was noted for only 2 (1.3%) dogs, both of which had bilateral laryngeal paralysis. Results of preoperative and postoperative blood sample analysis for PCV and total protein concentration were summarized **(Table 1)**.

Tumor size was determined from multiple measurements derived by various methods (by palpation or measurements made on CT images, during surgery,

Table 1—Comparison of preoperative and postoperative PCV and total protein concentration in blood samples collected from 156 dogs with naturally occurring thyroid tumors that underwent unilateral thyroidectomy.

Variable	Reference interval	No. of dogs with high values (%)	No. of dogs with values within reference interval (%)	No. of dogs with low values (%)	Mean ± SD	Range
PCV (%)						
Preoperative value	35–57	7 (4.5)	126 (80.8)	11 (7.1)	46.3 ± 6.3	23–65
Postoperative value	35–57	0	29 (18.6)	34 (21.8)*	36.9 ± 6.8	19–55
Total protein concentration (g/dL)						
Preoperative value	5.5–7.2	10 (6.4)	127 (80.8)	3 (1.9)	6.6 ± 0.8	4.2–9.0
Postoperative value	5.5–7.2	0	44 (28.2)	13 (8.3)†	5.6 ± 0.9	3.6–8.0

*Compared with preoperative values, the median decrease in PCV after surgery was 10.0% (range, 26% to 31.7%). †Compared with preoperative values, the mean ± SD decrease in total protein concentration was 1.2 ± 1.1 g/dL.

Table 2—Measurements of the maximal dimension (determined by various methods) and volumes of the thyroid masses in 156 dogs that underwent unilateral thyroidectomy.

	Measurement method					
Variable	Palpation (cm)	CT (cm)	During excision surgery (cm)	Histologic examination (cm)	Maximal dimension (cm)	Overall volume (cm^3)
Median	4.0	4.4	4.0	4.9	4.4	34.7
Range	1.0–12.0	1.0–18.3	0.5–11.0	2.0–18.3	1.0–18.3	1.5–455.8

Tumor size was determined from multiple measurements derived by various methods (by palpation, assessment of CT images, or determinations made during surgery or during histologic examination). For the 133 tumors for which data were available, the size of the mass was evaluated in 3 dimensions (in centimeters); the length of the maximal dimension was recorded, and the tumor volume was calculated.

or during histologic examination). Among the 133 tumors for which data were available, the length of the largest dimension was recorded, or the size of the mass was evaluated in 3 dimensions (in centimeters); the tumor volume was then calculated. Taking all measurements obtained by all methods into account, the median maximal dimension was 4.4 cm (range, 1.0 to 18.3 cm), and the median tumor volume was 34.7 cm^3 (range, 1.5 to 455.8 cm^3; **Table 2**). Thirty tumors had a maximal dimension of ≥ 7 cm **(Figure 1)**.

Of the 106 cases for which cytologic findings were recorded, 13 (12.3%) were considered nondiagnostic or not diagnostic for an epithelial or neuroendocrine neoplasm. Imaging methods used to evaluate the cervical region in 156 dogs included nuclear scintigraphy (15 [9.6%] dogs), ultrasonography (84 [53.9%] dogs), and CT (41 [26.3%] dogs). Lymph nodes were evaluated by means of CT (18/156 [11.5%] dogs), ultrasonography (23/156 [14.7%] dogs), or manual palpation (33/156 [21.2%] dogs). Fine-needle aspirate and cytologic assessments of lymph nodes were performed for 17 of 156 (10.9%) dogs. Preoperative staging included various diagnostic procedures; among 156 dogs, 15 (9.6%) underwent abdominal radiography, 59 (37.8%) underwent abdominal ultrasonography, 138 (88.5%) underwent thoracic radiography, 11 (7.1%) underwent thoracic CT, and 4 (2.6%) underwent abdominal CT. No evidence of neoplasia was found on abdominal radiographic views. Multiple abnormalities related to other disease processes were detected during abdominal ultrasonography and CT; however, no changes related to thyroid neoplasia were noted. For some dogs, thoracic radiography revealed a lung nodule or possible lung nodule (4/156 [2.6%] dogs), possible pneumonia (2/156 [1.3%] dogs), and megaesophagus (1/156 [0.6%] dogs). Thoracic CT revealed pulmonary nodules in 1 of 156 (0.6%) dogs. For 10 of 156 (6.4%) dogs, preoperative metastatic disease was suspected or diagnosed. In those cases, the locations of metastatic disease were lymph nodes (5/156 [3.2%] dogs), lungs (4/156 [2.6%] dogs), and lymph nodes and lungs (1/156 [0.6%] dogs). The retropharyngeal lymph nodes were most commonly affected, followed by the mandibular and mediastinal lymph nodes.

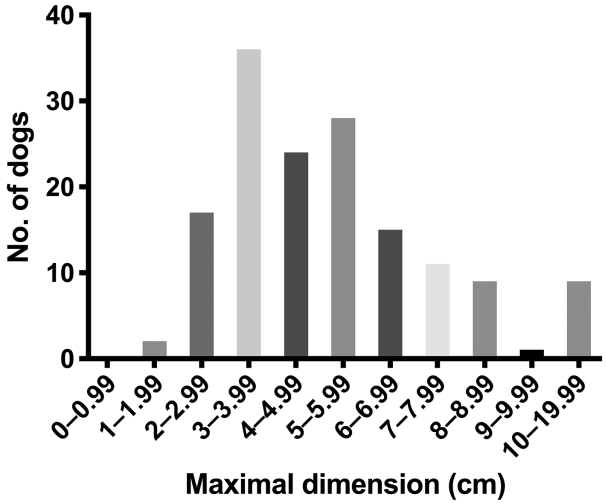

Figure 1—Distribution of maximal dimensions of naturally occurring thyroid tumors in 152 dogs for which data were available (data were not available for 4 dogs).

Surgery and histopathologic findings

At the time of surgery (and later confirmed by histologic examination), 11 of 156 (7.1%) dogs had residual macroscopic disease; gross vascular invasion and lymph node metastasis were recorded for 54 (34.6%) and 11 (7.1%) of the 156 cases, respectively. Median total anesthesia and surgical times were 115 minutes (range, 27 to 394 minutes) and 60 minutes (range, 16 to 305 minutes), respectively. The median duration of hospitalization was 1 day (range, < 1 to 5 days). Histologic examination of samples of the 156 tumors revealed that 7 (4.5%) were benign and 149 (95.5%) were malignant. For 80 of 156 (51.3%) dogs, surgical margins were reported; in 25 (31.3%) records, the margins were deemed incomplete. Histologic findings included lymphatic invasion (42/156 [26.9%] dogs), vascular invasion (68/156 [43.6%] dogs), and capsular invasion (96/156 [61.5%] dogs). The median number of mitotic figures/10 hpf among the tumors was 2 (range, 0 to 18).

Complications

In the perioperative period, complications occurred in 31 of 156 (19.9%) dogs. Thirteen dogs had major complications, and the remainder had minor complications. Intraoperative complications were reported for 23 of 156 (14.7%) dogs. Of these 23 dogs, 7 (4.5%) had anesthesia-related complications, 13 (8.3%) had surgery-related complications, and 3 (1.9%) had

both anesthesia- and surgery-related complications. Intraoperative complications included hypotension, hypo- or hyperthermia, hypoventilation, atrioventricular block, hemorrhage, the need to extend the planned surgical site to remove the tumor, and death. Hemorrhage was the most common intraoperative complication (12/156 [7.7%] dogs). For the dogs that had hemorrhage recorded as an intraoperative complication, 5 received a blood transfusion during surgery; 3 of those 5 dogs also received a transfusion following surgery.

Complications that occurred after surgery (between the time of extubation and hospital discharge) were reported for 20 of 156 (12.8%) dogs. The most common postoperative complication was aspiration pneumonia (5/156 [3.2%] dogs). In 2 of the dogs with aspiration pneumonia, laryngeal examination revealed bilateral laryngeal paralysis. For 1 dog, this problem had been identified before surgery, and the dog underwent unilateral cricoarytenoid lateralization; for the other dog, the problem was identified after thyroidectomy. In total, a postoperative laryngeal examination was documented for only 4 dogs, 3 of which had confirmed laryngeal paralysis. Among the 156 dogs, recorded postoperative complications included aspiration pneumonia, hematochezia, Horner syndrome, postoperative hemorrhage, hyperthermia, hypothyroidism, transient vestibular disease, laryngeal paralysis, respiratory arrest, and death. Only 4 of 156 (2.6%) dogs that underwent unilateral thyroidectomy did not survive to discharge from the hospital. Those dogs died of postoperative hemorrhage with hematoma formation, aspiration pneumonia, or cardiac arrest or were euthanized because reconstruction of the larynx was not possible.

Factors that were associated with the overall complication rate included duration of hospitalization and whether the mass was assessed as fixed or mobile during physical examination. The odds of developing complications for dogs with a fixed mass were 5.4 times the odds for dogs with a mobile mass (OR = 5.4; 95% CI, 1.8 to 16.7; $P = 0.003$). For each additional day of hospitalization, dogs had increased odds (OR = 2.2; 95% CI, 1.4 to 3.5; $P < 0.001$) of developing complications. Tumor size (volume or maximal dimension), whether the mass was benign or malignant, concurrent endocrinopathy, anesthetic time, and presence of gross vascular invasion seen at surgery were not significantly associated with development of complications.

Adjunctive treatments

Chemotherapy that involved various agents and dosing protocols was administered after surgery to 35 of 156 (22.4%) dogs. The most commonly used agents were doxorubicin (18 dogs) and carboplatin (12 dogs). Radiation therapy in the form of external beam radiation or treatment with radioactive iodine was performed in 6 of 156 (3.8%) dogs.

Long-term outcome

In 18 dogs, local recurrence was suspected and evaluated by several diagnostic methods, including physical examination, cervical ultrasonography, cervical CT, and microscopic examination of fine-needle aspirate specimens. Metastatic disease developed after surgery in 13 dogs. The location of metastatic disease included the lungs, kidneys, liver, spleen, cervical and prescapular lymph nodes, bones, and a mass in the pelvic region. Lung metastasis was most common with 8 cases reported. Overall postoperative metastatic disease or local recurrence developed in 22 dogs. Death related to thyroid carcinoma, either local disease or metastatic disease, occurred in 14 cases; however, 113 dogs were ultimately lost to follow-up (median follow-up period, 45 days [range, 1 to 1,658 days]). The mean ± SD progression-free interval was 851 ± 40 days. The median progression-free interval could not be determined because of the large number of dogs in which there was no tumor recurrence. The mean survival time was 1,158 ± 136 days, and the median survival time was 911 days (95% CI, 704 to 1,466 days; **Figure 2**).

The 2 factors that were significantly associated with a shorter progression-free interval were mitotic index (hazard ratio, 1.24; 95% CI, 1.09 to 1.41; $P < 0.001$) and the maximal dimension of the tumor (hazard ratio, 1.17; 95% CI, 1.02 to 1.35; $P < 0.001$). Factors that were significantly associated with survival time were mitotic index (hazard ratio, 1.15; 95% CI, 1.02 to 1.29; $P = 0.026$) and perioperative complications (hazard ratio, 2.09; 95% CI, 1.09 to 4.04; $P = 0.028$). The maximal dimension or volume of the tumor, whether the tumor was fixed or mobile, presence of histologically confirmed lymphatic or capsular invasion, and intraoperative hemorrhage were not significantly associated with survival time. The effect of whether the tumor was malignant or benign, incomplete margins, and histologically confirmed vascular invasion on progression-free interval or survival time were not evaluated owing to the low number of events that occurred in the study population (eg, recurrence, me-

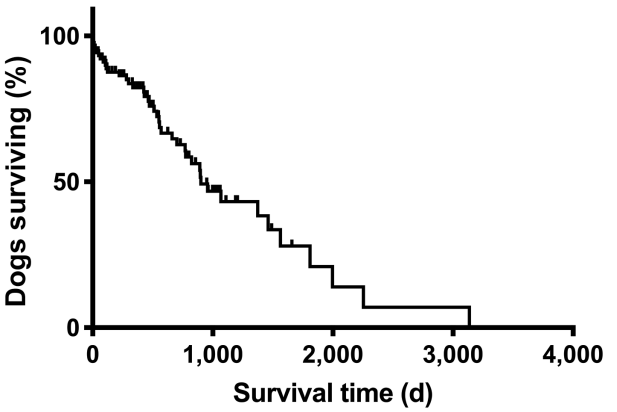

Figure 2—Kaplan-Meier curve for survival time in 156 dogs that underwent unilateral thyroidectomy for treatment of thyroid tumors. Survival time was calculated as the number of days from the date of the thyroidectomy to death or euthanasia as a result of any cause. Dogs were censored in the survival time analysis if they were alive at the time of last follow-up or at the time that they were lost to follow-up.

tastases, or death) and resulting constraints on the numbers of variables that could be assessed.

Discussion

To the authors' knowledge, the study of the present report is the first to focus on perioperative complication rate and outcomes associated with unilateral thyroidectomy in dogs with naturally occurring thyroid tumors. Although complications within the perioperative period were not uncommon (overall complication rate, 19.9% [31/156 dogs]), most complications were minor in nature with the exceptions of severe hemorrhage requiring blood transfusion, aspiration pneumonia, and death.

In the present study, intraoperative hemorrhage was documented in the records of 12 of 156 (7.7%) dogs; 5 of those dogs required at least 1 blood transfusion, suggesting that when hemorrhage occurs during unilateral thyroidectomy, it often involves a large volume of blood and results in hemodynamic compromise for the patient. It is also probable that for dogs in this study, the amount of blood loss was generally not directly evaluated and only noted in the medical record when hemorrhage was qualitatively assessed as severe. Given the retrospective nature of the study, quantitative information regarding blood loss was not available.

Aspiration pneumonia developed in 3.2% of dogs undergoing unilateral thyroidectomy. Although the proportion of dogs affected was not high, aspiration pneumonia was the most common postoperative complication. Moreover, the frequency with which this complication occurred was higher than that for postanesthesia aspiration pneumonia (0.17%) in dogs in another study.[23] In the present study, only 2 of the 5 dogs that developed aspiration pneumonia underwent a laryngeal examination before surgery, and both were found to have bilateral laryngeal paralysis. Laryngeal paralysis is a well-known risk factor for the development of postanesthesia aspiration pneumonia.[23] A laryngeal examination was performed for only a small number of dogs, and the percentage of dogs with laryngeal paralysis in the present study may have been underestimated. It is also not certain how many dogs had alterations in laryngeal function as a consequence of surgery. Given the risk of aspiration pneumonia and the risk of iatrogenic nerve damage, the authors believe that performance of pre- and postoperative laryngeal examinations is advisable in dogs with thyroid tumors that are undergoing thyroidectomy.

In the present study, concurrent laryngeal paralysis was evident in 10 of 156 (6.4%) dogs at the initial evaluation. Idiopathic acquired laryngeal paralysis is common in geriatric dogs as well as in certain breeds such as Golden Retrievers and Labrador Retrievers.[24] In 1 study,[25] the prevalence of laryngeal paresis in 250 dogs undergoing general anesthesia was 25%; approximately 5.2% had signs of bilateral laryngeal paralysis, and another 9.6% had evidence of unilateral, if not bilateral, laryngeal dysfunction. Laryngeal paralysis has also been associated with hypothyroidism, although this association is tentative.[26] It is possible, therefore, that concurrent laryngeal paralysis in dogs that require thyroidectomy may be related to hypothyroidism. However, laryngeal paralysis (specifically unilateral) can be caused by damage to the vagus or recurrent laryngeal nerve, which can be secondary to an invasive thyroid mass or associated with iatrogenic damage to these nerves at the time of thyroidectomy.

Among the dogs of the present report, factors associated with the perioperative complication rate were mobility of the mass (as determined by physical examination) and duration of hospitalization. In previous studies[1,12,13] of dogs with thyroid tumors, 24% to 55% of tumors were considered mobile, and ≤ 67% were considered fixed. In the present study, only 15 of 130 (11.5%) tumors that were classified were considered fixed, which likely represented a treatment bias. Mobility is an indirect measure of tumor invasiveness. Traditionally, surgical treatment of highly invasive tumors has been considered high risk with poor outcome; in patients with highly invasive tumors, alternative treatment options, such as radiation therapy, are often recommended. The data obtained in the present study supported this viewpoint, given that dogs with fixed tumors had increased odds of developing complications after unilateral thyroidectomy. However, other measures of tumor invasiveness should be considered. Results of preoperative cervical CT can help guide surgical decision-making; nevertheless, cervical exploratory surgery should be considered because most of the fixed tumors were still removable. Interestingly, in the present study, tumor volume and maximal dimension were not associated with the development of complications. Among the dogs of the present study, the median volume of the tumors was 34.7 cm^3, and the median maximal dimension was 4.4 cm. However, 30 of these tumors were large (maximal dimension, ≥ 7 cm), yet 27 of those tumors were successfully removed. Therefore, the data obtained in the present study have suggested that measures of tumor size should not be used for determination of surgical resectability and that greater importance should be placed on accurate measures of tumor invasiveness. Tumor size, whether the mass was benign or malignant, concurrent endocrinopathy, anesthetic time, and gross vascular invasion detected during surgery were not associated with development of complications. It is likely that the association of longer hospitalization with increased odds of development of perioperative complications was confounded by the fact that dogs with complications remain hospitalized longer. Nevertheless, duration of hospitalization as a factor in the development of complications was assessed in the present study because other factors could increase the duration of hospitalization; for example, prolonged opioid administration could result in regurgitation or postoperative ileus, which may in turn increase the risk of complications, such as aspiration pneumonia.

Overall, the short-term outcome for dogs that underwent unilateral thyroidectomy in the present study was very good, with a perioperative mortality rate of 3.4%. This low mortality rate could have been related to case selection because alternative treat-

ment options (eg, radiation therapy) may have been recommended for dogs with more invasive or fixed tumors. Long survival times were common, with a median survival time of 911 days. However, given that a large number of the study dogs were lost to follow-up, the survival time was likely underestimated. Likewise, only 14 of 156 (9.0%) dogs died as a result of their thyroid carcinoma, and additional deaths related to this disease may have been overlooked as a result of dogs being lost to follow-up.

The major limitations of the present study were those commonly associated with retrospective studies, such as missing data, variable methods of data reporting, and lack of uniform diagnostic testing, postoperative treatment, and histologic review processes across institutions. Surgery may not have been recommended for dogs with preoperative evidence of metastases or large tumors. Thus, it was possible that selection bias related to treatment recommendations contributed to the generally favorable outcomes for dogs in this study. Also, because of this bias, it is possible that there may have been confounding of the effects of tumor size and metastatic disease on complications and outcomes. However, on the basis of the study findings, we concluded that tumor size alone should not be used to decide whether surgery is an appropriate treatment option for dogs with naturally occurring thyroid tumors. A somewhat small proportion of the dogs in the present study received adjuvant treatment, such as chemotherapy or radiation therapy, and underwent unilateral thyroidectomy. Given the retrospective data acquisition, it was not possible to accurately determine the reasoning of clinicians for prescribing these adjuvant treatments. It was likely that the adjuvant treatments were prescribed for dogs with residual local or metastatic disease that had a worse prognosis, thereby resulting in confounding of any associations of these interventions with outcome. The benefit of adjuvant treatment was not the focus of this study and could not be accurately inferred from the data collected. The study results indicated that in dogs with naturally occurring thyroid carcinoma, unilateral thyroidectomy had a low perioperative mortality rate, and although perioperative complications occurred, severe complications were uncommon. Further research is needed to assess the benefits of adjuvant treatments in such cases.

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Footnotes

a. Excel for Mac 2011, version 14.4.4 Microsoft Corp, Redmond, Wash.
b. SAS, version 9.3, SAS Institute Inc, Cary, NC.

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