SMALL ANIMALS

Results of excision of thymoma in cats and dogs: 20 cases (1984–2005)

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Objective—To provide long-term follow-up information for a series of dogs and cats with invasive and noninvasive thymomas treated by excision alone.

Design—Retrospective case series.

Animals—9 cats and 11 dogs with thymoma.

Procedures—Medical records were reviewed. The following factors were analyzed for their effect on prognosis: age of dog or cat, invasiveness of the tumor, percentage of lymphocytes in the mass (percentage lymphocyte composition) on histologic evaluation, and mitotic index of the mass.

Results—All patients were treated with excision of the tumor alone. Median overall survival time for the cats was 1,825 days, with a 1-year survival rate of 89% and a 3-year survival rate of 74%. Median overall survival time for the dogs was 790 days, with a 1-year survival rate of 64% and a 3-year survival rate of 42%. Recurrence of thymoma was observed in 2 cats and 1 dog, and a second surgery was performed in each, with subsequent survival times of 5, 3, and 4 years following the first surgery. Percentage lymphocyte composition of the mass was the only factor that was significantly correlated with survival time; animals with a high percentage of lymphocytes lived longer.

Conclusions and Clinical Relevance—Results of this study indicated that most cats and dogs with thymomas did well after excision. Even cats and dogs with invasive masses that survived the surgery and the few cats and dogs with recurrent thymomas or paraneoplastic syndromes had a good long-term outcome. Excision should be considered an effective treatment option for dogs and cats with thymomas. (*J Am Vet Med Assoc* 2008;232:1186–1192)

Thymomas are uncommon neoplasms of the cranial mediastinum; they are derived from thymic epithelial cells[1] and have variable lymphocytic infiltration.[2] They are considered to be one of the most common tumors of the cranial mediastinum in dogs and cats.[3,4] Other differentials for mediastinal masses that must be considered include heart-based tumor, ectopic thyroid or parathyroid tumor, thymic branchial cyst, chemodectoma (aortic or carotid body tumors), metastatic neoplasia, granuloma, abscess, lipoma, teratoma, and schwannoma. It is important to differentiate between lymphoma and thymoma, as the therapeutic approach is different; lymphoma is treated medically, whereas surgery is the recommended treatment for thymoma. Paraneoplastic syndromes such as hypercalcemia, MG, polymyositis, dermatitis, arrhythmias, and other immune-mediated disease may worsen the prognosis in patients with thymoma[5] and may not always resolve following removal of the mass. In some instances, paraneoplastic syndromes may develop after surgery.[6]

Few clinical studies have been performed in which results of treatment in dogs and cats with thymoma were evaluated. More information is needed regarding results of treatment by excision alone. We hypothesized that complete excision of noninvasive thymomas in dogs and cats results in long-term survival, particularly if paraneoplastic syndromes are not present. The purpose of the study reported here was to provide long-term follow-up information for a series of cats and dogs with invasive and noninvasive thymomas treated by excision alone.

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ABBREVIATIONS

MG	Myasthenia gravis
CT	Computed tomography

Materials and Methods

Case selection—Medical records of all dogs and cats with thymoma examined between 1984 and 2005 at The Ohio State Veterinary Teaching Hospital were reviewed. Criteria for inclusion in the study were as follows: excision of a thymoma, a diagnosis made on the basis of microscopic evaluation of excised specimens, and availability of histologic slides of the tumor for further evaluation by a pathologist.

Medical records review—Data obtained from the medical records included history; physical examination findings; results of clinicopathologic testing (including CBC, serum biochemical analysis, urinalysis, and cytologic examination of fine-needle aspirates or core biopsy specimens); findings on thoracic radiography, ultrasonography, and CT (when available); treatment; and outcome. Follow-up information was obtained by telephone contact with referring veterinarians and owners and by review of medical records at reevaluation of patient visits to the veterinary teaching hospital.

Diagnostic evaluations—For the purpose of this study, all available thoracic radiographs, computed tomograms, and ultrasonograms were reviewed by a board-certified radiologist (VFS). Histologic sections from each tumor were reviewed by a board-certified pathologist (SEW).

Percentage of lymphocytes in each mass (percent lymphocyte composition) was graded on a scale of 0 to 10 at 4X magnification on all sections available. A grade of 0 = no lymphocytes, 1 = > 0% to < 10% of the mass composed of lymphocytes, 2 = 10% to < 20% of the mass composed of lymphocytes, and so on until a grade of 10 in which ≥ 90% of the mass was composed of lymphocytes. Mitotic index of cells in each mass was also determined. The mean number of mitotic figures observed in 10 consecutive 40X fields was recorded for each thymoma. Fields with the least amount of lymphocyte infiltration were chosen for evaluation of mitotic index.

Statistical analysis—Survival curves were estimated by use of the Kaplan-Meier method for 2 endpoints of interest.[a] For thymoma-specific survival, an event was defined as death resulting from the surgical procedure or progressive disease. Patients were considered censored if they were lost to follow-up or died of other causes. For overall survival, an event was defined as death resulting from any cause. Censoring only occurred if the patient was lost to follow-up.

In an attempt to determine prognostic factors, univariable Cox proportional hazards models were fit for age of the dog or cat, invasiveness of the tumor (an invasive tumor was defined as one that was not encapsulated or was found to be adhered to surrounding tissues during dissection), percent lymphocyte composition of the mass on histologic evaluation, and mitotic index of the mass on histologic evaluation (dichotomized to 0 and > 0). The outcome of overall survival was used. No models were attempted for thymoma-specific survival because of the small number of events (deaths). For all analyses, a value of $P < 0.05$ was considered significant.

Results

Signalment—Nine cats and 11 dogs met the criteria for inclusion in the study. Seven cats were domestic shorthair cats, 1 was a Siamese, and 1 was a domestic longhair cat. Six cats were spayed females, and 3 were castrated males. Mean and median ages of cats were 11.7 and 12 years, respectively (range, 6 to 15 years). Four dogs were mixed breed, 2 were Dalmatians, 1 was an Airedale Terrier, 1 was a Labrador Retriever, 1 was an Akita, 1 was a Golden Retriever, and 1 was a Collie. Seven were spayed females, and 4 were castrated males. Mean and median ages of the dogs were 10.4 and 10.5 years, respectively (range, 5 to 15 years).

Clinical signs and findings before surgery—Clinical signs of cats included dyspnea (n = 6), coughing (4), anorexia (2), lethargy (2), vomiting (1), and regurgitation (1). Clinical signs of dogs included dyspnea (5), lethargy (5), dysphonia (4), coughing (3), anorexia (3), exercise intolerance (2), and regurgitation (2). Physical examination findings in cats included poor compressibility of the cranial portion of the thorax (6), muffled heart sounds (4), and absence of ventral bronchovesicular sounds (1). One cat had ventroflexion of the neck; low palpebral response; and, subsequently, MG. Physical examination findings in dogs included muffled heart sounds (7), tachypnea (3), and absence of ventral bronchovesicular sounds (2).

Clinicopathologic findings

Blood samples for CBC determinations and serum biochemical analyses were obtained from each dog and cat. One cat had eosinophilia (1.7×10^9 cells/L), 1 had lymphocytosis (15.9×10^9 cells/L), 1 had neutrophilia (22×10^9 cells/L), and 1 had a low PCV (28%). Biochemical abnormalities in cats included high serum creatinine (n = 4 cats; range, 2.1 to 3.9 mg/dL; mean, 2.9 mg/dL), SUN (3; range, 37 to 49 mg/dL; mean, 43.3 mg/dL), and plasma protein (2; range, 8.1 to 9.1 g/dL; mean, 8.6 g/dL) concentrations and high serum creatinine kinase (1; 6,974 U/L) activity. Results of serologic testing for infection with FeLV and FIV by use of an ELISA were negative for all cats. One cat was tested for MG on the basis of clinical signs. An antibody titer of 37.4 nmol/L (reference value, < 0.3 nmol/L) against the acetylcholine receptor provided confirmation of MG in this cat.

Two dogs had neutrophilia (range, 20.0×10^9 cells/L to 39.9×10^9 cells/L; mean, 30.0×10^9 cells/L), 1 had leukocytosis (42.4×10^9 cells/L), and 1 had a low PCV (26%). Biochemical abnormalities in dogs included increased alkaline phosphatase activity (2; range, 271 to 617 U/L; mean, 444 U/L) and hypercalcemia (1; 19.1 mg/dL). The hypercalcemia was consistent with a diagnosis of hypercalcemia of malignancy confirmed by a high serum ionized calcium (2.4 mmol/L; reference range, 1.25 to 1.45 mmol/L) concentration, low serum parathyroid hormone (0.9 pmol/L, reference range, 2 to 13 pmol/L) concentration, and high serum parathyroid hormone-related protein (6.9 pmol/L, reference value, < 1.0 pmol/L) concentration.

Urinalysis results were available for 5 of 9 cats and 4 of 11 dogs. One cat had a specific gravity of 1.023, and 1 dog had a specific gravity of 1.021; the remainder of the cats and dogs had urinalysis results that were within reference range (specific gravity, 1.039 to 1.060).

Diagnostic imaging

Radiographic data were obtained by examining the radiology reports and reviewing the available radiographic images of the thorax. Radiographs from 6 dogs and 3 cats were available for review, and radiology reports were obtained from the medical records of the remaining patients. On lateral radiographic views of the thorax, a soft tissue opacity could be seen in the ventral aspect of the cranial mediastinum, causing caudal displacement of the cardiac silhouette and dorsal displacement of the trachea in all patients. Radiographic findings were compatible with a large cranial mediastinal soft tissue mass. All radiographic images of cranial mediastinal masses were reviewed, and the masses appeared lobulated. Upon review, masses in 2 of 3 cats and 2 of 6 dogs were poorly marginated. In addition, evidence of pleural effusion was observed in radiographs of 1 of 3 cats and in 5 of 6 dogs. No evidence of metastasis was detected in any radiographic images reviewed. Megaesophagus was observed in the radiographs of the cat with MG, and no radiographic evidence of aspiration pneumonia was found for any cat or dog.

Ultrasonographic data were obtained by examining ultrasonographic reports and reviewing available videotaped examinations. Ultrasonography was performed in 4 cats and 7 dogs. Of 2 cats with ultrasonograms available for review, 1 cat had findings that were compatible with a single fluid-filled cavity in the mass, whereas the other cat had a mass that appeared primarily solid. Of 4 dogs with ultrasonograms available for review, 2 dogs had findings that were compatible with multiple fluid-filled cavities in the masses, whereas the other 2 dogs had masses that appeared primarily solid. Ultrasonographic evidence of pleural effusion was observed in 1 dog. Echocardiography was performed in 3 cats, which revealed a cranial mediastinal mass and cardiac values within reference range.

Non–contrast- and contrast-enhanced CT was performed in 4 dogs. Dogs were placed in sternal recumbency, and helical CT acquisitions were performed. Images were acquired by use of a standard algorithm. No evidence of metastasis, pleural effusion, or enlarged perihilar lymph nodes was observed on computed tomograms. Based on CT findings in 4 dogs, 3 dogs had tumors that appeared noninvasive, 3 had tumors that displaced surrounding vessels, and 1 had a tumor that appeared invasive and wrapped around surrounding vessels, including the cranial vena cava.

Cytologic and histologic findings

Ultrasound-guided fine-needle aspiration of masses was performed before surgery in 7 of 9 cats and 9 of 11 dogs. All aspirates contained a mixed population of cell types, including lymphocytes (small, large, or both; 5 cats and 5 dogs), mast cells (3 cats and 4 dogs), neutrophils (3 cats and 3 dogs), mononuclear cells (4 cats and 1 dog), eosinophils (1 cat and 1 dog), epithelial cells (1 cat and 2 dogs), lymphoblasts (6 cats), mesenchymal cells (1 dog), and erythrocytes (4 cats and 1 dog). In 2 cats and 2 dogs, a presumptive diagnosis of thymoma could be made on the basis of established criteria of cell types found on cytologic examination.[7,8] Specifically, aspirates indicative of thymoma contained many small lymphocytes, a mixed population of thymic epithelial cells, few eosinophils, and mast cells. A CT-guided fine-needle biopsy was performed in 2 dogs; findings on histologic examination of core biopsy specimens were diagnostic for thymoma for both dogs.

Medical treatment

One cat had received 4 treatments of chemotherapy (vincristine, cyclophosphamide, and prednisone) by the referring veterinarian prior to surgery on the basis of a presumptive diagnosis of lymphoma. The mass had slightly decreased in size after the second treatment, but did not decrease in size subsequent to that treatment. One cat was being treated with prednisone and pyridostigmine for MG prior to surgery.

Surgical treatment and findings after surgery— Following induction of anesthesia, all cats and dogs were treated by excision of the thymoma. Tumor excision was performed twice in 2 cats and twice in 1 dog because of thymoma recurrence. Excision was performed via a median sternotomy in all 9 cats. For the 2 cats that had tumor excision performed twice, a median sternotomy was performed twice in 1 cat and a median sternotomy followed by a right third intercostal thoracotomy was performed in the other cat. A median sternotomy was performed in all 11 dogs, with a right third intercostal thoracotomy performed as a second surgery in 1 dog.

In cats, when considering the original and the recurrent tumors, 11 thymomas were removed from 9 cats. Four tumors were well encapsulated and were not adhered to surrounding structures. Seven tumors were found to be adhered to the pericardium and parietal pleura, with 2 of these tumors containing additional adhesions to surrounding vessels. Four of these 7 tumors were considered poorly encapsulated (1 of the masses was from a second surgery performed because of recurrence).

In dogs, when considering the original and recurrent tumors, 12 thymomas were removed from 11 dogs. Four tumors were well encapsulated and easily removed, and 8 tumors were adhered to the pericardium, surrounding vessels, and parietal pleura (1 of the masses was from a second surgery performed because of recurrence). Four of these 8 were adhered to surrounding lung lobes and required partial lobectomies. Additionally, removal of 1 of these 8 tumors required a venotomy of the caudal vena cava.

One cat and 3 dogs required debulking of the tumor because of invasiveness of the mass. In addition, debulking was performed on 1 cat with recurrent tumor at the time of the second surgery. Specimens of each tumor were submitted for histologic evaluation. Sternal lymph nodes were excised in 1 cat and 1 dog. All patients had thoracic drain tubes placed during surgery, 1 cat had an esophagostomy tube placed, and routine closure was performed on each incision.

Cytologic and histologic findings

Histologic evaluation of all tissues obtained at surgery confirmed thymoma. Tumors were predominantly composed of round, oval, or spindle-shaped thymic epithelial cells. All tumors contained mature lymphocytes to various extents. Thymic corpuscles were observed in tumors from 1 cat and 3 dogs. Two cats and 2 dogs had tumors with dense fibrous capsules with fibrous trabeculae. Cystic masses were present in tumors of 1 cat and 1 dog, and mast cells were seen in tumors of 1 cat and 1 dog. A tumor from 1 dog had a few epithelial cells (clear cells) with nonstaining cytoplasm. Other rare findings were hemosiderosis, necrosis, cavitation, and hemorrhage located in tumors from dogs only. Mitotic figures were infrequent; only 1 tumor from a dog had > 10 mitotic figures/10 hpf (400X). In a cat and dog from which sternal lymph nodes were resected, lymph nodes of the cat were free from metastases, whereas lymph nodes of the dog contained clusters of neoplastic cells on histologic evaluation.

Medical treatment

No cat or dog received adjuvant chemotherapy or radiotherapy after surgery. The cat that had been treated with prednisone and pyridostigmine for MG prior to surgery continued this treatment after surgery.

Outcome—All cats and dogs that survived the immediate 24-hour postoperative period (8/9 cats and 8/11 dogs) were reevaluated by physical examination and thoracic radiography (cats, mean of 31 days, median of 16 days, and range of 8 to 120 days; dogs, mean of 41.5 days, median of 14 days, and range of 7 to 240 days). Following surgery, the hospital stay ranged from 3 to 5 days (8 cats, 1 for the second surgery; 8 dogs), 7 days (1 cat; 1 dog for the second surgery), and 12 days (1 dog). Further follow-up information concerning welfare and survival status of each dog and cat was obtained by telephone contact with referring veterinarians or owners or by examination of the medical record. Median follow-up time for dogs was 365 days (mean, 526), and median follow-up time for cats was 730 days (mean, 849).

Thymoma-specific survival and overall survival for dogs and cats were determined by use of the Kaplan-Meier method **(Figures 1 and 2)**. Only 1 cat had a thymoma-specific event of death during surgery. Median overall survival time for cats was 1,825 days, with a 1-year survival probability of 0.889 (89% chance of survival) and a 3-year probability of 0.741 (74% chance of survival). Two cats died of unrelated causes, 1 cat had recurrence of a cranial mediastinal mass 2 years after the first surgery but died of chronic renal failure, and the second cat died of unrelated causes according to the referring veterinarian.

Median thymoma-specific survival time for dogs was 790 days, with a 1-year survival probability of 0.727 (73% chance of survival) and a 3-year survival probability of 0.485 (49% chance of survival). Median overall survival time for dogs was 790 days, with a 1-year survival probability of 0.636 (64% chance of survival) and a 3-year probability of 0.424 (42% chance of survival). One dog was euthanatized during surgery, and 2 dogs died within 24 hours of surgery. Two of the dogs that survived long-term died of other causes (1 was euthanatized because of a splenic mass, and 1 was euthanatized because of a low quality of life from arthritic problems), 1 died because of thymomas recurrence, 2 dogs were still alive, and 3 dogs were lost to follow-up. The dog with metastases to the sternal lymph nodes was known to survive for 2 years after surgery and was subsequently lost to follow-up.

One cat and 3 dogs had highly invasive masses in which only debulking of the tumor was possible. The cat underwent cardiac arrest during surgery and could not be resuscitated. One dog was euthanatized during surgery because of the invasiveness of the mass. Another dog died approximately 30 minutes after surgery, after developing respiratory distress and cardiac arrest following extubation. The third dog died several hours after surgery following cardiac arrest.

Other postoperative complications recorded were bleeding requiring transfusion (2 cats and 4 dogs), edema (3 dogs), bruising (3 dogs), fever (2 dogs), low blood pressure (2 dogs), bloody diarrhea (1 dog), cough (1 dog), mature neutrophilia (1 dog), ventricular premature contractions (1 dog), anorexia (1 cat), and corneal ulcers (1 cat).

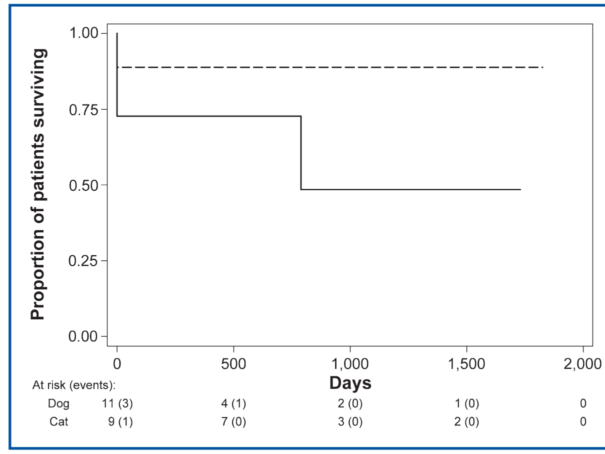

Figure 1—Kaplan-Meier estimates for thymoma-specific survival time for dogs (solid line) and cats (dashed line). Number of patients at risk is indicated below the plot with the number of deaths in parentheses.

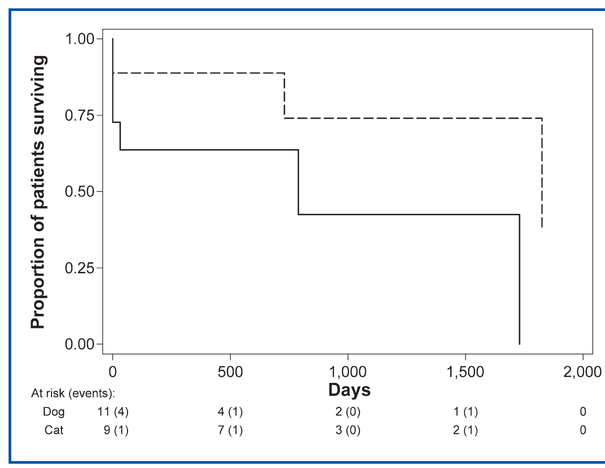

Figure 2—Kaplan-Meier estimates for overall survival time for dogs (solid line) and cats (dashed line). Number of patients at risk is indicated below the plot with the number of deaths in parentheses.

Tumors recurred in 2 cats and 1 dog. The first cat had a diagnosis of and was treated for MG; a cranial mediastinal mass was subsequently observed. Five years after the first surgery, the thymoma recurred and the mass was removed again. This cat was lost to follow-up 5.5 years after the first surgery. The second cat had been treated by the referring veterinarian for a cranial mediastinal mass that was thought to be lymphoma on the basis of results of cytology. Surgery was performed to remove the mass, which was determined to be a thymoma on histologic evaluation. The thymoma recurred 1 year after the first surgery. Debulking of the tumor was then performed, and excision was described as approximately 95% complete. The mass recurred 1 year later but was small. The owner opted not to treat the cat. The cat lived for 3 years after the first surgery and died of chronic renal failure.

In the dog that had tumor recurrence, a large well-encapsulated mass was removed and the thymoma recurred 1 year later. The mass had invaded surrounding lung lobes, so the lungs were partially resected with the mass. Two years after the second surgery, the mass was again observed on thoracic radiographs. The owner opted not to treat the dog at this time. The dog lived for 4 years after the first surgery.

Prognostic factors—Of the factors analyzed (age, tumor invasiveness, percentage of lymphocytes in the mass [percent lymphocyte composition], and mitotic index), only the percent lymphocyte composition was significantly correlated with survival. In a survival model for percent lymphocyte composition in which data of cats and dogs were pooled, the hazard ratio for a 10% increase in lymphocytes was 0.65 (95% confidence interval, 0.46 to 0.91; $P = 0.013$), indicating a 35% reduction in the death rate for a 10% increase in lymphocytes. In the same survival model with data from cats and dogs analyzed separately, results were similar to those of pooled data but were not significant.

Discussion

Excision is considered the definitive treatment for thymomas.[4,9] Metastases are uncommon in humans (1% to 15%),[10] although a higher rate of metastasis may be seen in invasive tumors.[11,12] Although staging (stage I to IVB) of thymomas has been found to be helpful in human patients, given the retrospective nature of the study reported here, we were only able to determine invasiveness versus noninvasiveness of tumors, but the degree of infiltration was eminently subjective and surgeon dependent.

Cytologic examination may aid in the diagnosis of mediastinal masses, but distinguishing between the 2 most common causes of mediastinal masses, lymphoma and thymoma, can be difficult.[1,13] In addition, the lymphoid component of the mass exfoliates more readily by aspiration or imprint techniques than do epithelial cells.[5,7,14] In our study, cytologic examination was suggestive of thymoma in 2 of 6 cats and 2 of 11 dogs. Histologic evaluation of biopsy specimens does not always provide a definitive diagnosis.[15] It has been reported that histologic evaluation of transthoracically obtained biopsy specimens can result in a definitive diagnosis in 50% of affected animals.[4] In our study, CT-guided true-cut type biopsy specimens were obtained from 2 dogs; evaluation of these biopsy specimens resulted in a histopathologic diagnosis of thymoma.

Histologic evaluation of tumor specimens is the only way to definitively establish a diagnosis of thymoma, although these results are not likely to provide prognostic information.[16] The degree of tumor invasiveness, as opposed to the histopathologic features of the mass, is considered the main determinant for prognosis in humans and dogs.[12,17,18]

The role of advanced imaging, such as CT or magnetic resonance imaging, is to distinguish masses that are locally invasive from those that are space occupying for surgical planning purposes. Historically, CT has been the modality of choice for imaging the cranial mediastinum in humans.[19] Computed tomography is considered to provide better information than survey radiographic images for determining the exact extent of mediastinal abnormalities.[13,20] Computed tomography is also considered superior to ultrasonography when examining the surrounding vasculature because of the limitations and artifacts caused by air within the lungs.[21] Currently, the ability to distinguish the degree of invasiveness in humans is considered better with magnetic resonance imaging than with CT,[22] and magnetic resonance imaging may improve the staging and differentiation of thymoma.[23]

In our study, CT was used in 4 dogs. One of these dogs had an invasive mass that wrapped around the vessels and displaced surrounding structures, which was verified in surgery. This mass was adhered to the pericardium, surrounding vessels, and lung lobes. However, the mass was surgically removed and thought to be completely excised. The other 3 dogs had masses that were considered noninvasive on the basis of CT evaluation. Two of the 3 masses were seen to be displacing surrounding structures. All 3 CT examinations revealed minimal vascularization and invasion, which corresponded with the encapsulated masses found in surgery. Therefore, in the study reported here, although the numbers were low, CT appeared to be helpful in determining the degree of invasiveness of thymomas. Our findings support the use of preoperative CT scans in patients with cranial mediastinal masses, although determining the resectability of a mass remains an intraoperative decision.

All cats and dogs in our study underwent a median sternotomy for adequate exposure and ease of tumor removal. Two of the 3 animals (1 cat and 1 dog) that had second surgeries underwent right third intercostal thoracotomy. This approach was used to avoid complications associated with subsequent adhesions after the first surgery.

The survival rate for animals with noninvasive, resectable thymomas is good, but the treatment for nonresectable thymomas has not yet been determined.[9] Excision of invasive thymomas is believed to be unrewarding, as vital surrounding structures are involved and prognosis is not well defined.[24] In humans with stage 1 noninvasive thymoma, the recurrence rate is 2%, whereas recurrence of the invasive forms (stage II to IV), believed resectable, is 20%.[25-27]

In our study involving 23 thymomas (recurrent thymomas in 2 cats and 1 dog), thymomas recurred with 0 of 4 noninvasive tumors of cats and 1 of 4 noninvasive tumors of dogs, 2 of 7 invasive tumors of cats, and 0 of 8 invasive tumors of dogs. In the study reported here, cats and dogs with invasive tumors appeared to have a high, immediate 24-hour postoperative mortality rate, but cats and dogs that survived surgery had a good prognosis. In previous reports,[5,28] the prognosis for dogs with a noninvasive thymoma, without signs of megaesophagus, has been thought to be good, whereas signs of megaesophagus in association with an invasive thymoma carry a poor prognosis. Good results have been seen in cats treated for thymoma by excision alone.[29] Results of our study reveal a 3-year overall survival rate of 74% for cats and 42% for dogs.

Thymomas can be associated with paraneoplastic syndromes in humans and animals, including MG,[30-33] megaesophagus,[1,33-35] hypercalcemia,[1] polymyositis, exfoliative dermatitis,[36-38] cranial vena cava syndrome,[39,40] nonthymic cancers, cytopenias, glomerulonephritis, systemic lupus erythematosus, rheumatoid arthritis, and thyroiditis.[5,27,41-49] Forty percent of affected dogs have been shown to have associated autoimmune syndromes such as acquired MG, polymyositis, and immune-mediated skin diseases.[30,50] The most common of these in humans and dogs is MG. In humans, MG occurs in 15% to 30% of humans with thymomas.[51] In 2 studies,[5,41] 14 of a total of 38 dogs with thymoma also had MG. Myasthenia gravis has also been found in cats with thymoma,[48] and in 1 report, 2 of 12 cats with thymoma developed MG 1 to 2 weeks following surgery.[29] Megaesophagus is a common feature of MG potentially involving secondary aspiration pneumonia. Results of 1 study[5] indicate that dogs with thymoma and megaesophagus have a poor short-term survival time following thymectomy, with a median survival time of 4 days after surgery.

Only 1 of 9 cats and 1 of 11 dogs in our study had paraneoplastic syndromes, which is much lower than previously reported.[30,50] One cat had MG as well as megaesophagus. This cat, similar to results of most studies, developed MG prior to surgical removal of the thymoma, although MG has developed after thymectomy in humans.[6,29] Myasthenia gravis did resolve in this cat after thymoma removal but recurred prior to thymoma recurrence. This cat was lost to follow-up 5.5 years after the first surgery. Hypercalcemia was observed in 1 dog in our study. This has been reported previously in dogs with thymomas[5,44,52,53] and may be caused by parathyroid hormone–related protein production by the thymoma.[54] After surgery, the calcium concentration was again found to be high at the last recheck appointment. This dog lived for 26 months after surgery. Therefore, although the numbers are low, the cat and dog with paraneoplastic syndrome in our study had good long-term postoperative survival.

For incompletely resected or nonresectable tumors, other nonsurgical treatments have been suggested. Chemotherapy for the treatment of thymomas has been considered unrewarding, although most treatment protocols were designed for lymphoma, the supposed diagnosis at the time.[3,4,5,41,55] Multimodality therapy combined with surgery and radiation therapy has been reported to be the most effective treatment for humans with incompletely resected tumors.[56] Although not the emphasis of this retrospective study, when considering invasive thymomas, radiation therapy may be useful as either adjunctive or primary treatment.[47,57,58]

Corticosteroids have been reported to induce remission or stabilize disease in thymomas in humans[59,60] as well as in animals.[3,4,47,57] Corticosteroids were given to 2 cats in our study. One cat had been given prednisone to help treat MG, and the other cat was suspected by the referring veterinarian to have lymphoma and received prednisone as part of a chemotherapy protocol, which was discontinued prior to surgical treatment.

Age of the animal, invasiveness of the tumor, percent lymphocyte composition of the mass on histologic evaluation, and mitotic index of the mass were factors analyzed in the study reported here for their effect on prognosis. Percent lymphocyte composition was the only factor that was significantly correlated with survival. Cats and dogs that had a high percentage of lymphocytes in their mass lived longer. This increased survival time in dogs with a lymphocyte-rich subtype of thymoma appears to correlate with a previous report[5] on Kaplan-Meier analysis of dogs grouped by histologic tumor type.

In conclusion, the results of this study found that most cats and dogs with thymomas did well after excision. Cats and dogs with invasive masses had a higher mortality rate, but if they survived the surgery, they had a good long-term survival. The few cats and dogs with recurrent thymomas or paraneoplastic syndromes also had good long-term survival. Excision should be considered an effective treatment option for dogs and cats with thymomas.

a. Stata, version 9.2, StataCorp, College Station, Tex.

References

1. Day MJ. Review of thymic pathology in 30 cats and 36 dogs. *J Small Anim Pract* 1997;38:393–403.
2. Moulton JE, Harvey JW. Tumors of the lymphoid and hematopoietic tissues: thymoma. In: Moulton JE, ed. *Tumors in domestic animals*. 3rd ed. Berkeley, Calif: University of California Press, 1990;231–307.
3. Withrow SJ. Miscellaneous tumors: thymoma. In: Withrow SJ, MacEwen EG, eds. *Small animal clinical oncology*. 2nd ed. Philadelphia: WB Saunders Co, 1996;530–533.
4. Ogilvie GK, Moore AS. *Managing the veterinary cancer patient: a practice manual*. Trenton, NJ: Veterinary Learning Systems, 1996.
5. Atwater SW, Powers BE, Park RD, et al. Thymoma in dogs: 23 cases (1980–1991). *J Am Vet Med Assoc* 1994;205:1007–1013.
6. Namba T, Brunner NG, Grob D. Myasthenia gravis in patients with thymoma, with particular reference to onset after thymectomy. *Medicine (Baltimore)* 1978;57:411–433.
7. Rae CA, Jacobs RM, Couto CG. A comparison between the cytological and histological characteristics in thirteen canine and feline thymomas. *Can Vet J* 1989;30:497–500.
8. Cowell RL, Tyler RD, Meinkoth JH. The lung parenchyma. In: *Diagnostic cytology of the dog and cat*. 2nd ed. St Louis: Mosby Inc, 1999;181.
9. Withrow SJ, Vail DM. Molecular/targeted therapy of cancer. In: *Small animal clinical oncology*. 4th ed. St Louis: Saunders Elsevier, 2007;797.
10. Denayer MA, Rao KR, Wirz D, et al. Hepatic metastatic thymoma and myasthenia gravis twenty-two years after the apparent cure of an invasive thymoma. A case report and review of the literature. *J Neurol Sci* 1986;76:23–30.
11. Chahinian AP, Bhardwaj S, Meyer RJ, et al. Treatment of invasive or metastatic thymoma: report of eleven cases. *Cancer* 1981;47:1752–1761.
12. Masaoka A, Monden Y, Nakahara K, et al. Follow-up study of thymomas with special reference to their clinical stages. *Cancer* 1981;48:2485–2492.
13. Yoon J, Feeney DA, Cronk DE, et al. Computed tomographic evaluation of canine and feline mediastinal masses in 14 patients. *Vet Radiol Ultrasound* 2004;45:542–546.
14. Naylor DC, Krinke GJ, Ruefenacht HJ. Primary tumours of the thymus in the rat. *J Comp Pathol* 1988;99:187–203.
15. Powers CN, Geisinger KR, Frable WJ. Fine-needle aspiration biopsy of the mediastinum. A multi-institutional analysis. *Am J Clin Pathol* 1996;105:168–173.
16. Aronsohn M. Canine thymomas. *Vet Clin North Am Small Anim Pract* 1985;15:755–767.
17. Walker AN, Mills SE, Fechner RE. Thymomas and thymic carcinomas. *Semin Diagn Pathol* 1990;7:250–265.
18. Carpenter JL. Andrews LK, Holzworth J. Tumors and tumor-like lesions. In: Holzworth J, ed. *Diseases of the cat: medicine & surgery*. Philadelphia: WB Saunders Co, 1987.
19. Batra P, Herrmann C Jr, Mulder D. Mediastinal imaging in myasthenia gravis: correlation of chest radiography, CT, MR, and surgical findings. *AJR Am J Roentgenol* 1987;148:515–519.
20. Brown LR, Aughenbaugh GL. Masses of the anterior mediastinum: CT and MR imaging. *AJR Am J Roentgenol* 1991;157:1171–1180.

21. Hylands R. Veterinary diagnostic imaging. Thymoma. *Can Vet J* 2006;47:593–596.
22. Pirronti T, Rinaldi P, Batocchi AP, et al. Thymic lesions and myasthenia gravis; diagnosis based on mediastinal imaging and pathological findings. *Acta Radiol* 2002;43:380–384.
23. Sakai S, Murayama S, Soeda H, et al. Differential diagnosis between thymoma and non-thymoma by dynamic MR imaging. *Acta Radiol* 2002;43:262–268.
24. Bellah JR, Smith AN. The thymus. In: Slatter D, ed. *Textbook of small animal surgery*. 3rd ed. Philadelphia: WB Saunders Co, 2003.
25. Monden Y, Nakahara K, Kagotani K, et al. Myasthenia gravis with thymoma: analysis of and postoperative prognosis for 65 patients with thymomatous myasthenia gravis. *Ann Thorac Surg* 1984;38:46–52.
26. Monden Y, Nakahara K, Iikoa S, et al. Recurrence of thymoma: clinicopathological features, therapy, and prognosis. *Ann Thorac Surg* 1985;39:165–169.
27. Monroe WE, Roth JA. The thymus as part of the endocrine system. *Compend Contin Educ Pract Vet* 1986;8:24–32.
28. Bellah JR, Smith AN. *Textbook of small animal surgery: the thymus*. 3rd ed. Philadelphia: Elsevier Science, 2003;1089.
29. Gores BR, Berg J, Carpenter JL, et al. Surgical treatment of thymoma in cats: 12 cases (1987–1992). *J Am Vet Med Assoc* 1994;204:1782–1785.
30. Shelton GD, Skeie GO, Kass PH, et al. Titin and ryanodine receptor autoantibodies in dogs with thymoma and late-onset myasthenia gravis. *Vet Immunol Immunopathol* 2001;78:97–105.
31. Lainesse MFC, Taylor SM, Myers SL, et al. Focal myasthenia gravis as a paraneoplastic syndrome of canine thymoma: improvement following thymectomy. *J Am Anim Hosp Assoc* 1996;32:111–117.
32. Stenner VJ, Parry BW, Holloway SA. Acquired myasthenia gravis associated with a non-invasive thymic carcinoma in a dog. *Aust Vet J* 2003;81:543–546.
33. Uchida K, Awamura Y, Nakamura T, et al. Thymoma and multiple cysts in a dog with acquired myasthenia gravis. *J Vet Med Sci* 2002;64:637–640.
34. Rusbridge C, White RN, Elwood CM, et al. Treatment of acquired myasthenia gravis associated with thymoma in two dogs. *J Small Anim Pract* 1996;37:376–380.
35. Hackett TB, Van Pelt DR, Willard MD, et al. Third degree atrioventricular block and acquired myasthenia gravis in four dogs. *J Am Vet Med Assoc* 1995;206:1173–1176.
36. Turek MM. Invited review: cutaneous paraneoplastic syndromes in dogs and cats: a review of the literature. *Vet Dermatol* 2003;14:279–296.
37. Rottenberg S, von Tscharner C, Roosje PJ. Thymoma-associated exfoliative dermatitis in cats. *Vet Pathol* 2004;41:429–433.
38. Scott DW, Yager JA, Johnston KM. Exfoliative dermatitis in association with thymoma in three cats. *Feline Pract* 1995;23(4):8–13.
39. Hunt GB, Churcher RK, Church DB, et al. Excision of a locally invasive thymoma causing cranial vena caval syndrome in a dog. *J Am Vet Med Assoc* 1997;210:1628–1630.
40. Holsworth IG, Kyles AE, Bailiff NL, et al. Use of a jugular vein autograft for reconstruction of the cranial vena cava in a dog with invasive thymoma and cranial vena cava syndrome. *J Am Vet Med Assoc* 2004;225:1205–1210.
41. Aronsohn MG, Schunk KL, Carpenter JL, et al. Clinical and pathologic features of thymoma in 15 dogs. *J Am Vet Med Assoc* 1984;184:1355–1362.
42. Martin RA, Evans EW, August JR, et al. Surgical treatment of a thymoma in a cat. *J Am Anim Hosp Assoc* 1986;22:347–354.
43. Mitcham SA, Clark EG, Mills JHL. Malignant thymoma with widespread metastases in a dog: case report and brief literature review. *Can Vet J* 1984;25:280–282.
44. Mills JN, Shaw SE, Kaybay MJ. The cytopathological features of thymoma in a dog. *J Small Anim Pract* 1985;26:167–175.
45. Harris CL, Klausner JS, Caywood DD, et al. Hypercalcemia in a dog with thymoma. *J Am Anim Hosp Assoc* 1991;27:281–284.
46. Klebanow E. Thymoma and acquired myasthenia gravis in the dog: a case report and review of 13 additional cases. *J Am Anim Hosp Assoc* 1992;28:63–69.
47. Hitt ME, Shaw DP, Hogan PM, et al. Radiation treatment for thymoma in a dog. *J Am Vet Med Assoc* 1987;190:1187–1190.
48. Scott-Moncrieff JC, Cook JR Jr, Lantz GC. Acquired myasthenia gravis in a cat with thymoma. *J Am Vet Med Assoc* 1990;196:1291–1293.
49. Hall GA, Howell JM, Lewis DG. Thymoma with myasthenia gravis in a dog. *J Pathol* 1972;108:177–180.
50. Darke PG, McCullagh KG, Geldart PH. Myasthenia gravis, thymoma and myositis in a dog. *Vet Rec* 1975;97:392–393.
51. Lovelace RE, Younger DS. Myasthenia gravis with thymoma. *Neurology* 1997;48(suppl 5):S76–S81.
52. Squires RA, Gaskell CJ, Kelly DF. Invasive thymoma complicated by pneumothorax and haemothorax in a dog. *J Small Anim Pract* 1986;27:89–96.
53. Elliott J, Dobson JM, Dunn JK, et al. Hypercalcemia in the dog: a study of 40 cases. *J Small Anim Pract* 1991;32:564–571.
54. Foley P, Shaw D, Runyon C, et al. Serum parathyroid hormone-related protein concentration in a dog with a thymoma and persistent hypercalcemia. *Can Vet J* 2000;41:867–870.
55. Bellah JR, Stiff ME, Russell RG. Thymoma in the dog: two case reports and review of 20 additional cases. *J Am Vet Med Assoc* 1983;183:306–311.
56. Hejna M, Haberl I, Raderer M. Nonsurgical management of malignant thymoma. *Cancer* 1999;85:1871–1884.
57. Smith AN, Wright J, Brawner WR Jr, et al. Radiation therapy in the treatment of canine and feline thymomas: a retrospective study (1985–1999). *J Am Anim Hosp Assoc* 2001;37:489–496.
58. Kaser-Hotz B, Rohrer CR, Fidel JL, et al. Radiotherapy in three suspect cases of feline thymoma. *J Am Anim Hosp Assoc* 2001;37:483–488.
59. Kirkove C, Berghmans J, Noel H, et al. Dramatic response of recurrent invasive thymoma to high dose corticosteroids. *Clin Oncol (R Coll Radiol)* 1992;4:64–66.
60. Shellito J, Khandekar JD, McKeever WP, et al. Invasive thymoma responsive to oral corticosteroids. *Cancer Treat Rep* 1978;62:1397–1400.