Long term survival after treatment of idiopathic lung lobe torsion in 80 cases.

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Abstract

Objective – To report outcomes of dogs treated for lung lobe torsion (LLT) and to determine prognostic factors for survival.

Study Design – Retrospective multicentric study from four veterinary teaching hospitals.

Animals – Dogs (n=80) with lung lobe torsion.

Methods – Medical records were reviewed for clinical and histopathological findings. Long-term outcome was assessed with owner questionnaire. LLT was classified as idiopathic or secondary based on the etiology.

Results – The most represented breeds were pugs (47.5%) and sighthounds (16.2%). The cause of the lung lobe torsion was considered primary in 77%, secondary in 21% and unknown in 2% of dogs. Postoperative complications were recorded in 14% of dogs. Overall, 95% of dogs survived to discharge and median follow up was 1095 days (range, 7-3809). Owner assessed outcomes and quality of life as excellent in 93% and 89% of dogs, respectively. Primary LLT was associated with a longer survival (median not reached in the study) compared to secondary LLT (921 days; range, 7 to 2073) (P=0.001).

Conclusions – Overall long term survival after lung lobectomy for LLT was excellent. Primary LLT was associated with longer survival then secondary LLT. Long-term owner evaluation of clinical outcome for dogs undergoing lung lobectomy for LLT was considered excellent.

Clinical relevance – Dogs with primary LLT undergoing lung lobectomy have a longer survival time compared to dogs with secondary LLT and have an excellent postoperative outcome.

Introduction

Lung lobe torsion (LLT) is a potentially life-threatening condition in dogs and cats[1-4]; consisting of a lobar rotation of the bronchovascular pedicle at the hilus. This condition results in airway obstruction and vascular compromise.[1,4-6] The incidence of LLT remains unclear in small animals but ranges in man between 0.09% to 0.4%. In addition, LLT is a postoperative complication reported in 0.2% to 0.4% of lung lobectomies.[5,7]

The pathophysiology of LLT has not be elucidated in any species but has been linked to changes in the spatial relationship between lung lobes as well as bronchial cartilage dysplasia. These factors are believed to increase mobility of lung lobes within the thorax, thereby predisposing to LLT.[2,3,5] In human patients, postoperative, post traumatic and spontaneous occurrence due to an underlying pneumonic process have been described.[5,8]

Overall most cases of lung lobe torsion occur after a lung lobectomy with the right middle lung lobe being the most affected following right-upper lobectomy.[5,8,9] In dogs, the etiology is primary (spontaneous or idiopathic), or secondary to an underlying process such as pulmonary (e.g. neoplasia) or pleural disease (e.g. pleural effusion).[4] Unlike the terminology used in human medicine, primary, idiopathic or spontaneous are terms used interchangeably to describe lung lobe torsion in animals when no predisposing factors can be identified.[1,2,10-12]

Large deep-chested dogs, such as Afghan hounds as well as other smaller breeds (e.g. pugs) are overrepresented. However, LLT has been also documented in a diversity of breeds ranging from chihuahuas to Newfoundlands.[1-4,11-19] It has been reported that small breed dogs are typically affected by secondary LLT[4], whereas primary LLT is more common in pugs; large breed dogs are equally affected by primary and secondary LLT.[1-4]

The treatment of LLT is surgical, with lung lobectomy considered the gold standard in animals whereas controversy still exits over the optimal treatment in human medicine. Resection of the non-viable tissue avoiding a reperfusion insult is the typical treatment in both dogs and human patients, but repositioning, with or without pexy, seems to represent a feasible option in some human studies.[5, 8,20-22] Mortality associated with lung lobe torsion in human patients ranges from 8.3% to 16%[5,6,21]. Reported mortality rate in dogs ranges from 31% to 61%[1,2]; however, more recent studies revealed a lower rate ranging from 8% to 14%.[4,19]

An important prognostic factor affecting survival in human patients with LLT is the extent of the lung torsion but survival is not affected by the underlying cause or by surgical techniques (reposition vs resection).[5] Similarly, the underlying cause of the torsion (idiopathic vs secondary) does not appear to affect survival to discharge, however dogs with left cranial lung lobe torsion seem more likely to survive to discharge than dogs with concurrent right cranial and right middle lung lobe torsion.[4] When breeds are taken into consideration, pugs have been found to have a better prognosis with a survival rate to discharge ranging from 86% to 92% compared to a 50% for non-pugs,[2] however this has been questioned by more recent studies where no survival advantage was found.[4,19] Given the conflicting reports regarding post-operative outcomes in dogs with LLT, the rarity of the disease and the poorly understood pathophysiology, further large-scale studies are always beneficial to determine risk factors affecting the outcome in these dogs.

The aim of this study was to describe short- and long-term outcomes of dogs presented for LLT, and to identify factors associated with survival using a large scale multicentric study.

We hypothesized that the outcome for pug and dogs with idiopathic LLT was better compared to other affected breeds or causes.

Materials and methods

Study design and eligibility criteria

This retrospective observational study used anonymized clinical data and was approved by the Liverpool Veterinary School Research Ethics Committee (VREC601). Electronic records from four small animal referral university hospitals in the UK (University of Liverpool, University of Bristol, Royal Veterinary College, University of Edinburgh) were searched to identify all dogs diagnosed with LLT between 2007 and 2018. Dogs diagnosed with LLT during the study period with comprehensive clinical records were included in the study. Affected dogs that presented for a second surgery to address another postoperative lobar torsion were not classified as a new case nor included in the statistical analysis.

Information retrieved from the records included signalment, clinical history, examination findings, preoperative blood test results, preoperative diagnostic findings, location of the LLT, time from presentation to surgery, surgical treatment, surgical and anesthetic time, pleural fluid analysis and histopathological findings, time from surgery to thoracic drain removal, time from surgery to discharge, bacteriology results, concomitant surgical procedures under the same general anesthetic, survival to hospital discharge, and recurrence of LLT. The inciting cause of LLT was determined on the basis of clinical, diagnostic and histopathology findings. The occurrence of any intraoperative and postoperative complication was recorded as well as the need of further surgical intervention or medical treatment. Complications were classified as minor, defined as complications that did not require additional surgical or medical treatment to resolve, and major, defined as complications or associated morbidity that required further surgical or

medical treatment to resolve.

To evaluate outcome, a questionnaire was designed (supplemental data S1) and owners were requested to answer six questions about their dog's outcome and quality of life.

Statistical analysis

Descriptive statistics were computed for all variables. Continuous explanatory variables assessed included were age, body weight, duration of clinical signs, time from presentation to surgery, anesthetic time, surgical time, time from surgery to thoracic drain removal, time from surgery to discharge, survival. Using a Shapiro-Wilk test, none of these datasets were likely to be from a normal distribution ($P<0.001$ for all) and, therefore, they are reported as median (range). Categorical variables assessed were sex, neuter status, breed (pug vs sighthounds; pug vs other breeds; sighthounds vs other breeds), location of the lobar torsion (left side vs right side and left cranial vs right middle), concomitant procedures, etiology, and occurrence of complications.

For each dog, disease-specific survival time was determined as the time elapsed from the date of surgery to the date of death or censorship. Dogs were censored from survival analysis if they were alive at the time of analysis or lost to follow-up. The Kaplan-Meier method and Cox proportional hazards analysis were used to determine the association of a range of variables with the survival time. The outcome variable was survival time, and the explanatory variables were those listed above. All the variables were initially tested separately via univariate Cox proportional hazards analysis and multivariate Cox proportional hazards model was then built, which initially included the variables identified as $P<0.2$ on univariate analysis. Cox proportional hazards analysis results are

reported as odds ratios (OR), 95% confidence intervals (95% CI) and the associated P-value. With regard to the breed distribution, Chi-Square test was initially used to determine any significant association between etiology and breeds. Given the significant association found, Fisher's exact test was then used to characterize the results, in particular whether pugs were more likely to suffer of primary LLT compared to sighthounds and other breeds as well as sighthounds compared to other breeds. The level of statistical significance was set at $P<0.05$ for two-sided analyses.

Results

Population data, clinical presentation and diagnostic investigations

In total, 84 dogs met the eligibility criteria, but four dogs were excluded due to incomplete medical records, leaving a study population of 80 dogs. The most represented breed was pugs (38, 47.5%) and sighthounds (13, 16.2% - including 5 whippets, 4 greyhounds, 3 lurcher and 1 saluki), followed by Labrador retriever (9), shih tzu (3), border collie (2), and others.

The population included 49 male dogs (31 neutered and 18 intact) and 31 female dogs (19 neutered and 12 intact), with a male-to-female ratio of 1.6:1. At the time of the surgery, the median age was 31.5 months (range 2.5 to 130 months) and median weight was 10 kg (range 1 to 61.9 kg). There were 15 juvenile dogs (≤12 months) and 11 of them were pugs.

Median duration of clinical signs was 4 days ranging from less than 24 hours prior to presentation to 90 days. Respiratory signs including dyspnea, tachypnea, increase respiratory effort, excessive panting were reported in 66 dogs (82%). Cough was described in 30 dogs (37%), in particular 4 dogs presented for hemoptysis. Other clinical signs reported were lethargy (45, 56%), anorexia/hyporexia (26, 32%), pyrexia (18, 22%), and exercise intolerance (8, 10%). In 9 dogs (11%) presented for lethargy, anorexia, gastrointestinal signs such as vomiting, regurgitation or diarrhea, pigmenturia with suspected lower urinary tract infection, abdominal, spinal or generalized pain, no clinical signs associated with the respiratory system were reported. In the majority of dogs, a combination of clinical signs was reported.

Findings on physical examination included increased respiratory effort (33, 41%) tachypnea (23, 29%), pyrexia (13, 16%), dyspnea (9, 11%), panting (9, 11%), upper respiratory sounds (4, 5%), shallow breathing (2, 2.5%) and paradoxical breathing (2, 2,5%). Cardiothoracic auscultation revealed attenuated pulmonary sounds (36, 45%), attenuated cardiac sounds (11, 14%), adventitial pulmonary sounds (8, 10%) increase lung sounds (2, 2.5%) and heart murmur (1, 1.2%). Pyrexia was documented in 13 dogs (16%), cranial abdominal pain in 4 dogs (5%) and kyphosis in 1 dog (1, 2%). In 7 dogs (9%) physical examination revealed no abnormalities.

Complete blood count (CBC) was available in 63 dogs and abnormalities included neutrophilia (>12 x 10^9/L) in 44 dogs (70%) with band neutrophils in 10 dogs, leukocytosis (>18 x 10^9/L) in 30 dogs (47%), monocytosis (>1.2 x 10^9/L) in 28 dogs (44%), anemia (HCT <35%) in 22 dogs (35%), lymphopenia (<1.2 x 10^9/L) in 10 dogs (16%), lymphocytosis (>3.8 x 10^9/L) in 6 dogs (9.5%), thrombocytopenia (<150 x 10^9/L) in 3 dogs (4.7%). In 9 dogs (14%) CBC was within reference limits.

Serum biochemistry was available in dog in 67 dogs. Hypoproteinemia and hypoalbuminemia were present in 10 dogs (15%) each. Alkaline phosphatase levels (ALP) were increased (>119 U/L) in 34 (51%) dogs, alanine aminotransferase (>125 U/L) and creatine kinase levels were elevated in 7 dogs (10%) respectively.

Hypercholesterolemia (cholesterol >8.3mmol/l) was present in 11 dogs (16%), hyperbilirubinemia (total bilirubin >15umol/l) in 8 dogs (12%), hyperlactatemia (lactate >2.5mmol/l) in 8 dogs (12%), hyperglycemia (glucose >6.6mmol/l) in 6 dogs, hyponatremia (<144mmol/l) in 6 dogs, hypokalemia (<3.5mmol/l) in 7 dogs,

hypocalcemia (<2.13mmol/l) in 8 dogs, hypochloremia (109mmol/l) in 6 dogs. In 13 dogs (19%) serum biochemistry was within normal limits.

Computed tomography (CT) was the most common diagnostic tool used to diagnose LLT. It was performed in 69 cases (86%). The most common abnormalities described were obliteration or tapering of the main bronchus (47, 68%), pleural effusion (45, 65%), vesicular pattern of the affected lung lobe (41, 59%), lung consolidation (19, 27%), local lymphadenopathy (12, 17%), atelectasis (9, 13%), emphysema (7, 10%). Thoracic radiographs were performed in 19 cases (24%) and the most common reported features were an increase radiopacity and vesicular pattern compatible with consolidation and suspected torsion of a lung lobe, pleural effusion and pneumothorax.

Thoracic ultrasound was used in 4 cases (5%), echocardiography was performed in 2 dogs (2.5%; one with pulmonary stenosis) due to suspected cardiac disease and bronchoscopy was used in 2 dogs (2.5%).

The left cranial lung lobe was affected in 40 dogs (50%), followed by right middle (28, 35%), right cranial (13, 16%), accessory (1, 1%). Two cases were presented with the torsion of two lung lobes: left cranial/right middle and right cranial/right middle. In pugs, the left cranial lung lobe was the most affected (25, 66%), followed by the right cranial (10, 26%) and the right middle (3, 8%). For sighthounds the right middle lung lobe was the most commonly affected (10, 77%) followed by the left cranial (2, 15%) and right cranial (1, 8%).

Surgical procedures

Four dogs died or were euthanized before surgery including three dogs presented with severe respiratory compromise who suffered cardio-pulmonary arrest before surgery and one dog who was diagnosed with LLT secondary to a pulmonary adenocarcinoma and for whom the owner elected euthanasia. These four cases were included in the initial descriptive analysis but there were not included in survival analysis.

Seventy-six dogs underwent surgery which included resection of the affected lung lobe; in none of the cases was de-rotation with or without pexy attempted. Median surgical time was 75 minutes (range, 40-250) and median anesthetic time was 180 minutes (range, 90-330). An intercostal thoracotomy was used as the surgical approach in 73 cases whereas median sternotomy was performed in the remaining 3 cases. Time from diagnosis to surgery ranged from less than 24 hours to 5 days, with 64 dogs (83%) undergoing surgical procedure less than 24 hours after initial presentation.

Lung lobectomy was performed with a stapling device in 70 dogs (in 6 cases the surgical site was reinforced with sutures); sutures only were used in 6 cases and, in 2 of them, hemoclips were also added (1kg pug and 2.7kg papillon).

A thoracic drain was placed in all but two dogs and it was removed from a range of less than 12 hours to a maximum of 15 days in a case with persistent chylothorax. In 39 dogs (51%) the drain was removed within the first 24 hours.

Post-operative hospitalization for monitoring, thoracic drain management and analgesia ranged from 72 hours to 20 days (median: 96 hours). Eleven concomitant surgeries were performed in 8 dogs including rhinoplasty, palatoplasty and laryngeal sacculectomy for BOAS (2), subtotal pericardiectomy with thoracic duct ligation (1), subtotal pericardiectomy (2), subtotal pericardiectomy, thoracic duct ligation, cisterna chyli

ablation and pleural access port placement (PleuralPort; Norfolk Vet Products, Skokie, Il.) (1), mediastinal biopsies (1), mediastinal mass biopsies (1), partial mediastinectomy (1), partial lung lobectomy of the left caudal lung lobe due to adhesions from the left cranial and left caudal lung lobe (1), rib resection to remove the affected lung lobe due to adhesions from the right middle lung lobe and the parietal pleura (1). Antibacterial and analgesia therapy was prescribed postoperatively at the discretion of the surgeon, a total of 30 dogs (39%) received prophylactic antibiotic postoperatively.

Clinico-pathological results

Aerobic and anaerobic bacterial culture and antimicrobial susceptibility testing from the pleural effusion or lung parenchyma was performed in 39 dogs. In 4 cases, bacterial culture was positive including mixed growth of *E. coli* and *Staphylococcus intermedius*, suspected *Nocardia* spp. or *Actinomyces spp*, *Bacillus spp* and *B-haemolytic Streptococcus* spp. Histopathologic evaluation was available in 68 cases. The most common findings included necrosis (58, 87%), hemorrhage (55, 82%), thrombosis (16, 24%), fibrosis (14, 21%), pleural fibroplasia (7, 10%), pleuropneumonia (6, 9%), pleuritis (5, 7%), and suppurative pneumonia (2, 3%). In 2 cases, pulmonary adenocarcinoma was diagnosed.

In 61 dogs (77%), a cause of the lung lobe torsion was not found therefore a diagnosis of idiopathic LLT was made; thirty-five (57%) idiopathic LLT were found in pugs. Two pugs were pregnant at the time of diagnosis, it is unknown if the pregnancy could have been an inciting factor for the torsion. In the remaining 17 dogs (21%) with an available diagnosis the condition was deemed secondary to chylothorax (9), concomitant pyothorax

(2), trauma (2), pulmonary adenocarcinoma (2), congenital lobar emphysema (1), pyogranulomatous pericarditis and mediastinitis (1), eosinophilic pleural effusion (1), mesothelioma (1). In 2 cases, 1 pug and 1 Pyrenean Mountain Dog (2%), the cause could not be verified as the dogs died before the surgical procedure. The distribution of primary and secondary LLT related to breeds is reported in Table 1, no difference was found between pugs and sighthounds (P=0.054) and between sighthounds and other breeds (P=0.434), however a difference was found between pugs and other breeds (P=0.001).

Complications- Surgery was uncomplicated in 74/76 cases. Two dogs had intraoperative complications (3%) recorded: one dog suffered hemorrhage following de-rotation of the lung lobe which did not require blood-product transfusion and in one dog suffering also of pulmonic valve stenosis, a patch-graft was planned but abandoned due to a sudden deterioration related to the general anesthetic. All dogs survived the surgical procedures. In the postoperative period, 12 complication events occurred in 11 dogs (14%). Five complications were considered minor: hypoxemia requiring oxygen supplementation (2), continued pleural effusion (2) with one dog developing hypoalbuminemia, peripheral edema and seroma of the surgical site (1). Seven complications were classified as major: pyothorax (2), chylothorax (3), hemoglobinuria and non-regenerative anemia requiring transfusion in one dog (1), aspiration pneumonia (1). Among these dogs, 8 were diagnosed with idiopathic LLT whereas three were diagnosed with secondary LLT. No difference was found between the LLT etiology and the risk of postoperative complications (P=0.413).

Specifically, among the 3 dogs developing chylothorax postoperatively, two dogs underwent a second surgical intervention, and one dog was euthanized. A 4-year-old greyhound developed chylothorax 2 days post lung lobectomy, conservative treatment was attempted but failed and a second surgery including thoracic duct ligation, subtotal pericardiectomy and pleural access port placement (PleuralPort; Norfolk Vet Products, Skokie, Illinois) was performed 13 days after. The dog recovered uneventfully, and clinical signs ceased after surgery. A 3-year-old saluki developed chylothorax 3 days after surgery, a pleural access port (PleuralPort; Norfolk Vet Products, Skokie, Illinois) was placed but eventually the dog was euthanized 11 months after surgery due to lack of improvement and failure of the pleural port. Finally, a 4-year-old Labrador developed chylothorax 13 days after lung lobectomy and he was euthanized at the owner's request. These three dogs had spontaneous torsion of the right middle lung lobe.

Outcomes- Considering all dogs presented for LLT, 76/80 dogs (95%) survived to discharge. If only dogs underwent surgical procedure were considered, 75/76 (99%) dogs survived to discharge.

Follow up was available for 56 dogs (70%) and ranged from 7 to 3809 days (median: 1095 days). Eleven dogs (20%) died or were euthanized during the follow up period between 7 and 2910 days, 5 dogs (9%) for reasons unrelated to the cause of the lung lobe torsion. An 8-year-old pug was diagnosed with intestinal lymphoma and euthanized three years after surgery and a 3-year-old whippet was diagnosed with epitheliotropic lymphoma and euthanized approximately 1 year after surgery. A 1-year-old pug was

euthanized after the occurrence of seizure. Finally, other 2 dogs were euthanized for reason unrelated to LLT however the specific cause was not indicated by their owners. Six dogs (11%) died or were euthanized for causes related to their secondary LLT: four for chylothorax, one for pulmonary carcinoma and one for mesothelioma. A 7-year-old doberman diagnosed with pulmonary adenocarcinoma was euthanized 9 months from surgery due to metastatic disease and subsequent deterioration. A 9-year-old weimaraner suffering from a pre-existent chylothorax and pyothorax was euthanized on the owner’s request 7 days after lung lobectomy due to persistent pleural effusion and lack of improvement.

Three dogs diagnosed with chylothorax represented 13 days, 11 and 12 months respectively with a chylothorax recurrence and the owners elected euthanasia, in particular one of them was a 18 month-old whippet diagnosed also with a second LLT (left cranial lung lobe). Lastly, a 5-year-old pug initially diagnosed with spontaneous left cranial LLT needed regular pleural fluid drainage. A diagnosis of mesothelioma was confirmed 11 months following the initial surgery and the dog euthanized.

Forty-five owners completed questionnaires (56%). Long term issues were reported in only 4 cases (9%), 3 suffering from chylothorax and one with recurrent eosinophilic pleural effusion, requiring occasional drainage. All dogs returned to full exercise and subjectively none seemed to be affected by the surgery.

The overall outcome of the surgery was described as excellent in 42 cases (93%), good in 2 cases (4.5%) and poor in a dog with chylothorax that required repeated thoracocentesis postoperatively (2.5%). The quality of life of the dogs was described as excellent in 40

cases (89%), good in 4 cases (9%), and poor in the dog suffering from chylothorax that was eventually euthanized.

Risk factors associated with survival of surgery for lung lobe torsion- Overall median disease-specific survival rate for dogs undergoing lung lobectomy for LLT as estimated for all 56 dogs was not reached. Based on Kaplan-Meier estimates the 1-, 2- and 5- year disease-specific survival rates were 93% (51/55), 91% (50/55) and 88% (49/55), respectively.

Logistic regression analysis was used to determine factors associated with survival, when taking into account possible confounding factors (Table 2). After the initial model was refined by backwards-stepwise elimination, the best-fit model was one that included four variables (age, breed [pug vs other breeds], concomitant procedures, etiology). In the final multiple regression model (Table 3), the only factor associated with a decreased risk of death included having an idiopathic LLT (P=0.002). Dogs with secondary LLT had a median disease-specific survival time of 921 days (range, 7 to 3073 days), whereas in those with idiopathic LLT the median disease-specific survival time was not reached.

Discussion

In this study dogs with idiopathic LLT lived longer after lung lobectomy than those with secondary disease, leading us to accept our first hypothesis that outcome for dogs with idiopathic LLT was better compared to other causes. However, we reject our second hypothesis as pugs suffering of idiopathic LLT did not have a better outcome compared to other breeds.

LLT can affect dogs at any age and of any size, despite occurring more frequently in young and small breed dogs.[1,2,4,18,19] Fifteen juvenile dogs (19%) were reported in this study, and 73% of them were pugs. Latimer et al. reported similar findings describing LLT in 7 juvenile dogs where 5 of them were pugs.[3] As previously reported, pugs were overrepresented comprising 47.5% of dogs with sighthound dogs accounting for the majority of the remaining population. In pugs, left cranial lung lobe was the most commonly affected lobe followed by the right cranial and the right medial, which is in concordance with the study by Park et al.[4]

Interestingly, pugs have been found to have a higher incidence of bronchomalacia which causes flaccidity of the supportive cartilage, hypotonia of myoelastic fibers and loss of integrity of the bronchial wall predisposing to bronchial collapse.[23,24] In this study, the occurrence of LLT in pugs was identical to the reported distribution of bronchomalacia and bronchial collapse, with the left cranial bronchus most affected followed by the right cranial and the right middle bronchus.[25] Factors contributing to this particular distribution included thoracic conformation and anatomical features of individual bronchi and lung lobes;[23-26] this could potentially explain the overrepresentation of pugs for LLT as bronchomalacia could cause bronchial collapse leading to atelectasis of the lung lobe,

altering the spatial conformation of lung lobes and increasing their mobility.[2,4,11,13,25] Histopathological and genetic studies analyzing the fibers of the bronchus of the torsed lung lobe would be needed to confirm this hypothesis and the prevalence of this condition. On the other hand, sighthounds were presented mainly for the torsion of the right middle lobe. This is believed to be due to its narrow shape and relative increased mobility potentially contributing to its torsion.[4,27]

Previously, pugs and other small breed dogs were found to have a better prognosis compared to other breeds.[1,18] However, our study failed to find an association between survival and any of the variables related to the signalment of our population even when pugs were tested separately from the rest of the population. This finding is in line with the more recent large published studies.[4,19] Interestingly, for the first time, a strong association was found between the etiology of the LLT and the survival: dogs suffering of idiopathic LLT that underwent surgical intervention were more likely to have a successful outcome compared to dogs with secondary LLT. We can speculate that idiopathic LLT has a more benign course and thus these dogs are less likely to have long term sequelae after surgical intervention.

In human patients, LLT is observed after thoracic surgery, with torsion of the right middle lobe following right upper lobectomy.[5,28,29] Lung lobectomy is not considered a risk factor for a subsequent lobar torsion in small animals; it is sporadically reported and, in our population, none of the dogs had previous thoracic surgery. Recurrence of LLT has been reported only occasionally, ranging from 3% to 7% of the cases, occurring usually between 5 and 180 days after the original presentation[4,18,19]. In our population only one case represented for a second LLT after initial lung lobectomy, however persistent

chylothorax was suspected to be the inciting cause for both the torsions. This has also been described in a recent study, where the 4 cases of LLT recurrence had continued pleural effusion postoperatively.[4] It was speculated that continued pleural effusion in conjunction with the increased available space in the thorax after the previous lung lobectomy predisposed these dogs to recurrence of lung lobe torsion.[4] Due to the paucity of cases in the literature with recurrent LLT, no specific risk factors for recurrence of torsion have been elucidated.

In human patients, resection or derotation (with or without pexy) are both acceptable surgical options with controversy over the best treatment: re-positioning can retain pulmonary function but direct resection avoids a reperfusion insult.[5] A recent systematic review found no differences in survival between the two proposed treatments and factors involved in the treatment choice were the presence of arterial flow preoperatively, the lack of hemorrhagic infarctions and the subjective visual assessment of the pulmonary parenchyma.[5] In small animals, it is unlikely that de-rotation and pexy will be considered as the excision of the affected lung lobe is well tolerated.

Complications after lung lobectomy due to LLT ranges from 8% to 24% with no standardized criteria to evaluate the complications among the studies.[1,4,18,19,30] In our population, only 3% of dogs suffered intraoperative complications and 14% suffered postoperative complications. Occurrence of postoperative complications was not associated with a shorter survival time. Due to the variety of encountered complications, it would be misleading to try and draw further conclusion however, in our population, the occurrence of chylothorax was associated with poorer outcome. Three cases developed chylothorax after lung lobectomy and either died or were euthanized in the first three

months from surgery. Chylothorax is thought to develop after disruption or obstruction of the thoracic duct or thoracic lymphatics, resulting in lymphangiectasia.[1,4,27,31] It has been reported as a possible cause of LLT or also a complication following lung lobectomy for LLT.[4,19,31] If spontaneous resolution of the chylothorax is not achieved in the short postoperative period, surgical treatment should be considered. In cases of pre-existent chylothorax corrective surgery can be performed at the time of lung lobectomy.[4] Considering the cases reported in this study a prompt and aggressive approach is suggested for cases of chylothorax and a more guarded prognosis should be given to the owners.

The main limitation of this study is its multi-institutional retrospective nature which can increase the variability in management and treatment of cases. Medical records were occasionally incomplete and follow-up data were inconsistent. The low number of dogs with a negative status (dead or euthanized) could preclude a reliable statistical analysis limiting the precision of the effects of the different variables. This is supported by the wide confidence intervals for the odds ratios in this study. The measures of outcome of the dogs in our study were based purely on a subjective questionnaire: this assessment may be less reliable leading to an incorrect perception by the owner. The follow-up period ranged from 7 to 3809 days; this could result in recall bias in which owners who completed the questionnaire a longer period of time after their dog's surgery have a less accurate recall of their dog's clinical outcome and therefore have less reliable questionnaire scores than owners who completed the questionnaire within a shorter period of time following their dog's surgery.

In conclusion the current study provides evidence that dogs undergoing lung lobectomy

for idiopathic LLT have a better prognosis with a longer survival time compared to dogs suffering from secondary LLT.

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Table 1. Breed distribution of primary and secondary lung lobe torsion[1]

Etiology	***Pugs***		***Sighthounds***		***Other breeds***	
	n	*%*	*n*	*%*	*n*	*%*
Primary	*35*	*92*	*9*	*69*	*17*	*59*
Secondary	*2*	*5*	*4*	*31*	*11*	*38*
Unknown	*1*	*3*	*0*	*0*	*1*	*3*
Chi-Square test	P=*0.03*					
Fisher's exact test (Pugs vs Sighthounds)	P=*0.054*					
Fisher's exact test (Sighthounds vs Other breeds)	P=*0.434*					
Fisher's exact test (Pugs vs Other breeds)	P=*0.001*					

Table 2. Prognostic factors for duration of survival after surgical treatment of lung lobe torsion in dogs, derived from univariate logistic regression

Logistic regression	**Lung lobar torsion survival**		
	OR[1]	95% CI[2]	P value
Age	***1.01***	***0.99-1.02***	***0.086***
Gender	*1.55*	*0.46-5.17*	*0.471*
Neuter Status	*0.62*	*0.17-2.32*	*0.487*
Body Weight	*1.00*	*0.99-1.00*	*0.212*
Breed			
pug vs sighthounds	*0.29*	*0.04-2.07*	*0.218*
pug vs other breeds	***1.79***	***0.03-0.86***	***0.032***
sighthounds vs other breeds	*0.60*	*0.12-2.90*	*0.526*
Duration of clinical signs	*0.99*	*0.96-1.03*	*0.971*
Time from presentation to surgery	*0.57*	*0.07-4.59*	*0.601*
Surgical time	*1.01*	*0.98-1.04*	*0.234*
Anesthetic time	*1.00*	*0.99-1.02*	*0.376*
Location of the torsion			
Left vs right	*1.00*	*0.29-3.46*	*0.997*
Left cranial vs right middle	*0.72*	*0.19-2.70*	*0.632*
Intraoperative complications	*2.55*	*0.31-20.95*	*0.381*
Postoperative complications	2.11	0.42-10.65	0.362
Concomitant procedures	**12.61**	**2.54-62.62**	**0.002**
Etiology	**14.76**	**3.05-71.47**	**0.001**

[1] OR: odds ratio; [2] 95% CI: ninety-five percent confidence interval: Reference category used in logistic regression. Variables highlighted in bold qualified for inclusion in the multiple regression analysis at P<0.20 (Table 2)

Table 3. Prognostic factors for duration of survival after surgical treatment of lung lobe torsion in dogs, derived from multivariate logistic regression

Logistic regression		**Complications**	
	OR[1]	95% CI[2]	P value
Age	1.00	0.98-1.02	0.460
Breed (pug vs others)	0.44	0.03-7.22	0.570
Concomitant Procedures	5.94	1.05-33.40	0.063
Etiology (idiopathic vs secondary)	**9.37**	**1.45-45.36**	**0.002**

[1] OR = odds ratio [2] 95% CI = ninety-five percent confidence

Figure 1 Kaplan-Meier survival curve for dogs with primary (n=43) and secondary (n=11) lung lobe torsion treated by lung lobectomy