

Surgical and nonsurgical management of and selected risk factors for spontaneous pneumothorax in dogs: 64 cases (1986–1999)

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Objective—To compare results of surgical versus nonsurgical treatment of spontaneous pneumothorax in dogs.

Design—Retrospective study.

Animals—64 dogs with pneumothorax without any history of antecedent trauma.

Procedure—Information on signalment, thoracic radiographic findings, treatment, histologic findings, and outcome was obtained from the medical records. Signalment of affected dogs was compared with signalment of a control population of 260 dogs examined by the emergency service for reasons other than pneumothorax during the study period.

Results—Siberian Huskies were overrepresented in the case population, compared with the control population of dogs examined by the emergency service for other reasons. Twenty-eight dogs were treated without surgery (ie, thoracocentesis or tube thoracostomy with or without cage rest), and 36 were treated with surgery. Information regarding final outcome was available for 33 dogs treated with surgery (median follow-up time, 485 days) and 15 dogs treated without surgery (median follow-up time, 366 days). Dogs that underwent surgery had significantly lower recurrence (1/30) and mortality (4/33) rates, compared with dogs treated without surgery (6/12 and 8/15, respectively). A definitive diagnosis was obtained for 38 dogs, including 34 of 36 dogs undergoing surgery; 26 had bullous emphysema and 4 had neoplasia. Two dogs developed spontaneous pneumothorax secondary to migration of plant foreign bodies.

Conclusions and Clinical Relevance—Results suggest that recurrence and mortality rates for dogs with spontaneous pneumothorax managed surgically were significantly lower than rates for dogs managed by nonsurgical means alone. Early surgical intervention is recommended for definitive diagnosis and treatment of dogs with spontaneous pneumothorax. (*J Am Vet Med Assoc* 2002;220:1670–1674)

Pneumothorax is a pathologic condition characterized by accumulation of air in the pleural space resulting in collapse of the lung lobes. Pneumothorax can be classified as open or closed and as traumatic,

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spontaneous, or iatrogenic. Spontaneous pneumothorax is defined as closed pneumothorax resulting from leakage of air from the lung parenchyma itself without any history of trauma.¹ Traumatic pneumothorax is common in dogs, whereas spontaneous pneumothorax is relatively rare.¹⁻⁵ Reported causes of spontaneous pneumothorax in dogs include pulmonary blebs or bullous emphysema, lobar emphysema, bacterial pneumonia, pulmonary abscesses, dirofilariasis, and neoplasia.^{1,4-14}

Historically, authors have suggested on the basis of recommendations published in the human literature that dogs with spontaneous pneumothorax be treated without surgery by use of a combination of intermittent thoracocentesis or tube thoracostomy and strict rest.⁴ Surgical exploration of the thoracic cavity was reserved for dogs in which nonsurgical treatment failed and dogs with radiographic evidence of pulmonary bullae.^{1,4,5} Results of more recent retrospective studies^{1,5} have suggested that earlier surgical intervention was associated with lower recurrence rates and higher success rates in dogs with spontaneous pneumothorax; however, reported case numbers were low. Therefore, the purpose of the study reported here was to compare results of surgical versus nonsurgical treatment of spontaneous pneumothorax in a larger group of dogs. In addition, we hoped to identify risk factors associated with development of spontaneous pneumothorax in dogs.

Criteria for Selection of Cases

The medical records database of the University of Pennsylvania was searched for records of dogs in which a diagnosis of pneumothorax had been made between 1986 and 1999. Dogs were eligible for inclusion in the study if they had radiographic evidence of pneumothorax; however, dogs were excluded if they had a history of trauma associated with development of pneumothorax or if pneumothorax had developed secondary to pyothorax, esophageal rupture, or tracheal rupture.

For comparison purposes, a control group of dogs was randomly selected from among all dogs other than those with spontaneous pneumothorax examined by the emergency service of the University of Pennsylvania during the same period.

Procedures

For case dogs, information collected from the medical records included age, weight, sex, breed, initial signs, duration of signs, treatment, radiographic findings, surgical approach, surgical findings, lung lobes involved, histologic diagnosis, complications, whether pneumothorax recurred, duration of hospital-

ization, outcome, and follow-up time. Follow-up information was acquired by reviewing the medical record and contacting the owner or referring veterinarian by telephone. Only dogs with at least 6 months of follow-up and dogs for which outcome was known if follow-up time was < 6 months (ie, dogs that died or were euthanized) were included in analyses of recurrence and mortality rates. For control dogs, information collected from the medical records included age, weight, sex, breed, and final diagnosis.

Statistical analysis—The Pearson χ^2 or Fisher exact test was used to compare categorical variables between groups. An unpaired Student *t*-test or Wilcoxon rank sum test was used to compare continuous variables between groups. Data are given as mean \pm SD if normally distributed and as median and range if not normally distributed. Values of $P < 0.05$ were considered significant. Statistical analyses were performed with a statistical software package.^a

Results

Signalment—Sixty-four dogs with spontaneous pneumothorax and 260 control dogs without pneumothorax examined by the emergency service during the same period were included in the study. Median age of the case dogs (median, 6.8 years; range, 4 months to 13.5 years) was not significantly different from median age of the control dogs (median, 4.3 years; range, 1 month to 18.9 years). The sex distribution of the case dogs (24 females [37.5%] and 40 males [62.5%]) was not significantly different from that of the control dogs (88 females [33.8%] and 172 males [66.2%]). In contrast, median weight of the case dogs (median, 29 kg [63.8 lb]; range, 3.8 to 75 kg [8.4 to 165 lb]) was significantly ($P < 0.001$) greater than that of the control dogs (median, 18.6 kg [40.9 lb]; range, 0.6 to 72.3 kg [1.3 to 159.1 lb]).

Case dogs represented 21 breeds, including 12 Siberian Huskies (19%), 7 German Shepherd Dogs (11%), 4 Doberman Pinschers (6%), 4 Rottweilers (6%), 3 Labrador Retrievers (5%), 2 Golden Retrievers (3%), 2 Great Danes (3%), 2 Akitas (3%), and 1 each of 13 other breeds. Fifteen case dogs (23%) were of mixed breeding. Sixty-nine (26.5%) of the control dogs were of mixed breeding; the remaining 191 represented 71 breeds. The 7 most common breeds of control dogs were Labrador Retriever (19, 7.3%), German Shepherd Dog (16, 6.1%), Rottweiler (15, 5.8%), Golden Retriever (11, 4.2%), American Pit Bull Terrier (9, 3.5%), Dalmatian (7, 2.7%), and Cocker Spaniel (6, 2.3%). Only 2 control dogs (0.8%) were Siberian Huskies. The proportion of Siberian Huskies in the case population (12/64, 19%) was significantly ($P < 0.001$) greater than the proportion in the control population (2/260, 0.8%; odds ratio, 28.8; 95% confidence interval, 6.3 to 277.4).

Initial complaint—The most common initial complaints for dogs with spontaneous pneumothorax were dyspnea (45, 70%), anorexia (27, 42%), tachypnea (14, 22%), cough (13, 20%), and vomiting (11, 17%). Other less-frequent initial complaints included lethargy, cyanosis, gagging, polyuria, polydipsia, and col-

lapse. Median duration of clinical signs prior to examination was 3 days (range, 0 to 28 days).

Radiographic findings—Thoracic radiography was performed in all 64 dogs with spontaneous pneumothorax. Fifty-seven (89%) had bilateral pneumothorax, and 7 (11%) had unilateral pneumothorax. Bullae were identified on radiographs of 20 (31%) dogs. Other radiographic findings included atelectasis (60 dogs), tension pneumothorax (5), pneumomediastinum (3), possible metastatic neoplasia (3), alveolar disease (2), and pneumonia (2).

Treatment—Twenty-eight dogs were treated without surgery (ie, thoracocentesis or tube thoracostomy with or without cage rest), and 36 were treated with surgery. The distribution of pneumothorax was not significantly different between dogs treated without surgery (3 dogs with unilateral pneumothorax and 25 dogs with bilateral pneumothorax) and dogs treated with surgery (4 dogs with unilateral pneumothorax and 32 dogs with bilateral pneumothorax). Also, the percentage of dogs treated without surgery that had radiographically visible bullae (8/28, 29%) was not significantly different from the percentage of dogs treated with surgery that had radiographically visible bullae (12/36, 33%).

Thoracocentesis was performed in 62 of the 64 dogs (97%). Of the 2 dogs that did not undergo thoracocentesis, 1 had thoracostomy tubes placed immediately after admission to the hospital, and the other did not require thoracocentesis and was treated strictly with cage rest. Median number of thoracocentesis attempts for dogs treated without surgery (median, 2; range, 0 to 4) was not significantly different from the median number thoracocentesis attempts for dogs treated with surgery (median, 2; range, 0 to 8). In contrast, the percentage of dogs treated with surgery that received a thoracostomy tube prior to surgery (24/36, 67%) was significantly ($P = 0.006$) higher than the percentage of dogs treated without surgery that received a thoracostomy tube (9/28, 32%). Duration of clinical signs prior to examination for dogs treated without surgery (median, 3 days; range, 0 to 14 days) was not significantly different from that for dogs treated with surgery (median, 3 days; range, 1 to 28 days).

Thirty-six dogs underwent surgery for diagnosis and treatment of the underlying cause of the spontaneous pneumothorax. Surgery was performed in 12 of the 20 dogs with radiographic evidence of bullae, and the radiographic description of the location and number of bullae correlated with surgical findings in 6 of 12. Prior to surgery, 8 of the 36 (22%) dogs had a recurrence of pneumothorax, 14 (39%) had continued air leakage, and 10 (28%) had persistence of pneumothorax. Four of the 36 (11%) dogs treated with surgery had the pneumothorax controlled with thoracostomy tubes (1 dog) and single thoracocentesis (3 dogs). Thirty-two dogs had a median sternotomy, 4 had a lateral thoracotomy, and 1 had thoracoscopic surgery (1 dog that underwent lateral thoracotomy also underwent median sternotomy because no lesions were seen during the initial surgery). Three of the dogs undergoing lateral thoracotomy had unilateral pneumothorax.

Lung lobectomy was performed in 34 dogs (94%). All dogs that underwent surgery had thoracostomy tubes placed after surgery.

Cause and distribution of lesions—A cause for the pneumothorax was identified in 34 of the 36 (94%) dogs that underwent surgery and in 2 dogs that underwent necropsy following unsuccessful nonsurgical treatment. Twenty-six of the 38 (68%) dogs had bullous emphysema, 4 (11%) had neoplasia (bronchoalveolar carcinoma, anaplastic carcinoma, multifocal ectatic carcinoma, and metastatic malignant melanoma), 2 (5%) had migrating plant material (grass awn and pine needle), 2 (5%) had pleuritis only, and 1 (3%) had pulmonary microabscesses with pleuritis. Lesions involved the left cranial lung lobe in 15 of the 38 dogs, the left caudal lung lobe in 10, the right cranial lung lobe in 15, the right middle lung lobe in 7, the right caudal lung lobe in 6, and the accessory lung lobe in 9. Lesions involving multiple lung lobes were detected in 14 of the 38 (37%) dogs; lesions were bilateral in 10 (26%) dogs. In 2 dogs, the cause of spontaneous pneumothorax was not determined despite surgical exploration.

Outcome—Information regarding the final outcome was available for 33 of the 36 dogs treated with surgery and 15 of the 28 dogs treated without surgery. Median follow-up time for dogs treated with surgery was 485 days (range, 110 to 3,658 days); median follow-up time for dogs treated without surgery was 366 days (range, 1 to 2,372 days). Duration of clinical signs prior to examination for dogs that survived (median, 3 days; range, 1 to 14 days) was not significantly different from that for dogs that did not survive (median, 2 days; range, 0 to 7 days). Median duration of hospitalization for dogs treated with surgery (median, 6 days; range, 1 to 13 days) was significantly ($P < 0.001$) longer than median duration of hospitalization for dogs treated without surgery (median, 4 days; range, 0 to 12 days).

Follow-up information regarding recurrence of pneumothorax was available for only 42 of the 48 dogs, because 6 of these 48 dogs were euthanatized or died without being discharged from the hospital. The recurrence rate for dogs treated with surgery (1/30, 3%) was significantly ($P = 0.001$) lower than the recurrence rate for dogs treated without surgery (6/12, 50%). None of the 7 dogs in which pneumothorax recurred survived. Two died at home and 5 were euthanatized.

Overall, 12 of the 48 dogs for which outcome information was available died or were euthanatized. The mortality rate for dogs treated with surgery (4/33, 12%) was significantly ($P = 0.004$) lower than the mortality rate for dogs treated without surgery (8/15, 53%). Of the 8 dogs treated without surgery that did not survive, 2 were euthanatized in the hospital, 2 died secondary to recurrent pneumothorax, and 4 were euthanatized because of recurrence of pneumothorax. The 4 dogs treated with surgery that did not survive were all euthanatized in the hospital. One in which gross lesions were not seen during surgery was euthanatized because of recurrence of pneumothorax, 2 were euthanatized because of multifocal neoplasia, and 1 was

euthanatized because of perioperative complications. The mortality rate for dogs with unilateral pneumothorax (0/5) was not significantly different from the mortality rate for dogs with bilateral pneumothorax (12/43, 28%).

Complications occurred in 6 of the 36 (17%) dogs that underwent surgery. One had a recurrence of pneumothorax that resulted in euthanasia. Two had intrathoracic hemorrhage that required a second surgery; both subsequently recovered. One had reflux esophagitis, aspiration pneumonia, and sepsis that resulted in euthanasia. Two had minor incision complications that responded to medical treatment.

Discussion

Results of the present study suggest that surgery is the treatment of choice for dogs with spontaneous pneumothorax. A definitive lesion was found in 34 of the 36 dogs that underwent surgery, and recurrence and mortality rates for dogs managed surgically were significantly lower than rates for dogs managed by nonsurgical means alone.

In the present study, we attempted to identify risk factors for development of spontaneous pneumothorax in dogs by comparing case dogs with a control population selected from dogs examined by the emergency service during the same period. Weight and breed distributions were significantly different between groups, whereas age and sex distributions were not. Siberian Huskies were overrepresented in the case population, compared with the control population, suggesting that this breed may have a predisposition for spontaneous pneumothorax. Interestingly, of the 8 Siberian Huskies in which a definitive diagnosis was obtained, 7 had bullous emphysema. This is similar to findings in a recent report^b of 4 Siberian Huskies that underwent surgical treatment of spontaneous pneumothorax secondary to pulmonary bullae. Median weight of control dogs in the present study was significantly less than median weight of the case dogs, which may indicate a possible increased risk for spontaneous pneumothorax in medium- to large-breed dogs.

Surgical exploration identified an underlying cause for pneumothorax in all but 2 dogs. The most common cause of pneumothorax was bullous emphysema, which is similar to results given in previous reports.^{1,4,5} Two dogs had pneumothorax secondary to migrating plant material, which has not been previously reported to our knowledge. Exploratory surgery in those 2 dogs was curative, and pneumothorax did not recur. Neoplasia has been previously reported as a cause of spontaneous pneumothorax in dogs^{5,13} and was identified in 4 dogs in the present study. Surprisingly, neoplasia was suspected during examination of preoperative radiographs in only 1 of these 4 dogs. In 2 of the dogs with neoplasia, neoplasia was associated with a pulmonary bulla, and lung lobectomy resulted in complete removal of the neoplasm. There was no evidence of recurrence of neoplasia in the dog with bronchoalveolar carcinoma, and neoplasia was controlled for 1 year in the dog with an anaplastic sarcoma. Thus, surgery may result in long-term survival in dogs with spontaneous pneumothorax secondary to

neoplasia. In a third dog with neoplasia, multifocal ectatic carcinoma associated with multiple bullae throughout the lungs was seen, and the dog was euthanized at the time of surgery. In contrast to other reports,^{1,5,11} no dogs in the present study were found to have pneumothorax secondary to heartworm disease or diffuse bullous emphysema.

Radiographic detection of pulmonary bullae is considered unreliable, but serial radiography may increase the possibility that pulmonary bullae will be detected.⁴ In the present study, the radiographic description of the location and number of pulmonary bullae correlated with surgical findings in only 6 of 12 dogs. Computed tomography has been found to be a useful diagnostic modality in humans with spontaneous pneumothorax^{15,16} and, thus, may be of benefit in dogs.

Thoracocentesis or tube thoracostomy may be needed during the initial treatment of dogs with spontaneous pneumothorax. A need for thoracocentesis more than twice during any 24-hour period and detection of tension pneumothorax have been reported as indications for tube thoracostomy.^{1,4,5} Of the 36 dogs in the present study that underwent surgery, 32 (89%) had a recurrence of pneumothorax, continued air leakage, or persistence of pneumothorax following initial treatment but prior to surgery. This suggests that air accumulation in dogs treated with surgery was more severe and, therefore, less likely to respond to nonsurgical treatment than air accumulation in dogs that were treated without surgery.

The most common surgical approach in the present study was a median sternotomy. This approach is advantageous because it allows access to both sides of the thoracic cavity and the accessory lung lobe. Identification of air leaks was facilitated by flooding the thoracic cavity with sterile saline (0.9 NaCl) solution in dogs in which lesions were not immediately obvious. Lesions were detected in all lung lobes and were bilateral in 10 of 38 (26%) dogs. Fourteen of 38 (37%) dogs had lesions in more than 1 lung lobe. Given this, and the low agreement between radiographic and surgical findings, we suggest that median sternotomy is the procedure of choice for thoracic exploration of dogs with spontaneous pneumothorax.

Thoracoscopy has been used for treatment of spontaneous pneumothorax in humans¹⁷⁻²⁰ and was successful in the present study in 1 dog with a solitary lesion (apical bleb with pleuritis) of the right cranial lung lobe. A partial lung lobectomy was performed. Effective exploration of the entire thorax in dogs may require bilateral thoracoscopic evaluation and 1 lung ventilation.^{21,22} In the future, if computed tomography of dogs with spontaneous pneumothorax yields accurate identification of the affected lung lobes, then thoracoscopy may become the preferred surgical approach.

The most important limitation of this study is that it was a retrospective evaluation. This can result in loss of information and introduction of bias. For example, outcome information was available for fewer dogs treated without surgery than dogs treated with surgery, and this may have resulted in response bias. However, response bias was likely minimal, as median follow-up time for the 2 groups was not significantly different.

The effect of response bias can be evaluated by testing for differences in recurrence and mortality rates between dogs treated with and without surgery, including the 13 dogs treated without surgery that were lost to follow-up. First, if all 13 dogs lost to follow-up were considered to have had a recurrence or to have died, analyses of recurrence and mortality rates would still indicate that rates were higher for dogs treated without surgery than for dogs treated with surgery. Second, if all 13 dogs lost to follow-up were considered to have had no recurrences and to have survived, analyses of recurrence and mortality rates would still indicate that recurrence rate for dogs treated without surgery was significantly higher than the rate for dogs treated with surgery. On the other hand, mortality rate would no longer be significantly different between groups; however, we consider it unlikely that all 13 dogs treated without surgery that were lost to follow-up would have survived, given that 8 of 15 dogs treated without surgery for which follow-up information was available died or were euthanized.

Of the 8 dogs treated without surgery that did not survive, 2 were euthanized in hospital, whereas 2 died and 4 were euthanized because of recurrence of pneumothorax. The mortality rate for dogs treated without surgery may have been artificially high because of this. Euthanasia or death of dogs in which pneumothorax recurred may have reflected an unwillingness or financial inability of clients to undertake surgical exploration that might have been recommended for their dogs. On the other hand, of the 4 dogs treated with surgery that did not survive, only 1 did not survive because of a recurrence of pneumothorax. However, none of the dogs in the present study had diffuse bullous disease, which has been associated with higher recurrence rates.¹

In summary, on the basis of results of the present study, we recommend stabilization with thoracocentesis or tube thoracostomy followed by surgical exploration via median sternotomy for dogs with spontaneous pneumothorax that do not have an identifiable nonsurgical disease (eg, paragonimiasis or dirofilariasis) or diffuse pulmonary disease. Delaying surgical intervention is unlikely to be successful and may ultimately lead to greater cost to the owner if surgical intervention later becomes necessary.¹ Nonsurgical treatment can be offered to owners if surgical exploration is not financially feasible, but owners should be advised of the higher recurrence and mortality rates.

^aIntercooled Stata 7.0 for Windows 98/95/NT, Strata Corp, College Station, Tex.

^bGrößlinger K, Lorinson D, Wiskocil L, et al. Spontaneous pneumothorax caused by bullae pulmonales in four Huskies (abstr). *Vet Surg* 2001;30:304.

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