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Retrospective Study

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Pneumomediastinum in cats: 45 cases (2000–2010)

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Abstract

Objective – To characterize the incidence, etiology, presenting complaint, clinical course, and outcome of cats with pneumomediastinum.
Design – Retrospective study from the period of January 1st, 2000 to December 31st, 2010.
Setting – University teaching hospital.
Animals – Forty-five cats with a radiographic diagnosis of pneumomediastinum.
Interventions – None.
Measurements and Main Results – Medical and radiographic records were reviewed to identify cats with a radiographic diagnosis of pneumomediastinum. Clinical data were retrieved, including signalment, history, presenting clinical signs, diagnostic test results, treatment, complications, and survival to discharge. In 31 of 45 (69%) cats the pneumomediastinum was secondary to an obvious inciting cause. General anesthesia with endotracheal intubation and positive pressure ventilation was the most common cause in 17 of 45 (38%) cases. This was followed by trauma in 12 of 45 (27%) cats, and tracheal foreign bodies in 2 of 45 (4%) cats. Spontaneous pneumomediastinum (unknown underlying cause) was diagnosed in 14 of 45 (31%) of cases. Onset of clinical signs and diagnosis of spontaneous pneumomediastinum was preceded by emesis in 6 of 14 cats. Common presenting signs were tachypnea seen in 27 of 45 (60%) cats, increased respiratory effort in 26 of 45 (58%) cats, and subcutaneous emphysema in 30 of 45 (66%) cats. Concurrent pneumothorax was identified in 21 of 45 (47%) cats, pleural effusion in 10 of 45 (22%), and pneumoretroperitoneum in 21 of 45 (47%). The mainstay of treatment was supportive care and treatment of the underlying disease process. The prognosis for recovery was good, with 87% survival until hospital discharge.
Conclusions – Pneumomediastinum in cats is an infrequently diagnosed condition. It is often secondary to an event such as general anesthesia with endotracheal intubation and positive pressure ventilation but less frequently may occur spontaneously. The prognosis is good with appropriate supportive care.

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Keywords: feline, pneumothorax, respiratory system, thoracic injuries, trauma

Introduction

Pneumomediastinum is defined as the presence of free air within the mediastinum and may be categorized as spontaneous or secondary.[1] Spontaneous pneumomediastinum has no known underlying cause and is considered a diagnosis of exclusion.[1] Secondary pneumomediastinum is preceded by an obvious inciting pathological event.[1] To date, most cases of pneumomediastinum reported in the veterinary literature are secondary. Inciting causes reported in dogs include blunt and penetrating trauma, primary pulmonary pathology, pericardiocentesis, and laryngeal surgery.[2–4] In cats, pneumomediastinum has been reported after endotracheal intubation with and without positive pressure ventilation, trauma, and endoscopic retrieval of a foreign body.[4–10] Spontaneous pneumomediastinum is rare but has been described in dogs after exercise, acute vomiting, and from unknown causes.[2,11] To the authors' knowledge it has not been reported in cats.

The purpose of this study was to characterize the incidence, etiology, presenting clinical signs, results of diagnostic testing, clinical course, and outcome of both spontaneous and secondary pneumomediastinum in cats.

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Materials and Methods

Case selection

The medical records database of the University of Pennsylvania's Veterinary Hospital from January 1st, 2000 through December 31st, 2010 was searched to identify all cats diagnosed with pneumomediastinum. Inclusion criteria consisted of the presence of pneumomediastinum on thoracic radiography as confirmed in the final radiological report from a board-certified radiologist. Cases in which pneumomediastinum was not confirmed were excluded from analysis.

Medical records review

Information collected from the medical record included the signalment, relevant clinical history, clinical signs at the time of diagnosis of the pneumomediastinum, and results of initial diagnostic testing. When recent general anesthesia was reported (which was considered to be within 7 days preceding diagnosis for the purpose of this study) the reason for anesthesia was analyzed and, where available, information from the anesthetic record was collected. If a dental procedure was performed the use (or not) of a pneumatic drill and the sites of any dental extractions were recorded.

When no obvious cause for the pneumomediastinum was apparent (defined as trauma, thoracic or neck surgery, endotracheal intubation, esophageal procedures, airway foreign bodies, and mechanical ventilation) it was classified as spontaneous, and the medical record was searched for potential precipitating events. These were defined as recent (which was considered to be within 7 days as above) events that could have caused pneumomediastinal injury or alveolar disruption. Precipitating events were defined based on previous reports in dogs and cats, and in the human literature.[1–10]

If the pneumomediastinum developed during hospitalization, the data described above were collected for the period immediately following its development. Tachypnea was defined as > 40 breaths per minute. Further data collection included treatment, complications, length of hospitalization, and outcome (defined as survival to discharge, versus death or euthanasia during hospitalization).

Statistical Analysis

Continuous variables (body weight, age at presentation, days in the hospital, and days in the ICU) were assessed for normality using the Shapiro–Wilk normality test. Normally distributed continuous variables are reported as mean (± SD) and those variables that were not found to be normally distributed are reported as median (minimum, maximum). Statistical analysis was performed using a statistical software package.[a]

Results

Sixty-seven records from cats with a medical record coding of pneumomediastinum were identified during the 10-year period searched, of which 45 cats met the inclusion criteria. Nineteen records were excluded because confirmatory imaging was not performed, and in 3 cases the final radiological report did not confirm the presence of a pneumomediastinum. The total feline hospital admissions during this period were 78,556; thus only 0.0006% of cats had a confirmed diagnosis of pneumomediastinum. Twenty-two cats were female (49%), of which 21 were spayed; 23 cats were male (51%), of which 22 were castrated. Forty cats were domestic short- or long-hair breeds (89%). Other breeds with pneumomediastinum were: Persian (2), Burmese (1), Himalayan (1), and Maine Coon (1). The median age at presentation was 7 years (1 month to 16 years). Body weight was recorded in 43 cats, with a median of 4.4 kg (0.87–6.9 kg).

Etiology

A definitive cause for the pneumomediastinum was apparent in 31 of 45 (69%) cases and a secondary pneumomediastinum was therefore diagnosed (Table 1). The most common inciting cause was general anesthesia with endotracheal intubation and positive pressure ventilation, occurring in 17 of 31 of these cases. The reasons for anesthesia were dental treatment (7 of 17), esophageal tube placement (3 of 17), and one case each of cystotomy, ureterotomy, fracture repair, cerebrospinal fluid tap, radiation therapy, removal of a nasopharyngeal polyp, and enema administration. In 5 of 17 cases an anesthetic complication was recorded, including a closed pop-off valve in 3 cats, esophageal intubation in 1 cat (presumptively causing an esophageal tear), and an undefined incident in another. Dental prophylaxis (routine cleaning without pneumatic drill usage) was performed in 4 of 7 cats receiving dental treatment. Two cats had dental extractions (maxillary premolar in both cats, and mandibular premolar in one). In 1 cat, an unknown dental procedure had been carried out by the referring veterinarian, although an anesthetic complication (closed pop-off valve) was noted. Further diagnostics to evaluate tracheal integrity were not performed in these cats and it is not known whether tracheal rupture had occurred.

Traumatic causes of pneumomediastinum were also common, being apparent in 12 of 31 cases, with blunt force trauma occurring more frequently than penetrating trauma. Blunt force trauma was secondary to falls from a height (2 cats), motor vehicle accident, accidental domestic injury, deliberate domestic injury (one case

Table 1: Causes of secondary pneumomediastinum

Cause	Number	Percentage (of cats with secondary pneumomediastinum, $n = 31$) %	Percentage (of total cats, $n = 45$) %
General anesthesia:	17	55	38
Dental procedure	7	23	16
Esophageal tube placement	3	10	7
Other	7	23	16
Trauma:	12	39	27
Penetrating	4	13	9
Blunt force	8	26	18
Tracheal foreign body	2	6	4

each), and was of unknown origin in 2 cats. Penetrating trauma was secondary to bite wounds in 3 cats, and was of unknown origin in one. One of the cats with bite wounds had also inhaled a tooth. In the remaining 2 cats with secondary pneumomediastinum, a tracheal foreign body (plant material) was found.

The underlying cause for pneumomediastinum was unknown in 14 of 45 (31%) cases, and a spontaneous pneumomediastinum was therefore diagnosed. Potential precipitating events were found in the medical record in 13 of 14 of these cases. Six cats had 2 or more possible triggers. Possible iatrogenic triggers included jugular venipuncture, administration of oral medication at home, and treatment for constipation with enemas under sedation without endotracheal intubation. No adverse events during these procedures were noted in the medical record, although one cat undergoing venipuncture was described as fractious. Potential respiratory triggers were coughing, hemoptysis, pulmonary parenchymal disease of varying etiology, and necrosuppurative laryngitis and pharyngitis. The most common nonpulmonary comorbidity was vomiting. This was also the most common overall event noted prior to onset of signs in 6 of 14 cats with spontaneous pneumomediastinum. None of the cats in this study had a history or diagnosis of asthma.

Clinical signs

Clinical signs of pneumomediastinum are summarized for cats with spontaneous or secondary pneumomediastinum and for cats as a whole in Table 2. The most common clinical finding for both spontaneous and secondary pneumomediastinum was increased respiratory rate with a median respiratory rate of 48 (40–150) breaths per minute. Respiratory effort was also commonly increased, as assessed subjectively by the attending clinician, but further information to characterize the breathing pattern was not available in any of the cats. Subcutaneous emphysema was found in 30 cats. This was clinically evident in 22 of 30 cats, and was found in the following locations: neck only (6 of 22), generalized (head, neck, trunk, and/or limbs) (6 of 22), thorax or neck and thorax (5 of 22), forelimbs only (2 of 22), head only (2 of 22), and axilla (1 of 22). The severity (where recorded) varied from mild to marked. Five cats were presented primarily because the owner had noted severe emphysematous swelling. In 8 of 30 cats, subcutaneous emphysema was only a radiographic finding.

Other systemic findings included lethargy (16 of 45), inappetance (15 of 45) or both (13 of 45). Twenty-one cats appeared painful on clinical examination, of which 11 had no obvious underlying source of pain other than the pneumomediastinum. Other pertinent clinical signs at presentation included traumatic injuries (6), neurological signs (3), hemoptysis (1), and a sublingual mass (1).

Diagnostics

Radiographic abnormalities other than pneumomediastinum were common, and many cats had multiple

Table 2: Clinical signs of cats with spontaneous and secondary pneumomediastinum

Clinical signs	Secondary pneumomediastinum	Spontaneous pneumomediastinum	All cats
Increased respiratory effort	17/31 (55%)	9/14 (64%)	26/45 (58%)
Increased respiratory rate (>40 breaths per minute)	19/31 (61%)	8/14 (57%)	27/45 (60%)
Subcutaneous emphysema	23/31 (74%)	7/14 (50%)	30/45 (66%)
Lethargy	8/31 (26%)	8/14 (57%)	16/45 (36%)
Inappetance or anorexia	8/31 (26%)	7/14 (50%)	15/45 (33%)
Pain	18/31 (58%)	2/14 (14%)	20/45 (44%)

abnormalities. Twenty-one cats had concurrent pneumothorax, of which 15 of 21 had secondary pneumomediastinum and 6 of 21 had spontaneous pneumomediastinum. Ten cats had pleural effusion, including 7 of 31 cats with secondary and 3 of 14 cats with spontaneous pneumomediastinum. Pneumoretroperitoneum was apparent in 21 cats, of which 15 of 31 had secondary and 6 of 14 had spontaneous pneumomediastinum. In 3 of 12 cats that had sustained trauma, rib fractures were evident. Only 11 cats had no radiographic changes other than the pneumomediastinum.

Pneumomediastinum was confirmed radiographically in all cases before any further imaging or invasive diagnostics were performed. Bronchoscopy was performed in 5 cats, 3 of which had bronchial foreign bodies (plant material in 2 cases, a tooth in another) that were presumed to have caused disruption of the bronchial wall. In 2 cats bronchoscopy was unremarkable and the pneumomediastinum was considered spontaneous. Computed tomography of the thorax was performed in 2 cats, esophagoscopy in one, and a contrast esophagram in another. These diagnostics did not reveal an underlying cause, and in all 4 cases a spontaneous pneumomediastinum was diagnosed.

Microbial cultures of the respiratory tract were performed in three cases. Two cats with spontaneous pneumomediastinum had an endotracheal wash, and a bronchial foreign body (tooth) from another cat was cultured. Clinically significant isolates were obtained in all 3 cases (*E. coli*, *Pasteurella multocida*, and an *Enterococcus spp*. from the tooth foreign body), with concurrent cytology supportive of respiratory tract infection apparent for both endotracheal washes.

Treatment

Supplemental oxygen was administered via oxygen cage therapy in 29 cats (with an inspired oxygen fraction of 0.30–0.80) for a median duration of 15 hours (4–74 hours). Twenty of these cats had concurrent pleural space disease, but 9 received oxygen supplementation for a pneumomediastinum alone. Thoracocentesis was performed in 9 cats with concurrent pneumothorax and in 1 cat with no evidence of pleural space disease in the medical record. Thoracocentesis was generally performed before thoracic radiography (8 of 10 cases). Chest tubes were placed in 3 cats with pneumothorax. Needle decompression of subcutaneous air was required in 1 cat with severe subcutaneous emphysema. Two cats required mechanical ventilation subsequent to diagnosis of a secondary pneumomediastinum but both cats also had severe pulmonary and pleural space disease. Other medical and surgical treatment was variable depending on the underlying etiology of the pneumomediastinum.

Hospitalization

Thirty-nine cats (87%) were hospitalized for a median of 2 days (1–17 days). Twenty-five patients (55%) in total required admission to the ICU, with a median stay of 1.5 days (0.5–9 days). Six of these had a spontaneous pneumomediastinum.

Survival to discharge

Thirty-nine cats (87%) survived until discharge from the hospital, although 3 were discharged for ongoing care at their primary care veterinarian before resolution of the pneumomediastinum and one was discharged against medical advice. These 4 cases were lost to follow up and their outcome is uncertain. Six cats (13%) were euthanized, 5 of them within 24 hours of hospitalization, and 1 at 42 hours after admission. One of these had sustained severe blunt trauma (motor vehicle accident) and 2 had severe penetrating bite wounds. However, 3 cases were classified as spontaneous. Necropsies were subsequently performed in 2 of these 3 cases and the results are discussed below. In the remaining case, severe underlying pulmonary disease had been diagnosed on thoracic radiographs. Five cats sustained respiratory or cardiorespiratory arrest while in the hospital. All were initially successfully resuscitated, although 2 were later euthanized. The 3 surviving cats had sustained arrest after developing a pneumomediastinum and tension pneumothorax during general anesthesia. The 2 that were euthanized both had bite wounds as described above.

Necropsies were performed in 3 of the 6 cats that were euthanized. One of these had been diagnosed with pneumomediastinum secondary to bite wounds, and the necropsy diagnosis in this cat was tracheal rupture with tracheitis and peri-tracheal cellulitis. The other 2 cats had been diagnosed with spontaneous pneumomediastinum. In these cats the necropsy findings were moderate multifocal acute interstitial pneumonia in 1 cat, and severe necrosuppurative pharyngitis and laryngitis in the other.

Discussion

The feline mediastinum is a potential space between the mediastinal pleurae, dividing the thorax into 2 halves. It communicates with the fascial planes of the neck cranially, and the retroperitoneal space caudally.[12] Air causing a pneumomediastinum may originate from intrathoracic (esophagus, trachea, bronchi, or pulmonary parenchyma) or extrathoracic (neck or abdomen) locations.[1,2] The source of air is sometimes difficult to determine. Overdistension and rupture of alveoli with subsequent air leakage into the pulmonary interstitium and dissection along bronchovascular sheaths

to the mediastinum, known as the Macklin effect, has been described as a potential source of air.[1,13] This pathogenesis, widely cited in the human literature, was originally proposed after a series of experiments in cats.[13] In people, events triggering a strong Valsalva maneuver with increased intra-alveolar pressure (such as emesis), may result in the Macklin effect, and are commonly reported prior to the development of spontaneous pneumomediastinum.[1]

Pneumomediastinum is an infrequently diagnosed disorder in cats, found in only 0.0006% of cats seen at our hospital during a 10-year period. An obvious cause for the pneumomediastinum was apparent in most cases (69%) and these were therefore classified as "secondary pneumomediastinum." The most common cause was general anesthesia with endotracheal intubation and positive pressure ventilation, followed by trauma and, less frequently, tracheal foreign bodies.

All 3 of these causes have previously been reported separately in cats, but the relative frequency was unknown.[5–10] Two case series describe tracheal rupture after endotracheal intubation in cats with subsequent pneumomediastinum likely due to air dissection along cervical fascial tissue planes.[5,6] In one of these case series tracheal rupture was confirmed by surgery or tracheoscopy in 62% of cases, and in the other it was confirmed in 20% of cases. In the remaining cats in these case series the diagnosis of tracheal rupture as the underlying cause of pneumomediastinum was presumptive.[5,6] In the present study 38% of all pneumomediastinum cases occurred after general anesthesia with endotracheal intubation or positive pressure ventilation, but further diagnostics to investigate tracheal integrity were not carried out. Besides tracheal rupture as a result of intubation, barotrauma associated with positive pressure ventilation or increased intra-alveolar pressure during anesthesia are 2 other potential mechanisms of anesthetic-related pneumomediastinum.[6,7,13] Barotrauma or tracheal rupture was presumed in the 5 cases in this study where an anesthetic complication was recorded. In the remaining 12 cases, causes other than barotrauma or tracheal rupture cannot be ruled out. Some of these cats had additional potential precipitating causes (such as esophageal tube placement).

Previous case series found that approximately 70% of cases related to endotracheal intubation occurred after intubation for dental procedures.[5,6] In the present study, only 41% of the intubated cats had undergone a dental procedure. This is slightly lower than previous findings but is still disproportionately high. It is important to note that our institution has a dentistry department and therefore the study population was considered to contain a reasonable proportion of dental patients. Overdistension of the endotracheal tube cuff is thought to occur more commonly during dental procedures in an attempt to prevent aspiration of fluid, and frequent repositioning of the head to access the oral cavity while intubated may also contribute to tracheal disruption.[5,6] Interestingly, there are multiple reports in the human literature of pneumomediastinum secondary to dental procedures during which patients have not undergone endotracheal intubation.[14,15] The proposed pathogenesis is high-pressure instillation of air by the pneumatic dental drill under disrupted oral mucosa, and its subsequent dissection through fascial sheaths to the mediastinum.[15] In people, pneumomediastinum occurs most commonly after mandibular procedures, particularly with 3rd molar extractions.[15] The number of cats undergoing dental extractions in this study is too small to infer a causal relationship for pneumomediastinum with use of a pneumatic dental drill, but this may warrant further consideration where an alternative pathogenesis has been ruled out.

Trauma was another common cause of secondary pneumomediastinum in this study, which is consistent with a previous case series in dogs in which blunt or penetrating trauma was the most common cause of pneumomediastinum.[2] Blunt force was the prevailing source of trauma in this study. The source of air was not determined in any of these cases, but in people with blunt trauma the Macklin effect is the most common source of air, with tracheobronchial lesions occurring less frequently.[16]

In 31% of cases in this study spontaneous pneumomediastinum was diagnosed. Spontaneous pneumomediastinum has not previously been reported in cats and this figure was higher than expected but is similar to the figure previously reported in dogs.[2] Cases were classified as spontaneous when a clear triggering event was not apparent in the history or diagnosed prior to death or euthanasia. Triggering and potential triggering events were defined based on previous reports in dogs and cats as well as in the human literature.[1–10,16–18] Given that advanced diagnostics were not carried out in most cases the definitions were necessarily arbitrary, and may overestimate cases that are truly spontaneous. Two cats in this category were found to have severe underlying respiratory disease at necropsy, but were nonetheless classified as spontaneous because there was no clinical or diagnostic evidence of this disease prior to death. Similarly, underlying disease cannot be ruled out in the surviving cats. The most common presumptive trigger for spontaneous pneumomediastinum was emesis, which is also the case in people and has been reported in dogs.[1,2] Reports in dogs also suggest an association of spontaneous pneumomediastinum with exercise.[2,11] Asthma

flare-ups are also regarded as common triggers in people, but there was no history or diagnosis of asthma in any cat in this study.[1]

More than half the cats in this group had more than one potential trigger. This contrasts with human reports, where a significant number of patients have no evidence of any predisposing condition.[1] Some of the triggers reported in people, such as intense physical activity and defecation, could not be assessed in this retrospective study.[1]

Regardless of the etiology, most cats presented with signs of respiratory distress, which is in contrast to a previous case series in dogs where 2 of 3 of dogs had no respiratory signs.[2] In people, respiratory distress also occurs less commonly, with chest pain as the major presenting complaint.[1] Many of the presenting clinical signs were nonspecific, but the combination of respiratory distress with subcutaneous emphysema should prompt further investigation for pneumomediastinum.

Pneumothorax or pneumoretroperitoneum were frequently seen concurrently with pneumomediastinum in our study. This was often, but not exclusively, associated with trauma, similar to previous findings in dogs.[2] Thoracic radiography is very sensitive in diagnosis of pneumomediastinum in people.[18] In the 2 cats where computed tomography was used, it was not helpful in delineating the underlying cause of the pneumomediastinum. Bronchoscopy was useful in the diagnosis and treatment of 2 cases with radiolucent tracheal foreign bodies, and of a third case where a tooth was removed. Tracheoscopy has been described for tracheal evaluation where mucosal disruption is suspected.[5] Given the relative risks of airway scoping and the good prognosis with supportive care alone its use may not be justified except in cases where a foreign body is suspected.

Treatment was variable but most cats received oxygen supplementation. The mainstay of treatment for pneumomediastinum is supportive care with analgesics and treatment of any underlying disease. "Nitrogen washout" by providing an enriched oxygen environment such as an oxygen cage is sometimes used to speed resolution of pneumomediastinum. Several small human and experimental studies suggest its efficacy although large scale and clinical studies are lacking, and the expense and risk of oxygen toxicity must be considered.[19–21] In a minority of cases with severe subcutaneous emphysema, needle drainage of this air may help to relieve discomfort, and is sometimes performed at our hospital. The prognosis for recovery was good, with 87% survival until hospital discharge, which is consistent with the outcomes of previous case reports and series.[5–10]

The main limitation of this study is the relative paucity of diagnostic information. Interpretation of the underlying cause and classification as spontaneous or secondary pneumomediastinum is therefore largely presumptive. Other limitations are typical of retrospective studies, including incomplete medical records. Given the retrospective nature of this study, it is not clear if patients were euthanized due to clinical deterioration from the pneumomediastinum, underlying pathology, or financial reasons. The survival data may not reflect the true morbidity from the pneumomediastinum. Recurrence of pneumomediastinum is rare in people, and has not previously been reported in veterinary medicine, but was not assessed in this population. Cats without thoracic radiographs were excluded, and the incidence of pneumomediastinum may therefore be underestimated.

In conclusion, pneumomediastinum in cats was usually associated with a relatively benign clinical course, although this may vary from an incidental finding to life-threatening signs. The primary presenting complaints were tachypnea, increased respiratory effort, and subcutaneous emphysema. Secondary pneumomediastinum was more frequent than spontaneous pneumomediastinum, and frequently diagnosed underlying causes were trauma and general anesthesia with endotracheal intubation or positive pressure ventilation. The majority of cases recovered uneventfully.

Footnote

[a] Stata 11.0 for Windows, Stata Corporation, College Station, TX.

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