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**Objective**—To characterize clinical features of tracheal rupture associated with endotracheal intubation in cats and to evaluate the most appropriate treatment for this condition.

**Design**—Retrospective study.

**Animals**—20 cats with a history of endotracheal intubation that subsequently developed dyspnea or subcutaneous emphysema.

**Procedure**—Medical records of cats with a presumptive diagnosis of tracheal rupture associated with intubation were reviewed. Clinical and clinicopathologic data were retrieved.

**Results**—Cats were evaluated 5 hours to 12 days after a surgical or medical procedure requiring general anesthesia with intubation had been performed. Fourteen (70%) cats were evaluated after dental prophylaxis. All cats radiographed had pneumomediastinum and subcutaneous emphysema. Eighteen of 19 cats were initially treated medically. Duration of medical treatment for cats that did not have surgery ranged from 12 to 72 hours. Cats that had surgery received medical treatment 3 to 24 hours prior to the surgical procedure. Medical treatment alone was administered to 15 cats that had moderate dyspnea, whereas surgical treatment was chosen for 4 cats that had severe dyspnea (open-mouth breathing despite treatment with oxygen) or worsening subcutaneous emphysema. Eighteen cats had improvement of clinical signs, 1 cat died after surgery, and 1 cat died before medical or surgical intervention.

**Conclusions and Clinical Relevance**—Most cats with tracheal rupture associated with intubation can be treated medically. Cats with worsening clinical signs (severe dyspnea, suspected pneumothorax, or worsening subcutaneous emphysema) should have surgery performed immediately to correct the defect. (J Am Vet Med Assoc 2000;216:1592–1595)

Tracheal ruptures associated with intubation in cats have been rarely reported in the literature, but recent information from the AVMA Professional Liability Trust indicates that it may be an important clinical entity. In the 1995 newsletter it was stated that “... cats developing subcutaneous emphysema following extubation may have developed a tracheal tear...” and, therefore, management or treatment needs to be promptly initiated. The purpose of the study reported here was to review clinical data on tracheal rupture associated with recent endotracheal intubation in cats and evaluate medical and surgical treatments for this condition.

**Criteria for Selection of Cases**

Medical records of 20 cats evaluated by Tufts University (n = 7), Angell Memorial Animal Hospital (3), The Animal Emergency Center (8), and Coastal Carolina Veterinary Specialists (2) from 1996 to 1998 were reviewed. Cats were included in this study if they had a history of receiving inhalation anesthesia that required endotracheal intubation and had signs of subcutaneous emphysema. Records were evaluated for signalment, history, initial complaint, clinical signs, physical examination findings, diagnostic tests performed, and treatment protocol. Owners and referring veterinarians were telephoned and asked questions from a standard questionnaire. Questions answered by owners included information regarding follow-up examinations, respiratory status, treatment of tracheal rupture with cage rest, length of time required for resolution of subcutaneous emphysema, whether follow-up thoracic radiographs were obtained, and whether general anesthesia had been performed since the tracheal rupture. Questions answered by referring veterinarians included information about types of endotracheal tubes used, methods of intubation, and endotracheal tube usage.

**Results**

Procedures performed on cats before referral included dental prophylaxis (n = 14; 70%), ovariohysterectomy (3; 15%), orchietomy and onychectomy (1; 5%), oral surgery for mass removal (1; 5%), and stifle and hip radiography (1; 5%). Cats were referred for evaluation 3 hours to 12 days after the procedure was performed. Median time from surgery to referral was 5.5 days. Breeds represented were domestic shorthair (n = 13; 65%), domestic longhair (3; 15%), Himalayan (2; 10%), Maine Coon (1; 5%) and Persian (1; 5%). Ages ranged from 4 months to 17 years, with a median age of 6.25 years. Median age of cats that were evaluated after receiving a dental prophylaxis (n = 14; 70%) was 7 years. Thirteen (65%) cats were spayed females, and 7 (33%) were castrated males.

The most common clinical signs were subcutaneous emphysema (n = 20; 100%), dyspnea (6; 30%), anorexia (6; 30%), lethargy (5; 25%), respiratory stridor (3; 15%), vomiting (2; 10%), dehydration (2; 10%), hemoptysis (2; 10%), and signs of depression (2; 10%). Other physical examination findings included syncope, tachycardia, tachypnea, increased bronchovesicular sounds, wheezing, gagging, coughing, ptysmal, pharyngeal swelling, submandibular edema, enlarged mandibular lymph nodes, sublingual swelling, fever, altered behavior, and vocalization.
Thoracic radiography of 18 cats revealed pneumomediastinum and subcutaneous emphysema (Fig 1 and 2). Of these 18 cats, 1 cat also had pneumoretroperitoneum, and 1 cat had pneumopericardium. Two cats did not have radiography performed; 1 of these cats died before radiographs could be obtained. Two cats that were to undergo surgical repair also had preoperative tracheoscopy performed; tracheal ruptures were not detected with this technique.

Medical treatment alone was chosen for 15 cats that had mild to moderate signs of dyspnea and subcutaneous emphysema. Mild to moderate signs were defined as dyspnea responsive to cage rest or treatment with oxygen. Medical treatment included monitoring of respiratory rate and effort (n = 6; 40%), supplemental oxygen administration (3; 20%), administration of sedatives (2; 13%), and cage rest (15; 100%). Subcutaneous emphysema was monitored by palpation of the affected areas and close observation during a 12- to 72-hour period (median, 24 hours). Two of these cats also had subcutaneous air removed by needle aspiration or active drain system placement. It could not be determined if the subcutaneous emphysema resolved with this technique. Medical treatment was adequate in each instance in which it was used.

Surgical treatment was chosen for cats with signs of severe respiratory distress (overt dyspnea and cyanosis unresponsive to treatment with oxygen) or worsening subcutaneous emphysema. All cats that received surgical treatment also received medical treatment and were monitored for respiratory rate and effort and treated with oxygen prior to surgical intervention. Subcutaneous emphysema was also evaluated over time, ranging from 3 to 24 hours, and was assessed by close observation and palpation of affected areas. Duration of medical treatment before surgery ranged from 3 to 24 hours, with a median time of 17 hours. Surgical approach to the tracheal rupture involved either a ventral cervical midline approach to the level of the thoracic inlet (n = 1), a ventral cervical midline approach with a partial median sternotomy (2), or a combined left lateral thoracotomy and partial median sternotomy (1). In the 2 cats that had a ventral cervical midline approach and partial median sternotomy, only the first 3 sterna-brae were incised to find the rupture. Each tracheal rupture was located at the level of the thoracic inlet (Fig 3).
Ruptures were longitudinal, 2 to 5 cm in length, and located on the dorsolateral aspect of the trachea at the junction of the tracheal rings and the trachealis muscle. Ruptures were closed with a simple continuous (n = 1) or a simple interrupted suture pattern (3), with absorbable (3) or nonabsorbable suture material (1).1

Surgical treatment was successful in 3 of the 4 cats. In the cat that died, respiratory arrest occurred before surgical intervention. Closed chest cardiopulmonary resuscitation was initiated when resistance to ventilation was noticed, and tension pneumothorax was suspected. An emergency fifth intercostal left lateral thoracotomy was performed, and tension pneumothorax was confirmed. A small amount of air appeared to be leaking from the cranial thoracic portion of the trachea near the thoracic inlet. The endotracheal tube was deflated, and the tube was advanced further into the trachea. Once it was assessed that the cat was resuscitated (the heart was beating normally and the lungs were inflating), the lateral thoracotomy incision was temporarily closed, and the cat was surgically prepared for a median sternotomy. Median sternotomy confirmed a 3-5-mm tracheal rupture on the left dorsolateral aspect of the trachea. This cat died 14 hours after surgery.

Responses to owner questionnaires were complete for 17 of 18 surviving cats. Duration from tracheal rupture to questionnaire ranged from 3 to 30 months, with a median of 15 months. Thirteen cats had been rechecked by a veterinarian; 9 for evaluation of the tracheal rupture and 4 for new problems. The cats did not have a recurrence of respiratory problems. Five cats received cage rest for 1 to 4 weeks after discharge from the hospital. Many owners attempted cage rest at home, but most were not successful in confining their cats. Owners reported that their pets remained sufficiently quiet on their own. Subcutaneous emphysema took 1 to 6 weeks to resolve, as assessed by the owner; median time for resolution of subcutaneous emphysema was 2 weeks. One cat had follow-up radiographs taken 3 weeks after initial evaluation, and results were normal; subcutaneous emphysema or pneumomediastinum were not evident. Two cats had been anesthetized with injectable drugs without complications since their tracheal rupture incident.

Eighteen referring veterinarians responded to the questionnaire. Seven cats had been intubated with a high pressure, low volume (HPLV) endotracheal tube, and 11 had been intubated with a low pressure, high volume (LPHV) endotracheal tube. In 3 cats, the endotracheal tube cuff had been inflated by sound only (until pressure on the reservoir bag did not result in audible amounts of air escaping around the cuff), in 10 cats, by feel only (until the operator experienced resistance to further inflation and the pilot balloon appeared inflated), and in 5 cats, by sound and feel. A stylet was used in 15 cats. Fifteen veterinarians routinely disconnected the cat from the anesthetic circuit when changing the cat's recumbent position.

Discussion

History of inhalation anesthesia requiring endotracheal intubation with development of subcutaneous emphysema is consistent with a diagnosis of tracheal rupture.1,2 Unless confirmed by surgery or tracheoscopy, this diagnosis is presumptive. Marginal alveolar rupture has been reported in 1 cat and in humans and can cause clinical signs similar to a tracheal rupture. Positive-pressure ventilation appears to be a requirement for this syndrome, and clinical signs appear immediately.3 In the cats evaluated in the study reported here, only 4 were referred the same day as intubation, and none had received positive-pressure ventilation. Two of these 4 cats had a tracheal rupture induced by a stylet.

Tracheoscopy has been reported to provide an effective means of diagnosing tracheal defects.1,4 Tracheoscopy was performed in 2 cats before surgery but was unsuccessful in detecting a lesion. It is possible that lack of success was caused by operator error, or that the tracheal membrane was draped over the defect. A tracheogram could be considered as an alternative technique to confirm a tracheal rupture not detected by tracheoscopy, but it was not used in these cats.5

Subcutaneous emphysema is a consistent clinical sign in cats with tracheal rupture, because air dissects along connective tissue planes in the cervical area surrounding the trachea, and air travels into the mediastinum, which causes pneumomediastinum (Fig 1). Pneumothorax may develop if pressure is high enough to rupture the mediastinum. Tension pneumothorax may develop if the tracheal defect acts as a 1-way valve.6 Resolution of subcutaneous emphysema is slow, because absorption of air is dependent on the diffusion gradient of nitrogen, and this gradient is quite small. In order to speed absorption, human patients with subcutaneous emphysema are treated with 93% oxygen for 4 hours. This treatment decreases the partial pressure of nitrogen in the blood and promotes diffusion of nitrogen from the interstitium into the blood.7

The cause of tracheal rupture in the cats of this study is unknown. Possible explanations include over-inflation of the endotracheal tube cuff, change of the cat’s recumbent position without proper disconnection of the endotracheal tube from the anesthetic machine, traumatic intubation with a stylet, type of endotracheal tube used, and retrieval of the endotracheal tube without deflation of the cuff.

In 2 of the cats reported here, the veterinarians knew that the endotracheal tube cuff had been over-inflated. In 1 cat, after inflation of the endotracheal tube cuff, the cuff was palpated outside the tracheal lumen. The endotracheal tube cuff was subsequently deflated, and the surgical procedure was continued. This cat was admitted to an emergency clinic 5 days later. In the second cat, the veterinarian continued to hear an air leak around the endotracheal tube cuff, despite positive pressure ventilation and, therefore, continued to inflate the cuff. The leak was later found to be in another part of the endotracheal tube, and the tube was replaced. This cat was admitted to an emergency clinic 2 days later. Both of these cats underwent surgical repair of tracheal rupture because of worsening respiratory status and subcutaneous emphysema. All 4 cats in this study that had surgery had a tracheal rupture at a location consistent with that of the endotracheal tube cuff (Fig 3). On the basis of a recent study in which cadavers were used, over-inflation of the endotracheal tube cuff is
the most likely cause of tracheal rupture. Tracheal ruptures in humans secondary to overinflation of the endotracheal tube cuff have also been reported.\(^1\)

Disconnecting the endotracheal tube from the anesthetic circuit is recommended when changing an animal’s recumbent position during surgery, because rotation of the endotracheal tube and cuff could result in tracheal disruption. In this study, all except 3 referral practices reported they disconnected the anesthetic circuit when turning the cat during a procedure; this potential cause of tracheal rupture in cats was not supported in a recent study.\(^1\)

In 2 cats, both referred by the same clinic, tracheal rupture was thought to be trauma-induced by a stylet. A technician at this practice used a coat hanger stylet that extended beyond the distal end of the endotracheal tube. Both of these cats subsequently died. One cat died before any treatment could be attempted; the other cat died after surgery. Although thought to be caused by the stylet, the tracheal rupture seen at surgery was identical in appearance to ruptures in other cats that were not intubated with the assistance of a stylet. It is possible that the stylet initiated the rupture, and the rupture was further propagated by the endotracheal tube cuff, or more likely, the stylet was not the cause of the tracheal rupture.

Both HPLV and LPHV endotracheal tubes were used in the cats of this study. In general, these tubes can be identified by the appearance of the cuff as it is attached on the endotracheal tube. High pressure, low volume endotracheal tubes have a cuff that lies flat on the endotracheal tube surface, whereas the cuffs on LPHV tubes are raised away from the tube (Fig 4). It has been reported that either type of tube, if overinflated, can cause tracheal rupture.\(^1\) Endotracheal tube usage, rather than tube type, may be more important in causing tracheal rupture; if extent of cuff inflation is evaluated only by palpation of the pilot balloon, cuff overinflation is a definite possibility.

Deflation of the cuff at extubation was not assessed in this study. Extubation of the endotracheal tube with the cuff inflated is thought to help avoid aspiration of fluid and debris. A preferred technique may be to pack the oropharynx with gauze.

Most of the cats in this study were intubated for dental prophylaxis. In a recent study, 12 of 16 cats with tracheal rupture that were evaluated for signs of subcutaneous emphysema had received dental prophylaxis. It is possible that changes in head position during a dental procedure may cause excessive manipulation of the endotracheal tube and cuff, resulting in trauma to the trachea. However, overinflation of the endotracheal tube cuff to ensure that fluid and debris is not aspirated is the most likely cause of tracheal rupture in the cats in this study.\(^1\) Cats receiving dental prophylaxis were older than the other cats with tracheal rupture; therefore, age may or may not be a contributing factor in the cause of this disorder.

Determination of the most appropriate treatment for cats with tracheal rupture requires serial evaluation of respiratory status and subcutaneous emphysema. Medical treatment was successful for all 15 cats with moderate signs of dyspnea and static subcutaneous emphysema. Cats with severe dyspnea, as evidenced by open-mouth breathing despite treatment with oxygen, or worsening subcutaneous emphysema, required surgery. A ventral cervical midline approach with a partial median sternotomy provided adequate exposure to the tracheal ruptures. A moderate amount of manipulation of the trachea is required to access the defect on the dorsolateral surface of the trachea. The defect can be repaired with absorbable or nonabsorbable suture in a simple continuous or simple interrupted pattern. None of the surviving cats have had respiratory problems since medical or surgical treatment of the tracheal rupture.

References