**History**

A 1.5-year-old neutered male domestic shorthair cat was evaluated at an emergency veterinary hospital immediately after vehicular trauma. Blood in the cat’s mouth and around the nose, severe dyspnea, and instability of the pelvic limbs were noted on initial examination. Radiographic findings included a complete left femoral diaphyseal fracture, fracture of the left maxillary canine tooth, a minimally displaced mandibular symphyseal fracture, and moderate bilateral pneumothorax. The cat was hospitalized overnight in an oxygen cage (40% oxygen) and monitored. The following day, the patient was transferred to its regular veterinarian; the cat was sedated (protocol unknown), and orotracheal intubation was attempted but was unsuccessful because of coughing and possible iatrogenic laryngospasm. Traces of blood were noted on the endotracheal tube, possibly resulting from iatrogenic trauma during attempted intubation or from preexisting oral lesions caused by the vehicular trauma. A splint bandage was placed on the left pelvic limb to stabilize the fracture, and buprenorphine (unknown dose, IV) was administered for analgesia. The cat was hospitalized, and its physical condition improved over the course of 2 days. The patient was then referred to the Small Animal Emergency Service at the University of Georgia Veterinary Teaching Hospital for further supportive care and treatment of the femoral fracture.

On examination, the cat was bright, alert, and responsive, with pink mucous membranes and capillary refill time < 2 seconds. The cat’s body condition score was 5 on a scale from 1 to 9, and body weight was 4 kg (8.8 lb). Rectal temperature was 39.1°C (102.4°F), heart rate was 220 beats/min, and respiratory rate was 40 breaths/min. On thoracic auscultation, heart and lung sounds were normal and the patient was eupneic. Results of an initial CBC and serum biochemical panel were within reference limits, and extra abdominal radiographs and ECG were normal. A 22-gauge catheter was placed in the right cephalic vein, and buprenorphine (10 µg/kg [4.35 µg/lb], IV, q 6 h) was administered. The splint bandage on the left pelvic limb was removed, and a new one was applied.

Right lateral and ventrodorsal thoracic radiographs were obtained (3.2 mAs and 85 kVp; Figure 1).\(^b\) A well-defined and sharply margined radiolucent lesion was associated with the right lateral aspect of the trachea, at the level of the second to fourth intercostal spaces. The adjacent ventral margin of the trachea was indistinct on the lateral view, with mild narrowing of the trachea evident at the level of the fourth intercostal space. The following day, the patient was sedated with butorphanol (0.4 mg/kg [0.18 mg/lb], IV) and dexmedetomidine (5 µg/kg [2.27 µg/lb], IV) and supplemental oxygen was administered via face mask. The cat was then positioned in sternal recumbency for CT of the thorax (200 mA and 120 kVp).\(^c\) One-millimeter-thick transverse images were acquired from the level of C1 through the caudal aspect of the thorax before and after contrast agent administration. Iohexol\(^d\) (330 mg of I/mL) was administered (600 mg of I/kg [272.73 mg/lb]) via a cephalic vein at 3.4 mL/s with a pressure injector. Computed tomography revealed that from the level of T2 to T3 to the midbody of T4, the trachea was abruptly dilated with moderately undulant margins. At the rostral and caudal aspects of the dilated area, there was discontinuity of the faint mucosal contrast enhancement evident on the postcontrast images. Immediately caudal to this area, the trachea was focally narrowed. The length of the

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tracheal dilation as measured on CT images was 1.9 cm. There was no evidence of pneumomediastinum or pneumothorax (Figure 2). Atipamezole (50 µg/kg [22.73 µg/lb], IM) was administered at the completion of CT. On the basis of results of diagnostic imaging, a diagnosis of intrathoracic tracheal avulsion with subsequent pseudoairway was made. Surgical repair of the tracheal avulsion via a lateral thoracotomy was planned for the following day. Food but not water was withheld overnight.

**Question**

What are the important preanesthetic considerations for this patient? How will an airway be established and maintained during general anesthesia, and how should this cat be managed during and after surgery?

**Answer**

In this cat with intrathoracic tracheal avulsion, induction of general anesthesia by means of IV premedication and IV administration of anesthetics followed by endotracheal intubation and administration of isoflurane in oxygen for anesthetic maintenance was planned. Accurate measurements of the tracheal internal diameter cranial and caudal to the avulsion site were made on CT images (diameter of proximal segment, 9.0 mm; diameter of distal segment, 8.7 mm; length of distal segment, 2.9 cm), and a sterile Murphy endotracheal tube (internal diameter, 5.0 mm; outer diameter, 6.7 mm) with a high-volume low-pressure cuff was selected. The length of the endotracheal tube from the proximal end of the cuff to the tip of the bevel was measured and compared with the length of the distal segment of the trachea (from the avulsion site to the carina) on CT images to confirm the appropriate tube size. This measurement was obtained to avoid endobronchial intubation and to ensure that the cuff of the endotracheal tube would be positioned in the distal segment of the trachea, caudal to the surgical field and lesion.

The cat was sedated with dexmedetomidine (7 µg/kg [3.18 mg/lb], IV) and ketamine (2 mg/kg [0.9 mg/lb], IV), and supplemental oxygen was administered via face mask during surgical preparation until orotracheal intubation was performed. A bronchoscope (diameter, 3.8 mm) was inserted into the endotracheal tube lumen and used as astylet as well as to allow direct examination during intubation. Ketamine (5 mg/kg, IV) and midazolam (0.2 mg/kg [0.09 mg/lb], IV) followed by propofol (1 mg/kg [0.45 mg/lb], IV) were administered to induce general anesthesia. Lidocaine (1 mg/kg; total volume, 0.2 mL) was then sprayed on the arytenoids to facilitate orotracheal intubation. Monitoring included oxygen saturation measured by means of pulse oximetry (SpO₂), end-tidal PCO₂, respiratory rate, blood pressure and pulse rate via Doppler ultrasonic flow detector, lead II ECG, and rectal temperature.

With the patient stable, the bronchoscope was used to evaluate the glottis and confirm the appropriate endotracheal tube size, to visualize the tracheal avulsion, and to place the endotracheal tube into the distal segment of the trachea with the cuff past the avulsion site. The mandibular fracture did not interfere with endotracheal tube placement, and orotracheal intubation was uncomplicated. A complete tracheobronchoscopy was not performed because of a sudden decrease in SpO₂ (from 98% to 86%), which was thought to be a result of partial airway obstruction caused by the endoscope as well as possible hypoventilation induced by propofol administration. When this evidence of hypoxemia occurred, the bronchoscope was quickly removed and the proximal end of the endotracheal tube was connected to a non-rebreathing system. General anesthesia was maintained with isoflurane in oxygen (1 L/min), and a bolus of fentanyl (5 µg/kg, IV) was administered, followed by constant rate infusion of fentanyl (5 µg/kg/h, IV). After the patient was connected to the breathing circuit, the SpO₂ returned to normal (98%) after approximately 2 minutes. A balanced electrolyte solution (5 mL/kg/h, IV) was administered throughout surgery.

**Outcome**

Local anesthesia was provided by perineural injection of 2 intercostal nerves cranial and 2 intercostal nerves caudal to the right fourth intercostal space with 0.3% bupivacaine (total dose, 2 mg/kg; 0.4 mL/site of injection). A right fourth intercostal thoracotomy was performed to access the lesion, and mechanical intermittent positive pressure ventilation (IPPV) was instituted. The right middle lung lobe was retracted caudally. A 2-cm pseudoairway was identified within the mediastinum approximately 3.5 cm cranial to
the carina. Sharp and blunt dissection was used to expose the avulsed trachea. The abnormal mediastinal tissue surrounding the trachea and the proximal and distal ends of the avulsion site were sharply debrided. Tracheal anastomosis was performed with 4-0 monofilament absorbable suture (polydioxanone) in a simple interrupted pattern. The thoracic cavity was lavaged with sterile saline (0.9% NaCl) solution, and negative intrathoracic pressure was reestablished after the thorax was closed routinely. On extubation, traces of blood were present on the endotracheal tube, but no complications occurred in the postoperative period. The patient was transferred to the intensive care unit, and fentanyl constant rate infusion (5 mg/kg/h, IV) was continued for 12 hours after surgery. Postoperative treatment included buprenorphine (20 μg/kg [9.1 mg/lb], oral transmucosally, q 8 h) after fentanyl was discontinued, amoxicillin-potassium clavulanate (15 mg/kg [6.8 mg/lb], q 12 h), and enrofloxacin (5 mg/kg, q 24 h). The owner elected to medically manage the femoral fracture and other injuries, and the cat was discharged from the hospital 5 days after surgery. At a 3-week follow-up examination, the cat appeared in good condition with no signs of respiratory distress. Right lateral and ventrodorsal thoracic radiographs showed complete resolution of the tracheal avulsion. Three months later, the cat still had mild weight-bearing lameness on the left pelvic limb, but on palpation and radiographic examination of the fracture site, a large amount of bony callus was present, indicative of fracture healing by second intention. A bony callus was also palpable at the site of the mandibular fracture.

Discussion

Intrathoracic tracheal avulsion is an uncommon but well-described condition in cats caused by hyperextension of the head and neck during blunt trauma. The separation of the tracheal rings usually occurs in the cranial part of the intrathoracic trachea, but avulsion adjacent to the carina with involvement of the mainstem bronchi has also been reported. Evidently when the trachea is ruptured, a thin line of adventitia maintains a patent airway and creates the pseudoairway. Tracheal rupture has been reported in feline patients. Several causes of tracheal rupture in cats have been described, including traumatic intubation, repositioning of the patient without disconnection of the endotracheal tube from the Y-piece of the breathing system, overinflation of the endotracheal tube cuff, and extubation prior to deflation of the endotracheal tube cuff. Because the cat described in the present report had been the victim of vehicular trauma, this was assumed to be the most likely cause of tracheal avulsion. Prior to surgery, an attempt to intubate the patient with sedation was made. Induction of general anesthesia is paramount before attempting orotracheal intubation in cats. If an adequate plane of general anesthesia is not achieved, intubation may result in laryngospasm and pharyngeal and tracheal trauma. We cannot rule out the possibility that previous intubation attempts caused or worsened the tracheal avulsion in this cat. Historically, thoracic radiography has been the mainstay of diagnosis, with CT used selectively to further evaluate the lesion and the thoracic anatomy. Radiographically, common findings include a ballooned radiolucent area near the cranial part of the intrathoracic trachea with the absence of visible tracheal rings. At the rostral and caudal margins of the pseudoairway, tracheal narrowing may be present, particularly in more chronic cases. In the patient described in this report, CT was helpful to confirm the diagnosis, assess the extent and anatomy of the avulsion and pseudoairway, and evaluate for concurrent thoracic trauma. Specifically, CT was helpful in providing measurements of the diameter and length of the pseudoairway and the proximal and distal segments of the trachea for anesthetic planning purposes. These measurements could have been obtained from the radiographs, but superimposition of structures, particularly on the ventrodorsal view, and inherent magnification by this modality can make obtaining precise measurements difficult and prone to error. Computed tomography overcomes these limitations by imaging a volume of tissue, which is displayed as a 2-D image, without superimposition of structures and magnification, and thus we suggest it is the preferred imaging modality for obtaining such measurements.

Butorphanol, a κ-receptor agonist and μ-receptor antagonist opioid, and dexmedetomidine, an α₂- adrenergic receptor agonist, were administered IV to acquire the CT images in this cat. This protocol was selected to achieve adequate sedation for the procedure without causing marked respiratory depression. Dexmedetomidine with ketamine and midazolam with ketamine were used to sedate the cat and induce general anesthesia for the surgical procedure. Ketamine, a dissociative anesthetic, and diazepam, a benzodiazepine, have minimal effect on ventilation. A small dose of propofol was added during induction to prevent coughing during bronchoscopy and intubation. Propofol is a short-acting hypnotic anesthetic agent, which causes dose-dependent respiratory depression. The induction dose, after sedation, ranges between 4 and 6 mg/kg (1.82 and 2.73 mg/lb). Midazolam and ketamine were used as main induction agents instead of propofol, in an effort to decrease the amount of propofol required to suppress the cough reflex and, consequently, to try to minimize respiratory depression. The cat of this report had signs of hypoxemia during bronchoscopy. The bronchoscope reduced the airway diameter and, likely, represented the main cause of hypoxemia. However, it cannot be excluded that the small amount of propofol, in addition to other sedative and induction drugs, contributed to the hypoxemic event.

Anesthetic management of cats with tracheal rupture or avulsion can be challenging, and different techniques have been described. Some clinicians prefer the use of total IV protocols for anesthesia to decrease potential interference of the endotracheal tube with the surgical repair and decrease the escape of volatile anesthetics during surgery, resulting in environmental pollution and inadequate inhalation anesthetic delivered to the patient. Oxygen can be provided to such patients via face mask or jet ventilation. The disadvantages are lack of protection of the airway, inability to provide IPPV, and cost and limited availability of a jet ventilator. Another technique involves orotracheal intubation with an uncuffed endotracheal tube, which is replaced by a sterile cuffed endotracheal tube during surgery. The first tube is retrieved while the second is inserted in the distal segment of the trachea via the thoracotomy incision. Before the tracheal anastomosis is completed, the
second endotracheal tube is replaced with another one placed via orotracheal intubation. The disadvantages of this technique are the presence of the endotracheal tube in thoracotomy site and the increased risk of iatrogenic tracheal trauma due to multiple intubations. In cats, endotracheal intubation is not without risk and may result in tracheal rupture. The feline airway is small and more sensitive to trauma, spasm, and edema than that of other species, and orotracheal intubation has been reported to increase the risk of death in anesthetized cats. A third technique includes endotracheal tube placement proximal to the avulsion site. Once the thoracic cavity and the pseudoairway are entered, the surgeon manually guides the endotracheal tube into the distal segment of the trachea. When this technique is used, care should be taken if IPPV is instituted. Because the endotracheal tube is initially positioned proximal to the avulsion site, the positive pressure delivered to the airway can potentially rupture the pseudoairway.

In the patient described in this report, a bronchoscope was used to evaluate the glottis and confirm the correct choice of endotracheal tube size, to visualize the tracheal defect, and to facilitate the placement of the endotracheal tube in the trachea caudal to the lesion. This technique enabled direct visualization of the tracheal avulsion and also provided a secure means to intubate the distal segment of the trachea, avoiding multiple intubations that could potentially cause further tracheal damage. With this technique, the bronchoscope will effectively reduce the airway diameter, increasing the chance of hypoxemia. It is paramount that these patients are continuously monitored (SpO₂, ECG, blood pressure, pulse quality, and mucous membranes) before and during the induction of anesthesia and that the anesthesiologist be ready to provide oxygen and other treatments in case of complications. Other disadvantages of this technique are cost and the requirement for a bronchoscope. Size of the patient and the endotracheal tube are other considerations; the smallest bronchoscopes available have an external diameter of 3 mm, enabling use with endotracheal tubes with an internal diameter ≥ 3.5 mm. For smaller endotracheal tubes, a rigid scope or a fiberoptic stylet could be used for this purpose.

Regardless of the technique used to secure and maintain the airway, cats with intrathoracic tracheal avulsion caused by blunt trauma should be considered at high risk (American Society of Anesthesiologists class IV) prior to and during anesthesia. A complete physical examination, laboratory tests including CBC and serum biochemical analysis, thoracic and abdominal radiography, and ECG should be performed before anesthesia to assess the patient for respiratory distress, shock, anemia from blood loss, organ dysfunction, and presence of pneumomediastinum, pneumothorax, and arrhythmias caused by the trauma. Patients should be stabilized before the anesthetic event if possible. An appropriate choice of preanesthetic sedation and preoxygenation before induction of general anesthesia may prevent exacerbation of respiratory distress and minimize the chance of hypoxemia during intubation. Monitoring the patient during the anesthetic event is of paramount importance to rapidly detect complications such as hypoxemia, arrhythmias, and excessive blood loss. Mechanical ventilation should be avoided to prevent rupture of the pseudoairway. However, if the patient cannot spontaneously ventilate to maintain a normal SpO₂, gentle manual ventilation with peak inspiratory pressure < 10 cm H₂O (instead of the typical 15 to 20 cm H₂O) can be applied. Pain should be treated appropriately during the surgical procedure and in the postoperative period. At the end of the procedure, when negative intrathoracic pressure has been reestablished, the patient should be monitored closely for any complications including signs of respiratory distress.

In the cat described in the present report, preoperative CT helped to identify the correct size and length of the endotracheal tube, avoiding additional trauma to the trachea and inadvertent endobronchial intubation. The use of the bronchoscope during intubation ensured correct placement of the endotracheal tube in the distal segment of the trachea, allowing rapid and efficient protection of the airway and the option to initiate IPPV when the thoracic cavity was entered.

References