Lower respiratory tract endoscopy in the cat: Diagnostic approach to bronchial disease
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What is This?
LOWER RESPIRATORY TRACT ENDOSCOPY IN THE CAT
Diagnostic approach to bronchial disease

Jonathan D Dear and Lynelle R Johnson

Why consider bronchoscopy over blind sampling?

Endoscopy of the respiratory tract is invaluable in the diagnostic work-up of animals with respiratory disease. Laryngeal examination is indicated for cats with upper airway complaints such as voice change or inspiratory difficulty and can easily be performed as a sole procedure or immediately prior to lower airway evaluation. The cat with a cough, respiratory difficulty or tachypnea is likely to have lower airway or parenchymal disease and is best examined by bronchoscopy.

Bronchoscopic evaluation of the respiratory tract allows visualization of airway abnormalities as well as collection of bronchoalveolar lavage (BAL) samples to investigate respiratory tract disease in cats.1,2 Due to the small airway diameter in cats, necessitating specialized endoscopic equipment, and the potential for life-threatening bronchoconstriction in feline patients, bronchoscopy is often reserved for severe, refractory or tertiary referral cases. Despite the potential risk associated with the procedure, bronchoscopy can be performed safely in the vast majority of cases when the animal is examined by an experienced individual.3

Clinicians sometimes elect to perform blind endotracheal BAL due to concerns about anesthesia or the lack of appropriate equipment.4 While this technique might provide an appropriate cytology sample, bronchoscopy offers many advantages over blind sampling techniques through the ability to visualize the airway and to obtain samples from specific lung lobes.5 Airway lesions tend to be less dramatic in cats than in dogs; nonetheless, there is more to learn by performing a complete examination of the airways.

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A thorough laryngeal examination is warranted in any cat anesthetized for a respiratory procedure because hyperemia, accumulation of secretions and edema are often found with lower airway disease.
Indications

Endoscopic examination of the respiratory tract undoubtedly contributes to diagnostic assessment and also allows therapeutic intervention in cats with obstructive large airway disease. As mentioned above, laryngoscopy is indicated for cats with clinical signs related to upper airway obstruction such as stertor or stridor. Gagging, voice change and inspiratory noise or effort are also indications for laryngoscopy. Some of these signs can be seen with cervical tracheal lesions and will require tracheoscopy. Radiographs of the region are helpful in localizing the lesion and determining whether laryngoscopy, tracheoscopy or bronchoscopy might be required. Importantly, a thorough laryngeal examination should be performed in any cat anesthetized for a respiratory procedure because hyperemia, accumulation of secretions and edema are often found in conjunction with lower airway disease and can contribute to clinical signs.

A common indication for bronchoscopy is to document a specific cause for acute or chronic coughing. Coughing is usually associated with an infectious or inflammatory etiology. However, other causes include airway collapse, bronchiectasis or foreign body aspiration. Bronchoscopy can also be helpful in determining the etiology for respiratory difficulty or tachypnea associated with lung disease. However, caution is particularly warranted in these cases because of the risks associated with anesthetizing a cat in respiratory distress.

Bronchoscopy with BAL is useful primarily in airway-oriented processes; its utility is limited in cases of interstitial lung disease and respiratory neoplasia due to the lack of cellular infiltration into the airways. While an endoscopic biopsy or brushing can detect neoplasia that is endobronchial, these lesions are rare and typically require a lung biopsy to obtain a histologic diagnosis.7,8

Another advantage of performing bronchoscopy rather than blind BAL is the unique ability to undertake therapeutic interventions. For example, bronchoscopy can be used to visualize and remove foreign material.9 It can also assist in debulking or removing airway-associated masses.10 Finally, airway samples can be collected from specific sites for cytologic or histopathologic evaluation using endoscopic brushes, transbronchial aspiration needles and endoscopy biopsy forceps.

In instances where surgical disease might be encountered (ie, significant laryngeal disease, obstructive tracheal or bronchial masses, or when there is the potential for pneumothorax to develop because of bullous disease), it is essential that appropriate surgical facilities are available following the diagnostic procedure. This will decrease patient morbidity as well as potential mortality and will facilitate transfer of care. While bronchoscopy can be safely performed in many animals, the procedure should be avoided in cats that are not suitable for anesthesia. This includes cats with severe obstructive upper or lower airway disease that cannot be stabilized, cats with severe parenchymal disease or those with unidentified compromise of ventilation or perfusion.
Specialized endoscopes are required for bronchoscopic evaluation of cats. The ideal flexible endoscope would have an insertion tube outer diameter of 2.5–4.0 mm (Figure 1), working insertion tube length of 55–60 cm (longer endoscopes are cumbersome to manipulate within the airway), a biopsy channel diameter of 1.2–2.0 mm, an excellent light source and, preferably, image capture capability for archiving findings. By convention, two-way deflection endoscopes are used most commonly for respiratory endoscopy. Larger endoscopes (ie, pediatric gastroscopes) have a larger biopsy channel and four-way tip deflection, which are useful for foreign body removal. However, the larger insertion tube diameter precludes evaluation of all airways in the cat as well as ‘wedging’ into distal airways for BAL fluid collection.

Rigid endoscopic telescopes can also be used for evaluation of the upper airways and trachea. Extreme care should be taken to avoid iatrogenic damage to the trachea – perforation can lead to pneumothorax or pneumomediastinum. These scopes also do not allow directed sampling of the airways through BAL.

Appropriate ventilation of feline patients can be difficult during bronchoscopy and is one of the more challenging aspects of the procedure. Some endoscopists elect to stabilize the animal under gas anesthesia and periodically extubate for bronchoscopic examination. Specialized adaptors attached to an endotracheal tube allow administration of oxygen and anesthetic gas during the procedure; however, bronchoscopes used in cats will obstruct the lumen of the adaptor and endotracheal tube, resulting in hypoventilation and hypercapnia. Smaller bronchoscopes (2.8–3.8 mm) and ureteroscopes are also too delicate to pass through endotracheal tube adaptors and thus adaptors attached to the endotracheal tube are rarely used in feline bronchoscopy.

Ancillary tools

Ancillary supplies that are useful for sample collection include endoscopic cytology (and microbiology) brushes, transbronchial aspiration (Wang) needles, and a variety of flexible and rigid biopsy instruments and snares (Figure 2). The size of the biopsy channel must be taken into consideration when selecting these instruments. For a 1.2 mm channel (generally found in 2.8–3.8 mm endoscopes), instruments such as biopsy forceps and brushes are sized at 1.0 mm, while in a 5.0 mm endoscope with a 2.0 mm channel, a greater variety of instruments can be used, including wire snares, three-prong grabbers, and Wang needles with a diameter of 1.8 mm.

In some practices, suction trap devices are used to collect BAL samples via a tracheal catheter or endoscopic biopsy channel and these can be utilized in line with house suction (Figure 3).

Cleaning of equipment

Lower respiratory endoscopy should be considered a clean procedure and, therefore, facilities should exist for proper cleaning of both endoscopes and ancillary supplies. After finishing the procedure, suction, air and water channels (if present) should be leak tested and gross organic material removed from the scope manually with a commercially available enzymatic cleaner. Next the scope should either be disinfected with high-level glutaraldehyde or sterilized by autoclave, as appropriate. Endoscopic instruments should similarly be cleaned using an ultrasonic cleaner with enzymatic cleaning solution followed by autoclave sterilization.
Pulse oximetry is valuable as a baseline assessment prior to bronchoscopy and useful for ongoing patient monitoring following the procedure and into treatment.

**Patient assessment and preparation**

It is important to gauge the severity of respiratory compromise and to localize disease prior to performing respiratory investigations because clinical signs can worsen during recovery from anesthesia. Respiratory rate and effort are easy clinical parameters to assess. In addition to thoracic and cervical radiographs, pulse oximetry is recommended prior to anesthesia. If SPO2 readings do not exceed 95%, hypoxemia is likely and arterial blood gas measurement is recommended when possible. While hypoxemia is not necessarily a contraindication to bronchoscopy, pulse oximetry is valuable as a baseline assessment prior to the procedure and useful for comparison with post-procedural values. Similarly, pulse oximetry is useful as a baseline for ongoing patient monitoring following bronchoscopy and into treatment.

Bronchoscopy is typically performed with the patient in sternal recumbency with the head elevated near the edge of the table, although some clinicians prefer lateral recumbency. Terbutaline (0.01 mg/kg SC) administered before the procedure and immediately before BAL reduces the risk of life-threatening bronchoconstriction and enhances the safety of the procedure.3,6 While inhaled albuterol might be equally effective, bronchoconstriction and at times it is necessary to administer doxapram to stimulate the respiratory cycle for proper assessment of laryngeal motion. A summary of intravenous protocols is provided in Table 1.

In cases of upper airway obstruction (laryngeal paralysis or airway-associated masses), preparations should be made to provide for temporary tracheostomy if needed to allow appropriate recovery. In the case of absent ventilation following extubation, the animal should be re-intubated and mechanical ventilation provided.

**Laryngoscopy procedure**

Immediately on induction, a careful laryngeal examination should be performed, especially when there is clinical evidence of upper airway disease or obstruction. It is important that laryngeal function is evaluated under a light plane of anesthesia. Rigid telescopes are easier to maneuver within the caudal oropharynx and provide excellent illumination and magnification. It is essential to have an assistant announce the respiratory cycle to the clinician to allow monitoring for appropriate laryngeal movement (abduction of the arytenoid cartilages) corresponds to inspiration. Paradoxical laryngeal motion can be mistaken for normal movement; therefore, it is critical to ensure that the abduction (outward movement of the arytenoid cartilages during inspiration) provides a smooth and balanced anesthetic induction; however, it is most important that the anesthetic regimen is tailored to the patient. Propofol often causes apnea during induction and at times it is necessary to administer doxapram to stimulate the respiratory cycle for proper assessment of laryngeal motion.

**Table 1** Drugs used for respiratory endoscopy

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dose</th>
<th>Route</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anesthetic agents</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propofol (10 mg/ml) and midazolam (2 mg/ml)</td>
<td>2–4 mg/kg slowly, then CRI (0.1–0.4 mg/kg/min) and 0.1–0.3 mg/kg</td>
<td>IV</td>
</tr>
<tr>
<td>Ketamine (100 mg/ml) and diazepam (5 mg/ml)</td>
<td>1.0 mg/kg (to effect) and 0.2–0.5 mg/kg (to effect)</td>
<td>IV</td>
</tr>
<tr>
<td><strong>Local anesthetic agents</strong></td>
<td>1 drop per vocal fold</td>
<td>Topically</td>
</tr>
<tr>
<td>Lidocaine (2%)</td>
<td>1 spray</td>
<td>Aerosol</td>
</tr>
<tr>
<td>Aerosolized lidocaine (10%)</td>
<td>0.01 mg/kg</td>
<td>IV, IM or SC</td>
</tr>
<tr>
<td><strong>Bronchodilator</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terbutaline (1 mg/ml)</td>
<td>0.01 mg/kg</td>
<td>IV, IM or SC</td>
</tr>
<tr>
<td><strong>Anti-inflammatory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dexamethasone SP (4 mg/ml)</td>
<td>0.05–0.2 mg/kg</td>
<td>IV, IM or SC</td>
</tr>
</tbody>
</table>
can be diagnosed via cytology or histopathology (Figure 4).

**Tracheoscopy and bronchoscopy procedures**

Before an endoscope is placed into the airways, adequate depth of anesthesia is confirmed and the patient’s mouth is held open with a mouth gag to avoid inadvertent damage to the bronchoscope. Spring-loaded mouth gags should be used with caution due to the potential for extensive jaw opening to compress blood supply and cause cortical blindness in cats.11 Several methods can be used to maintain oxygenation throughout the procedure. A long 16 gauge catheter can be placed down the trachea and attached to a jet ventilator. A sterile open-ended red rubber catheter can be passed to the mid-thoracic trachea and attached to low flow oxygen (<1 l/min). Finally, an endotracheal tube can be inserted for stabilization then removed for endoscopic evaluation. Pre-oxygenation, using either an endotracheal tube or anesthesia mask, can be used to increase the blood oxygen saturation prior to beginning or between procedures. The animal is prepared for appropriate cardiovascular monitoring, including pulse oximetry, direct or indirect blood pressure monitoring and electrocardiography.

Following anesthetic induction and laryngeal examination, topical anesthesia (one drop of 2% lidocaine or aerosolized 10% lidocaine) is administered to reduce the risk of laryngospasm associated with passage of equipment through the larynx.12 Topical preparations containing tetracaine or benzocaine should be avoided in cats due to the risk of oxidative injury and subsequent methemoglobinemia. Care should be taken to direct the scope through the laryngeal aditus without causing excessive irritation to the arytenoid cartilages, laryngeal saccules or vocal folds. By raising and extending the neck, the trachea is straightened, allowing easier access to the lower airways.

The endoscope is advanced down the trachea while maintaining a mid-luminal view to facilitate evaluation of all mucosal surfaces. Normal mucosa appears pale pink to slightly yellow and blood vessels are generally apparent beneath the surface. The trachea can usually be quickly examined because tracheal collapse is a rare finding in cats compared with dogs.13,14 This allows the majority of the procedure time to be spent exploring the lower airways. A systematic approach to evaluation of the lower airways ensures that all are thoroughly examined, remembering that with a cat in sternal recumbency the anatomy will be reversed in relation to the operator’s orientation facing the animal (ie, the right hemithorax appears on the left side of the screen and vice versa).15

The endoscopist must have a firm understanding of the airway branching pattern to perform a comprehensive examination (Figure 5). If location within the lower airways is unknown, the endoscope is retracted back into the trachea until the carina is reached to provide a landmark to regain perspective. Any lesions induced by the scope should be noted in the report to prevent misinterpretation as a sign of pathology.
Bronchoalveolar lavage

Prior to performing BAL, the endoscope should be withdrawn orally, the external surface wiped with saline-soaked sponges and the biopsy channel flushed with sterile saline to remove any airway material. The endoscope can then be reintroduced and advanced into the lower airways, taking care to avoid oropharyngeal contamination while maintaining a luminal view. This will minimize contamination of the endoscope tip and iatrogenic contamination of lavage samples.

BAL is performed by gently advancing the distal tip of the flexible endoscope deep into the terminal airways. Aliquot volume depends on the size of the endoscope and the size of the airway being occluded. In general, 3–5 ml aliquots of warm sterile saline are instilled at each lavage site up to a total of 10–20 ml per cat (total volume 2.5–5 ml/kg). During BAL fluid collection, the tip of the endoscope should be agitated slightly to prevent adherence of the channel to the mucosal wall. If negative pressure is found during aspiration, pressure should be relieved temporarily and the tip of the endoscope should be withdrawn and repositioned before subsequent suction attempts.

BAL samples are collected via the endoscopic biopsy channel into a 20 ml syringe using hand suction. Alternatively, a suction trap can be employed to collect the sample for submission. Approximately 50–75% return of fluid should be anticipated.
Standardization of BAL fluid analysis, interpretation and its relation to clinical disease state is currently lacking in veterinary medicine. A differential cell count is typically used to assess the predominant type of inflammation present, with ‘normal’ reference intervals for cats of 65–80% macrophages, up to 20% eosinophils, 10% lymphocytes and 7% neutrophils.20,21 The value of total cell counts has not been established although 200–400 cells/µl has been reported as an accepted reference range.20,21 Multisegment airway lavage is recommended in animals that are stable throughout the procedure, and airway samples are submitted separately for cytologic analysis. A recent study found different cytologic interpretations in samples from separate lobar sites in approximately half of cases with diffuse lower respiratory tract disease.21 Interestingly, different cytologic findings at two sites were even found in cats that had normal thoracic radiographs.

Suppurative inflammation
Suppurative inflammation is characterized by airway neutrophilia and can indicate a sterile or infectious process (Figure 9).22 Sterile suppurative inflammation is encountered most commonly in chronic bronchitis but also in bronchiectasis or with neoplasia. Septic suppurative inflammation, characterized by degenerate neutrophils with intracellular bacteria, could be considered a reliable indicator of bacterial pneumonia, although culture of such samples is essential to identify species and antimicrobial susceptibilities patterns.

Eosinophilic inflammation
Bronchoalveolar fluid of normal cats can have up to 20% eosinophils and, thus, airway eosinophilia is not always specific for underlying disease in a cat lacking respiratory signs.20,23 However, the presence of excessive eosinophils (>20%) with the corresponding clinical signs of cough, wheeze or tachypnea (in the absence of other disease) is suggestive of feline bronchial disease (Figure 10). Other causes of airway eosinophilia include eosinophilic pneumonitis or granuloma, cardiorespiratory parasites such as Dirofilaria, Aelurostrongylus, Eucoleus or Paragonimus species, systemic hypersensitivity due to external or internal parasites, larval migration of gastrointestinal parasites (Toxocara species), certain fungal (Coccidioides species) organisms or viral (feline herpesvirus-1) pneumonia. These causes should be further investigated with fecal evaluation (Baermann technique and sedimentation) for larvae, fungal titers or heartworm antibody and antigen testing.

Pyogranulomatous inflammation
The majority of nucleated cells identified within a BAL sample should be macrophages and the presence of an elevated cell count with normal differential can be difficult to interpret. However, the presence of activated macrophages and neutrophils, with or without lymphocytes and eosinophils, is suggestive of pyogranulomatous inflammation. This generally occurs in response to significant airway insult and is usually due to chronic disease such as fungal (Histoplasma capsulatum) infection, chronic aspiration pneumonitis, smoke inhalation, bronchiectasis or neoplasia.

Hemorrhagic inflammation
Pulmonary hemorrhage can be found with rodenticide intoxication (vitamin K antagonists), Dirofilaria or Paragonimus species infections, trauma or erosive neoplasms, although these are infrequently encountered in feline patients. Evidence of previous airway hemorrhage (ie, erythrophagocytic macrophages) is common in cats with both congestive heart disease and chronic respiratory disease including feline bronchial disease, neoplasia and pneumonia.24

Neoplastic inflammation
Endobronchial neoplasms are rarely identified in cats but occasionally malignant cells associated with primary or metastatic carcinomas will exfoliate into bronchoalveolar fluid. Pulmonary involvement with lymphoma can also be detected, although this is rare.25 Cytologic markers of malignancy include cellular crowding, variation in cell size or nuclear size and shape, increased nuclear/cytoplasmic ratio and mitotic figures. These conditions can be difficult to confirm cytologically because dysplastic epithelial abnormalities associated with severe, chronic inflammation often mimic neoplastic change. Furthermore, inflammatory changes associated with necrotic lesions within a neoplasm can hinder identification of neoplastic cells. Review of several samples, advanced imaging (computed tomography) and alternate sampling techniques can be required to confirm the presence of an underlying neoplasm.
Airway endoscopy with bronchoalveolar lavage (BAL) can provide crucial diagnostic information and, when combined with clinical history, physical examination and thoracic radiographs, offers a complementary assessment of the upper and lower airways of cats.

Bronchoscopic evaluation provides several advantages over blind BAL sampling techniques including the ability to visually obtain directed lavage samples and to perform other diagnostic and therapeutic procedures.

With appropriate case selection, anesthetic monitoring and training, laryngoscopy, tracheoscopy and bronchoscopy are rewarding additions to a clinician’s diagnostic armamentarium.
References


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