Airway Evaluation and Flexible Endoscopic Procedures in Dogs and Cats: Laryngoscopy, Transtracheal Wash, Tracheobronchoscopy, and Bronchoalveolar Lavage

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KEYWORDS

• Bronchoscopy • Respiratory tract • Airway cytology
• Canine • Feline

Flexible endoscopy is routinely used to visualize and sample the upper and lower respiratory tract. Laryngoscopy is indicated for evaluation of the structure and function of the larynx. Tracheal washes include transtracheal and endotracheal techniques and are minimally invasive diagnostic procedures that blindly collect samples from the respiratory tract. Both of these procedures can be performed in minutes, with limited need for special equipment. For this reason, a wash may be performed as a screening test, before more invasive airway diagnostics. Tracheobronchoscopy is a more invasive diagnostic procedure that allows direct visualization of the lumen and mucosa of the respiratory tree and also facilitates sampling by means of bronchial brushing, biopsy, and bronchoalveolar lavage (BAL). In cases of foreign bodies or aspirated material, tracheobronchoscopy may become a therapeutic intervention. These procedures are reviewed and compared in this report.

LARYNGOSCOPY

Laryngoscopy is indicated for dogs or cats with voice change, stridor, increased inspiratory effort, or exercise intolerance as a primary respiratory sign.[1–3] Most clinicians

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perform this procedure from an oral approach under sedation, with an intubating laryngoscope or penlight and tongue depressor; however, use of a flexible endoscope for laryngoscopy from an oral or transnasal approach (in dogs greater than 20 kg) is also reported.[4] The use of flexible endoscopy from an oral approach enables closer inspection of the area and facilitates taking photographs, if needed, whereas the transnasal approach may decrease the need for deep sedation.[3,4]

In each of these approaches, dogs and cats require sedation. The ideal protocol for this purpose is controversial, because of the concern of interfering with laryngeal function. When using an oral approach, whether by means of an intubating laryngoscope or a flexible endoscope, a depth of anesthesia sufficient to intubate the animal is required to enable open-mouthed restraint for visualization and to suppress the gag reflex. Thiobarbiturates, propofol, and ketamine–diazepam (Valium), with or without premedication, have all been described for this purpose. One small prospective study showed that thiopental was preferred to propofol or other sedative protocols because it exhibited the least depressive effect on laryngeal motion.[5] A case series of dogs undergoing flexible laryngoscopy by way of a transnasal approach reported that the use of premedication only (acepromazine and an opioid) was adequate to facilitate nasal passage of the endoscope without an induction agent, thus avoiding the issue of respiratory depression by the induction agent.[4] However, the use of opioids may also depress the cough reflex sufficient to interfere with assessment of laryngeal function.[3] A prospective study found that doxapram (2.2 mg/kg, intravenous) increased intrinsic laryngeal motion in dogs that were premedicated with an opioid and induced with propofol, thus facilitating evaluation of laryngeal function.[6]

From the oral approach, the clinician depresses the epiglottis and/or restrains the soft palate from obstructing the view; this manipulation is not needed from the transnasal approach, which may allow the larynx to be evaluated in a more normal anatomic position. The larynx is inspected for color, structure, symmetry, motion, and the presence of masses or foreign bodies; however, the most common reason for laryngoscopy is suspicion of laryngeal dysfunction. In the normal animal, both arytenoid cartilages abduct equally with each inspiration. Absence of abduction of the arytenoid cartilages upon inspiration confirms the diagnosis of laryngeal paralysis. Care must be taken to ensure that arytenoid function is evaluated during the inspiratory phase of respiration because passive paradoxic movement of the arytenoids may be observed during forceful expiration and may be mistaken for true abduction. This may be achieved by an assistant verbalizing the phase of breathing, for example, ''in'' and ''out,'' while the larynx is monitored. Unilateral or bilateral laryngeal paresis or paralysis occurs in dogs and rarely in cats.[2] Most dogs with laryngeal paralysis also have erythematous vocal folds because of turbulent airflow; in cats, the paralyzed laryngeal folds may appear soft or floppy, and may seem to flutter upon expiration.[3] The laryngospasm that occurs in cats associated with any manipulation of the pharyngeal area can be confusing and must not be interpreted as laryngeal paralysis. One investigator notes that the arytenoids in such cats should normally appear firm and tight and will be observed to move after a sufficient period of waiting. The same investigator suggests that particularly challenging cases may be clarified by closing the sedated cat's mouth over a rigid laryngoscope to minimize stimulation of laryngospasm for a longer period of observation.[3]

Regardless of the anesthetic protocol or the approach chosen, it is essential to avoid an erroneous diagnosis of laryngeal paralysis based on shallow breathing as a result of too deep a plane of sedation, inadvertent pressure on the glottis by the blade of the laryngoscope, and/or positioning the neck at an acute angle that obscures visualization of both vocal folds.[1,2] Though suspicion of laryngeal paralysis is the most

common reason that laryngoscopy is performed, it is critical that the clinician has knowledge of less common laryngeal disease processes, such as laryngitis, laryngeal masses, or laryngeal collapse. Laryngeal collapse is a loss of cartilage rigidity that allows medial deviation of the components of the larynx and is generally secondary to chronic upper airway obstruction in brachycephalic dogs. Thorough knowledge of normal anatomy and the appearance of normal arytenoid movement enables recognition of these anatomic changes. Surgical management of laryngeal paralysis and laryngeal collapse are significantly different and have been reviewed.[7]

TRANSTRACHEAL WASH

Cooperative dogs of medium size or larger are candidates for transtracheal wash (TTW), whereas smaller dogs, cats, or uncooperative patients of either species are better suited to endotracheal wash (ETW). Although consensus does not exist on a size cut-off for TTW, this author prefers ETW for dogs less than 7 kg and for all cats. Both washing techniques are used to obtain diagnostic samples from nonspecific regions of the proximal respiratory tree, although TTW can also obtain material from deeper regions, as the animal is able to cough during the procedure. In either case, infectious, inflammatory, and neoplastic conditions may be diagnosed.[8]

TTW is performed with the patient awake, which is one of its advantages. An awake dog coughs during the procedure, increasing the likelihood of obtaining diagnostic material from the airways. TTW is contraindicated in fractious or aggressive dogs because of the risk for tracheal or handler injury. Dyspneic dogs or dogs that may progress to a dyspneic state when stressed also have better diagnostic alternatives than TTW.[8]

Comfortably, but firmly, restrain the patient in sternal recumbency, with its nose slightly elevated. The TTW procedure takes several minutes, and the patient will need to maintain this position. Lidocaine (2%) is infused intradermally and subcutaneously for local anesthesia and requires at least 10 minutes to take effect. Clip a wide square over the ventral neck, encompassing the larynx and proximal cervical trachea, and prepare it using sterile gloves and surgical scrub (eg, 4% chlorhexidine).

Several catheters have been used, but this author prefers a long through-the-needle, intravenous catheter (eg, Venocath, Abbott Labs, Abbott Park, Ilinois or Intracath, BD, Franklin Lakes, New Jersey), for its ease and speed of use and the ability to remove the sharp needle from the trachea once the catheter has been introduced. After the skin is prepared, palpate the cricothyroid ligament with a gloved finger as a half-circular, slightly yielding depression distal to the firm and prominent thyroid cartilage. With the bevel facing ventrally, introduce the needle through the skin and through the cricothyroid ligament, into the tracheal lumen. Resistance, followed by a light pop, is felt as the cricothyroid ligament is crossed, at which point the advancement of the needle is stopped. Gently angle the tip of the needle down approximately 45° and advance the catheter through the needle. If the needle is properly positioned, the catheter feeds easily down the open tracheal lumen. Resistance suggests that the needle bevel has not fully crossed the ligament or has abutted the dorsal (far) wall of the trachea. Close examination and careful repositioning should allow correction of this situation. Feed the catheter until it locks into the needle hub, then extract the needle and snap its guard into place, leaving only the soft, flexible catheter in the airway.

Attach a preloaded syringe containing 5 to 20 mL of sterile (nonbacteriostatic) 0.9% saline to the catheter and flush the fluid into the trachea. The volume of fluid is proportional to patient size, although there is no consensus as to the dose of TTW fluid per body weight. Typically, the dog begins to cough promptly, but if not, it can be encouraged to do so by coupage. Meanwhile, use the syringe to aspirate fluid and secretions

back though the catheter. Air will also be aspirated, usually in far greater proportion than fluid; air must be evacuated from the syringe to avoid losing any portion of the fluid sample, or additional syringes must be used to continue aspiration. Expect to retrieve a tenth or less of the infused volume. Infuse additional aliquots of saline and recover samples until adequate diagnostic material is obtained.

Gently and firmly extract the catheter from the trachea, and apply a sterile nonadherent gauze square with firm pressure covered by a light neck wrap, which is left in place for the next several hours. Monitor the dog for development of subcutaneous emphysema, which is rare, and usually self-limiting. Samples obtained by TTW are suitable for cytology and culture, as described later, or for special diagnostics, such as polymerase chain reaction (PCR), virus isolation, or specific antigen assays.

Endotracheal Wash

ETW is a similar technique used in patients in whom TTW is not appropriate. ETW requires a brief period of general anesthesia sufficient to permit intubation. Intubation of the patient is achieved with a sterile endotracheal tube by an operator wearing sterile gloves with the patient in sternal or lateral recumbency (with the more severely affected side down). Feed a sterile, red rubber catheter down the endotracheal tube, and use syringes preloaded with sterile (nonbacteriostatic) 0.9% saline to infuse and aspirate as described earlier.

Disadvantages to this procedure include the inability of the patient to cough, which reduces yield, and the possibility of oropharyngeal contamination at the time of intubation. Material collected by ETW is suitable for cytology, culture, or special diagnostics; cytology should always be closely evaluated for evidence of oropharyngeal contamination, such as the presence of *Simonsiella* species organisms, or squamous epithelial cells, as described in more detail below.

TRACHEOBRONCHOSCOPY

Dogs and cats are candidates for tracheobronchoscopy if acute or chronic clinical signs of cough, hemoptysis, stridor, or dyspnea have not been diagnosed by other means.[1,9] Animals with primarily vascular lesions, focal pulmonary lesions, or diffuse interstitial disease may be less likely to benefit from direct visualization of the airways by tracheobronchoscopy. Tracheobronchoscopy is useful in animals with suspected, or confirmed, tracheal collapse, because it provides additional information regarding the severity, extent, and dynamic aspects of collapse that may not be appreciated with radiographic or fluoroscopic examination.[2] Tracheobronchoscopy is most valuable when coupled with BAL for diseases located in the small airways or alveoli.[10] Caution is indicated in patients with severe respiratory compromise, or patients considered high-risk for general anesthesia. In two studies in cats, bronchoscopy and guided sampling diagnosed inflammatory airway disease, bacterial and fungal pneumonia, neoplasia, pulmonary fibrosis, and bronchial collapse/bronchiectasis.[11,12] Comprehensive descriptions of veterinary tracheobronchoscopy equipment and its care and use have been reported.[9,10,13–16]

Anesthesia

The subject of anesthesia for bronchoscopic procedures has been thoroughly addressed, and the reader is referred to these publications for greater detail.[13,17,18] A few points bear special mention.

General anesthesia is required, and most clinicians prefer inhalant anesthesia for all but the smallest patients. In two reviews of bronchoscopy in cats, anesthesia consisted of propofol infusion, and oxygen was provided by jet ventilation.[11,12] Similarly, two reviews of bronchoscopy in dogs described injectable anesthesia without intubation, regardless of the size of the dog.[15,19]

When using inhalant anesthesia, the largest possible, sterile, endotracheal tube is used for intubation. Use a sterile T- or Y-shaped adapter, containing a soft, snug port for the passage of the bronchoscope to connect the endotracheal tube to the anesthetic breathing system. Place a mouth gag to prevent endoscope trauma, should the plane of anesthesia decrease for any reason.

In cats and some small dogs, the bronchoscope may occlude the lumen of an appropriate-sized endotracheal tube sufficiently to prevent simultaneous adequate delivery of oxygen and gas anesthesia. If injectable agents are not chosen in these cases, the examination and diagnostic sampling must be performed in several brief segments. During visual examination, while the bronchoscope occludes the lumen of the endotracheal tube, deliver oxygen to the patient through the working channel of the bronchoscope.[13] After a brief inspection, remove the endoscope and resume anesthetic gas delivery, and repeat the procedure to complete the examination. Diagnostic sampling can be performed on subsequent passes of the endoscope down the endotracheal tube. Other clinicians prefer to anesthetize and stabilize the patient with inhaled agents, then extubate immediately before the bronchoscopic examination, maintaining anesthesia with injectable agents. Application of a topical anesthetic, such as lidocaine, may help decrease laryngospasm in cats any time a bronchoscope is passed in the absence of an endotracheal tube.

In addition to anesthetic premedications, some clinicians advocate premedication with a bronchodilator, such as aminophylline or terbutaline, because of a concern for bronchoconstriction induced by the procedure.[10] Preliminary evidence from a retrospective study in cats suggested that pretreatment with terbutaline for 12 to 24 hours before bronchoscopy reduced the rate of complications seen after bronchoscopy and BAL.[11]

Tracheobronchoscopic Anatomy and Appearance

Canine tracheobronchial anatomy has been described, and a schematic system of nomenclature for reports of bronchoscopic findings has been reported (**Fig. 1**).[20] Most authors accept this anatomic map as a general guideline for use in the cat, and subtle differences in feline anatomy have been described.[15,21] The extent to which lobar, segmental, and subsegmental bronchi can be visualized in a given patient depends upon patient size, bronchoscope diameter and length, and clinician skill. In all but the smallest patients, the endoscope passes easily through the trachea, carina, and right and left mainstem bronchi, and the origins of the lobar bronchi can be visualized. In the largest patients, a bronchoscope of adequate length can be passed through lobar, segmental, and some subsegmental bronchi.

Normal tracheobronchial mucosa is light pink and moist with scant secretions. Submucosal vessels are easily visible, as are tracheal cartilage rings. The dorsal tracheal membrane is visible as a tight, narrow band of tissue firmly fixed to the dorsal wall. The carina appears as a sharp division, and the normal entrances to the right and left principal bronchi are smooth, round, and well defined. Branching of the airways quickly becomes more complex, and size may preclude entry of the endoscope, but all normal branches seen have a well-defined, round, patent orifice.

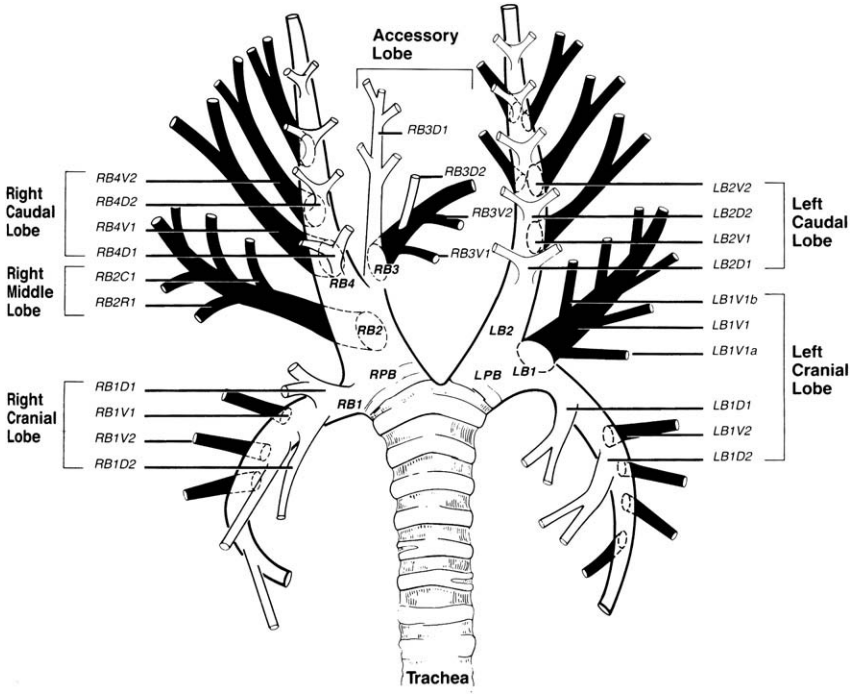

Fig. 1. Bronchoscopic anatomy of the dog. (*From* Amis TC, McKiernan BC. Systematic identification of endobronchial anatomy during bronchoscopy in the dog. Am J Vet Res 1986;47(12):2655; with permission.)

Examination Procedure

With the dog or cat positioned in sternal recumbency, gently pass the bronchoscope through the respiratory tract, and do not use force at any time. Endoscopists familiar with gastrointestinal endoscopy will note the difference between that system, where insufflation is required to maintain lumen patency and the walls yield to pressure as the endoscope passes around turns, and the rigid, patent respiratory tract.

Examine the respiratory tree in a systematic manner, passing down the trachea, into the right mainstem bronchus and each of its subsequent branches to the limit of length of the endoscope or diameter of the airway lumen. Retract the endoscope and enter the opposite bronchus and repeat the procedure. Should the clinician lose track of the anatomic location of the scope at any time, back the endoscope to the level of the carina and resume the examination from there to provide reorientation. Throughout the examination, patency, color and character of mucosa, presence and character of secretions, and presence and location of masses or foreign bodies are observed and recorded. Clinician experience plays a substantial role in the ability to recognize normal versus abnormal tissue.[13] If properly equipped, digital photographs should be made of areas of interest. A standardized reporting form, including an anatomic diagram shown earlier, helps to maintain a consistent approach in each patient. Only after the visual examination is complete should sampling be done.

SAMPLE COLLECTION

Bronchoalveolar Lavage

BAL samples cells and material from the small airways and alveoli, deeper than typically obtained with TTW or ETW. Samples can be obtained from a specific anatomic region, if warranted by endoscopic findings, or from a random selection of sites. Some clinicians do not find BAL reliable for focal lesions because of the difficulty in reliably accessing a specific site and consider it more appropriate for diffuse lower airway disease.[22] BAL is typically performed after visual examination but before any other sampling procedures, such as brushing or biopsy, to avoid altering the results by the presence of iatrogenic hemorrhage.

Pass the endoscope down the trachea toward the region of interest until it wedges in the smallest bronchus that accommodates it. Because overall length of the bronchoscope can limit distal reach, sometimes the tip of the endoscope must be directed into the nearest branching airway at each subsequent level. This may direct the bronchoscope away from the region of interest; however, if there is diffuse disease, wedge the endoscope as distal as possible on the right side, and repeat the procedure on the left.

Successful collection of diagnostic fluid samples requires infusion of an adequate volume of fluid and tight fit of the bronchoscope into the regional bronchus to facilitate recovery of a high percentage of that fluid. However, as is the case with TTW/ETW, there is debate surrounding the ideal dose of fluid for BAL, although most authors do agree that at least two bolus infusions per site should be performed. One author used at least two boluses, 25 mL each, per site of interest in most dogs. For dogs less than 8 kg and all cats, he used at least four boluses, 10 mL each, per site of interest.[10] In a report on dogs, another author used a total volume of 15 to 75 mL per dog, divided into two or more aliquots.[23] In a retrospective study of 68 cats, the mean volume of fluid infused for BAL ranged from 2.62 to 5.05 mL/kg. This corresponded to the use of 5- or 10-mL aliquots, at the preference of the attending clinician.[11] Another feline retrospective used 5- to 20-mL aliquots for BAL, according to the preference of the attending clinician.[12] In dogs, recovery of 40% to 50% of infusate has been reported.[23] In the retrospective of 68 cats, 50% to 75% of the infused fluid was recovered, and the cell counts were considered adequate for cytologic evaluation in 97% of the procedures, independent of infusate volume.[11]

Once the endoscope is wedged, attach a syringe preloaded with the chosen amount of sterile (nonbacteriostatic) 0.9% saline solution to the working channel. Push the saline as a bolus and begin recovery of fluid as soon as infusion is complete. Use the same syringe to forcefully aspirate the working channel. If the bronchoscope is imperfectly wedged, air is frequently aspirated, and the syringe quickly fills with fluid and air. Use a new syringe to continue aspiration, or the original syringe may be detached and its air contents ejected into the room, taking care not to eject any portion of the recovered sample. In some cases, aspiration yields negative pressure without fluid recovery, which is presumed to be because of airway collapse in response to suction. The endoscope should be backed out very slightly if this occurs, and aspiration repeated.[10] An alternate technique used at the author's institution is to attach a suction trap to the suction port of the bronchoscope. Vacuum suction is attached to the suction trap, and the endoscope's suction feature is used to recover the infused fluid immediately after bolus injection through the working channel. In the author's hands, this allows for a greater yield on fluid recovery, without the need for repeated changing or evacuating of syringes. Especially in the case of a large patient, where the endoscope may not be completely wedged into the area of interest, the use

of continuous vacuum suction seems preferable. There are anecdotal concerns of excessively forceful suction and/or disrupted cellular architecture by this technique, but to the author's knowledge, these outcomes have not been reported.

In rare instances, the endoscope will be too short to wedge into a desired region. In these instances, lavage may still be performed as described earlier, with the knowledge that the percentage of fluid recovered will be decreased. Alternatively, clinicians at the author's institution and elsewhere have used a long polytetrafluoroethylene catheter (eg, ASPC-1, Endoscopy Support Services, Brewster, New York) or polyethylene catheter,[15] fed down the working channel of the bronchoscope. Feed the tubing out the end of the endoscope and pass it further down the bronchus until resistance is felt. The tubing can be observed bronchoscopically as it is fed, but its final distal location cannot be seen or controlled. Infuse sterile saline through the catheter as described earlier, and recover the fluid by syringe aspiration. Care must be taken when sampling blindly in this manner, because of the concern that diseased airway is likely more sensitive to trauma by mild pressure.[15] Samples retrieved in this way are heavily mixed with air, but the technique does enable sampling of an otherwise unreachable area.

Samples retrieved by BAL are appropriate for cytology, culture, or special diagnostics, such as PCR, virus isolation, or specific antigen assays. Because multiple infusions are typically performed, samples are generally recovered in discrete syringes. A study evaluated cytology results based on individual samples (first to third) from a patient versus a pooled sample from that same patient and found no difference in results; pooling samples therefore seems appropriate.[24]

Bronchial Brushing

Bronchial brushing may obtain cells that are adherent to the mucosa and are not collected by BAL.[23] Perform the procedure using endoscopic brushes contained within a retractable plastic sheath. Pass the brush down the working channel to the area of interest, and advance it from the plastic sheath; drag it gently over the mucosa in the region of interest, retract it back into the sheath, and then withdraw it from the working channel. Material retrieved by bronchial brushing is suitable for culture or cytology. For culture, the brush end may be transected with sterile scissors and placed into a sterile container for transport to the laboratory, or the brush end may be swirled through culture medium, taking care not to contaminate the medium with the plastic sheath. For cytology, gently roll the brush across glass slides.

Biopsy

Biopsy, using specially designed endoscopic biopsy forceps, is indicated for nodules or masses within the airway lumen.[25] Sample collection is technically difficult because the rigid anatomy of the airways orients the endoscope and biopsy forceps parallel to the lesion.[15] Sample size is also limited by the size of forceps that passes through the working channel; any pieces retrieved are small and are subject to crush artifact at the time of acquisition. [25] Because of these challenges, bronchoscopic biopsy is the least commonly performed bronchoscopic diagnostic sampling technique. Multiple samples are required to assure a consistent finding, but increasing the number of samples also increases the risk of hemorrhage or perforation; an optimal number of biopsy samples has not been determined. [13,25]

SAMPLE SUBMISSION

Cytology

Fluid obtained by TTW, ETW, or BAL and material obtained by bronchial brushing are all suitable for cytologic examination. Cytologic samples may be submitted as fluid or

as prepared slides, depending on the preference of the laboratory and the nature of the material obtained. Fluid submissions enable the laboratory to use cytospin techniques to concentrate low numbers of cells. When submitting samples as fluid, ethylenediaminetetraacetic acid is recommended to preserve cellular morphology.[22]

Presence of infectious agents is also evaluated by cytology, and cytologic findings are used to interpret culture results. As the tracheobronchial tree is not a sterile site in normal dogs, the cytologic finding of intracellular bacteria, particularly as a monomorphic population, is most supportive of true infection.[19,26,27] Again, the finding of *Simonsiella* organisms or squamous epithelial cells on cytology indicates oral contamination and suggests that culture results are suspect. Differences in findings among sampling techniques bear mention here, and the reader is referred to other reports for comprehensive review of normal and abnormal respiratory cytology.[22]

Transtracheal wash or endotracheal wash

Normal cytologic findings from TTW or ETW are cells that are easily washed from the proximal mucosal surface, including respiratory epithelial cells, neutrophils, eosinophils, lymphocytes or macrophages, and mucus. Cytologic descriptions should include estimated cellularity, differential counts, and morphologic descriptors of cells encountered, although precise and accurate cell counts are not possible with this technique.

It is important to recall that neutrophils, macrophages, and eosinophils are part of normal immune surveillance of the respiratory mucosa and are normally found in this site, but their relative frequencies and morphology can be informative.[1] The predominant leukocyte in most small-animal TTW/ETW is the neutrophil.[13,22] However, normal cats may have up to 25% eosinophils recovered.[15,22,27] Mucus is a normal finding on TTW/ETW cytology, but Curschmann's spirals represent inspissated mucus and small-airway obstruction.[22] Although occasional bacteria are seen in normal TTW/ETW samples, special attention should be paid to the finding of intracellular bacteria, especially if the population is monomorphic, and to the presence of fungal elements.[28] Neoplastic cells are of particular significance, although caution is warranted in discriminating between clusters of hyperplastic epithelial cells versus squamous metaplasia and true neoplasia.[1,22]

Bronchoalveolar lavage

Cytology obtained by BAL differs from TTW or ETW, in that the cells are sampled from deeper branches of the respiratory tree. In addition to morphologic description and relative cellular percentages, some clinicians perform total nucleated cell counts on samples obtained by BAL. Although normal counts have been reported, inconsistencies in fluid volumes and sample handling techniques make establishment of absolute counts controversial.[10,13,22,29]

Cellular percentages and morphology are generally considered more important than absolute counts, and relative increases in white blood cells can be seen with inflammation and infection. The alveolar macrophage is the most common cell recovered in BAL fluid, (>70%) which differs from the predominance of the neutrophil in TTW/ETW.[13,22] Surfactant (rather than mucus, as seen in TTW/ETW) is a normal finding in BAL samples and causes foaminess in the recovered fluid.[22] Diagnoses achievable by BAL, perhaps preferentially to other means, include bacterial, fungal, viral, parasitic, and protozoal (*Toxoplasma gondii*) infection, noninfectious inflammation, lymphoma, and carcinoma, but variable cell yield, location, and diseases which poorly exfoliate can limit usefulness.[10,12] A small, feline retrospective study compared the diagnosis achieved by BAL with histopathology (necropsy or lung lobectomy). The

correlation between BAL and histopathology was incomplete; particularly noteworthy were cases in which neoplasia was diagnosed on histopathology, but inflammation was diagnosed on BAL. This highlights the concern that neoplastic cells may not exfoliate readily under BAL conditions, and more invasive diagnostics may need to be considered if a strong index of suspicion for neoplasia exists despite an inflammatory diagnosis from BAL.[12]

Bronchial brushing

Cytology obtained by bronchial brushing is similar to BAL, but it may include cells that would not have been easily washed free from the mucosa. In a study that compared BAL to bronchial brushing in dogs with chronic cough, brushing was found to yield an increased number of neutrophils compared with BAL. Additionally, in five dogs where neutrophil counts in BAL fluid were considered normal, four samples obtained by brushing revealed neutrophilic inflammation.[23] This finding suggested that brushing may be more sensitive than BAL for inflammatory states because brushing detected the white blood cells that were adherent to bronchial walls in addition to those that readily washed free.

Culture

The tracheobronchial tree is not a sterile site in normal dogs, and bacteria of unknown clinical significance are reported in dogs with chronic bronchitis.[13,19,26,27] For this reason, some clinicians recommend quantitative or semiquantitative bacterial cultures of BAL fluid, and it has been reported that greater than 10^4 colony forming units (CFU)/mL (or grown from primary culture) represents true infection whereas less than 10^3 CFU/mL (or grown from subculture) represents contamination.[1,13] However, many clinicians still perform only routine cultures because of financial or logistic concerns.[10] Because BAL also dilutes the organisms present (if any) by a variable amount, even quantitative cultures need to be interpreted in light of cytologic and clinical findings. In addition to standard aerobic bacterial cultures, mycobacterial cultures, particularly in cats, and fungal cultures in properly equipped laboratories, may also be indicated.

BAL is often reserved for patients who have failed therapeutic trials; as such, BAL fluid is commonly collected from animals that are receiving or have recently received antimicrobial therapy. Even antimicrobial agents that have failed to resolve the clinical signs may exist in high enough concentration to inhibit in vitro culture, so some clinicians recommend that BAL samples always be cultured from enrichment broth.[10]

A study described quantitative bacterial cultures and cytologic examination of fluid obtained by BAL in dogs. A cut-off point of 1.7×10^3 CFU/mL or more yielded a sensitivity of 86% and specificity of 100% for the diagnosis of lower respiratory tract infection. The presence of intracellular bacteria on cytologic examination as an additional diagnostic criterion changed these values slightly, yielding a sensitivity of 87% and a specificity of 97%.[19]

COMPLICATIONS

Complications associated with airway endoscopic and diagnostic procedures are rare and include worsening of cough or induction of bronchospasm, especially in cats with hyperreactive airways.[15] Complications reported in a retrospective study in cats included hemoglobin desaturation during the procedure (12 of 68 cats), prolonged anesthetic recovery (4 cats), requirement for supplemental oxygenation following the procedure (4 cats), and pneumothorax (2 cats); all of these cats survived to discharge.[11] In the same study, however, 4 cats were euthanized after bronchoscopy

because of inability to alleviate the underlying cause of respiratory distress (1 cat) or lack of recovery of spontaneous ventilation after anesthesia (3 cats).[11] Factors such as signalment, duration of clinical signs before bronchoscopy, and final diagnosis did not predict the occurrence of complications.[11] In any animal with chronic respiratory disease that has become dependent on exaggerated respiratory effort to maintain airway patency, there is a concern that respiratory suppression (by sedation or anesthesia) may permit collapse of diseased airways.[15]

SUMMARY

Flexible endoscopy is a valuable diagnostic approach to the upper and lower respiratory tract, because it allows direct visualization and sample collection. Techniques requiring a range of specialized equipment and varying levels of experience have been developed to access and evaluate each anatomic region. Familiarity with appropriate indications for each procedure and normal appearance, cytology, and culture results from each region will enhance diagnostic success.

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