Comparison of bronchoalveolar lavage fluid obtained by manual aspiration with a handheld syringe with that obtained by automated suction pump aspiration from healthy dogs

Katharine S. Woods, DVM; Alice M. N. Defarges, DMV, MSc; Anthony C. G. Abrams-Ogg, DVM, DVSc; Howard Dobson, BVM&S, DVSc; Brigitte A. Brisson, DMV, DVSc; Laurent Viel, DVM, PhD; Dorothee Bienzle, DVM, PhD

Objective—To compare bronchoalveolar lavage (BAL) fluid obtained by manual aspiration (MA) with a handheld syringe with that obtained by suction pump aspiration (SPA) in healthy dogs.

Animals—13 adult Beagles.

Procedures—Each dog was anesthetized and bronchoscopic BAL was performed. The MA technique was accomplished with a 35-mL syringe attached to the bronchoscope biopsy channel. The SPA technique was achieved with negative pressure (5 kPa) applied to the bronchoscope suction valve with a disposable suction trap. Both aspiration techniques were performed in each dog in randomized order on opposite caudal lung lobes. Two 1 mL/kg aliquots of warm saline (0.9% NaCl) solution were infused per site. For each BAL fluid sample, the percentage of retrieved fluid was calculated, the total nucleated cell count (TNCC) and differential cell count were determined, and semiquantitative assessment of slide quality was performed. Comparisons were made between MA and SPA techniques for each outcome.

Results—1 dog was removed from the study because of illness. The mean percentage of fluid retrieved (mean difference, 23%) and median TNCC (median distribution of differences, 100 cells/µL) for samples obtained by SPA were significantly greater than those for samples obtained by MA.

Conclusions and Clinical Relevance—in healthy dogs, BAL by SPA resulted in a significantly higher percentage of fluid retrieval and samples with a higher TNCC than did MA. Further evaluation of aspiration techniques in dogs with respiratory tract disease is required to assess whether SPA improves the diagnostic yield of BAL samples. (Am J Vet Res 2014;75:85–90)

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From the Departments of Clinical Studies (Woods, Defarges, Abrams-Ogg, Dobson, Brisson, Viel) and Pathobiology (Bienzle), Ontario Veterinary College, University of Guelph, Guelph, ON N1G 2W1, Canada; and CanCog Technologies Inc., 24 Lippincott St, Toronto, ON M5T 2R3, Canada (Dobson). Dr. Woods’ present address is Department of Small Animal Clinical Sciences, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, SK S7N 5B4, Canada. This manuscript represents a portion of a thesis submitted by Dr. Woods to the Ontario Veterinary College Department of Clinical Studies as partial fulfillment of the requirements for a Doctor of Veterinary Science degree.

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Address correspondence to Dr. Woods (woods.katharine@gmail.com).
ity of BALF from healthy dogs.6,7 To our knowledge, the
method of BALF retrieval from dogs has not been evalu-
ated. It has been hypothesized that SPA may result in
decreased cell viability in BALF because excessive nega-
tive pressure can cause cell lysis.7 Results of another
study8 performed by our research group indicate that
BALF from healthy dogs obtained by automated SPA has
a better diagnostic quality than that obtained by MA
through polyethylene tubing. The purpose of the
study reported here was to compare quantity and qual-
ity of BALF samples obtained by MA with a handheld
syringe with those of BALF samples obtained by auto-
mated SPA in healthy dogs. We hypothesized that the
method of aspiration would affect BALF sample quality
and potentially influence the diagnostic yield of BALF
in dogs.

Materials and Methods

Animals—Dogs included in the study were re-
quired to be free of respiratory tract disease. Thirteen
adult Beagles were determined to be healthy on the ba-
sis of medical history and results of physical examina-
tion, CBC, serum biochemical analysis, and evaluation
of lateral and ventrodorsal orthogonal thoracic radio-
graphs by a board-certified veterinary radiologist (HD). The
dogs regularly received prophylactic anthelminthic
preparation but had not received any other medications
within 30 days prior to study initiation. Dogs were cared
for at a Canadian Council on Animal Care–accredited
facilities in accordance with the council's guidelines, and
the study protocol was approved by the University of
Guelph Animal Care Committee.

Anesthesia—Each dog was sedated, and anesthesia
was induced and maintained as described for a previous
study.8 Intravenous fluid therapy was administered, and
supplemental oxygen was provided through a soft ster-
ile catheter9 that was placed in the trachea via the oral
cavity. During anesthesia, each dog was instrumented
with a continuous ECG and pulse oximeter, and the
heart rate and rhythm, respiratory rate, percentage oxy-
gen saturation, and body temperature were monitored.
Clinically normal oxygen saturation was defined as ≥
95%. The experimental procedure was aborted and a
dog was allowed to recover from anesthesia if the oxy-
gen saturation decreased to < 90% for 10 minutes or <
85% for 5 minutes or bradycardia (< 60 beats/min) that
did not respond to standard interventions developed.

BAL—Each dog was positioned in sternal recum-
bency during the experimental procedure. Bronchos-
copy was performed in a routine manner9 and recorded
with a video bronchoscope.9 The trachea and all lung
lobes, including second- and third-generation bronchi,
were visually examined following infusion of 2 mL of
sterile 0.2% lidocaine solution at the carina to abate
coughing during the examination.

The SPA and MA BAL techniques were performed
in the caudal lung lobes in each dog; the aspiration
technique used in each caudal lung lobe and the order
in which the techniques were performed were randomly
allocated by use of a random number table. The caudal
lung lobes were lavaged with a weight-based volume
(2 mL/kg, divided into 2 aliquots), with the second ali-
quots infused immediately after retrieval of the first ali-
quo.7 To perform SPA, the tip of the bronchoscope was
wedged into a second-generation bronchus and warmed
(37°C) sterile saline solution was infused through the
biopsy channel followed by injection of 4 mL of air to
empty the channel. Immediately after infusion, pulsa-
tile aspiration with a maximum negative pressure of
5 kPa (37.5 mm Hg) was performed with a portable au-
tomated surgical suction pump3 connected directly to
the suction valve of the bronchoscope by a disposable
suction trap.6 The MA technique was performed on the
contralateral caudal lung lobe by wedging the tip of the
bronchoscope into a second-generation bronchus, and
the introduction of warmed sterile saline solution and air
were performed as described for the SPA technique. A
35-mL syringe was directly attached to the broncho-
scope’s biopsy channel, and gentle pulsatile MA was
applied, with the syringe emptied of air as necessary
for continence aspiration. For both techniques, aspiration
was continued until fluid could no longer be recovered.
Between use in dogs, the bronchoscope was cleaned
and sterilized in accordance with a standard cold steril-
ization method.8,9

The duration of BAL (time from infusion of saline
solution until the end of aspiration for the second
aliquot), lowest percentage oxygen saturation, and
amount of BALF retrieved were recorded for each tech-
nique. A minimum retrieval of 33% of the BAL infusate
volume was defined as a diagnostic BALF sample.10
Dwell time (time from infusion of saline solution to the
first attempt at aspiration) was < 20 seconds for each
collection.

Examination of BALF—Immediately after collection,
microscopic surfactant was indirectly assessed by visual
estimation of foam in each sample and assign-
ment of a surfactant score on a dichotomized scale of
absent (0) or present (1). Each BALF sample was then
identified by a unique code of 3 letters, placed on ice,
and processed for analysis within 120 minutes after
collection. Samples were not filtered during processing.

Total nucleated cell counts were determined with an
automated cell counter3 by use of electrical impedance;
the typical count precision for this counter was 2% to
3% counting variability, with a lower limit for particle
detection of 1 µm. A 200-µL aliquot of each sample was
centrifuged for 6 minutes at 180 × g, and additional
direct smears were prepared from BALF that was cen-
trifuged for 5 minutes at 500 × g. Slides were stained
with Wright stain, and differential cell counts of 400 leuko-
cytes were performed on cytocentrifuge preparations
examined with a microscope5 set at 400x magnification
by a board-certified veterinary clinical pathologist (DB)
who was unaware of the technique used to obtain each
collection. For each slide, the pathologist also assessed 5
semiqualitative variables associated with sample and
slide quality as described,8 and scores ≥ 2 for cellular-
ity and cellular preservation were required for a BALF
sample to be considered of adequate diagnostic quality.
Additionally, the cells on each slide were evaluated for
evidence of erythrophagocytosis; scores > 2 for epithel-
ial cells or RBCs (without erythrophagocytosis) were
considered indicative of excessive suction or trauma
and a low-quality BALF sample. The phospholipid con-
centration in the BALF samples was not determined because an insufficient amount of each sample to perform the method described by Bligh and Dyer remained after the other analyses were completed.

**Statistical analysis**—Data distributions were assessed for normality with a Shapiro-Wilk test. For continuous outcomes that were normally distributed (duration of BAL, percentage BALF retrieval, percentage oxygen saturation, percentage lymphocytes, and percentage macrophages), comparisons between MA and SPA were performed with a paired student t test. For analysis purposes, results were dichotomized as absent (0) or present (1) for macroscopic surfactant, RBCs, bacteria, and mast cells, and comparisons between MA and SPA were performed with a McNemar test. Results were dichotomized as absent (0) or present (1) for macroscopic surfactant, RBCs, bacteria, and mast cells, and comparisons between MA and SPA were performed with a McNemar test. Statistical analyses were performed with a statistical software program, and values of P < 0.05 were considered significant.

**Results**

**Animals**—Thirteen adult Beagles were evaluated for inclusion in the study. During physical examination, 1 dog had bilateral purulent nasal discharge and was excluded from the study. The 12 dogs included in the study consisted of 3 sexually intact males, 5 castrated males, and 4 spayed females with a mean ± SD age of 9.7 ± 0.8 years (range, 8.1 to 10.8 years) and weight of 10.8 ± 2.1 kg (range, 8.1 to 15.5 kg). For all study dogs, body temperature and heart and respiratory rates were within reference limits during physical examination and results of CBCs and serum biochemical analyses were unremarkable. Three dogs had a left-sided systolic murmur (1 grade II/VI, 1 grade III/VI, and 1 grade IV/VI) auscultated during physical examination and evidence of mild to moderate left atrial enlargement on thoracic radiographs. Because none of those dogs had clinical signs of heart disease or evidence of pulmonary edema on thoracic radiographs, it was suspected they had compensated left mitral valve disease, and they were not excluded from the study.

**Bronchoscopy and BAL**—Bronchoscopy examination findings were within reference limits for 8 of

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**Table 1**—Mean or median values for variables evaluated following bronchoscopic BAL of 12 healthy adult Beagles in which BALF samples were obtained by MA and SPA.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Technique</th>
<th>Mean or median</th>
<th>SD or IQR</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of BAL (s)</td>
<td>MA</td>
<td>78.4</td>
<td>21.5</td>
<td>0.069</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>65.9</td>
<td>0.04</td>
<td>0.52</td>
</tr>
<tr>
<td>Lowest oxygen saturation during BAL (%)</td>
<td>MA</td>
<td>93</td>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>92</td>
<td>0.04</td>
<td>0.52</td>
</tr>
<tr>
<td>Macroscopic surfactant score†</td>
<td>MA</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Percentage of BALF retrieved (%)</td>
<td>MA</td>
<td>46.5</td>
<td>8.8</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>69.5</td>
<td>23.0</td>
<td>0.12</td>
</tr>
<tr>
<td>BALF quality score</td>
<td>MA</td>
<td>3.5</td>
<td>1.0</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>4</td>
<td>0.5</td>
<td>0.062</td>
</tr>
<tr>
<td>Cellularity‡</td>
<td>MA</td>
<td>1</td>
<td>0.5</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>4</td>
<td>1</td>
<td>1.00</td>
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<tr>
<td>Epithelial cells</td>
<td></td>
<td></td>
<td>MA</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>RBCs†</td>
<td>MA</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Bacteria†</td>
<td>MA</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>TNCC (cells/µL)#</td>
<td>MA</td>
<td>200</td>
<td>50</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>200</td>
<td>100</td>
<td>0.02</td>
</tr>
<tr>
<td>BALF differential cell count#</td>
<td>MA</td>
<td>72</td>
<td>8</td>
<td>0.24</td>
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<tr>
<td></td>
<td>SPA</td>
<td>75</td>
<td>3</td>
<td>0.24</td>
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<tr>
<td>Macrophage (%)</td>
<td>MA</td>
<td>2</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>2</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>Neutrophil (%)</td>
<td>MA</td>
<td>24</td>
<td>9</td>
<td>0.37</td>
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<tr>
<td></td>
<td>SPA</td>
<td>19</td>
<td>9</td>
<td>0.37</td>
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<tr>
<td>Lymphocyte (%)</td>
<td>MA</td>
<td>2</td>
<td>6</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>0</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>Mast cell†</td>
<td>MA</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>SPA</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

* A positive value for the mean or median distribution of differences indicates that the value for samples obtained by SPA was higher than the value for samples obtained by MA, whereas a negative value for the mean or median distribution of differences indicates that the value for samples obtained by SPA was lower than the value for samples obtained by MA. Results dichotomized as absent (0) or present (1). †Scored on the basis of cytologic evaluation on a scale of 0 to 4 (0, < 10 cells/slide; 1, 10 to 100 cells/slide; 2, 101 to 200 cells/slide; 3, 201 to 500 cells/slide; and 4, > 500 cells/slide). §Scored on the basis of cytologic evaluation on a scale of 0 to 4 (0, < 10% well-preserved cells/slide; 1, 10% to 25% well preserved cells/slide; 2, 26% to 50% well-preserved cells/slide; 3, 51% to 80% well-preserved cells/slide; and 4, > 80% well-preserved cells/slide). | Scored on the basis of cytologic evaluation on a scale of 0 to 4 (0, absent; 1, < 50 cells/slide; 2, 51 to 100 cells/slide; 3, 101 to 200 cells/slide; and 4, > 200 cells/slide). #Represents data from only 9 dogs; data for 2 dogs were excluded because they had asymmetric bronchoscopic abnormalities, and data for another dog were excluded because it had evidence of septic suppurative inflammation on cytologic evaluation. — = Not determined.

Both MA and SPA were performed during the same bronchoscopy examination in all dogs; the aspiration technique used in each caudal lung lobe and the order in which the techniques were performed were randomly allocated.
12 dogs. In 2 dogs, the bronchial mucosa had a mild nodular appearance in the left lung lobes but not in the right lung lobes. One dog had a diffuse, mildly increased amount of bronchial mucous, compared with that of the other study dogs, and airway collapse was observed during BAL with both MA and SPA in 1 dog. The duration of the BAL did not differ significantly between MA and SPA (Table 1) and ranged from 46 to 107 seconds for MA and 43 to 137 seconds for SPA.

Adverse effects of BAL—Following BAL, mild bilateral bruising of the bronchial mucosa was observed in 1 dog. Transient (< 2-minute) decreases in the percentage oxygen saturation during MA and SPA were observed in 8 and 6 dogs, respectively; however, none of the dogs required intervention. The mean lowest percentage oxygen saturation did not differ significantly between MA (93%) and SPA (92%).

BALF analysis—Surfactant was macroscopically present in 12 of 12 samples obtained with SPA and 11 of 12 samples obtained with MA, and the surfactant scores did not differ significantly between MA and SPA. The mean ± SD percentage of BALF retrieved by SPA (69.5 ± 6.5%) was significantly (P < 0.001) greater than that retrieved by MA (46.5 ± 10.2%), with a mean ± SD difference of 23.0 ± 12.6%. For 3 BALF samples (2 obtained by MA and 1 obtained by SPA), no TNCCs were detected by electrical impedance; there was no association between TNCC and visual assessment of surfactant. In fact, the cytocentrifuge preparations of those 3 samples had adequate cellularity for cytologic evaluation such that TNCCs were manually estimated by the clinical pathologist (DB) and retained in the analysis. However, BALF samples from 3 dogs were excluded from the TNCC and differential cell count analyses. Two dogs had asymmetric bronchoscopic abnormalities and 1 dog had respiratory tract disease as evidenced by a markedly increased TNCC from reference limits and septic suppurative inflammation identified during cytologic evaluation of one of its BALF samples.

For all study dogs, the median cellularity score for samples obtained by MA (3.5; range, 2 to 4) did not differ from that for samples obtained by SPA (4; range, 3 to 4). All cellular preservation scores were 3 or 4, and the median cellular preservation score did not differ significantly between MA and SPA. Similarly,()the scores for RBCs, bacteria, and epithelial cells did not differ significantly between MA and SPA.

For the 9 study dogs for which TNCC and differential cell counts were analyzed, the median TNCC was 200 cells/µL (range, 100 to 300 cells/µL; IQR, 100 cells/µL) in BALF obtained by MA and 200 cells/µL (range, 200 to 400 cells/µL; IQR, 100 cells/µL) in BALF obtained by SPA, with a median distribution of differences in TNCC between SPA and MA of 100 cells/µL (IQR, 50 cells/µL), which indicated that the TNCC in BALF samples obtained by SPA was significantly (P = 0.02) greater than that in BALF samples obtained by MA. Conversely, the respective differential counts of macrophages, neutrophils, lymphocytes, eosinophils, and mast cells did not differ between BALF samples obtained by MA and SPA.

Discussion

Results of the present study indicated that BAL with SPA recovered a greater percentage of BALF that had a higher TNCC than did MA. Collection of BALF by MA is the most commonly used technique in veterinary medicine3-5,7; however, results of another study8 conducted by our research group suggest that retrieval of BALF by SPA yielded samples of higher quality, compared with BALF samples obtained by MA through polyethylene tubing. The present study differed from that study8 in that the MA did not include the use of polyethylene tubing. The surfactant score was refined in consideration of the fact that it is currently unknown whether the method of fluid retrieval influences the amount or characteristics of foam and therefore the volume of bubbles in BALF. It should also be emphasized that no evidence-based recommendations currently exist regarding acceptable limits for cellular preservation or RBCs, and these scores8 were created on the basis of expert opinion. Yet, the results of both the present study and the previous study8 suggest that SPA provides BALF samples of higher diagnostic quality than does MA.

In the present study, SPA resulted in retrieval of a significantly greater percentage of BALF than did MA. The higher the percentage of BALF retrieved, the greater the likelihood that the BAL successfully sampled the alveoli as well as the bronchi.12 In human patients, the use of small-volume aliquots with a small percentage of fluid retrieval is considered a bronchial wash instead of an alveolar wash.12 Recovery of a minimum of 33% to 40% of the BALF is considered necessary for diagnostic purposes in human patients and dogs12,13; therefore, we considered retrieval of < 33% of BALF insufficient for diagnostic purposes. In the present study, < 33% of the BALF was retrieved by MA in 1 of 12 dogs, whereas > 59% of the BALF was retrieved by SPA in all 12 study dogs. Consequently, the mean percentage of BALF retrieved was significantly greater for SPA, compared with that for MA.

In healthy dogs, decreased BALF retrieval could be caused by improper placement of the bronchoscope (eg, abuttal of the bronchoscope tip against a bronchial wall or improper wedging of the bronchoscope tip).2,14 In the present study, placement of the bronchoscope within the bronchus was visually assessed to ensure that the tip was not occluded against the bronchial wall prior to all BALs. Thus, bronchoscope occlusion was an unlikely cause of the low rate of BALF retrieval by MA. Failure to achieve a seal between the bronchoscope tip and the bronchial wall will result in the retrieval of air rather than infusate during the aspiration phase of a BAL.14 During aspiration, this seal can be lost by movement of the bronchoscope. Movement of the bronchoscope is more likely to occur during MA than it is during SPA because MA is performed by an assistant, whereas SPA is performed by the clinician who is operating the bronchoscope. Moreover, it is possible that SPA results in a better seal between the wedged bronchoscope and bronchial wall because of the creation of greater negative pressure than MA creates.

Occasionally, BALF cannot be retrieved despite adequate wedging of the bronchoscope into the bronchus,
and in those instances, it is recommended that the bronchoscope be retracted a few millimeters. In the present study, this was done prior to discontinuation of BAL for both aspiration techniques in all dogs; therefore, it is unlikely that this was the cause of a nondiagnostic amount of BALF being obtained during MA in 1 dog. Furthermore, it is also unlikely that use of the handheld 35-mL syringe was insufficient to create the negative pressure needed to retrieve BALF because this technique has been successfully used in another study. Assuming that the amount of BALF retrieved was independent of wedging the bronchoscope into the bronchus, it is likely that the high percentage of BALF retrieved by SPA was the result of the creation of a more consistent negative pressure without concurrent airway collapse, compared with that created by MA.

In the present study, 3 BALF samples had TNCCs of 0 as determined by electrical impedance. However, the cytocentrifuge preparations for those 3 samples contained a sufficient number of cells for differential counts to be performed. Cell lysis as a cause for the 3 acellular BALF samples by electrical impedance was considered unlikely because, if cell lysis were the result of BAL technique or BALF processing, inadequate cell numbers would have been expected on cytocentrifuge preparations. In fact, the opposite was identified in the present study. This suggested that laboratory error might have caused the failure of the automated cell counter to accurately count the TNCCs in those samples. Mucus in BALF can cause cells to clump and occlude the aperture of the automated cell counter, resulting in artificially decreased cell counts. Regardless, one of the apparently acellular BALF samples acquired by MA had a low cellularity score (2) on cytocentrifuge preparation and would have been classified as nondiagnostic on the basis of a low percentage of BALF retrieval (25%).

Although the BALF obtained by SPA had significantly higher median distribution of TNCC than did that obtained by MA in the present study, the cellularity scores, including the cellular preservation scores, did not differ significantly between BALF samples obtained by SPA and MA. This contrasts with concerns expressed by other clinicians that the increased negative pressure created by SPA, compared with that created by MA, would cause cellular damage. Additionally, the differential cell counts did not differ significantly between samples obtained by SPA and MA, which suggested that no particular type of leukocyte was preferentially destroyed during aspiration by SPA or MA, despite the fact that the disposable suction trap (polystyrene) and handheld syringe (polypropylene) were made of different materials. Similarly, the RBC, epithelial cell, and bacterial scores did not differ significantly between samples obtained by SPA and MA, which suggested that one technique was not any more traumatic to the bronchial mucosa than was the other. Thus, in regard to the quality and preservation of cells, BALF samples obtained by SPA were comparable to BALF samples obtained by MA.

The question remains as to whether the significantly increased percentage of BALF retrieved and TNCC in samples obtained by SPA, compared with those in samples obtained by MA, are clinically relevant for dogs with respiratory tract disease. An increased number of TNCC is unlikely to increase the likelihood of identification of neoplastic cells or pathogenic organisms in BALF because these changes are classified as either present or absent during cytologic analysis. In human patients, studies that assessed the association between diagnostic yield and percentage of BALF retrieved have yielded conflicting results. Results of 1 study in which BALF samples obtained from human patients by MA with and without tubing were compared, indicate that diagnostic yield was highest for BALF samples obtained by MA via tubing, and diagnostic yield was positively correlated with percentage of BALF retrieved. Conversely, results of another study, in which BALF samples obtained from human patients with hematologic or nonhematologic malignant cancer were compared, indicate that the amount of BALF retrieved was not correlated with diagnostic yield. However, investigators of that study only assessed BALF for evidence of infectious pneumonia or malignancy, and this might have biased their results. For dogs with respiratory tract disease, further evaluation of BAL aspiration techniques is necessary to assess whether aspiration technique affects the diagnostic yield of BAL.

Strengths of the present study included randomly allocating the caudal lung lobe and order in which SPA and MA were performed, having the same operators (KSW and AMND) perform all BALs, and ensuring that the pathologist who performed the cytologic evaluations was unaware of the aspiration technique used to obtain each sample. Another strength of this study was the comparison BALF samples obtained by MA through a handheld syringe attached directly to the bronchoscope biopsy channel with those obtained by SPA because MA is the aspiration technique most frequently used to obtain BALF from dogs.

Limitations of the present study included the small study population that consisted of healthy dogs of similar age, body weight, and breed and the fact that surfactant was not directly measured in BALF samples. These limitations might restrict the extrapolation of results to dogs with respiratory tract disease or different signalment. For example, wedging a bronchoscope in a bronchus is more difficult in larger dogs; therefore, some clinicians will use an endoscope with a larger diameter than that used in the present study for BAL in large-breed dogs. Different working channel diameters and lengths (eg, longer endoscopes) will likely alter negative pressure achieved during the aspiration phase of BAL.

For the healthy dogs of the present study, SPA resulted in retrieval of a significantly greater percentage of BALF that had a greater TNCC than did MA. However, cytologic quality did not differ significantly between BALF samples obtained by SPA and MA. These results suggested that SPA might improve the diagnostic yield of BAL in dogs, but further evaluation of BAL aspiration technique on BALF quantity and quality in dogs with respiratory tract disease is warranted.


b. Olympus BF type TSI60 video bronchoscope, outer diameter 6.0 mm, working length 60 cm, biopsy channel inner diameter 2.8 mm, Olympus Canada Inc, Richmond Hill, ON, Canada.

c. Olympus SSU-2 endoscopic aspiration pump, Olympus Canada Inc, Richmond Hill, ON, Canada.

e. Video bronchoscope cleaning and cold sterilization protocol, Olympus Canada Inc, Richmond Hill, ON, Canada.

f. Enzozyme, dual enzymatic cleaning, Ruhof Corp, Mineola, NY.

g. Glutacide, Pharmax Ltd, Etobicoke, ON, Canada.

h. Z2 Coulter counter, Bedsee Coulter Inc, Missoula, MT.


j. Olympus BX33 system microscope, Olympus Canada Inc, Richmond Hill, ON, Canada.

k. SAS, version 9.1, SAS Institute Inc, Cary, NC.

References


