# Evaluation of a new chest physiotherapy technique in dogs with airway fluid accumulation hospitalized in an intensive care unit

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# Evaluation of a new chest physiotherapy technique in dogs with airway fluid accumulation hospitalized in an intensive care unit

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***Abstract***

**Objective** – To evaluate the feasibility, benefits, and adverse effects of prolonged slow expiration (PSE) and assisted cough (AC) as chest physiotherapy (CP) techniques in dogs with airway fluid accumulation.
**Design** – Prospective interventional study.
**Settings** – University teaching hospital.
**Animals** – Intervention group of 30 client-owned dogs and retrospective control group of 71 client-owned dogs.
**Interventions** – PSE was performed on dogs with evidence of airway fluid accumulation, identified based on physical examination and thoracic radiographs. AC was performed if spontaneous cough or swallowing were not evident. The PSE treatment was performed every 6 hours until normalization of respiratory status or hospital discharge. Animals were monitored for respiratory distress, discomfort, and $SpO_2$ during the procedure. A retrospective control group was identified by computer search.
**Measurements and Main Results** – One hundred thirty-three sessions of CP were performed on 30 dogs. Discomfort frequency during physiotherapy was low (9%). The most commonly used position for CP was in lateral recumbency (95%) and this was well tolerated in most cases. There was no significant difference in the median $SpO_2$ before and after CP sessions ($P = 0.24$). Sixty percent of sessions had a spontaneous cough or swallowing evident, 21% had successful AC performed, and no cough or swallowing occurred in the remaining (19%) sessions despite attempts of AC being made. The length of hospitalization was significantly longer in the intervention group (6 days vs 4) ($P = 0.02$). There was no difference in survival between the intervention (76.7%) and the control (57.7%) group ($P = 0.055$).
**Conclusions** – PSE associated with AC are easily adaptable, well-tolerated techniques in dogs. The benefit of CP in dogs with airway fluid accumulation remains to be determined and it is hoped that future randomized controlled prospective studies may help answer this line of inquiry.

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***Keywords:*** canine, cough, dyspnea, respiratory physiotherapy

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The authors declare no conflict of interests.

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**Abbreviations**

| | |
|---|---|
| AC | assisted cough |
| CP | chest physiotherapy |
| ICU | intensive care unit |
| PSE | prolonged slow expiration |

### *Introduction*

Chest physiotherapy (CP) can be defined as the external application of a combination of forces to increase expiratory flow with the goal to optimize mucus transport.[1] In human medicine, CP is routinely used to help expectoration of airway secretions in children and adults with a variety of respiratory diseases such as acute bronchiolitis, community-acquired pneumonia, or cystic fibrosis.[2–6] It is considered especially helpful for patients with large amounts of secretions or ineffective cough.[2,7] Physiotherapy is commonly implemented in human intensive care units.[5,8,9] CP has been reported to reduce the duration of mechanical ventilation, length of hospitalization, incidence of ventilator-associated pneumonia, and risk of mortality in human ICU patients.[10–12] A recent systematic review of physiotherapy in mechanically ventilated pediatric patients concluded that these techniques aid in secretion clearance.[13] Physiotherapy techniques were also associated with clinical improvement in children and adults with bronchiectasis.[14]

Numerous studies have also demonstrated the potential adverse effects of various CP maneuvers, mostly in very small and fragile patients. In human infants, there is an increased risk of gastroesophageal reflux and hemoglobin desaturation, potentially severe hypoxemia, rib fractures, and brain damage.[15–18] However, most of these studies are based on percussion and vibration techniques.[2]

There are many different techniques described for CP; some use specific devices while others are manual techniques. Two manual techniques used for improving airway clearance are prolonged slow expiration (PSE) and assisted cough (AC).[2,19] These techniques could be of particular relevance to veterinary patients as they are passive techniques that do not require patient cooperation. During PSE, manual compression of the thorax is aimed at achieving distal airway flow limitation at low lung volume to facilitate fluid clearance.[2] Slow thoracoabdominal compression is applied by a physiotherapist to impede bronchial collapse and avoid interruption of air flow associated with forced expirations.[19] AC is known to facilitate large-airway clearance, and is obtained with a brief pressure applied on the trachea.[19]

To date, airway clearance techniques have rarely been investigated or discussed in the veterinary literature. The aims of the present study were to evaluate the feasibility, benefits, and any adverse effects of PSE and AC techniques in dogs with airway fluid accumulation hospitalized in an intensive care unit.

## *Materials and Methods*

The study protocol was approved by the VetAgro Sup Ethics committee (approval number 1268). Owner consent for CP was obtained prior to enrolment of dogs into the study.

**Figure 1:** Physiotherapist hand placement for the increased exhalation technique on the dog in lateral recumbency. In this position, increased exhalation technique involved the generation of synchronized thoracic-abdominal movement by the hands of the physiotherapist at the beginning of expiration with one hand on the thorax (5th–6th intercostal spaces), and the other hand on the abdomen, centered behind the diaphragm in order to apply an abdominal counterweight. Arrows show the movement of the forces on the thorax.

### CP intervention group

The intervention group included client-owned dogs presented to the emergency unit with respiratory diseases between January 2012 and June 2013. We included dogs from any age, sex, or breed with clinical and radiological criteria of airway fluid accumulation of any cause. Exclusion criteria included hospitalization for <24 hours; the presence of thoracic or abdominal pain during manipulations; congestive heart failure; or a suspicion of zoonotic diseases limiting contact with the dog due to aerosolized transmission of the pathogen.

Clinical criteria of bronchial fluid accumulation were defined as the association of dyspnea with the presence of crackles, cough, or fluid expectorations in a dog with a disease process considered likely to be associated with airway fluid accumulation. The disease processes identified included bronchopneumonia from any cause (eg, infectious causes, aspiration), and coagulation disorders. All dogs had thoracic radiographs performed and reviewed by a radiologist independent of the study. Radiological criteria of airway fluid accumulation included alveolar opacity of 1 or more lung lobes or an increased interstitial pattern. As thoracic radiographs are of limited value to evaluate bronchial fluid accumulation, clinical suspicion was more commonly used to determine study eligibility. Thoracic radiographs were used to aid in diagnosis and to rule out nonpulmonary or neoplastic causes of dyspnea. The signalment, body weight, clinical signs at onset of dyspnea, respiratory diagnosis, pulse oxymetry ($SpO_2$) readings during CP sessions, and adverse reactions of the dog during CP sessions were recorded for all enrolled dogs. Presence or absence of spontaneous or induced cough or swallowing was noted at the end of each CP session.

### Historical control group

The control group was a cohort of dogs identified retrospectively with similar respiratory disease processes to the intervention group. A computer-based search of the university database (years 2002–2012) was conducted for dogs with the term "pneumonia" and "bronchopneumonia."

Similar to the intervention group, all of them were admitted to the intensive care unit through the emergency service and had thoracic radiographs. No dog in the historical control group received any kind of CP, including coupage. No breed, sex, or age discrimination was made. Exclusion criteria included incomplete medical records, and hospitalization length <24 hours.

### CP techniques

All CP sessions were performed by 3 veterinarians and 2 technicians. Prior to initiation of the study, all participating veterinarians and technicians received formal training in the physiotherapy techniques by a senior human medical respiratory physiotherapist (DB). Dogs were constantly monitored for discomfort or distress during CP and had $SpO_2$ recorded during all PSE and AC sessions. If a dog was on oxygen therapy, oxygen delivery was continued by the use of a nasal catheter or prongs during the CP session.

All enrolled dogs received PSE and AC during the prospective study period. Both the PSE and AC techniques used in the present study were derived from well-described human techniques[8] and adapted for use in dogs with the assistance of a human physiotherapist. PSE involved the generation of synchronized thoracic-abdominal movement by the hands of the physiotherapist at the beginning of expiration with one hand on the thorax (5th–6th intercostal spaces), and the other hand on the abdomen, centered behind the diaphragm in order to apply an abdominal counterpressure (Figure 1). The maneuver began at the beginning of expiration, and was pursued until the end of expiration. The resulting dynamic compression of the respiratory system aimed to increase expiratory airflow. The range and velocity of the manoeuver varied according to the quantity of secretions observed for each dog. This quantity was assessed by pulmonary auscultation (intensity, presence of crackles), volume of expectoration if present, and cough frequency. In very small dogs (<2 kg) and in dogs that would not tolerate lateral recumbency, PSE was performed while standing. The PSE technique with the animal standing

**Figure 2:** Hand position of the physiotherapist for chest physiotherapy session in standing position. In this position, increased exhalation is performed by applying a continuous force starting at the beginning of exhalation with 2 hands on one side of the dog's thorax. The body of the physiotherapist blocks the other side of the thorax.

is performed by applying a continuous force with the 2 hands on one side of the dog's thorax. The body of the physiotherapist blocks the other side of the thorax (Figure 2).

Data recorded during treatments included body position during CP, evidence of discomfort (agitation, struggling to get up, aggressiveness, vocalization), need for sedation, respiratory rate, respiratory auscultation before and after the session, and $SpO_2$ during the session. Accuracy of $SpO_2$ readings was assessed by graphical analysis of the oximetry curve. At the end of the session, the animal was evaluated for the presence or absence of spontaneous or induced cough or swallowing, signs of worsening of respiratory distress or any other adverse responses evident.

The PSE procedure was repeated for 5–10 successive forced expirations, then a break of 5 normal respiratory cycles was allowed. This cycle was repeated for a 5-minute period; the animal was then given a 1-minute break in sternal recumbency before repeating the 5-minute treatment in the opposite recumbency. The procedure was stopped if the dog had increased respiratory distress, present vomiting, showed signs of discomfort, or if the $SpO_2$ dropped under 85% during the CP session. The treatment was applied at least 1 hour after the last meal in an effort to avoid regurgitation or vomiting during expectoration.

The PSE treatment was performed every 6 hours until normalization of respiratory status or until hospital discharge. The physiotherapist, depending on the tolerance of the dog and evaluation of mucus accumulation in the dog, could modify the number of sessions per day. Clinical effectiveness during the session was assessed principally by hearing the sound of expiratory flow through the mouth or nostrils at each thoracic compression.

Secondary clinical signs of effectiveness were observation of fluid expectoration, cough, or swallowing during the session. The physiotherapist also evaluated the CP effectiveness by thoracic auscultation before and at the end of the session, assessing for a decrease in abnormal sounds on auscultation. If no spontaneous coughing occurred during forced expirations, AC was induced by digital compression of the trachea at the end of PSE session. For every AC session, dogs were placed in sternal recumbency. All other therapies were administered at the discretion of the attending clinician depending on the underlying disease.

**Statistical analysis**

Welch and Mann-Whitney-Wilcoxon tests were performed for comparison of means (for parametric data) or medians (for nonparametric data) between 2 independent series depending of the size of the sample ($n > 30$ and $<30$, respectively). We compared adverse events frequency using the Fisher's exact test. Survival curves were estimated for each group and compared by using the log-rank test. Significance was set at $P < 0.05$. Statistical analysis was performed by a commercial statistical software program.[a]

## Results

**Canine population**

Thirty dogs were included in the intervention group (Table 1). All data were found to be nonparametric in nature and the results are expressed as median (range). The main clinical signs noted at onset of respiratory signs were respiratory distress evident in 80% (24/30), crackles in 83% (25/30), and cough in 57% (17/30). All dogs in the intervention group had thoracic radiographs. The main radiographic findings were an alveolar pattern of 1 or more lobes (67%, 20/30) and bronchointerstial pattern (33%, 10/30). The most common underlying etiologies in the intervention group were aspiration bronchopneumonia (43%, 13/30), infectious bronchopneumonia (23%, 7/30), anticoagulant toxicosis (10%, 3/30), and leptospirosis (7%, 2/30).

The electronic database search for the historical control group identified 85 dogs. Fourteen of these dogs were excluded leaving a control group of 71 dogs (Table 1). The main clinical signs at admission were respiratory distress evident in 80% (57/71), crackles in 45% (32/71), and cough in 24% (17/71). The main underlying etiologies in the control group were aspiration bronchopneumonia (52%, 37/71), infectious bronchopneumonia (11%, 8/71 dogs), and anticoagulants toxicosis (3%, 2/71 dogs).

Brachycephalic dogs were the most represented breeds in both groups (30% in intervention group and 27% in control group). There was no statistical difference between intervention and control groups for age, weight, sex distribution, and presence of dyspnea (Table 1). Crackes and cough were more frequently encountered in the intervention group than in the control group ($P < 0.05$).

**Feasibility and tolerance of CP**

During the present study, 133 sessions of CP were carried out on the 30 enrolled dogs. Each animal received between 1 and 16 sessions during their hospitalization (average: 4.5 sessions/dog) at the rate of 1 to 4 sessions daily. Median hospitalization length was 6 days (2–15 days). Position during CP session was recorded for 109 sessions. Of these 109 sessions, lateral recumbency was the most commonly used position (95 %, 104/109 sessions) and was well tolerated in most cases. Discomfort rate during the physiotherapy (mainly reluctance to stay in lateral recumbency) was low (9%, 12/133). CP was neither terminated, nor was sedation administered in any case. In 95% of the sessions (126/133 sessions), no deterioration of clinical parameters was noted. In the remaining 5% (7/133 sessions, observed in 6 dogs), a transitory and spontaneously resolving episode of tachypnea at the end of the session was observed. No other adverse effect such as bradycardia, vomiting during the procedure, or desaturation was observed during the study. There was no significant difference in the median $SpO_2$ before and after CP sessions with a median $SpO_2$ of 91% (73–100%) before CP and a $SpO_2$ of 92% (59–100%) after CP ($P = 0.24$). There was also no significant difference between the median $SpO_2$ before the first CP session (90%, 67–98%) and the median $SpO_2$ before the last CP session (92%, 81–97%) ($P = 0.43$).

**Effectiveness of CP**

The presence or absence of cough or swallowing following CP was recorded in 107 of the 133 sessions. Of these 107 sessions, 64/107 (60%) had spontaneous cough or swallowing evident, 22/107 (21%) had successful AC performed, and no cough or swallowing occurred in the remaining 21/107 (19%) of sessions, despite attempts of AC being made. Eleven dogs had no cough or swallowing in all of their CP sessions.

The length of hospitalization was significantly longer for dogs in the intervention group (median 6 days, range 2–15 days) compared to the control group (4 days, range 1–13 days) ($P = 0.02$). Survival rate comparison between the intervention group (76.7%, 23/30) and the control group (57.7%, 41/71) showed a $P$-value that approached the significance ($P = 0.055$). No death occurred in the study group after 5 days of hospitalization, whereas

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**Table 1:** Characteristics of dogs that received chest physiotherapy (Intervention group) compared to a historical control group that did not receive chest physiotherapy (Control group)

| Variable | Intervention group, $n = 30$ median (range) | Control group, $n = 71$ median (range) | *P*-value |
|---|---|---|---|
| Age (years) | 4.75 (2 months–14 years) | 3 (11 days–16 years) | 0.71 |
| Body weight (kg) | 11.75 (1–73) | 14 (0.5–70) | 0.54 |
| Males/females | 16/14 | 33/38 | 0.66 |
| Presence of dyspnea | 80% | 80% | 1 |
| Brachycephalic breed | 30% | 27% | 0.81 |
| English Bulldog | 2 | 4 | |
| French Bulldog | 1 | 5 | |
| Shih-Tzu | 1 | 1 | |
| Pug | 2 | 2 | |
| Cavalier King Charles Spaniel | 2 | 2 | |
| Dogue de Bordeaux | 1 | 1 | |
| Lhasa Apso | 0 | 3 | |
| Pekingese | 0 | 1 | |

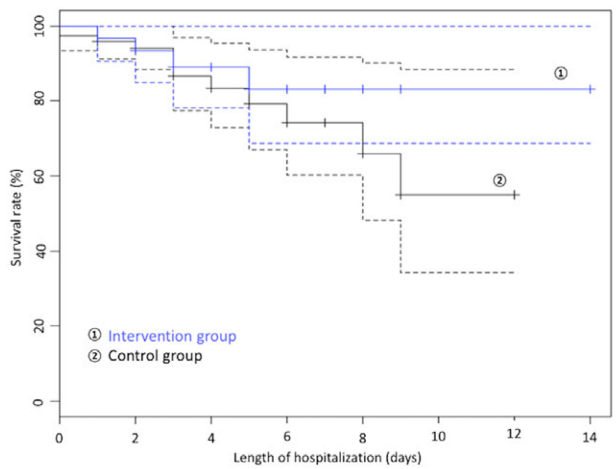


**Figure 3:** Survival curves in dogs undergoing chest physiotherapy (intervention group, $n = 30$, blue lines) and control dogs (control group, $n = 71$, black lines). Dotted lines are confidence intervals. No difference was observed between groups at any time ($P > 0.05$).

deaths continued to occur in the control group beyond the first 5 days (Figure 3).

## Discussion

The present study demonstrates that the CP techniques of PSE associated with AC were easily adaptable and well-tolerated techniques in dogs. There were minimal adverse events identified and evidence that mucus transport was augmented by the maneuvers was present in many cases. Although clear clinical benefit could not be demonstrated by the present study, comparison with a historical control group suggested that these techniques did not negatively impact patient outcome.

CP can be defined as the external application of a combination of forces to increase expiratory flow with the goal to optimize mucus transport.[1] CP in general, and PSE and AC in particular, is used in human infants and adults for the removal of retained airway secretions.[2,4,5,8–10] This variety of techniques are designed to help improve the patient's respiratory strength, control the sensations of dyspnea, and to help improve gas exchange.[b] The application of these techniques to animals has inherent limitations due to the inability to force a dog to take slow deep breaths (eg, incentive spirometry) or to voluntarily cough.[b] Standard described therapies in dogs are coupage and patient positioning, but despite a fairly substantial body of evidence suggesting that these techniques are helpful in people, there is no significant information in animals. Moreover, coupage is known to induce lung atelectasis in dogs.[20] To the authors' knowledge, the present study is the first to evaluate feasibility and benefits of PSE and AC in dogs.

The majority of dogs enrolled in the present study had pneumonia, which is a disease process likely to be associated with increased airway fluid and mucus production. Pneumonia is a common disease process in which CP has been applied in human patients[4,11,21,22] and seems to be a good indication in dogs for PSE and AC. Our study also included several dogs with anticoagulant rodenticide toxicosis in both the intervention group and the control group. The animals in the control group with anticoagulant intoxication also had pneumonia listed as a possible diagnosis, hence they were found on the computer search. In the study group, dogs with pulmonary hemorrhage were enrolled in the study as they were expected to have increased airway fluid and airway fluid clearance was likely to improve pulmonary function. The safety of performing CP in these animals was considered at the time of enrolment. On consultation with the human medical physiotherapist (DB), we were advised that coagulopathy was not considered a contraindication to CP. Indeed, given that the PSE technique does not involve any impact to the thoracic wall and these dogs were receiving therapy to normalize their coagulation system at the time of CP, the interventions were considered safe. Our study showed no adverse events associated with CP in the dogs with anticoagulant toxicosis. The present study also enrolled 2 dogs with leptospirosis in the intervention group. Pulmonary disease is common in dogs with leptospirosis and is associated with noncardiogenic pulmonary edema, pulmonary hemorrhages, and fibrinosuppurative exudation resulting in increased airway fluid accumulation.[23–27]

Despite the large heterogeneity of signalment in the intervention group, with ages varying from 2 months to 14 years, body weight from 1 to 73 kg, breeds from Chihuahua to Irish Wolfhound, it was always possible to find a comfortable position for the dog in which to practice PSE and AC. This is due to the high adaptability of our CP technique that could be used with the animal standing or in lateral recumbency as best tolerated by the dog. In our study, lateral recumbency was the most used position, and is recommended by the authors as the first choice when performing CP.

Discomfort rate during the physiotherapy sessions was low, the procedure did not need to be interrupted nor was sedation needed in any case. Moreover, no deterioration of clinical parameters, or desaturation was noted after CP sessions in the majority of dogs. In 6 dogs, transient tachypnea at the end of the session was evident. In human patients, it was reported that a CP treatment session increases heart rate, systolic blood pressure, oxygen consumption, and production of carbon dioxide.[28] These responses could explain the development of tachypnea in the dogs in the present study. Stress and anxiety may also be a reason for tachypnea in these dogs. It is worth noting that these side effects were transient and resolved as soon as the procedure was interrupted.

Coupage has been associated with pulmonary atelectasis in dogs[20] and gastroesophageal reflux, multiple rib fractures, and brain lesions in infants.[15,17,18] In the present study, PSE and AC showed no adverse events, even in dogs with coagulation disorders, although the number of enrolled dogs was relatively small and further evaluation will be needed to fully determine the potential adverse effects of these techniques. This absence of adverse events has also been observed in infants treated with PSE techniques.[2,19,28–30] As coupage has been described to have adverse effects, PSE technique seems to be safer.[15,17,18]

In the present study, frequency and length of the PSE sessions used were adapted to each individual dog depending on the degree of bronchial fluid accumulation, and dog comfort. Moreover, most of the sessions were short (5 minutes maximum on each recumbency) and frequent (every 6 hours) sessions. It has been shown in a human study that full time 24 h/d physiotherapy care is associated with reduction in the duration of mechanical ventilation and hospitalization as well as the incidence of respiratory infection and mortality when compared to a 6 h/d service.[10] The authors of this study concluded that CP should be provided in an as-needed manner. Even if it is not possible to extrapolate data from ventilated patients to our patients, it seems reasonable to consider that CP would ideally be provided in an as-needed manner in the nonventilated patient. At any time point, clinicians need to weigh the clinical benefit needs of this technique against animal compliance and the cost of personnel.

Spontaneous cough was not always evident in the dogs of the intervention group at the end of the CP session. Even with attempts of AC, cough was not always triggered. In practice, we found that many dogs tended to swallow secretions accumulated in the pharynx rather than cough. The same observation was made in infants.[19] One study in healthy dogs showed that AC with digital compression of the trachea was not successful to induce cough.[31] In addition, several of our intervention group dogs were receiving analgesic drugs that may have suppressed their cough response. So cough, spontaneous or assisted, is not a good clinical endpoint, and evidence of swallowing appears to be a better way to assess CP efficacy.

The length of hospitalization was significantly longer for dogs submitted to the PSE and AC treatment compared to the control group. For owner convenience, CP was performed only during hospitalization. It is possible that dogs were kept hospitalized longer if ongoing CP was considered to be of benefit by the primary clinician. It is also possible that by enrolling these dogs in the study and performing frequent CP, they had more clinical evaluations and monitoring performed than the animals in the control group. This may have resulted in a higher level of care and recognition of disease, prompting longer hospitalization. This greater level of care could also be the result of evolution of care over the past 10 years in the authors' ICU. Moreover, based on the survival curves, fatalities continued to occur in the control group after Day 5 following presentation, whereas no fatalities were observed in the intervention group after the first 5 days of presentation. The intervention group had more crackles and cough than the control group, despite the same prevalence of dyspnea. It is therefore possible to consider that the intervention group was sicker than the control group. However, it would have been ideal to have applied an illness severity score to compare both groups at admission. Unfortunately, there was insufficient information available in the control group to allow us to assess illness severity. The parameters we

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evaluated are not ideal indicators of relative illness severity and as the control group was retrospective, we relied on documented clinical signs in the medical records. So, it is likely that signs were underreported compared to the intervention group. Finally, it is also possible that the increase in length of hospitalization could be due to undetected adverse effects of CP. Prospective studies with long-term patient monitoring may allow further evaluation of this issue. Currently, there are no studies in veterinary medicine that have evaluated the impact of CP on length of hospitalization. In human literature, the reported impact of CP on length of hospitalization varies and depends on the population studied, and CP modality used.[2,7,10,22,32,33]

The present study showed no difference in survival rate, although the small number of enrolled dogs would make identifying a survival difference unlikely. There are few human studies that report a benefit of CP.[10,29,30,34] This treatment modality may primarily improve patient comfort and aid in the resolution of clinical signs but not necessarily alter case outcome. Reported benefits range from increased sputum expectoration, improved gas exchange parameters, and improved quality of life.[1,2,34] Studies showed that CP using prolonged slow exhalation techniques was associated with a reduction in the disease severity in infants compared with airway suction only,[29] or nebulization only.[19] The true benefits of CP in dogs will require further investigation.

The present study has several limitations. A major limitation is the comparison between an intervention group and a historical control group. In the 10 years over which the historical control group was identified, it is likely that changes in medical therapy have occurred. For example, in our institution, we introduced new techniques of nebulization therapy that could have modified the results. In an effort to better define the role of CP in dogs, a prospective randomized controlled study is currently underway at our institution. Another limitation is the small sample size of the intervention group, making identification of differences between groups challenging. The other limitations are related to clinical feasibility. It would have been ideal to have extensive respiratory monitoring (eg, plethysmography, spirometry) of the dogs enrolled in the intervention group before, during, and after each physiotherapy session. Given this was a clinical study, this degree of monitoring was not feasible. Oxygenation was assessed only with pulse oximetry, in which readings can be affected by several parameters. Arterial blood gas analysis may have provided valuable information in the evaluation of CP and AC in our dogs. For financial and technical reasons, arterial blood gas was not used for respiratory monitoring in our study. The inter-physiotherapist variability could also be a limitation. Despite having taken great care in optimizing the training, some variability in the way compression was applied may persist and is difficult to evaluate. We deliberately chose to have more than 1 physiotherapist provide treatment, to allow CP to be performed at any time of the day, every day of the week. This reflects the reality of clinical settings. Finally, thoracic radiographs are not the best diagnostic tool to evaluate fluid accumulation in the bronchial tree, and adding bronchoscopic evaluation for each dog would have been ideal. Unfortunately, given the risk associated with performing bronchoscopy in dyspneic patients, we could not justify its use unless clinically indicated.

To the authors' knowledge, the present study is the first to evaluate the feasibility, benefits, and effectiveness of PSE and AC in dogs with naturally occurring respiratory disease. Our findings suggest that PSE associated with AC are easily adaptable, and well tolerated techniques in dogs. Despite these techniques being easily learned, it is still advisable to only have trained veterinary staff performing the maneuvers in order to prevent adverse effects and maximize efficacy. The lack of clear benefit of CP in our study may reflect the small study size and the heterogeneous nature of the diseases of the enrolled dogs, and future randomized controlled prospective studies would be needed to determine if CP improves patient outcomes.

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## Footnotes

[a] R version 3.0.2 (2013-09-25), The R Foundation for Statistical Computing. Available at: http://www.R-project.org.

[b] Rozanski EA. Respiratory physiotherapy. In Proceedings of the International Veterinary Emergency and Critical Care Symposium, 2005, Atlanta, USA.

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