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Short Communication

Novel Insights on the Pattern of Cough Associated with Tracheal Collapse in Griffon Dogs

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Abstract

A prospective study was designed to test the hypothesis that the degree and location of tracheal collapse may influence its pattern of cough. Objective evaluation of cough was made in 45 dogs with tracheal collapse. The relationship between location and degree of collapse and cough was tested. Location of collapse did not have a significant effect on cough except for the moderate effect on the nature of cough (P=0.002; rs=0.45) while its degree had a significant effect (P<0.0001) on all cough parameters except for nature of cough (P=0.354). The pattern of cough associated with tracheal collapse is mainly influenced by the degree of collapse rather than its location.

Keywords: *Tracheal collapse, Cough, Dog*

Griffon Irkı Köpeklerde Trakeal Kollaps İle İlişkili Öksürük Modelinde Yeni Yaklaşımlar

Öz

Bu prospektif çalışma, trakeal kollaps derecesi ve lokalizasyonunun öksürük şeklini etkileyebileceği hipotezini araştırmak için tasarlandı. Trakeal kollaps şekillenmiş olan 45 köpekte öksürüğün objektif değerlendirmesi yapıldı. Lokasyon ve kollaps derecesi ile öksürük arasındaki ilişki incelendi. Kollaps lokasyonunun öksürük şekline orta düzeyde etkisi (P= 0.002; rs= 0.45) dışında öksürük üzerinde anlamlı bir etkisi olmamakla birlikte, derecesinin öksürük şekli (P=0.354) dışındaki tüm öksürük parametreleri üzerinde anlamlı etkisi (P<0.0001) olduğu belirlendi. Trakeal kollaps ile ilişkili öksürük modeli esas olarak kollapsın lokasyonu yerine derecesinden etkilenir.

Anahtar sözcükler: *Trakeal kollaps, Öksürük, Köpek*

INTRODUCTION

Tracheal collapse is a dynamic dorso-ventral reduction in the tracheal diameter which may involve isolated tracheal segment (cervical or thoracic) or the entire tracheal length [1,2]. The condition is commonly diagnosed in middle aged toy and miniature breed dogs with a prevalence of 0.5-2.9% [3-5]. The exact cause of tracheal collapse is unknown; the condition may arise due to flaccid dorsal tracheal membrane, weakened cartilaginous rings or both [6]. In lateral radiographs, tracheal collapse may be graded into mild, moderate and severe tracheal collapse based on the degree of reduction of the tracheal lumen diameter compared to the thoracic inlet width [7].

Tracheal collapse may remain asymptomatic till signs of respiratory distress appear including dyspnea, labored breathing, abnormal respiratory sounds and frequent cough. Cough is a protective air way function serving both corrective and preventive role [8]. It's a reflex triggered by compression or irritation of the airways and controlled by cough centers in the brainstem [9]. A characteristic paroxysmal goose-honking cough is the most common sign of tracheal collapse in order to overcome the resistance of air flow to maintain ventilation [2,10]. This pattern of cough may be a result of the action exerted by respiratory muscles to overcome the increased resistance of air flow at the area of the narrowed tracheal lumen. Based on *Poiseuille Law*, the resistance to air flow in straight circular tube is inversely proportional to the fourth power of its radius ($R=1/r^4$). This means that if the tracheal diameter is reduced by one half (50% reduction), the resistance of air within the tracheal lumen increases 16-fold [11].

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It is not clear whether the degree and possibly the location of tracheal collapse may have an influence on the pattern of cough associated with tracheal collapse. The aim of the present study was to test the hypothesis that the degree and location of tracheal collapse may have an influence on the pattern of cough in Griffon dogs with tracheal collapse.

MATERIAL and METHODS

Animals and Design

A prospective study was conducted on 45 Griffon dogs (32 males and 13 females), weighing 16.4±4.2 (mean±SD) kg and aging 7.5±3.2 (mean±SD) years. These dogs were admitted to clinic of the Department of Surgery, Anesthesiology and Radiology, Faculty of Veterinary Medicine, Cairo University. All study procedures were approved by Cairo University Institutional Animal Care and Use Committee (CU-IACUC) (approval No. CU/II/F/56/18). All dogs' owners were aware that their animals will be included in research purposes and signed a written consent indicating their approval.

Inclusion criteria of dogs included in the study are those dogs diagnosed with tracheal collapse based on clinical and radiographic examination and did not receive medicinal therapy during the last two weeks. The clinical manifestation of these dogs included signs of respiratory distress, periodical attacks of dyspnea and frequent coughing. Diagnosis of tracheal collapse was confirmed by right lateral inspiratory and expiratory radiographs.

Radiographic Evaluation

The location of tracheal collapse was categorized into cervical or thoracic tracheal collapse based on inspiratory and expiratory radiographs *(Fig. 1)*. The degree of tracheal collapse was graded based on the degree of reduction in tracheal lumen into mild, moderate and severe (25%, 50%, >75% respectively) based on Tanger and Hobson [7] grading system of tracheal collapse.

Objective Evaluation of Cough

Objective evaluation of cough was scored by the same examiner who was blind to the result of radiographic examination. Scoring was done based on clinical examination as well as owners' questionnaire designed to score cough evaluation parameters. Evaluation parameters included the onset of cough (acute: 0-3 weeks; subacute: 3-8 weeks; chronic: >8 weeks), frequency of cough (Grade I: 6 cough/h; Grade II: 6-12 cough/h; Grade III: >12 cough/h), nature of cough (Productive; Non productive), cough reflex (Present; Absent), control of cough (Voluntary; Involuntary), type of cough (Typical: initiated by inspiratory phase, pause then forced expiration; Atypical: missing inspiratory phase of cough) and wheezes (Present; Absent).

Statistical Analysis

Cough evaluation scores were tabulated for all dogs. A Spearman's correlation was run to determine the relationship between the degree and location of tracheal collapse with different cough evaluation parameters. Data were considered statistically significant when the P value <0.05. The strength of relationship was judged based on Spearman's correlation coefficient (r_s=0.00-0.19 very weak; 0.20-0.39 weak; 0.40-0.59 moderate; 0.60-0.79 strong; 0.80-1.00 very strong correlation). Data were analyzed using SPSS software 21 (IBM SPSS Inc., Chicago, IL).

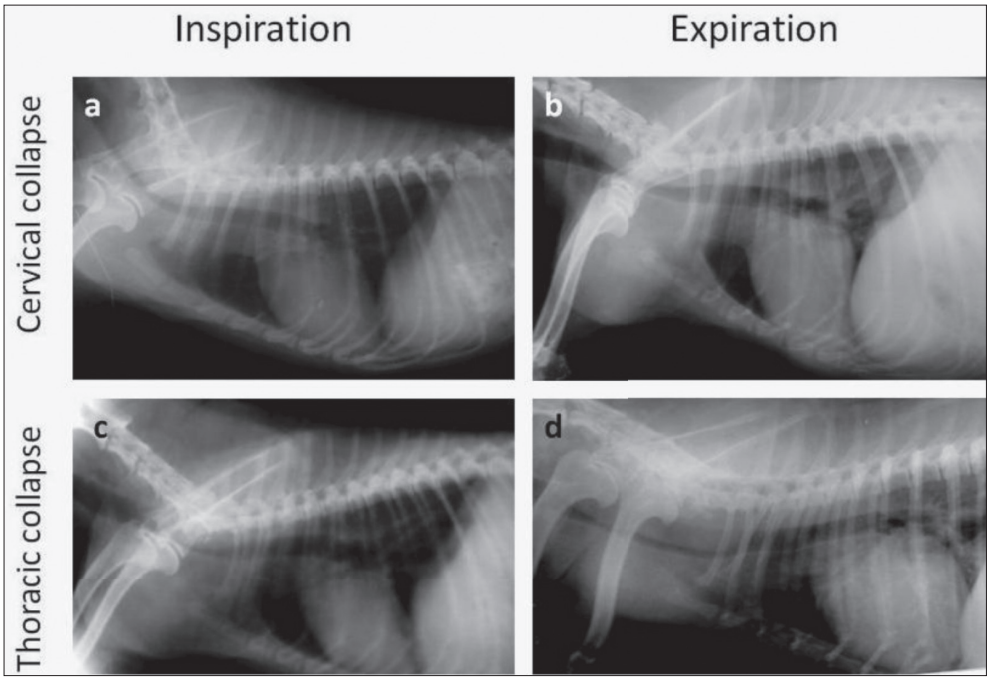

Fig 1. Right lateral inspiratory **(a,c)** and expiratory **(b,d)** thoracic radiographs demonstrating reduction in the tracheal diameter at the cervical **(a,b)** and thoracic **(c,d)** trachea

RESULTS

Radiographic Evaluation

Fortyfive Griffon dogs were diagnosed with tracheal collapse based on clinical and radiographic examination. The location of the collapsed trachea was in the cervical region in 33 (73.3%) dog and in the thoracic region in the remaining 12 (26.7%) dogs. Tracheal collapse was graded to be mild in 11 (24.4%), moderate in 22 (48.9%) and severe in 12 (26.7%) dogs. Distribution of the degree and location of tracheal collapse among presented dogs is demonstrated in *Table 1*.

Objective Evaluation of Cough

The characteristic cough associated with tracheal collapse had an acute onset in dogs with mild and moderate tracheal collapse, while dogs with severe tracheal collapse had a history of chronic cough lasting for more than 8 weeks *(Fig. 2)*. The frequency of cough increased with the more compromised tracheal lumen as manifested by increased frequency of cough in severe of degree of tracheal collapse *(Fig. 3)*. Productive cough was mostly prevalent in severe degree of tracheal collapse, while non-productive cough was predominant in mild and moderate degrees of tracheal collapse. In cervical tracheal collapse the nature of cough was mostly non-productive while productive cough was predominant in thoracic tracheal collapse *(Fig. 4)*. The presence of cough reflex and the voluntary control of cough were mostly associated with mild and moderate degrees of tracheal collapse. While dogs with severe tracheal collapse exhibited involuntary control of cough and absence of cough reflex *(Fig. 5, Fig. 6)*. Typical cough was only reported in mild tracheal collapse, while atypical form of cough was reported in moderate to severe tracheal collapse *(Fig. 7)*. Wheezes was absent in mild tracheal collapse, while it was recorded in moderate to severe degrees of tracheal collapse *(Fig. 8)*.

The location of tracheal collapse did not have a significant effect on all cough evaluation parameters except moderate effect on the nature of cough. A non significant correlation was reported between the location of tracheal collapse and

Table 1. *Degree and location of tracheal collapse among the presented 45 Griffon dogs*

Degree of Tracheal Collapse	Location of Tracheal Collapse		Total
	Cervical	Thoracic	
Mild (25% reduction)	8	3	11
Moderate (50% reduction)	17	5	22
Severe (75% reduction)	8	4	12
Total	33	12	45

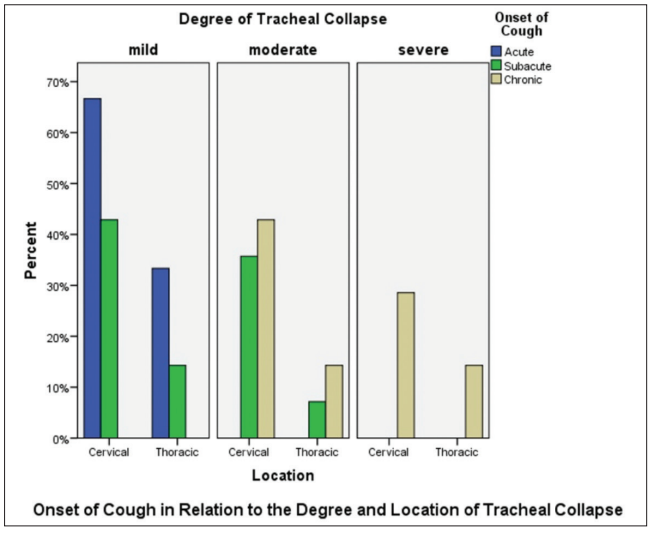

Fig 2. Evaluation of the onset of cough (acute-subacute-chronic cough) in relation to the location and degree of tracheal collapse

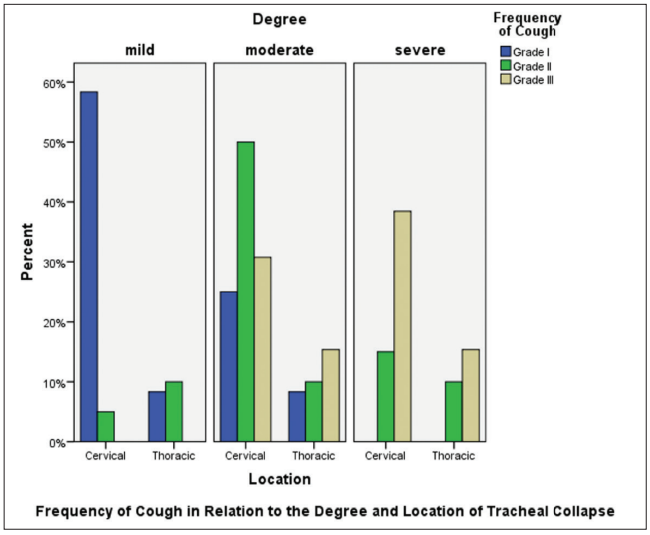

Fig 3. Evaluation of the frequency of cough (acute-subacute-chronic cough) in relation to the location and degree of tracheal collapse

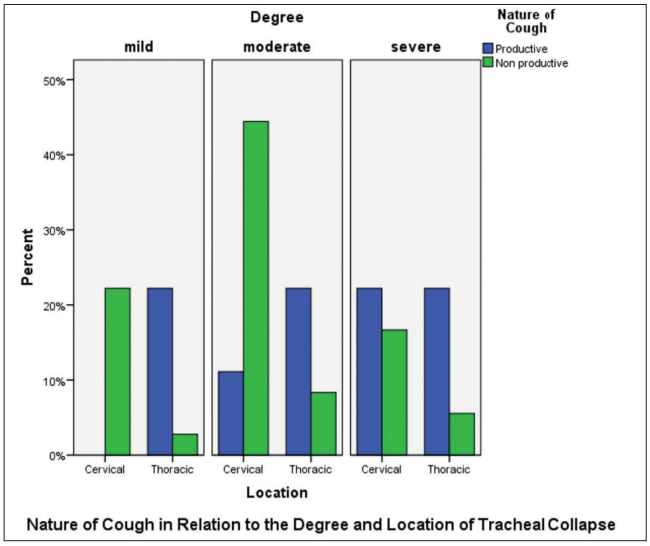

Fig 4. Evaluation of the nature of cough (productive-non productive cough) in relation to the location and degree of tracheal collapse

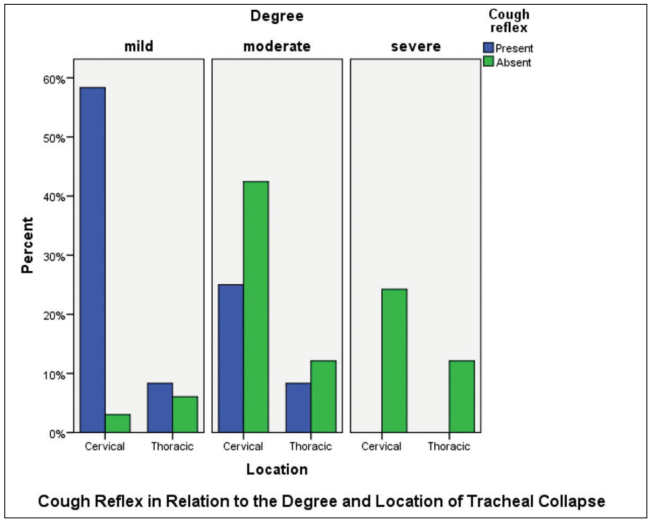

Fig 5. Evaluation of cough reflex (present-abscent) in relation to the location and degree of tracheal collapse

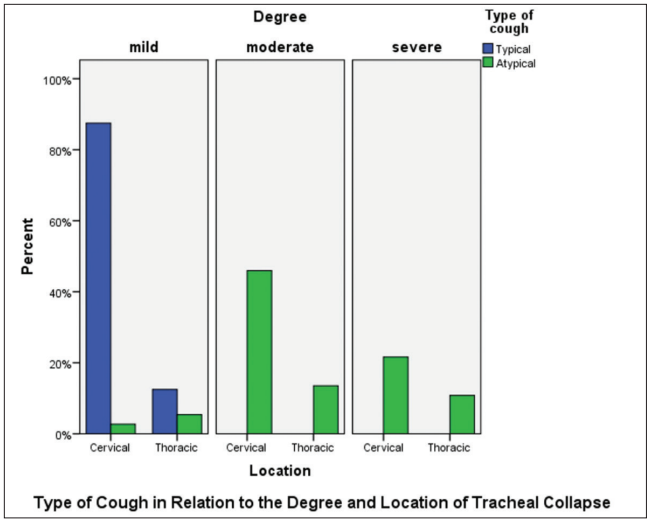

Fig 7. Evaluation of the type of cough (typical cough-atypical cough) in relation to the location and degree of tracheal collapse

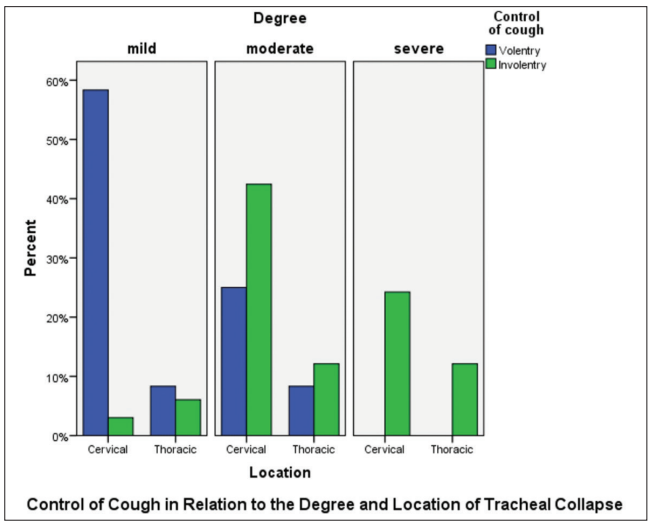

Fig 6. Evaluation of the control of cough (voluntary-invoulantry cough) in relation to the location and degree of tracheal collapse

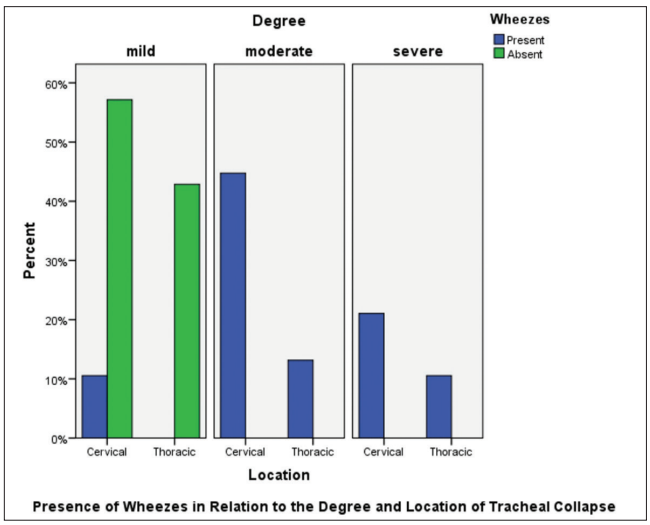

Fig 8. Evaluation of wheezes (presence-absence of wheezes) associated with cough in relation to the location and degree of tracheal collapse

duration of cough (P=0.78; r_s=0.04); frequency of cough (P=0.45*;* r_s=0.17); cough reflex (P=0.73*;* r_s=0.14); control of cough (P=0.37; r_s=0.14); type of cough (P=0.33*;* r_s=0.15) and wheezes (P=0.30*;* r_s=0.16). The only significant correlation between the location of tracheal collapse and the pattern of cough was on the nature of cough (P=0.002*;* r_s=0.45).

The degree of tracheal collapse had a significant effect (P<0.0001*)* on all cough evaluation parameters except for the nature of cough (P=0.354*)*. A strong positive correlation was reported between the degree of tracheal collapse and the duration of cough (r_s=0.74), frequency of cough (r_s=0.62), type of cough (r_s=0.66) and wheezes (r_s=0.61). Moderate correlation was reported between the degree of tracheal collapse and the presence of cough reflex and its voluntary control (r_s=0.58). No significant correlation between the degree of tracheal collapse and the nature (productive /non-productive) of cough (r_s=0.74).

DISCUSSION

The present study demonstrated that the pattern of cough associated with tracheal collapse is mainly influenced by the degree of the collapse rather than its location.

All presented dogs were of middle age (7.5±3.2 years) which is concurrent with the progressive nature of the disease. Advancement of age may results in lack of tracheal cartilage rigidity and laxity of the dorsal tracheal membrane resulting in dorso-ventral narrowing in the tracheal lumen. Ideally, normal trachea should be relatively firm to allow free movement of the air during respiration when negative pressure is induced by breathing in. Although numerous toy breeds may be affected with tracheal collapse [3-5], all presented cases were Griffon dogs which is mainly attributed to the over presentation of Griffon dogs among the admitted dog population.

In the present study, the diagnosis of tracheal collapse was made through radiographic examination. Inspiratory radiographs were more helpful in the diagnosis of cervical tracheal collapse while expiratory radiographs were recommended for diagnosing thoracic tracheal collapse. This supports the concept that tracheal collapse is a dynamic rather than static compression in the dorso-ventral diameter in tracheal lumen [12]. During inspiration, there is a negative pressure created within the pleural space, the wall of the cervical trachea tends to collapse as the surrounding pressure in the neck is relatively positive. In the mean time, the wall of the intrathoracic trachea tends to be held open. During expiration, the reverse process occurs, where the wall of the intrathoracic trachea tend to collapse and the cervical trachea are forced to be open by the change in the relative pressure [11].

The progressive nature of tracheal collapse was clearly manifested by the predominance of chronic cough in dogs with severe tracheal collapse while acute and subacute duration of cough were reported in dogs with mild and moderate degrees of tracheal collapse. Persistent chronic cough can seriously impair the quality of life and may result in vomiting and muscle pain [13]. The increased frequency of cough in dogs with severe tracheal collapse may be a result of the more forced action of respiratory muscles to maintain ventilation. The prevalence of productive cough in severe tracheal collapse may be a result of long standing inflammation of the tracheal mucosa resulting in loss of epithelium, fibrinous membrane formation, squamous metaplasia and increased subepithelial glands secreation [14]. Thoracic tracheal collapse was mostly productive which could be correlated to the predominance of subepithelial secretory glands and cilia in the thoracic part of the trachea [15].

The presence of cough reflex and its voluntary control in mild and moderate tracheal collapse is an attempt of the body to overcome the narrowed tracheal lumen. While severe tracheal collapse is a life threatening condition resulting in spontaneous involuntary cough to overcome the severe reduction in tracheal lumen. Typical cough initiated by inspiratory phase followed by pause and expiratory cough was only reported in mild tracheal collapse. Typically, cough is an aerodynamic sequence of inspiration, compression and forced exhalation against a closed glottis [8]. Atypical cough that was not preceded by inspiratory phase was reported in moderate and severe tracheal collapse to achieve faster maintenance of ventilation. The presence of wheezes in moderate and severe tracheal collapse could be attributed to turbulence of air within the reduced tracheal lumen.

The main limitations of the present study are the use of only one breed of dogs (Griffon dog) and the absence of follow up data of cough following medical or surgical treatment. Further studies should be directed to studying the pattern of cough following medical and surgical treatment in different breeds of dogs with tracheal collapse. In conclusion, the pattern of cough associated with tracheal collapse is mainly influenced by the degree of the collapse rather than its location.

Conflict of Interest

The authors declare that there is no conflict of interest.

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Author Contributions

All authors contributed equally in conceiving and designing the study, analyzing the obtained data, critically revising the manuscript for important intellectual contents and approving the final version.

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