A DISSERTATION FOR THE DEGREE OF MASTER

Fluoroscopic Characteristics of Tracheal Collapse and Cervical Lung Herniation in Dogs

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ABSTRACT

Tracheal collapse is a common disease in small breeds and known as cause of chronic cough. Cervical lung herniation is protrusion of the lung through the apex of each hemithorax and there are not many reports in veterinary society. The purpose of the present study was to investigate fluoroscopic characteristics of tracheal collapse and cervical lung herniation (CLH), and pursue any potential relationship to various influencing factors in dogs.

From 2012 to 2014, cases performed fluoroscopic examination of trachea with coughing phase were included and cases with lacking of records about a history of

cough were excluded. Medical records were reviewed for history, signalment, clinical signs and physical examination findings of patients performed fluoroscopy examinations. Presence and grade of tracheal collapse, CLH were investigated and presence of kinking of trachea is recorded on fluoroscopic examination. Severity of CLH was graded by comparing level of apex of the lung lobe and the adjacent cervical vertebrae.

In 330 cases performed fluoroscopic examination, 306 cases met inclusion criteria. Many of cases with a history of cough and most of the cases without a history of cough were proceeded examination for pre-anesthesia evaluation. Tracheal collapse was shown in 270 cases and there was no correlation with a history of cough. The mean age of the cases was 10.853 ± 3.109 years old (range 1~18) and the cases with tracheal collapse (11.041 ± 2.996) older than cases without tracheal collapse (9.444 ± 3.597). To evaluate CLH, cases with unknown duration of cough and failed to induce coughing phase in dorsal recumbence were excluded and 238 cases met the inclusion criteria. In 238 cases, there were 132 cases showed CLH. CLH showed significant association with a history of cough and intrathoracic tracheal collapse. But in cases without a history of cough or without tracheal collapse, CLH was not rare phenomenon. In univariate analysis significant correlation was shown between CLH and duration of cough, but in multivariate analysis, there was no correlation between them. There was no significant association between the severity of CLH (grade of CLH) and cough. In 10 dogs of grade 3 and 4, Shih Tzus (4/10, 40.0%) and Pekingeses (3/10, 30.0%) occupied large portion and Pekingese and Shih Tzu dogs presented wider thoracic

compared to other breeds. And cases with high grade of CLH closed to barrel chested. The cases with higher grade of CLH showed the larger portion of tracheal kinking. No patient with tracheal or esophageal obstruction resulted from cervical lung herniation in the present study.

In conclusion, tracheal collapse can be seen without a history of cough. So when tracheal collapse is regarded as critical factor, such as anesthetic situation, it should be ruled out using physical examination and diagnostic image. CLH is a common appearance in dogs and associates a history of cough, breeds and intrathoracic tracheal collapse. Without a history of chronic cough, transient cough can elicit cervical herniation of the lung. The greater grade of CLH, the more tracheal kinking were identified and there was possibility, mechanical irritation of trachea deteriorate the clinical sign.

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Keyword: cervical lung herniation, tracheal collapse, chest conformation, fluoroscopy, dog

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INTRODUCTION

Tracheal collapse is known as congenital cartilaginous tracheal ring problem and is predisposed in small breed. Tracheal collapse usually diagnosed by radiography, fluoroscopy and tracheobronchoscopy. In dogs with chronic cough, 51% dogs showed tracheobronchomalacia and it is regarded as common cause of cough (Hawkins *et al*., 2010). Upper airway obstruction, infectious tracheobronchitis, heart enlargement, parasitic disease, obesity and oral problem can exacerbate clinical sign of tracheal collapse (Eleanar, 2014). However, studies investigating tracheal collapse without a history of cough are lacking. In human, anesthesia is regarded as tricky procedure in patient with tracheomalacia (Austin and Ali, 2003). Although risk of tracheal collapse associated with anesthesia is not reported in dogs, tracheal collapse can be important factor of morbidity in postoperative care. In these patient, excitation and respiratory distress after extubation make worse tracheal collapse and it can make vicious cycle. So information about tracheal collapse is important to plan anesthetic protocol.

Lung hernia is defined as a protrusion of the lung parenchyma beyond the confine of the thoracic cavity (Moncada *et al*., 1996). Lung hernia is classified by their etiology and location (Morel-Lavallée, 1845). It may be appeared as congenital or acquired (spontaneous or traumatic), and it can be classified as cervical or thoracic or diaphragmatic hernia by their location. In human medicine, cervical lung hernia usually occur during infancy or childhood and is disappeared spontaneously as grown up. It can be unilateral or bilateral and particularly, right

lung hernias occur three times more frequently than left lung hernias (Thompson, 1976). Partial absence laxity, or attenuation of Sibson's fascia results in acquired type of cervical lung hernia with protrusion of the lung between the anterior scalene and sternomastoid muscle (Lightwood and Cleland, 1974; Moncada *et al*., 1996). Most of the acquired cervical lung hernia occur due to penetrating chest trauma or surgery, chest wall neoplasms, or chest wall infections. However, 29% of acquired cervical lung hernia can be appeared without special event, due to chronic cough and repeated Valsalva maneuver (McAdams *et al*., 1996; Moncada *et al*., 1996). Cervical lung herniation (CLH) is a common phenomenon in dogs, but there are not many reports about influencing factor of CLH (Choi *et al*., 2015; Coleman *et al*., 2005; Coutu *et al*., 2015; Guglielmini *et al*., 2007; Nafe *et al*., 2013). Differently from human, in dogs, there is no significant relationship between the duration of cough and CLH while intrathoracic large tracheal collapse strongly associated with CLH (Nafe *et al*., 2013).

The purpose of the present study was to pursue any potential relationship to various influencing factors and investigate fluoroscopic characteristics of tracheal collapse and CLH in dogs.

MATERIALS AND METHODS

1. Inclusion criteria

Cases with fluoroscopic and radiographic images of the trachea, between January 1, 2012 and December 31, 2014 which presented to the Seoul National University Veterinary Medical Teaching Hospital, were retrospectively evaluated and medical records of each case were reviewed. Signalment, a history of cough, grade of heart murmur and chief complaint were recorded. Cases, lacked record about cough and failed to induce coughing phase during fluoroscopic examination, were excluded for investigating tracheal collapse. Without coughing phase in fluoroscopy, tracheal collapse might be underestimated. For evaluating relationship between cervical lung herniation (CLH) and duration of cough, cases had ambiguous record about duration of cough also excluded. And cases with pectus excavatum and ill-defined vertebral and sternal borders were excluded for investigating influence of thoracic conformation on CLH. After exclusion of cases with potential causes of cough (tracheal collapse, heart murmur and significant abnormality of the lung field on radiograph), association between a history of cough and trachealis muscle redundancy was investigated.

2. Radiographic image evaluation

Each case obtained at least two thoracic radiographs in ventrodorsal and right lateral recumbence. Presence or absence of tracheal collapse, pulmonary abnormality were evaluated. In cases shown trachealis muscle redundancy without tracheal collapse on fluoroscopic image, heart murmur, and pulmonary abnormality, percentage of opacification of trachealis muscle redundancy compared to tracheal diameter were recorded.

To investigating relationship between the chest conformation and CLH, several diameters were measured on digital radiographs. On right lateral view, diameter of the thoracic inlet and depth of the thorax were measured and on ventrodorsal view, width of the thorax at the 1st and 8th rib level were measured. Diameter of the thoracic inlet on lateral view was measured from the ventral margin of vertebral body at the midpoint of the most cranial rib to the dorsal margin of the manubrium at the level of minimal thickness (Hayward *et al*., 2008). Thoracic depth was defined as distance from dorsal aspect of the xiphoid process to the ventral aspect of the vertebral body perpendicular to the line from the xiphoid process. Width of the thorax was measured as the distance between the medial border of 1st and 8th rib (Figure 1). Thoracic depth to width at the level of 8th rib ratio (depth/R8) and thoracic inlet distance to thoracic depth ratio (LAT ratio) and thoracic width at the level of 1st to 8th rib ratio (VD ratio) were calculated (Jepsen-Grant *et al*., 2013).

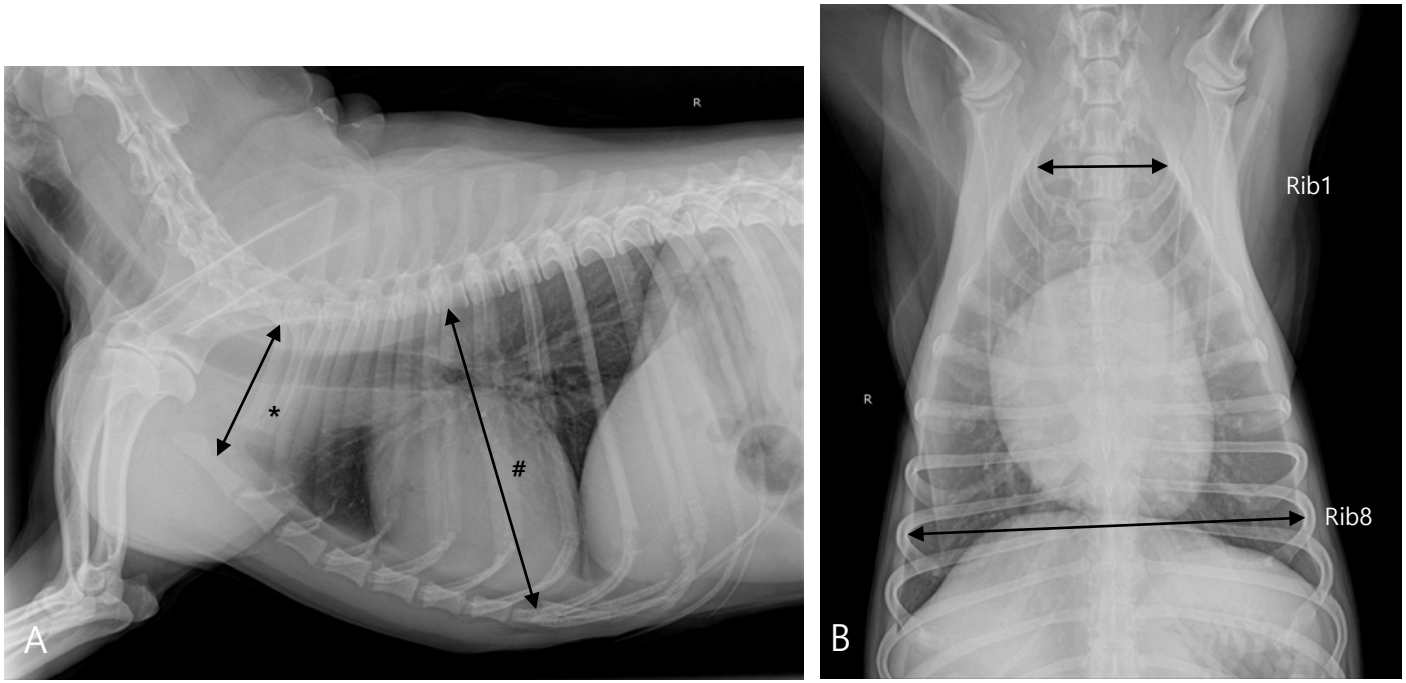

Figure 1. Right lateral (A) and ventrodorsal view (B) of canine thorax. Illustration of the thoracic inlet distance (*), thoracic depth (#), and width of the thorax at the level of 1st and 8th rib measurement. Diameter of the thoracic inlet was measured from the ventral margin of vertebral body at the midpoint of the most cranial rib to the dorsal margin of manubrium at the level of minimal thickness. Thoracic depth was measured from the xiphoid process to vertebral body perpendicular to line from xiphoid process. Width of the thorax was measured from the inside of the 1st and 8th rib.

3. Fluoroscopic image evaluation

Images of normal respiration status and forceful expiration (coughing) status were obtained through fluoroscopic examination. On the right lateral position, normal respiratory phase was evaluated and cervical trachea was compressed for evaluation of coughing phase. In order to investigate CLH, humanoid position images were acquired during coughing phase.

Location and grade of tracheal collapse, grade of CLH, and presence of the trachealis muscle redundancy and kinking of the trachea were recorded. Tracheal regions were divided as cervical, thoracic inlet, intrathoracic, and carinal region and mainstem bronchi. In this present study, tracheal collapse included mainstem bronchi. Degree of tracheal collapse was graded by degree of decrease luminal diameter as 0~25% (grade 1), 25~50% (grade 2), 50~75% (grade 3) and greater than 75% (grade 4). The highest grade was recorded. The mainstem bronchi were only divided as presence or absence. CLH was graded by comparing apical level of the cranial lung lobe to cervical vertebral body as grade 1 (7th cervical vertebra), grade 2 (6th cervical vertebra), grade 3 (5th cervical vertebra) and grade 4 (4th cervical vertebra, Figure 2). Because of breed variation, relative value using vertebral body was selected instead of absolute value. If lung protruded to intervertebral disc space, closer vertebral body was using to decide grade of CLH.

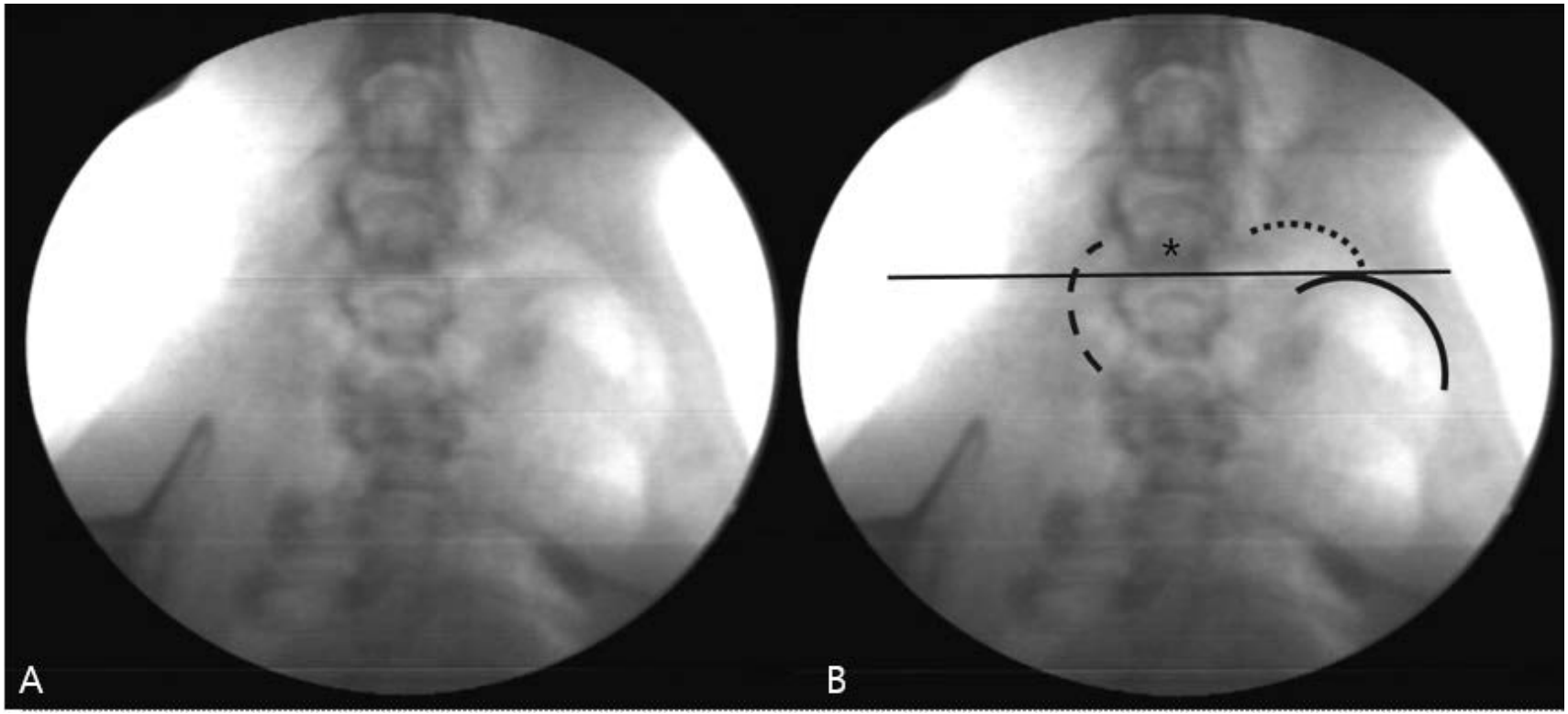

Figure 2. Unmarked (A) and marked (B) fluoroscopic image on humanoid position during coughing phase. Left cranial lung lobe (solid line) is extruded to the caudal 4th cervical spine (asterisk). This dog was decided as grade 4 CLH. Dotted line, esophagus; dashed line, trachea.

4. Statistical analyses

For investigating influence factor of tracheal collapse, Chi-squared test and Mann-Whitney U test were used. Fischer's exact test was used to evaluated association between trachealis muscle redundancy and a history of cough. Data were analyzed between CLH and influencing factors (age, duration of cough, a history of cough, tracheal collapse, kinking of trachea) using Chi-squared test, Mann-Whitney U test and logistic regression. The age of the dogs, ratio of the chest conformation were presented as the mean ± standard deviation (SD) values. Logistic regression, independent t-test and Mann-Whitney U test were used to assess the relationship between the chest conformation and high grade CLH (grade 3 and 4), and breed. A value of $P < 0.05$ was considered statistically significant. All statistics were calculated using SPSS (IBM SPSS Statistics, IBM Corp., Armonk, NY).

RESULTS

Three hundred and thirty fluoroscopic examination was performed for patients with a history of cough, suspicion tracheal collapse on radiograph, respiratory distress and cough induced by stimulating the trachea.

1. Tracheal collapse

In 306 cases, except the cases failed inducing coughing phase in fluoroscopic examination and absent the record about cough (unknown history of cough), tracheal collapse showed in 270 cases (3 grade 1; 17 grade 2; 34 grade 3; 216 grade 4). One hundred and twenty three cases were neutered male, 83 cases were neutered female, 41 cases were intact female and 23 cases were intact male. There was no correlation with tracheal collapse. The age range was 1 to 18 years and mean age of cases with tracheal collapse was 11.041 ± 2.996 and cases without tracheal collapse was 9.444 ± 3.597 (p = 0.019). Malteses were the most common dogs followed by Yorkshire Terriers and Shih Tzus (Table 1). Heart murmur was detected 87 cases (87/256, 34.0%) with tracheal collapse. Fourteen cases with tracheal collapses had ambiguous records about heart murmur. One hundred ninety seven cases had a history of cough and there was no correlation between tracheal collapse and a history of cough (Table 2).

Table 1. Breeds identified with tracheal collapse

Breeds	Tracheal collapse (n = 270)
Maltese	79 (29.3%)
Yorkshire Terrier	70 (25.9%)
Shih Tzu	34 (12.6%)
Pomeranian	22 (8.1%)
Poodle	21 (7.8%)
Mixed breed	16 (5.9%)
Chihuahua	6 (2.2%)
Cocker Spaniel	5 (1.9%)
Miniature Pinscher	5 (1.9%)
Pekingese	4 (1.5%)
Dachshund	2 (0.7%)
Japanese Chin	2 (0.7%)
Schnauzer	2 (0.7%)
Beagle	1 (0.4%)
Papillion	1 (0.4%)

Table 2. Association between the tracheal collapse and a history of cough

	A history of cough	No history of cough
Tracheal collapse	197	73
No tracheal collapse	25	11
p value	0.657	

To investigate influence of trachealis muscle redundancy on a history of cough, excluded cases with tracheal collapse and heart murmur and pulmonary abnormality on thoracic radiographs. In 25 cases, there were no association between the trachealis muscle redundancy and a history of cough. And percentage of trachealis muscle redundancy opacification was greater than 50% in 7 cases among 10 cases with trachealis muscle redundancy.

2. Cervical lung herniation

Two hundred and thirty eight cases met the inclusion criteria and CLH were showed in 132 cases. Grade 1 (n = 79) is the most common grade, followed by grade 2 (n = 42), grade 3 (n = 9), and grade 4 (n = 2). In 237 cases (except one case absent fluoroscopic image in humanoid view), left side CLH (n = 120) appeared more common than right side CLH (n = 84). In cases with CLH, 124 cases had tracheal collapse and 103 cases had a history of cough (Table 3). Although there were correlation between CLH and tracheal collapse and a history of cough, 8 cases without tracheal collapse (8/26, 30.8%) and 29 cases without a history of cough (29/76, 38.2%) showed CLH. Univariate analyses showed that tracheal collapse, intrathoracic tracheal collapse, a history of cough, age and duration of cough were significantly associated with CLH. Whereas multivariate logistic regression analysis showed that only intrathoracic tracheal collapse and a history of cough were significant factors correlated with CLH (Table 4). Association between kinking of trachea and CLH was significant ($p < 0.001$).

Table 3. Association between CLH and tracheal collapse and a history of cough

	Tracheal collapse (n = 212)	A history of cough (n = 162)
CLH (n = 132)	124	103
No CLH (n = 106)	88	59

Table 4. Result of the multivariate analysis. Tracheal collapse and a history of cough associated with CLH

Variables	Odds ratio	95% CI	*p* value
Intrathoracic tracheal collapse	3.396	1.665-6.928	0.001
A history of cough	2.544	1.413-4.578	0.002
Age	1.079	0.986-1.181	0.099

$\ln(p/1-p) = -2.210 + 1.223x_1 + 0.934x_2 + 0.076x_3$, where p is probability of CLH, x_1 is intrathoracic tracheal collapse, x_2 is a history of cough, and x_3 is age.

In cases with CLH, grade of CLH had no association with a history of cough, but cases with high grade CLH showed more portion of kinking of the trachea (Figure 3). Ten cases showed greater than grade 3 CLH (4 Shih Tzus, 3 Pekingeses, 2 Yorkshire Terriers, and a Miniature Pinscher). In the present study, no complication caused by CLH.

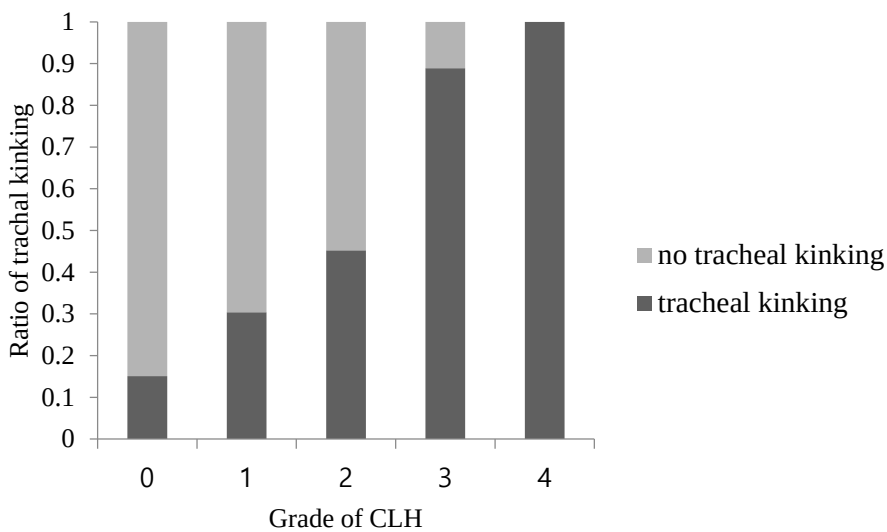

Figure 3. The higher grade of CLH, the more portion of kinking of the trachea.

3. Conformation of the chest

Two hundred and eight cases met inclusion criteria investigating the chest conformation and breed. Among LAT ratio, VD ratio, depth/R8, only depth/R8 was significantly lower in cases with high grade CLH (grade 3 and 4). Also univariate logistic regression analysis showed depth/R8 influenced high grade CLH (p = 0.020). In Shih Tzu and Pekingese dogs, occupied large portion of high grade CLH, LAT ratio and VD ratio were larger than other breeds (Table 5).

Table 5. Association between the chest conformation and high grade CLH and breeds

	LAT ratio	VD ratio	Depth/R8*
G3 and G4 CLH	0.534 ± 0.081	0.339 ± 0.043	0.609 ± 0.104[a]
G1 and G2 CLH	0.502 ± 0.051	0.321 ± 0.033	0.668 ± 0.079[b]
ST, Peki	0.552 ± 0.060[a]	0.340 ± 0.033[a]	0.663 ± 0.064
Other breeds	0.494 ± 0.456[b]	0.318 ± 0.033[b]	0.665 ± 0.078

[a, b] statistically different

* influence on grade of CLH, odds ratio = 0.000 (95% CI 0.000-0.225); ST, Shih Tzu; Peki, Pekingese; CLH, cervical lung herniation.

DISCUSSION

Almost cases were small breeds and it was consist with previous studies. Although older cases were common in this present study, age of cases with tracheal collapse were older than cases without tracheal collapse. It should be noted that there were no association between tracheal collapse and a history of cough. Many patients, showed cough during physical examination or narrowed airway on radiograph, had tracheal collapse without a history of cough. So differentiation tracheal collapse through physical examination and diagnostic image is important, especially when patient is plan to be anesthetized, tracheal collapse can lead to life threatening situation (Austin and Ali, 2003). Trachealis muscle redundancy is known as subclinical phenomenon and it occupied more portion of tracheal height in dogs with tracheal collapse. In the present study, percentage of trachealis muscle redundancy height portion was larger than previous study (Lindl Bylicki *et al*., 2015). Trachealis muscle redundancy was not shown association with a history of cough in the present study.

In human, cervical lung hernia is not common. Among the lung hernias, cervical lung hernia occupy 25% and usually it is the congenital problem and disappear spontaneously. In adult, many cervical lung hernias result from chest trauma or surgery, chest wall neoplasms, or chest wall infections (del Rey and Cunha, 1990; McAdams *et al*., 1996). Twenty nine percent of acquired type occur without special event and are associated with increase of intrathoracic pressure resulted from chronic cough, emphysema and repetitive respiratory maneuvers (McAdams *et al*.,

1996; Moncada *et al*., 1996). Similarly, there are not many reports of CLH in veterinary medicine. There were 126 cases had been reported (Choi *et al*., 2015; Coleman *et al*., 2005; Coutu *et al*., 2015; Guglielmini *et al*., 2007; Nafe *et al*., 2013). CLH was known as rare phenomenon in dogs. But in a report, CLH were evaluated in 121 cases by fluoroscopy and 70% of the cases had CLH. There were no association between CLH and duration of cough (Nafe *et al*., 2013). In the present study, there were enough cases without a history of cough so relationship between cough and CLH can be evaluated. CLH showed significant correlation with a history of cough and tracheal collapse. But CLH were also showed 8 cases without tracheal collapse (8/26, 30.8%) and 29 cases without a history of cough (29/76, 38.2%). This portion is significant, so other factors beside a history of cough might be associated with CLH. Aging is suggested one of the factors affecting CLH because most cases in the present study were older patients. Although in multivariate analysis, age was not significant influencing factor, in univariate analysis, it correlated CLH. Muscle weakness with aging may be important factor of CLH in dogs as human (Bidstrup *et al*., 1966; Fenichel and Epstein, 1955). If already thoracic muscles are weakened, even transient cough can make cervical lung lobe protrusion beyond the thoracic cavity. And repeated barking can be one of the cause increasing pressure in thoracic cavity. So caution is needed when blood collection from external jugular vein, even if patient have no clinical sign of cough (Bhalla *et al*., 1990). CLH can be showed result from just transient increased intrathoracic pressure. No association between duration of cough and CLH in multivariate analysis was consistent with a previous paper (Nafe

et al., 2013). Intrathoracic tracheal collapse and a history of cough associated with CLH in multivariate logistic regression analysis. Tracheal kinking also showed relationship with CLH and higher grade of CLH had more portion of tracheal kinking. Kinking trachea may be damaged and can be associated with clinical signs and prognosis as human (McAdams *et al*., 1996). But more studies are needed to show the relationship between the kinking of the trachea and deformation of the trachea. Although cervical lung hernias can result in complication such as coughing caused by irritated trachea, dysphagia, incarceration of the lung and pain due to compression nerve in human, no cases showed definite complication associated CLH in the present study (Bhalla *et al*., 1990; Rahman *et al*., 2006). However, because coughing was a common sign in the present cases, and follow up was not approached, it is not clear whether kinking trachea influenced on coughing or not. In veterinary medicine, one case of dysphasia due to CLH was reported in a juvenile dog (Coutu *et al*., 2015).

Frequency of the breeds had having CLH was similar with the breeds having tracheal collapse. But interestingly, Pekingese and Shih Tzu dogs had large portion in the high grade (grade 3 and 4) of lung herniation. Also among lung herniation reports, except the retrospective study (Nafe *et al*., 2013), 40% (2/5) cases were Pekingeses (Choi *et al*., 2015; Coleman *et al*., 2005; Coutu *et al*., 2015; Guglielmini *et al*., 2007). Especially, in the present study, only 4 Pekingeses were included criteria and large portion (3/4, 75%) was decided high grade CLH. Difference of thoracic anatomy can be a cause of CLH, but there is no report about anatomy of lung herniation in dogs and difference of thoracic anatomy of

Pekingese compared to other breeds. According to a previous study, breed predisposition and association with the chest conformation were not made (Nafe *et al*., 2013). In the present study, depth/R8 showed influence on CLH grade. As depth/R8 decreased, or closed to barrel chested, possibility of high grade CLH (grade 3 and 4) increased. Pekingese and Shih Tzu dogs had wider thoracic inlet (higher LAT and VD ratio) compared to other breeds. Because relatively small number of high grade CLH cases, further studies are needed about anatomic aspect of CLH with larger group. Because the left cranial lung lobes located cranial to the right cranial lung lobes in dogs, left cranial lung lobes protrude more commonly beyond the thoracic cavity than right cranial lung lobes (Evans HE and de Lahunta A, 2013). There was no case with a history of trauma or disease at cranial thoracic region. From this, in dogs, acquired CLH is different from human, having thoracic trauma in most acquired CLH (del Rey and Cunha, 1990; McAdams *et al*., 1996). Although congenital CLH cannot be excluded, spontaneous acquired CLH is an assumed major type in the dogs because there were large population of older dogs in the present study. Relationship between lung herniation and intrathoracic tracheal collapse is consented to a previous study (Nafe *et al*., 2013). Increased intrathoracic pressure is a cause of CLH and usually intrathoracic tracheal collapse can increase intrathoracic pressure during expiration (Hayward *et al*., 2008). So intrathoracic tracheal collapse can result in CLH.

There were several limitations in the present study, including it being a retrospective in nature. Also as the absence of further follow up of the cases, it is unknown whether CLH makes worse clinical sign or not. And only 2 cases in grade

4 group, 100% of kinking trachea portion could be overestimated. When investigating association between trachealis muscle redundancy and coughing, major causes of cough such as tracheal collapse, pulmonary abnormalities and heart problem were excluded. But there might be other causes of cough, such as upper respiratory disease or pulmonary disease not manifested on radiographs, can be included in the investing group.

CONCLUSIONS

Many tracheal collapse can be diagnosed through fluoroscopic examination in patients without a history of cough. It should be noted, especially when make anesthetic protocol because excitation. After extubation, induce respiratory distress followed by narrowed airway and this makes vicious cycle. Whether patient have a history of cough or not, physical examination and diagnostic image are comprehensively needed for ruling out tracheal collapse.

During fluoroscopic examination, CLH is common finding in the older dogs. Although intrathoracic tracheal collapse is the most influence factor on CLH and a history of cough is second factor, CLH can be appeared without a history of cough and tracheal collapse. Kinking of trachea is more common in severe CLH and mechanical irritation of trachea can make worse clinical sign. So in severe CLH, detected in physical examination, more caution is needed. Interestingly, Pekingese and Shih Tzu dogs tend to show high grade CLH and they have wider thoracic inlet.

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국문초록

기관허탈은 소형견종에서 흔하게 발생하는 질환으로 만성 기침의 주요 원인 중 하나로 알려져 있다. 경부 폐 허니아는 폐가 흉곽입구를 통해 흉곽을 벗어나는 것을 말한다. 본 연구는 투시 영상에서 기관허탈과 경부 폐 허니아의 특징과 이들에 미치는 영향을 알아보는 것을 목적으로 하였다.

2012년부터 2014년까지의 330건의 투시검사 중 기침 관련 기록이 있고, 투시 검사 시 기침이 유발된 306건의 사례를 대상으로 기관허탈의 빈도와 환자의 병력과 품고 등을 조사하였다. 또한 기침기간이 불명확하고 인간상에서 기침유발이 되지 않았던 개체를 제외한 238건에서 경부 폐 허니아의 빈도와 정도, 이와 관련이 있는 요소들을 알아보았다. 투시검사는 주로 기침을 주증으로 내원한 환자를 대상으로 하였으며 그 밖에 호흡곤란이나 일반영상에서 기관이 좁아져 있는 환자, 신체검사에서 기관허탈이 의심되는 환자를 대상으로 하였다.

306건 중 270건에서 기관허탈이 나타났으며 기침과의 관련성은 확인되지 않았다. 전체 건수에서 평균 연령은 10.853 ± 3.109세로 나타났으며 기관허탈이 있는 경우는 11.041 ± 2.996세, 없는 경우는 9.444 ± 3.597로 기관허탈이 있는 경우가 없는 경우보다 많은 것으로 확인되었다. 경부 폐 허니아는 238건 중 132건에서 확인되었으며 기침의 유무

와 흉곽 내 기관허탈 여부와 관련이 있는 것으로 나타났다. 경부 폐 허니아는 흉곽 내 기관허탈이 있을 경우 발생할 확률이 3.396배로 증가하며 평소 기침 증세가 있을 경우는 2.544배로 증가하는 것으로 나타났으나 기침과 기관허탈이 없는 개체에서도 각각 38.2%, 30.8%가 경부 폐 허니아를 보였다. 다변량 분석에서 기침의 기간과 경부 폐 허니아는 유의적인 관련성이 없는 것으로 나타났으며 경부 폐 허니아의 정도와도 유의적인 관련성은 없었다. 3단계 이상의 고도의 폐 허니아를 보이는 10건 중 7건이 페키니즈와 시츄로 나타났으며 이들 품종에서 흉곽의 입구가 넓은 것으로 확인되었다. 폐 허니아와 관련하여 다른 요인을 찾기 위해 흉곽입구의 비율과 흉곽 깊이와 너비의 비를 구하여 비교하였으며 심한 경부 폐 허니아를 보이는 그룹에서 흉곽 깊이와 너비의 비가 유의적으로 작게 나타났다. 투시영상에서 기관의 구부러짐은 경부 폐 허니아의 정도가 심할수록 나타나는 비율이 높게 나타나는 것으로 보였으나 임상증상과 직접적인 관련성은 찾을 수 없었다. 본 조사에서 경부 폐 허니아에 의한 증상을 보이는 경우는 없었다.

결론적으로 기침과 기관허탈이 유의적인 상관관계를 보이지 않는 바 기침경력이 없더라도 마취와 같이 기관허탈의 유무가 중요한 경우에는 면밀한 신체검사와 영상진단 검사를 통해 감별할 필요가 있다. 개에서 경부 폐 허니아는 기침의 유무, 품종, 흉곽 내 기관허탈과 관련이 있는 것으로 나타났으나 만성적인 기침 없이 일시적인 흉곽 압력 증가만으

로도 발생할 수 있는 현상으로 생각된다. 또한 경부 폐 허니아와 함께 관찰될 수 있는 기관의 구부러짐은 기관의 물리적인 자극을 가할 수 있으며 이로 인한 임상증상의 악화 가능성을 제시할 수 있다.

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주요어: 경부 폐 허니아, 기관허탈, 흉곽 형태, 투시영상검사, 개

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A DISSERTATION FOR THE DEGREE OF MASTER

Fluoroscopic Characteristics of Tracheal Collapse and Cervical Lung Herniation in Dogs

개에서 기관허탈과 경부 폐 허니아의 투시영상학적 특징

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ABSTRACT

Tracheal collapse is a common disease in small breeds and known as cause of chronic cough. Cervical lung herniation is protrusion of the lung through the apex of each hemithorax and there are not many reports in veterinary society. The purpose of the present study was to investigate fluoroscopic characteristics of tracheal collapse and cervical lung herniation (CLH), and pursue any potential relationship to various influencing factors in dogs.

From 2012 to 2014, cases performed fluoroscopic examination of trachea with coughing phase were included and cases with lacking of records about a history of

cough were excluded. Medical records were reviewed for history, signalment, clinical signs and physical examination findings of patients performed fluoroscopy examinations. Presence and grade of tracheal collapse, CLH were investigated and presence of kinking of trachea is recorded on fluoroscopic examination. Severity of CLH was graded by comparing level of apex of the lung lobe and the adjacent cervical vertebrae.

In 330 cases performed fluoroscopic examination, 306 cases met inclusion criteria. Many of cases with a history of cough and most of the cases without a history of cough were proceeded examination for pre-anesthesia evaluation. Tracheal collapse was shown in 270 cases and there was no correlation with a history of cough. The mean age of the cases was 10.853 ± 3.109 years old (range 1~18) and the cases with tracheal collapse (11.041 ± 2.996) older than cases without tracheal collapse (9.444 ± 3.597). To evaluate CLH, cases with unknown duration of cough and failed to induce coughing phase in dorsal recumbence were excluded and 238 cases met the inclusion criteria. In 238 cases, there were 132 cases showed CLH. CLH showed significant association with a history of cough and intrathoracic tracheal collapse. But in cases without a history of cough or without tracheal collapse, CLH was not rare phenomenon. In univariate analysis significant correlation was shown between CLH and duration of cough, but in multivariate analysis, there was no correlation between them. There was no significant association between the severity of CLH (grade of CLH) and cough. In 10 dogs of grade 3 and 4, Shih Tzus (4/10, 40.0%) and Pekingeses (3/10, 30.0%) occupied large portion and Pekingese and Shih Tzu dogs presented wider thoracic

compared to other breeds. And cases with high grade of CLH closed to barrel chested. The cases with higher grade of CLH showed the larger portion of tracheal kinking. No patient with tracheal or esophageal obstruction resulted from cervical lung herniation in the present study.

In conclusion, tracheal collapse can be seen without a history of cough. So when tracheal collapse is regarded as critical factor, such as anesthetic situation, it should be ruled out using physical examination and diagnostic image. CLH is a common appearance in dogs and associates a history of cough, breeds and intrathoracic tracheal collapse. Without a history of chronic cough, transient cough can elicit cervical herniation of the lung. The greater grade of CLH, the more tracheal kinking were identified and there was possibility, mechanical irritation of trachea deteriorate the clinical sign.

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Keyword: cervical lung herniation, tracheal collapse, chest conformation, fluoroscopy, dog

Student Number: 2014-21951

CONTENTS

INTRODUCTION

Tracheal collapse is known as congenital cartilaginous tracheal ring problem and is predisposed in small breed. Tracheal collapse usually diagnosed by radiography, fluoroscopy and tracheobronchoscopy. In dogs with chronic cough, 51% dogs showed tracheobronchomalacia and it is regarded as common cause of cough (Hawkins *et al*., 2010). Upper airway obstruction, infectious tracheobronchitis, heart enlargement, parasitic disease, obesity and oral problem can exacerbate clinical sign of tracheal collapse (Eleanar, 2014). However, studies investigating tracheal collapse without a history of cough are lacking. In human, anesthesia is regarded as tricky procedure in patient with tracheomalacia (Austin and Ali, 2003). Although risk of tracheal collapse associated with anesthesia is not reported in dogs, tracheal collapse can be important factor of morbidity in postoperative care. In these patient, excitation and respiratory distress after extubation make worse tracheal collapse and it can make vicious cycle. So information about tracheal collapse is important to plan anesthetic protocol.

Lung hernia is defined as a protrusion of the lung parenchyma beyond the confine of the thoracic cavity (Moncada *et al*., 1996). Lung hernia is classified by their etiology and location (Morel-Lavallée, 1845). It may be appeared as congenital or acquired (spontaneous or traumatic), and it can be classified as cervical or thoracic or diaphragmatic hernia by their location. In human medicine, cervical lung hernia usually occur during infancy or childhood and is disappeared spontaneously as grown up. It can be unilateral or bilateral and particularly, right

lung hernias occur three times more frequently than left lung hernias (Thompson, 1976). Partial absence laxity, or attenuation of Sibson's fascia results in acquired type of cervical lung hernia with protrusion of the lung between the anterior scalene and sternomastoid muscle (Lightwood and Cleland, 1974; Moncada *et al*., 1996). Most of the acquired cervical lung hernia occur due to penetrating chest trauma or surgery, chest wall neoplasms, or chest wall infections. However, 29% of acquired cervical lung hernia can be appeared without special event, due to chronic cough and repeated Valsalva maneuver (McAdams *et al*., 1996; Moncada *et al*., 1996). Cervical lung herniation (CLH) is a common phenomenon in dogs, but there are not many reports about influencing factor of CLH (Choi *et al*., 2015; Coleman *et al*., 2005; Coutu *et al*., 2015; Guglielmini *et al*., 2007; Nafe *et al*., 2013). Differently from human, in dogs, there is no significant relationship between the duration of cough and CLH while intrathoracic large tracheal collapse strongly associated with CLH (Nafe *et al*., 2013).

The purpose of the present study was to pursue any potential relationship to various influencing factors and investigate fluoroscopic characteristics of tracheal collapse and CLH in dogs.

MATERIALS AND METHODS

1. Inclusion criteria

Cases with fluoroscopic and radiographic images of the trachea, between January 1, 2012 and December 31, 2014 which presented to the Seoul National University Veterinary Medical Teaching Hospital, were retrospectively evaluated and medical records of each case were reviewed. Signalment, a history of cough, grade of heart murmur and chief complaint were recorded. Cases, lacked record about cough and failed to induce coughing phase during fluoroscopic examination, were excluded for investigating tracheal collapse. Without coughing phase in fluoroscopy, tracheal collapse might be underestimated. For evaluating relationship between cervical lung herniation (CLH) and duration of cough, cases had ambiguous record about duration of cough also excluded. And cases with pectus excavatum and ill-defined vertebral and sternal borders were excluded for investigating influence of thoracic conformation on CLH. After exclusion of cases with potential causes of cough (tracheal collapse, heart murmur and significant abnormality of the lung field on radiograph), association between a history of cough and trachealis muscle redundancy was investigated.

2. Radiographic image evaluation

Each case obtained at least two thoracic radiographs in ventrodorsal and right lateral recumbence. Presence or absence of tracheal collapse, pulmonary abnormality were evaluated. In cases shown trachealis muscle redundancy without tracheal collapse on fluoroscopic image, heart murmur, and pulmonary abnormality, percentage of opacification of trachealis muscle redundancy compared to tracheal diameter were recorded.

To investigating relationship between the chest conformation and CLH, several diameters were measured on digital radiographs. On right lateral view, diameter of the thoracic inlet and depth of the thorax were measured and on ventrodorsal view, width of the thorax at the 1st and 8th rib level were measured. Diameter of the thoracic inlet on lateral view was measured from the ventral margin of vertebral body at the midpoint of the most cranial rib to the dorsal margin of the manubrium at the level of minimal thickness (Hayward *et al*., 2008). Thoracic depth was defined as distance from dorsal aspect of the xiphoid process to the ventral aspect of the vertebral body perpendicular to the line from the xiphoid process. Width of the thorax was measured as the distance between the medial border of 1st and 8th rib (Figure 1). Thoracic depth to width at the level of 8th rib ratio (depth/R8) and thoracic inlet distance to thoracic depth ratio (LAT ratio) and thoracic width at the level of 1st to 8th rib ratio (VD ratio) were calculated (Jepsen-Grant *et al*., 2013).

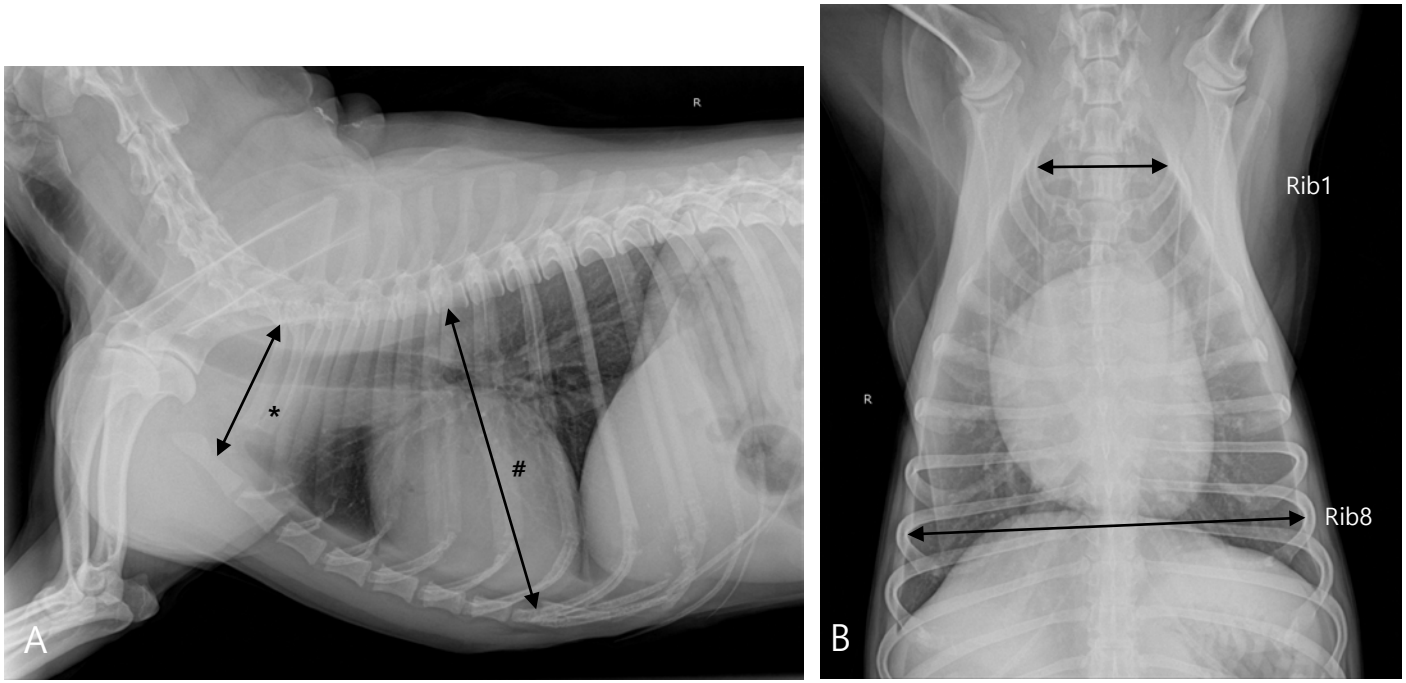

Figure 1. Right lateral (A) and ventrodorsal view (B) of canine thorax. Illustration of the thoracic inlet distance (*), thoracic depth (#), and width of the thorax at the level of 1st and 8th rib measurement. Diameter of the thoracic inlet was measured from the ventral margin of vertebral body at the midpoint of the most cranial rib to the dorsal margin of manubrium at the level of minimal thickness. Thoracic depth was measured from the xiphoid process to vertebral body perpendicular to line from xiphoid process. Width of the thorax was measured from the inside of the 1st and 8th rib.

3. Fluoroscopic image evaluation

Images of normal respiration status and forceful expiration (coughing) status were obtained through fluoroscopic examination. On the right lateral position, normal respiratory phase was evaluated and cervical trachea was compressed for evaluation of coughing phase. In order to investigate CLH, humanoid position images were acquired during coughing phase.

Location and grade of tracheal collapse, grade of CLH, and presence of the trachealis muscle redundancy and kinking of the trachea were recorded. Tracheal regions were divided as cervical, thoracic inlet, intrathoracic, and carinal region and mainstem bronchi. In this present study, tracheal collapse included mainstem bronchi. Degree of tracheal collapse was graded by degree of decrease luminal diameter as 0~25% (grade 1), 25~50% (grade 2), 50~75% (grade 3) and greater than 75% (grade 4). The highest grade was recorded. The mainstem bronchi were only divided as presence or absence. CLH was graded by comparing apical level of the cranial lung lobe to cervical vertebral body as grade 1 (7th cervical vertebra), grade 2 (6th cervical vertebra), grade 3 (5th cervical vertebra) and grade 4 (4th cervical vertebra, Figure 2). Because of breed variation, relative value using vertebral body was selected instead of absolute value. If lung protruded to intervertebral disc space, closer vertebral body was using to decide grade of CLH.

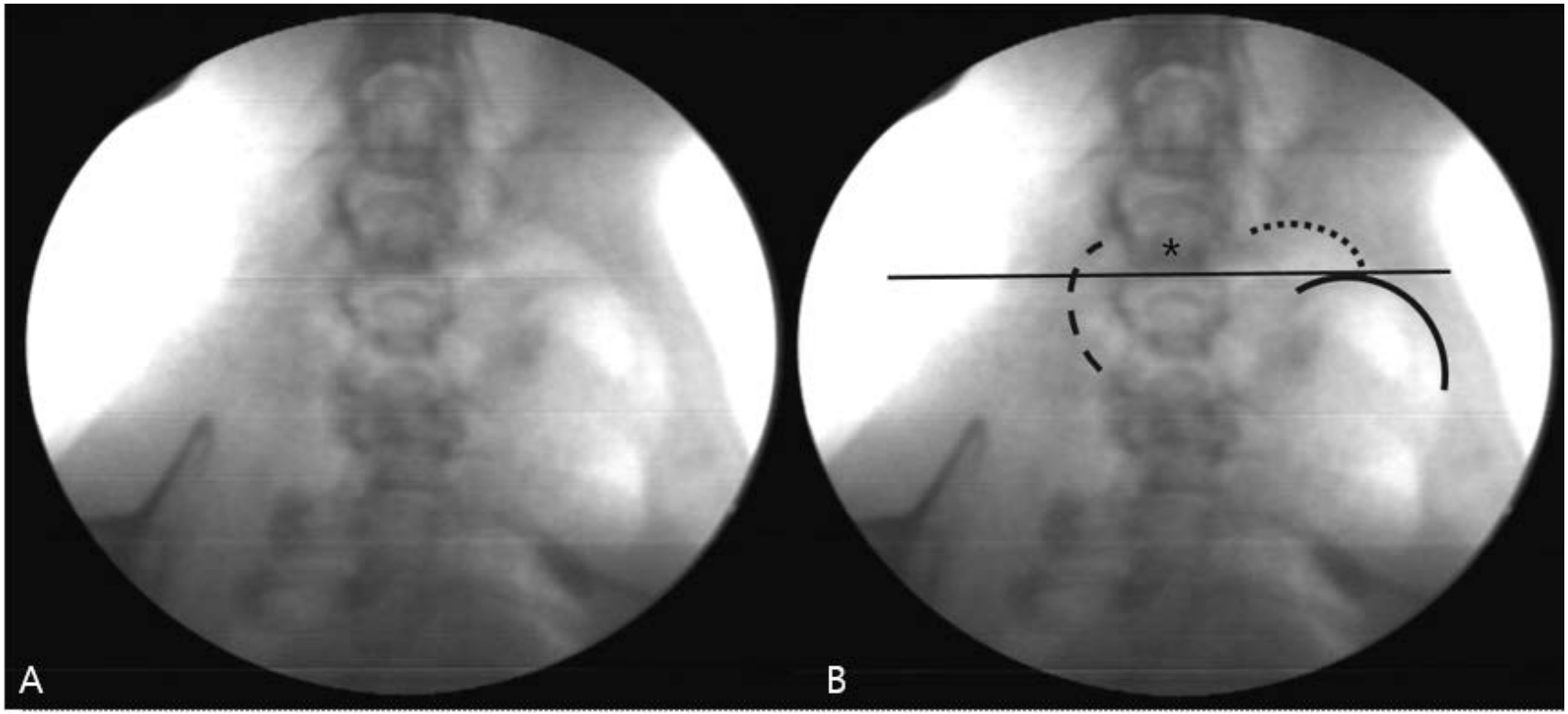

Figure 2. Unmarked (A) and marked (B) fluoroscopic image on humanoid position during coughing phase. Left cranial lung lobe (solid line) is extruded to the caudal 4th cervical spine (asterisk). This dog was decided as grade 4 CLH. Dotted line, esophagus; dashed line, trachea.

4. Statistical analyses

For investigating influence factor of tracheal collapse, Chi-squared test and Mann-Whitney U test were used. Fischer's exact test was used to evaluated association between trachealis muscle redundancy and a history of cough. Data were analyzed between CLH and influencing factors (age, duration of cough, a history of cough, tracheal collapse, kinking of trachea) using Chi-squared test, Mann-Whitney U test and logistic regression. The age of the dogs, ratio of the chest conformation were presented as the mean ± standard deviation (SD) values. Logistic regression, independent t-test and Mann-Whitney U test were used to assess the relationship between the chest conformation and high grade CLH (grade 3 and 4), and breed. A value of $P < 0.05$ was considered statistically significant. All statistics were calculated using SPSS (IBM SPSS Statistics, IBM Corp., Armonk, NY).

RESULTS

Three hundred and thirty fluoroscopic examination was performed for patients with a history of cough, suspicion tracheal collapse on radiograph, respiratory distress and cough induced by stimulating the trachea.

1. Tracheal collapse

In 306 cases, except the cases failed inducing coughing phase in fluoroscopic examination and absent the record about cough (unknown history of cough), tracheal collapse showed in 270 cases (3 grade 1; 17 grade 2; 34 grade 3; 216 grade 4). One hundred and twenty three cases were neutered male, 83 cases were neutered female, 41 cases were intact female and 23 cases were intact male. There was no correlation with tracheal collapse. The age range was 1 to 18 years and mean age of cases with tracheal collapse was 11.041 ± 2.996 and cases without tracheal collapse was 9.444 ± 3.597 (p = 0.019). Malteses were the most common dogs followed by Yorkshire Terriers and Shih Tzus (Table 1). Heart murmur was detected 87 cases (87/256, 34.0%) with tracheal collapse. Fourteen cases with tracheal collapses had ambiguous records about heart murmur. One hundred ninety seven cases had a history of cough and there was no correlation between tracheal collapse and a history of cough (Table 2).

Table 1. Breeds identified with tracheal collapse

Breeds	Tracheal collapse (n = 270)
Maltese	79 (29.3%)
Yorkshire Terrier	70 (25.9%)
Shih Tzu	34 (12.6%)
Pomeranian	22 (8.1%)
Poodle	21 (7.8%)
Mixed breed	16 (5.9%)
Chihuahua	6 (2.2%)
Cocker Spaniel	5 (1.9%)
Miniature Pinscher	5 (1.9%)
Pekingese	4 (1.5%)
Dachshund	2 (0.7%)
Japanese Chin	2 (0.7%)
Schnauzer	2 (0.7%)
Beagle	1 (0.4%)
Papillion	1 (0.4%)

Table 2. Association between the tracheal collapse and a history of cough

	A history of cough	No history of cough
Tracheal collapse	197	73
No tracheal collapse	25	11
p value	0.657	

To investigate influence of trachealis muscle redundancy on a history of cough, excluded cases with tracheal collapse and heart murmur and pulmonary abnormality on thoracic radiographs. In 25 cases, there were no association between the trachealis muscle redundancy and a history of cough. And percentage of trachealis muscle redundancy opacification was greater than 50% in 7 cases among 10 cases with trachealis muscle redundancy.

2. Cervical lung herniation

Two hundred and thirty eight cases met the inclusion criteria and CLH were showed in 132 cases. Grade 1 (n = 79) is the most common grade, followed by grade 2 (n = 42), grade 3 (n = 9), and grade 4 (n = 2). In 237 cases (except one case absent fluoroscopic image in humanoid view), left side CLH (n = 120) appeared more common than right side CLH (n = 84). In cases with CLH, 124 cases had tracheal collapse and 103 cases had a history of cough (Table 3). Although there were correlation between CLH and tracheal collapse and a history of cough, 8 cases without tracheal collapse (8/26, 30.8%) and 29 cases without a history of cough (29/76, 38.2%) showed CLH. Univariate analyses showed that tracheal collapse, intrathoracic tracheal collapse, a history of cough, age and duration of cough were significantly associated with CLH. Whereas multivariate logistic regression analysis showed that only intrathoracic tracheal collapse and a history of cough were significant factors correlated with CLH (Table 4). Association between kinking of trachea and CLH was significant ($p < 0.001$).

Table 3. Association between CLH and tracheal collapse and a history of cough

	Tracheal collapse (n = 212)	A history of cough (n = 162)
CLH (n = 132)	124	103
No CLH (n = 106)	88	59

Table 4. Result of the multivariate analysis. Tracheal collapse and a history of cough associated with CLH

Variables	Odds ratio	95% CI	*p* value
Intrathoracic tracheal collapse	3.396	1.665-6.928	0.001
A history of cough	2.544	1.413-4.578	0.002
Age	1.079	0.986-1.181	0.099

$\ln(p/1-p) = -2.210 + 1.223x_1 + 0.934x_2 + 0.076x_3$, where p is probability of CLH, x_1 is intrathoracic tracheal collapse, x_2 is a history of cough, and x_3 is age.

In cases with CLH, grade of CLH had no association with a history of cough, but cases with high grade CLH showed more portion of kinking of the trachea (Figure 3). Ten cases showed greater than grade 3 CLH (4 Shih Tzus, 3 Pekingeses, 2 Yorkshire Terriers, and a Miniature Pinscher). In the present study, no complication caused by CLH.

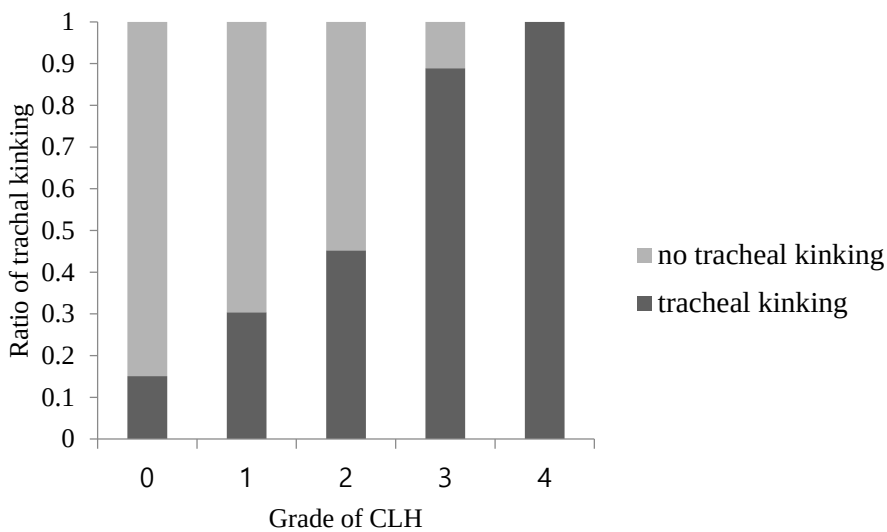

Figure 3. The higher grade of CLH, the more portion of kinking of the trachea.

3. Conformation of the chest

Two hundred and eight cases met inclusion criteria investigating the chest conformation and breed. Among LAT ratio, VD ratio, depth/R8, only depth/R8 was significantly lower in cases with high grade CLH (grade 3 and 4). Also univariate logistic regression analysis showed depth/R8 influenced high grade CLH (p = 0.020). In Shih Tzu and Pekingese dogs, occupied large portion of high grade CLH, LAT ratio and VD ratio were larger than other breeds (Table 5).

Table 5. Association between the chest conformation and high grade CLH and breeds

	LAT ratio	VD ratio	Depth/R8*
G3 and G4 CLH	0.534 ± 0.081	0.339 ± 0.043	0.609 ± 0.104[a]
G1 and G2 CLH	0.502 ± 0.051	0.321 ± 0.033	0.668 ± 0.079[b]
ST, Peki	0.552 ± 0.060[a]	0.340 ± 0.033[a]	0.663 ± 0.064
Other breeds	0.494 ± 0.456[b]	0.318 ± 0.033[b]	0.665 ± 0.078

[a, b] statistically different

* influence on grade of CLH, odds ratio = 0.000 (95% CI 0.000-0.225); ST, Shih Tzu; Peki, Pekingese; CLH, cervical lung herniation.

DISCUSSION

Almost cases were small breeds and it was consist with previous studies. Although older cases were common in this present study, age of cases with tracheal collapse were older than cases without tracheal collapse. It should be noted that there were no association between tracheal collapse and a history of cough. Many patients, showed cough during physical examination or narrowed airway on radiograph, had tracheal collapse without a history of cough. So differentiation tracheal collapse through physical examination and diagnostic image is important, especially when patient is plan to be anesthetized, tracheal collapse can lead to life threatening situation (Austin and Ali, 2003). Trachealis muscle redundancy is known as subclinical phenomenon and it occupied more portion of tracheal height in dogs with tracheal collapse. In the present study, percentage of trachealis muscle redundancy height portion was larger than previous study (Lindl Bylicki *et al*., 2015). Trachealis muscle redundancy was not shown association with a history of cough in the present study.

In human, cervical lung hernia is not common. Among the lung hernias, cervical lung hernia occupy 25% and usually it is the congenital problem and disappear spontaneously. In adult, many cervical lung hernias result from chest trauma or surgery, chest wall neoplasms, or chest wall infections (del Rey and Cunha, 1990; McAdams *et al*., 1996). Twenty nine percent of acquired type occur without special event and are associated with increase of intrathoracic pressure resulted from chronic cough, emphysema and repetitive respiratory maneuvers (McAdams *et al*.,

1996; Moncada *et al*., 1996). Similarly, there are not many reports of CLH in veterinary medicine. There were 126 cases had been reported (Choi *et al*., 2015; Coleman *et al*., 2005; Coutu *et al*., 2015; Guglielmini *et al*., 2007; Nafe *et al*., 2013). CLH was known as rare phenomenon in dogs. But in a report, CLH were evaluated in 121 cases by fluoroscopy and 70% of the cases had CLH. There were no association between CLH and duration of cough (Nafe *et al*., 2013). In the present study, there were enough cases without a history of cough so relationship between cough and CLH can be evaluated. CLH showed significant correlation with a history of cough and tracheal collapse. But CLH were also showed 8 cases without tracheal collapse (8/26, 30.8%) and 29 cases without a history of cough (29/76, 38.2%). This portion is significant, so other factors beside a history of cough might be associated with CLH. Aging is suggested one of the factors affecting CLH because most cases in the present study were older patients. Although in multivariate analysis, age was not significant influencing factor, in univariate analysis, it correlated CLH. Muscle weakness with aging may be important factor of CLH in dogs as human (Bidstrup *et al*., 1966; Fenichel and Epstein, 1955). If already thoracic muscles are weakened, even transient cough can make cervical lung lobe protrusion beyond the thoracic cavity. And repeated barking can be one of the cause increasing pressure in thoracic cavity. So caution is needed when blood collection from external jugular vein, even if patient have no clinical sign of cough (Bhalla *et al*., 1990). CLH can be showed result from just transient increased intrathoracic pressure. No association between duration of cough and CLH in multivariate analysis was consistent with a previous paper (Nafe

et al., 2013). Intrathoracic tracheal collapse and a history of cough associated with CLH in multivariate logistic regression analysis. Tracheal kinking also showed relationship with CLH and higher grade of CLH had more portion of tracheal kinking. Kinking trachea may be damaged and can be associated with clinical signs and prognosis as human (McAdams *et al*., 1996). But more studies are needed to show the relationship between the kinking of the trachea and deformation of the trachea. Although cervical lung hernias can result in complication such as coughing caused by irritated trachea, dysphagia, incarceration of the lung and pain due to compression nerve in human, no cases showed definite complication associated CLH in the present study (Bhalla *et al*., 1990; Rahman *et al*., 2006). However, because coughing was a common sign in the present cases, and follow up was not approached, it is not clear whether kinking trachea influenced on coughing or not. In veterinary medicine, one case of dysphasia due to CLH was reported in a juvenile dog (Coutu *et al*., 2015).

Frequency of the breeds had having CLH was similar with the breeds having tracheal collapse. But interestingly, Pekingese and Shih Tzu dogs had large portion in the high grade (grade 3 and 4) of lung herniation. Also among lung herniation reports, except the retrospective study (Nafe *et al*., 2013), 40% (2/5) cases were Pekingeses (Choi *et al*., 2015; Coleman *et al*., 2005; Coutu *et al*., 2015; Guglielmini *et al*., 2007). Especially, in the present study, only 4 Pekingeses were included criteria and large portion (3/4, 75%) was decided high grade CLH. Difference of thoracic anatomy can be a cause of CLH, but there is no report about anatomy of lung herniation in dogs and difference of thoracic anatomy of

Pekingese compared to other breeds. According to a previous study, breed predisposition and association with the chest conformation were not made (Nafe *et al*., 2013). In the present study, depth/R8 showed influence on CLH grade. As depth/R8 decreased, or closed to barrel chested, possibility of high grade CLH (grade 3 and 4) increased. Pekingese and Shih Tzu dogs had wider thoracic inlet (higher LAT and VD ratio) compared to other breeds. Because relatively small number of high grade CLH cases, further studies are needed about anatomic aspect of CLH with larger group. Because the left cranial lung lobes located cranial to the right cranial lung lobes in dogs, left cranial lung lobes protrude more commonly beyond the thoracic cavity than right cranial lung lobes (Evans HE and de Lahunta A, 2013). There was no case with a history of trauma or disease at cranial thoracic region. From this, in dogs, acquired CLH is different from human, having thoracic trauma in most acquired CLH (del Rey and Cunha, 1990; McAdams *et al*., 1996). Although congenital CLH cannot be excluded, spontaneous acquired CLH is an assumed major type in the dogs because there were large population of older dogs in the present study. Relationship between lung herniation and intrathoracic tracheal collapse is consented to a previous study (Nafe *et al*., 2013). Increased intrathoracic pressure is a cause of CLH and usually intrathoracic tracheal collapse can increase intrathoracic pressure during expiration (Hayward *et al*., 2008). So intrathoracic tracheal collapse can result in CLH.

There were several limitations in the present study, including it being a retrospective in nature. Also as the absence of further follow up of the cases, it is unknown whether CLH makes worse clinical sign or not. And only 2 cases in grade

4 group, 100% of kinking trachea portion could be overestimated. When investigating association between trachealis muscle redundancy and coughing, major causes of cough such as tracheal collapse, pulmonary abnormalities and heart problem were excluded. But there might be other causes of cough, such as upper respiratory disease or pulmonary disease not manifested on radiographs, can be included in the investing group.

CONCLUSIONS

Many tracheal collapse can be diagnosed through fluoroscopic examination in patients without a history of cough. It should be noted, especially when make anesthetic protocol because excitation. After extubation, induce respiratory distress followed by narrowed airway and this makes vicious cycle. Whether patient have a history of cough or not, physical examination and diagnostic image are comprehensively needed for ruling out tracheal collapse.

During fluoroscopic examination, CLH is common finding in the older dogs. Although intrathoracic tracheal collapse is the most influence factor on CLH and a history of cough is second factor, CLH can be appeared without a history of cough and tracheal collapse. Kinking of trachea is more common in severe CLH and mechanical irritation of trachea can make worse clinical sign. So in severe CLH, detected in physical examination, more caution is needed. Interestingly, Pekingese and Shih Tzu dogs tend to show high grade CLH and they have wider thoracic inlet.

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국문초록

기관허탈은 소형견종에서 흔하게 발생하는 질환으로 만성 기침의 주요 원인 중 하나로 알려져 있다. 경부 폐 허니아는 폐가 흉곽입구를 통해 흉곽을 벗어나는 것을 말한다. 본 연구는 투시 영상에서 기관허탈과 경부 폐 허니아의 특징과 이들에 미치는 영향을 알아보는 것을 목적으로 하였다.

2012년부터 2014년까지의 330건의 투시검사 중 기침 관련 기록이 있고, 투시 검사 시 기침이 유발된 306건의 사례를 대상으로 기관허탈의 빈도와 환자의 병력과 품고 등을 조사하였다. 또한 기침기간이 불명확하고 인간상에서 기침유발이 되지 않았던 개체를 제외한 238건에서 경부 폐 허니아의 빈도와 정도, 이와 관련이 있는 요소들을 알아보았다. 투시검사는 주로 기침을 주증으로 내원한 환자를 대상으로 하였으며 그 밖에 호흡곤란이나 일반영상에서 기관이 좁아져 있는 환자, 신체검사에서 기관허탈이 의심되는 환자를 대상으로 하였다.

306건 중 270건에서 기관허탈이 나타났으며 기침과의 관련성은 확인되지 않았다. 전체 건수에서 평균 연령은 10.853 ± 3.109세로 나타났으며 기관허탈이 있는 경우는 11.041 ± 2.996세, 없는 경우는 9.444 ± 3.597로 기관허탈이 있는 경우가 없는 경우보다 많은 것으로 확인되었다. 경부 폐 허니아는 238건 중 132건에서 확인되었으며 기침의 유무

와 흉곽 내 기관허탈 여부와 관련이 있는 것으로 나타났다. 경부 폐 허니아는 흉곽 내 기관허탈이 있을 경우 발생할 확률이 3.396배로 증가하며 평소 기침 증세가 있을 경우는 2.544배로 증가하는 것으로 나타났으나 기침과 기관허탈이 없는 개체에서도 각각 38.2%, 30.8%가 경부 폐 허니아를 보였다. 다변량 분석에서 기침의 기간과 경부 폐 허니아는 유의적인 관련성이 없는 것으로 나타났으며 경부 폐 허니아의 정도와도 유의적인 관련성은 없었다. 3단계 이상의 고도의 폐 허니아를 보이는 10건 중 7건이 페키니즈와 시츄로 나타났으며 이들 품종에서 흉곽의 입구가 넓은 것으로 확인되었다. 폐 허니아와 관련하여 다른 요인을 찾기 위해 흉곽입구의 비율과 흉곽 깊이와 너비의 비를 구하여 비교하였으며 심한 경부 폐 허니아를 보이는 그룹에서 흉곽 깊이와 너비의 비가 유의적으로 작게 나타났다. 투시영상에서 기관의 구부러짐은 경부 폐 허니아의 정도가 심할수록 나타나는 비율이 높게 나타나는 것으로 보였으나 임상증상과 직접적인 관련성은 찾을 수 없었다. 본 조사에서 경부 폐 허니아에 의한 증상을 보이는 경우는 없었다.

결론적으로 기침과 기관허탈이 유의적인 상관관계를 보이지 않는 바 기침경력이 없더라도 마취와 같이 기관허탈의 유무가 중요한 경우에는 면밀한 신체검사와 영상진단 검사를 통해 감별할 필요가 있다. 개에서 경부 폐 허니아는 기침의 유무, 품종, 흉곽 내 기관허탈과 관련이 있는 것으로 나타났으나 만성적인 기침 없이 일시적인 흉곽 압력 증가만으

로도 발생할 수 있는 현상으로 생각된다. 또한 경부 폐 허니아와 함께 관찰될 수 있는 기관의 구부러짐은 기관의 물리적인 자극을 가할 수 있으며 이로 인한 임상증상의 악화 가능성을 제시할 수 있다.

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주요어: 경부 폐 허니아, 기관허탈, 흉곽 형태, 투시영상검사, 개

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