

Radiographic diagnosis of diaphragmatic hernia: review of 60 cases in dogs and cats

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Sixty cases of diaphragmatic hernia in dogs and cats were radiologically reviewed and categorized by their characteristic radiographic signs. Any particular predilection for age, sex, or breed was not observed. Liver, stomach and small intestine were more commonly herniated. At least two radiographs, at different angles, were required for a valid diagnosis, because some radiographic signs were not visible in a single radiographic view and more clearly detectable in two radiographic views. In addition to previously reported radiographic signs for diaphragmatic hernia, we found that the location of the stomach axis and the displacement of tracheal and bronchial segments were also useful radiographic signs.

Key words: diaphragmatic hernia, radiography, traumatic, x-ray, diagnosis

Introduction

Diaphragmatic hernia is a protrusion of abdominal viscera through an opening in the diaphragm and is caused mainly by trauma such as an automobile accident and rarely by congenital defects. Radiographic diagnosis is the single most important diagnostic method of detecting diaphragmatic hernia in dogs and cats, although it is not always easy to identify diagnostic radiographic signs, especially in cases with pleural effusion. Therefore, a radiographic diagnosis should be accompanied by other diagnostic measures such as contrast studies and ultrasonography [1,4,5,8,9,10]. Loss of diaphragmatic line and cardiac shadow, abdominal gas shadow in thorax, and wasp-shaped abdomen are characteristic radiographic signs [2,3,4,6,7,11,12,14,15].

In this study, 60 clinical cases of diaphragmatic hernia were radiologically examined and categorized by their radiographic features. Additionally, several new radiographic

signs have been included in our radiographic observation list for diaphragmatic hernia.

Materials and Methods

Sixty cases of diaphragmatic hernias from 1975 to 1997 at the Small Animal Teaching Hospital, the University of Queensland, were radiologically examined. Congenital diaphragmatic hernias (true diaphragmatic hernias) were not included in this study. Details of affected animals, main herniated organs and location of herniation were recorded. Characteristic radiographic signs were categorized by the following observation points:

- i) Diaphragm: diaphragmaticolumbar recess, diaphragmatic line, divergence of the diaphragmatic crura, contrast between the diaphragm and liver
- ii) Thorax: intrathoracic density, pleural effusion, mediastinal shift, pneumothorax, tracheal displacement
- iii) Heart: cardiac displacement, cardiac shadow, cardiophrenic angle
- iv) Lung: displacement of bronchial segment, lung shadow, pulmonary vascular marking, pulmonary vascular condition
- v) Abdomen: Abdominal gas shadow, wasp-shape of abdomen, loss of abdominal organ shadow, cranial displacement of abdominal organ, loss of falciform ligament, stomach axis
- vi) Miscellaneous: traumatic signs

Results

Animals

Forty-two cases were dogs (24 males, 17 females and 1 undetermined) and 18 were cats (9 males, 5 females and 4 undetermined). The age of affected animals varied from 7 weeks to 10 years (mean: 2.64 years old, dog: 2.63 years, cat: 2.66 years). The mean age of affected male animals was 3.71 years old (dog: 3.51 years, cat: 3.22 years), while that of female animals was 1.44 years old (dog: 1.49 years, cat: 1.44 years). Any particular predilection for either age, sex, breed or species was not observed.

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Table 1. The composition of the herniated site and organs in diaphragmatic hernia

	Right	Left	Both	Central	Un-certain	Total
L	10		1	1	1	13
L,St	2	3		1		6
L, St, SI	1	7			1	9
L, St, SP	1		1			2
L,St, Sp, SI		2				2
L, St, SI, LI			3			3
L, St, Sp, SI, LI			1			1
L, SI	8	1	4			13
L, SI, LI				1		1
L, LI	1					1
St		5				5
St, SI		1				1
St, Sp, SI		1				1
SI	1					1
SI, Sp					1	1
Total	24	20	10	3	3	60

L: liver, St: stomach, SI: small intestine, LI: large intestine, Sp: spleen

Table 2. Radiographic abnormalities in diaphragm

Signs	Presence	Type	Frequency
Decreased diaphragmaticolumbar recess	Present	Right	6
		Left	12
		Both	5
	Absent	Right	20
		Left	8
		Both	5
	Uncertain		1
Loss of diaphragmatic line	Present	Partial	40
		Complete	20
	Absent	Absent	0
Divergence of diaphragmatic crura	Present		15
	Absent		44
	Uncertain		1

The site of herniation and the herniated organs

Right side diaphragmatic hernias were more common, although a noticeable difference in the site of herniation was not observed (Table 1). The site of herniation could not be determined in 3 cases, because either only one radiographic view was available or severe pleural fluid accumulation was present. In 41 cases (68%), more than one organ was herniated (Table 1). Liver was the predominant herniated organ (85%), especially in right side hernias (96% but 65% in left side) whereas stomach was the prominent organ in the left side hernias (95% but 17% in right side; Table 1).

Table 3. Radiographic changes in thorax

Signs	Alteration	Frequency
Intrathoracic density	No change	3
	Increased	52
	Decreased	5
Pleural effusion	No change	39
	Right	2
	Left	6
	Both/central	12
	Uncertain	1
Tracheal displacement	Normal	11
	Dorsal	46
	Cranial	2
	Ventral	1
Mediastinal shift	No change	16
	Right	18
	Left	17
	Uncertain	9

Regardless of the site of herniation, hernias involving the small intestine was more evenly distributed (42% in the right side and 50% of the left side; Table 1).

Radiographic signs related to diaphragm

Decreased diaphragmaticolumbar recess (angle) was observed in 40% of the cases and more obvious in left side diaphragmatic hernias (60%) than any other side hernias (Table 2). Due to fluid accumulation, we were unable to determine the diaphragmaticolumbar recess in one of the cases. Loss of the diaphragmatic line was obvious in all cases, although it varied by radiographic views (Table 2). In some cases, partial loss of the diaphragmatic line was seen in lateral view but completely obliterated in the dorsoventral (D-V) view and vice versa. The diaphragmatic crura was diverged in 25% of the cases (Table 2) and was undetermined in some cases with pleural effusion. A loss of contrast between diaphragm and liver was also observed in all cases.

Radiographic signs in thorax

Increased intrathoracic density was the most common intrathoracic sign (87%) seen on the radiograph, although this density could be decreased due to the herniated stomach gas shadow (8%; Table 3). Pleural effusion was predominantly found in the both and central side hernias (both side: 10/10, central side: 3/3; Table 3). In 58% of the cases, a distinct mediastinal shift was observed (35/60; Table 3), usually located at the opposite side of herniation. In 9 cases, this mediastinal shift was unable to determine due to a lack of D-V view (3 cases), poor positioning (1 case), fluid accumulation (2 cases) and severe abdominal organ prolapse

Table 4. Radiographic abnormalities in heart

Signs	Presence	Type	Frequency
Cardiac displacement	Present	Left	15
		Right	17
		Dorsal	9
		Cranial	1
	Absent		14
	Uncertain		4
Loss of cardiac shadow	Present	Partial	39
		Complete	19
	Absent		0
	Uncertain		2
Obliterated cardiophrenic angle	Present	One	15
		Both	33
	Absent		0
	Uncertain		12

(3 cases). Two cases of rib fractures were also observed, where one had radiographic signs of pneumothorax. In 82% of the cases, the trachea was abnormally displaced (mostly dorsal displacement; Table 3).

Radiographic signs related to heart

The heart was displaced in 70% of the cases, where the direction of displacement varied (Table 4). However, this displacement could not be determined in 4 cases owing to fluid accumulation and severe herniation of abdominal organs. Cardiac shadow and cardiophrenic angles were partially or completely obliterated in all cases except 2 undetermined cases (Table 4).

Radiographic signs related to lung

In 82% of the cases, lung shadows were either partially (6/49) or completely (43/49; Table 6) obliterated ventrally in the lateral view, but more obvious in the same side of herniation in the D-V view. In many of the cases, pulmonary vascular markings were not clearly visible and the lungs were compressed (Table 6). Bronchial segments were displaced in 48% of the cases, especially in the middle bronchus (23/29; Table 6). However, it was not examinable in 30% of the cases due to the invasion of the stomach into the thoracic cavity.

Radiographic signs related to abdomen and miscellaneous radiographic signs

In 73% of the cases, abdominal gas shadows originating from small intestines or stomach were observed in the thoracic cavity (Table 6). The abdominal organs were displaced cranially in 97% of the cases and variably disappeared from the abdomen, depending on the severity of

Table 5. Radiographic abnormalities in lung

Signs	Presence	Type	Frequency
Displacement of bronchial segment	Present	CR	3
		MID	18
		CA	2
		UP	1
	CR+MID	5	
	Absent		13
	Uncertain		18
Loss of lung shadow	Present	Left	Partial: 1 Complete: 19
		Right	Partial: 3 Complete: 18
		Both	Partial: 2 Complete: 6
	Absent		8
	Uncertain		3
Loss of pulmonary vascular marking	Present	Left	21
		Right	22
		Both	6
		Ventral	5
	Absent		6
Lung condition	Compressed	Left	20
		Right	23
		Both	7
		Uncertain	3
	Uncertain		1
Invisible		5	

CR: Cranial, MID: Middle, CA:Caudal, UP:upright, CR+MID: Cranial and middle.

the herniation (Table 6). In 68% of the cases, the falciform ligament was not visible and a wasp-shaped abdomen, which is a particular sign of diaphragmatic hernia, was observed in 52% of the cases with diaphragmatic hernias (Table 6). The stomach axis was abnormally displaced in 67% of the cases (more commonly craniocaudal direction; Table 6). Additionally, traumatic signs such as rib fractures were also detected in 16.7% of the cases examined.

Discussion

In this study, 60 clinical cases with diaphragmatic hernia documented over a period of 22 years were radiologically reviewed. Although it was more common in younger and female animals, we could not conclude there was any particular predilection for age and sex, because only a small number of cases were used in this study.

In previous studies, the left sided hernia was believed to be

Table 6. Radiographic abnormalities in abdomen

Signs	Presence/Type	Frequency
Loss of falciform ligament	Present	41
	Absent	19
Abdominal gas shadow	Present	44
	Absent	16
Wasp shape	Present	31
	Absent	29
Loss of abdominal organ	Present	60
	Absent	0
Cranial displasment	Present	58
	Absent	2
Stomach axis	Normal	22
	Craniocaudal	27
	Dosorcranial	7
	Ventral	2
	Perpendicular	1
	Invisible	1

more common, since the right sided location of the liver could serve as a barrier for the herniation of abdominal organs into the thorax [12]. However, this predilection was not observed in this study, which is consistent with previous reports [3,5,13,14].

The type of herniated organs is more related to the anatomical proximity of the organ to the rupture site. Thus liver, stomach and small intestine were more commonly found in thorax [11,14]. Since the stomach is anatomically closer to the left side of the diaphragmatic crura than the liver which is closer to the right side crura, the stomach was found to be more prominent in left side hernias whereas the liver in right side hernias [4,5]. Similar findings have found previously [4,5].

Consistent with previous reports [4,7,12], the diaphragmaticolumbar recess was moved further caudally than normal, the angle between the lumbar spine and diaphragm was decreased and the separation of the crura was also increased. Loss of the diaphragmatic outline, a classic radiographic sign of diaphragmatic hernia, was found to be vary from partial to complete loss depending on the severity of the rupture and number of radiographs taken at different angles [11]. This loss of the diaphragmatic outline was also more easily detected in the lateral view than the D-V view. Divergence of the diaphragmatic crura should also be considered to be a radiographic sign of diaphragmatic hernia [7]. However, it was undetectable in many of the cases, especially if the intrathoracic density was increased due to loss of the contrast between diaphragm and liver by pleural effusion and prolapse of abdominal organs.

Pleural effusion and herniated organs may not only be the major causes of the increased intrathoracic density but also

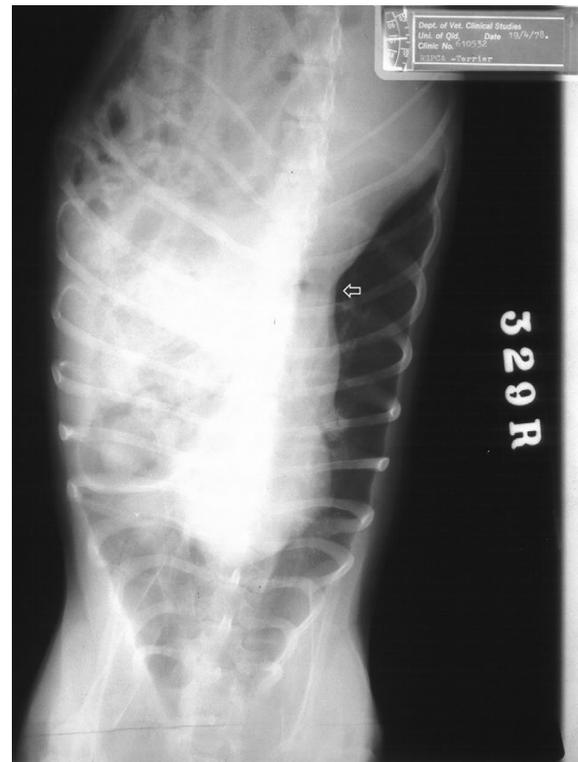


Fig. 1. Radiographic diagnosis of diaphragmatic hernia (dorsoventral view), Airedale terrier dog, male, 4 years old. The diaphragmatic line is obliterated due to the increased intrathoracic density. The lung is collapsed (arrow) and its shadow is obliterated by the cranial displacement of abdominal organs. Due to pneumothorax, the right-side cardiac shadow is more clearly visible. The characteristic abdominal gas shadow is also observed in the thoracic cavity.

be the major inhibitor of radiographic interpretation [11,14]. Kealy [7] found a close relationship between hepatic prolapse and body fluid effusion in diaphragmatic hernia. The impairment of venous return by a herniated liver can be resulted from pleural effusion suggests that pleural effusion would be more common in right side hernias. However, we found that pleural effusion was more common in left side hernias suggesting that the presence of ascites is more closely related to pleural effusion than the hepatic prolapse [14]. In this study, pleural effusion was observed in all both side hernias indicating that the severity of rupture was related to the presence of pleural effusion. The pleural effusion appeared to be nonhomogeneous, possibly due to the fat from falciform ligament or omentum, in contrast to homogeneous appearances observed in cases with pulmonary neoplasm and heart diseases [4,12]. Mediastinal shift is an another common finding in diaphragmatic hernias [2,7,12]. The mediastinum in affected animals shifted to either the right or the left side in the lateral view and dorsally in the D-V view. In previous studies, tracheal displacement was overlooked as an indicator of diaphragmatic hernias.

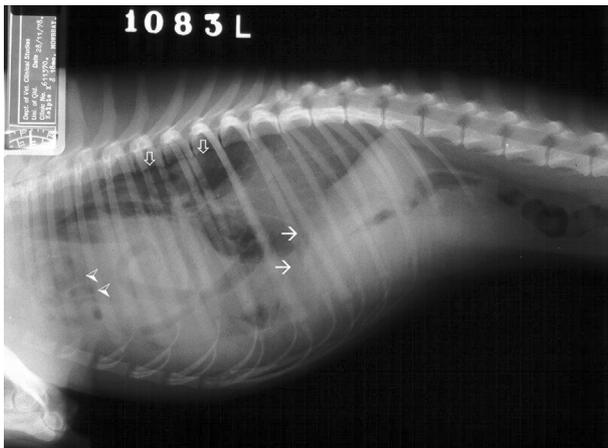


Fig. 2. Radiographic diagnosis of diaphragmatic hernia (lateral view), Kelpie dog, male, 18 months old. The diaphragmatic line is partially obliterated (white arrow) due to the cranial displacement of abdominal organs. The increased intrathoracic density and abdominal gas shadow are observed in the thoracic cavity (arrow head). The cardiac shadow is completely obliterated due to the pleural effusion and the invasion of the abdominal organs. The lung is collapsed (open arrow) and the trachea is displaced dorsally. Due to the cranial displacement of the abdominal organs, the characteristic empty and wasp-shaped abdomen is also clearly observed on this radiograph.

Although several diseases can cause tracheal displacement, it was a very consistent and reliable indicator of diaphragmatic hernia in this study. Dorsal displacement was prominent in our findings suggesting that the herniated abdominal organs might have pushed the trachea upward. High incidences of pneumothorax, pneumomediastinum and intrathoracic and intrapulmonary hemorrhage have previously been reported in diaphragmatic hernias [7]. Since more than 90% of the cases resulted from automobile accidents, higher incidence rate of pneumothorax was expected in this study. However, only two cases were involved with pneumothorax.

Radiographic changes related to cardiac shadow and location, and the angle between heart and diaphragm are also important radiographic points for distinguishing diaphragmatic hernia, although it will be invisible in cases with either pleural effusion or a heavy prolapse of abdominal organs [2,11,12]. In this study, the degree and direction of the cardiac displacement varied with the rupture site and the amount of abdominal viscera within the pleural space. Also, cardiac displacements generally were in the opposite direction to the ruptured site in the D-V view and dorsally in the lateral view. This displacement was more easily detectable on two different views of radiography. Cardiac shadow was obliterated either partially or completely in most cases, depending on the severity of effusion and prolapse. Regardless of radiographic angles, it was easily detected (Lateral: 89%, D-V: 90%) as reported by

Sullivan and Lee [11]. Cardiophrenic angles, the angles between the heart and diaphragm, can be obliterated or reduced in detail, in diaphragmatic hernias with pleural effusion and a heavy prolapse of abdominal organs. In this study, either side of angles were either partially or completely obliterated in 80% of the cases, however, more commonly both angles were obliterated.

Because of cranial displacement of abdominal organs and pleural effusion, lung lobes can be compressed or collapsed in diaphragmatic hernia and thus the clarity of normal pulmonary vascular markings and lung shadow can be affected on the radiograph [7,11,12]. In this study, lung compressions were observed in 88% of the cases, mainly in the lung lobes closely located to the rupture site, although it occurred less (27%) in previous reports [11]. This difference may be due to wider range of the radiographic scope employed in this study. Radiographic changes in lung shadow and pulmonary vascular markings are not direct signs of diaphragmatic hernia, and furthermore many other pulmonary diseases can cause similar radiographic changes [7,11,12]. A displacement of the pulmonary bronchi has never been reported previously, however, we found that in more than 50% of the cases, the pulmonary bronchi were interrupted in their pattern, and either displaced or curved dorsally towards the lung in cases with heavy prolapse in hilus, or caudodorsally if less compressed, as the result of the compression of the pulmonary segments by herniated organs. The displacement of the middle bronchus was more obvious in many cases due to its anatomical proximity to herniated organs.

Presence of abdominal gas shadows in thorax is the most reliable radiographic sign indicating diaphragmatic hernia [2-4,6,11-14]. The cranial displacement of abdominal organs results in the abdominal gas shadow in thoracic cavity and an empty and wasp-shaped abdomen [4,7,12,14]. In this study, abdominal gas shadows and wasp-shaped abdomen were observed in 73% and 52% of the cases, respectively.

The falciform ligament is located between the ventral border of the liver and ventral abdominal wall. If this falciform ligament is herniated into the thoracic cavity, the ventral border of the liver will displace toward the abdominal wall and the shadow of falciform ligament will be obliterated from the abdomen [4]. Therefore, this can be a good radiographic sign of diaphragmatic hernia. Although locating the falciform ligament is challenging in dogs, we found the falciform ligament was disappeared from the abdomen in 68% of the cases.

In diaphragmatic hernias, the stomach can be displaced cranially and also its axis can be directed cranioventrally, instead of caudoventrally if the liver is involved in the hernia. Therefore, the displacement of the stomach should be included in the radiographic signs of the diaphragmatic hernia [4]. In more than 50% of the case, this axis was

displaced cranioventrally.

Because automobile accidents are the predominant cause of diaphragmatic hernias, traumatic signs such as rib fractures should not be overlooked [11,13]. However, it was observed only in 16% of the cases, although the automobile accident was the major cause of diaphragmatic hernia in this study.

In summary, 60 cases of diaphragmatic hernia were radiologically reviewed and categorized by radiographic features. The type of herniated organ was more closely related to the anatomical proximity of the organ to the ruptured site. Many characteristic radiographic signs were not identifiable in case of pleural effusion or heavy prolapse of abdominal organ. More than two radiographs taken at different angles (e.g. lateral and D-V views) were essential for valid diagnosis. In addition to previously documented radiographic signs, we found displacement of tracheal and bronchial segments and the location of the stomach axis to be good radiographic indicators of diaphragmatic hernia.

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