Review

Medicina Veterinária

e-ISSN 2675-6617
v. 18 n. 4 (2024)

Considerations about traumatic diaphragmatic hernia in small animals

Considerações sobre a hérnia diafragmática traumática em pequenos animais

Raíne da Luz Nogueira de **Toledo**, Sheila Canevese **Rahal**, Luciane dos Reis **Mesquita**, Geovane José **Pereira**, Cláudia Valéria Seullner **Brandão**, Maria Jaqueline **Mamprim**, Jeana Pereira **da Silva**, Ricardo Shoiti **Ichikawa**

Department of Veterinary Surgery and Animal Reproduction, School of Veterinary Medicine and Animal Science (UNESP), Botucatu-SP, Brazil.
**Corresponding author: ricardo.ichikawa@unesp.br*

Article info

Keywords
Diaphragm rupture
Dogs
Cats
Surgery

DOI
10.26605/medvet-v18n4-6638

Citation
Toledo, R. L. N., Rahal, S. C., Mesquita, L. R., Pereira, G. J., Brandão, C. V. S., Mamprim, M. J., da Silva, J. P., & Ichikawa, R. S. (2024). Considerations about traumatic diaphragmatic hernia in small animals Medicina Veterinária, *18*(4), 300-318. https://doi.org/10.26605/medvet-v18n4-6638

Received: January 23, 2024
Accepted: September 2, 2024

Resumo

Diaphragmatic hernia is a relatively common disorder in routine surgical procedures for small animals. This hernia is characterized by discontinuity of the diaphragm due to a rupture or defect, which may result in the displacement of abdominal organs into the thoracic cavity. Therefore, this review aims to provide information about the anatomy of the diaphragm and associated structures, as well as the causes, clinical signs, diagnosis, and treatment options for acquired diaphragmatic hernia. The diaphragm is an inspiratory muscle composed of a muscle portion that surrounds a central tendon. Traumatic diaphragmatic hernia is commonly associated with motor vehicle accidents. The diagnosis is based on clinical history and physical examination, but the final definition requires imaging studies, in which plain radiographic examination is the most frequently used. However, an ultrasound examination is necessary in some cases. Treatment involves surgical correction of the rupture, usually performed through a median celiotomy.

Abstract

A hérnia diafragmática é uma desordem relativamente frequente na rotina cirúrgica de pequenos animais. Essa hérnia se caracteriza pela descontinuidade do diafragma devido a uma ruptura ou defeito, que pode resultar no deslocamento de órgãos abdominais para a cavidade torácica. Sendo assim, objetiva-se, com esta revisão, fornecer informações sobre a anatomia do diafragma e estruturas associadas, bem como as causas, sinais clínicos, diagnóstico e opções de tratamento para hérnia diafragmática adquirida. O diafragma é um músculo inspiratório composto de uma porção muscular que circunda um centro tendíneo. A hérnia diafragmática traumática é frequentemente associada com acidentes com veículos motores. O diagnóstico se baseia na história clínica e exame físico, porém a definição final requer exames de imagem, sendo o mais frequentemente empregado o exame radiográfico simples. Entretanto, em alguns casos faz-se necessário o exame ultrassonográfico. O tratamento envolve a correção cirúrgica da ruptura, geralmente realizada por meio de uma celiotomia mediana.
Keywords: ruptura do diafragma; cães; gatos; cirurgia.

1 | Introduction

Diaphragmatic hernia is a relatively common disorder in routine surgical procedures for small animals, characterized by discontinuity of the diaphragm due to a rupture or defect through which the organs of the abdominal cavity have the possibility of displacement to the thoracic cavity (Levine, 1987; Worth and Machon, 2005; Baines, 2018; Fossum, 2019). Depending on the origin, the diaphragmatic hernia can be congenital or acquired (Levine, 1987; Hunt, 2010; Baines, 2018). The acquired hernia is the most observed, with traumatic processes as the principal cause, such as those due to motor vehicle accidents (Levine, 1987; Worth and Machon, 2005).

Depending on the displaced viscera, the animal may present mainly respiratory and/or digestive alterations (Worth and Machon, 2005; Baines, 2018; Fossum, 2019), which highlights the importance of clinical history and physical examination to obtain an adequate diagnosis. Diaphragmatic hernia has a good prognosis if adequately managed, considering the initial evaluation, care during the physical examination and at the time of complementary imaging tests, the choice of the anesthetic technique, and the type of surgical procedure (Worth and Machon, 2005; Hunt, 2010; Fossum, 2019).

Therefore, this review aims to provide information about the anatomy of the diaphragm and associated structures, as well as the causes, clinical signs, diagnosis, and treatment options for acquired diaphragmatic hernia.

2 | Development

2.1 | Anatomy

The diaphragm is the most important muscle of inspiration that separates the thoracic and abdominal cavities (Levine, 1987; Worth and Machon, 2005). In its composition, there is a peripheral muscular portion divided into lumbar (pars lumbalis), costal (pars costalis) and sternal (pars sternalis) parts, and a central tendinous portion with the approximate shape of a Y (Hunt, 2010; McClaran, 2013; Baines, 2018; Liebich et al., 2020).

The diaphragm projects into the thoracic cavity, like a dome, with the point of maximum convexity (Levine, 1987; Liebich et al., 2020). Thus, the diaphragmatic dome allows a part of the abdominal cavity to be intrathoracic (Liebich et al., 2020). Additionally, the diaphragm has three openings: the aortic hiatus that allows passage to the aorta artery, the azygos and hemiazygos veins, and the thoracic duct; the esophageal hiatus, which is the area for the passage of the esophagus, its vessels, and vagal trunk nerves; and the caval foramen, through which the caudal vena cava passes (Levine, 1987; Hunt, 2010; Baines, 2018).

During inspiration, the muscular part of the diaphragm contracts, causing the abdominal viscera to move caudally and enlarging the thoracic cavity, allowing the lungs to expand (Hunt, 2010; Baines, 2018; Liebich et al., 2020). During expiration, the muscular part of the diaphragm relaxes, leading to a cranial displacement of the abdominal viscera, reducing the size of the thoracic cavity and compressing the lungs (Clair, 1986; Liebich et al., 2020). Therefore, the diaphragm is crucial for maintaining negative intrapleural pressure (Hunt, 2010).

2.2 | Causes

Acquired diaphragmatic hernias of traumatic origin are considered the most common, based on the clinical-surgical routine of dogs and cats (Raiser, 1994; Hunt, 2010; McClaran, 2013; Baines, 2018). Traumatic diaphragmatic hernias are more frequently caused by motor vehicle accidents (Levine, 1987; Worth and Machon, 2005; McClaran, 2013). Traumas resulting from blows to the abdomen, twists, kicks, falls from a height, and penetrating wounds can also induce injury but are less frequent (Levine, 1987; Hunt and Johnson, 2018).

The lesions are promoted indirectly; that is, the glottis at the time of trauma is open in inspiration and, with increased intra-abdominal pressure, there is rapid deflation of the lungs and increased pleuroperitoneal pressure gradient with consequent diaphragm rupture (Levine, 1987; Fossum, 2019). On the other hand, some authors state that the most important factor is the development of a severe and acute pressure gradient between the cavities, regardless of the opening or closing of the glottis (Worth and Machon, 2005). Once the rupture occurs, abdominal viscera may be displaced into the chest cavity (Bellah, 2014).

Direct injuries can be caused iatrogenically, such as during thoracentesis or celiotomy, when the

linea alba incision is extended cranially beyond the xiphoid cartilage (Hunt, 2010; Bellah, 2014; Baines, 2018). Other possibilities of direct injuries are caused by penetrating injuries, such as gunshot or stab wounds, that reach the thoracoabdominal region (Hunt, 2010; Baines, 2018).

The probability of diaphragm rupture is highest in the muscular portion, considered the weakest, rather than in the central tendinous area (Kagan, 1980; Worth and Machon, 2005; Hunt, 2010; Fossum, 2019) (Figure 1).

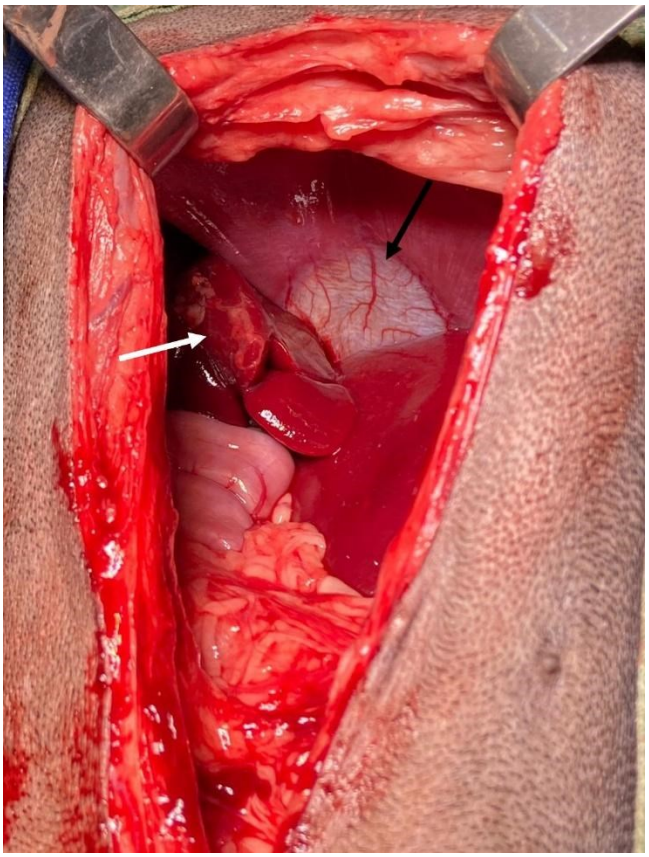

Figure 1. Diaphragm rupture in the muscular portion and central tendinous portion intact (black arrow). A portion of the liver is herniated (white arrow).

Diaphragm tears can be oriented circumferentially, radially, or a combination of both (Levine, 1987; Worth and Machon, 2005) (Figure 2). Regarding the organs and other abdominal structures that can move to the thoracic cavity, the liver is the most frequently herniated, followed by the small intestine, stomach, spleen, omentum, pancreas, colon, cecum, and uterus (Raiser, 1994; Worth and Machon, 2005; Hunt, 2010). Factors that influence the type of herniated organ are the site and extent of the diaphragmatic tear, anatomical proximity, and amount of movement of the ligaments or mesentery (Hunt, 2010). In right-sided tears, the organs most prone to displacement are the liver, small intestine, and pancreas, whereas in left-sided tears, the stomach, spleen, and small intestine are usually observed (Levine, 1987; Worth and Machon, 2005; Hunt, 2010).

2.3 | Clinical Signs

The most common clinical sign in animals with traumatic diaphragmatic hernia is respiratory dysfunction (dyspnea, tachypnea, cyanosis) due to decreased thoracic expansion by the herniated organs (Raiser, 1994; Worth and Machon, 2005; McClaran, 2013; Pereira et al., 2023). However, the signs are not pathognomonic (Levine, 1987; Baines, 2018). Incorrect lung inflation and pulmonary atelectasis impair ventilation and perfusion (Worth and Machon, 2005; Hunt and Johnson, 2018).

An animal with a traumatic diaphragmatic hernia is usually presented due to the occurrence or history of a traumatic process and may exhibit other simultaneous injuries (Levine, 1987; Hunt, 2010; McClaran, 2013; Deveci et al., 2022; Pereira et al., 2023). In acute cases, the animals can be presented in shock with pale or cyanotic mucous membranes, tachypnea, tachycardia, oliguria, and depression (Levine, 1987; Fossum, 2019). In chronic processes, the animals can be asymptomatic or with nonspecific clinical signs, including respiratory and gastrointestinal changes (Fossum, 2019; Larson, 2024).

The organs of the digestive system, such as the stomach and intestine, can suffer strangulation or obstruction and induce clinical signs of anorexia, emesis, diarrhea, and weight loss (Hunt, 2010; Fossum, 2019). In more severe cases, these organs may suffer ischemia and necrosis, or even perforation leading to shock or even animal death (Hunt, 2010; Hunt and Johnson, 2018).

3 | Diagnosis

3.1 | Physical examination

As previously mentioned, some animals with a diaphragmatic hernia may or may not show clinical signs (Levine, 1987; Worth and Machon, 2005; Fossum, 2019; Larson, 2024). On auscultation, heart sounds can be found in abnormal areas and muffled, as well as lung sounds (Kagan, 1980; Raiser, 1994;

Baines, 2018). Borborygmus can be auscultated in the thorax due to intestinal loop occurrence but may not be present in the first 24 to 36 hours (Levine, 1987; Hunt and Johnson, 2018). On percussion, the sounds may vary according to the displaced viscera, such as hyperresonant areas if the stomach distended with gas is present and dullness with the liver (Kagan, 1980).

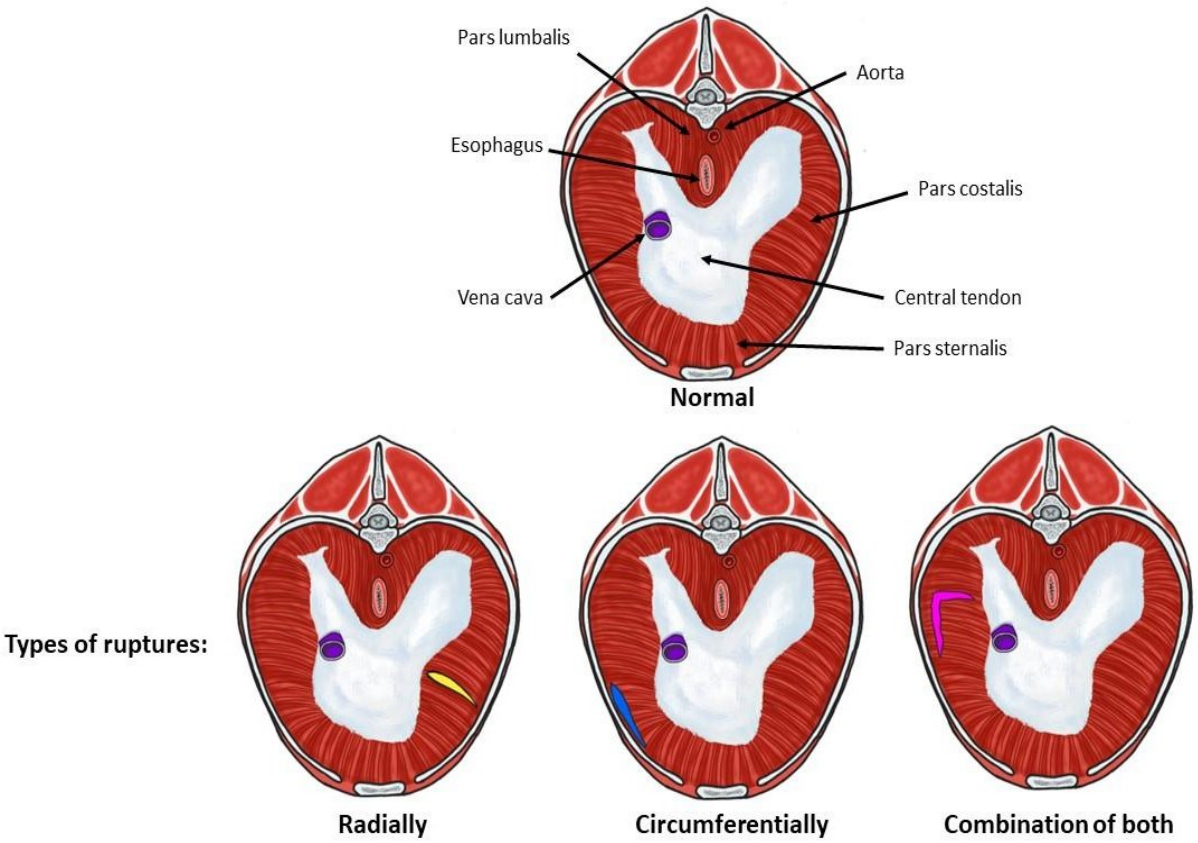

Figure 2. Anatomical schematic drawing of the dog's diaphragm and types of ruptures found.

3.2 | Radiographic examination

Thoracic radiography is one of the imaging modalities of choice in diagnosing a diaphragmatic hernia; however, excessive effort should be avoided during radiographic positioning, as animals with respiratory and cardiac dysfunctions may have an aggravated condition (Levine, 1987; Worth and Machon, 2005). The lateral view is one of the most useful for making the diagnosis (Hunt and Johnson, 2018), but at least two projections are necessary to obtain a valid diagnosis (Levine, 1987; Hyun, 2004).

Plain radiographs can show discontinuity of the diaphragmatic outline, loss of cardiac silhouette, and dorsal or lateral displacement of the lung fields, in addition to the presence of intestinal loops, stomach, and liver in the thoracic cavity (Levine, 1987; Worth and Machon, 2005; McClaran, 2013) (Figure 3). A study included other radiographic signs to be evaluated, including stomach axis location and displacement of the trachea and bronchial segments (Hyun, 2004). The displacement of organs such as the liver or spleen complicates differentiation from pleural effusion or pulmonary consolidation only on plain radiography (Larson, 2024). Contrast radiography with orally administered contrast media allows the visualization of the viscera of the gastrointestinal tract but must be used with caution due to the possibility of obstruction or delay of transit associated with the viscera displacement (Levine, 1987; Baines, 2018). In addition, abdominal radiographs can be valuable in demonstrating the absence of organs in the abdominal cavity and gastric axis displacement (McClaran, 2013).

3.3 | Ultrasonography

Ultrasonography is an option in cases of inconclusive radiographic examination and may help identify herniated organs (Baines, 2018). Pleural

effusion can even aid in the diagnosis, as the fluid can help visualize and identify the viscera (Bellah, 2014; Hunt and Johnson, 2018). However, in cases of pulmonary contusion, the lung may appear similar to the liver, making ultrasound analysis difficult (Fossum, 2019). Sometimes, it is possible to visualize the torn muscle moving together with respiratory motion (Hunt and Johnson, 2018). Figures 4 and 5 show examples of ultrasound findings.

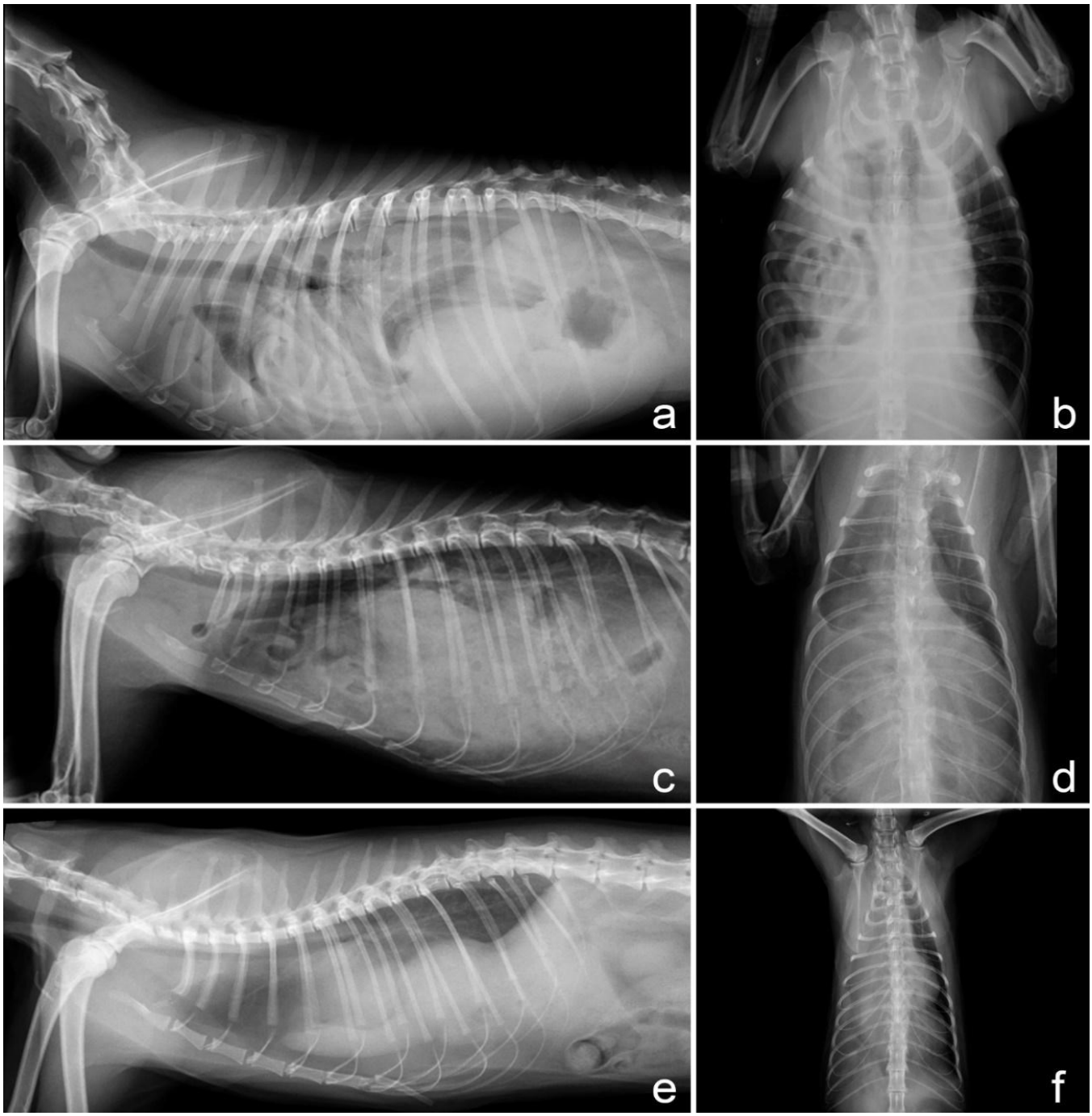

Figure 3. Right lateral (a, c, e) and ventrodorsal (b, d, f) views of the thorax. (a, b) A 3.2-year-old female mixed-breed cat: loss of the diaphragmatic line, abdominal organs cranially displaced to the thoracic cavity overlapping the cardiac silhouette and lung fields, and presence of intestinal loops in the right hemithorax. (c, d) A 5-year-old female mixed-breed dog: areas of soft tissues/fluid covering the entire right hemithorax, presence of intestinal loops, mediastinal shift, and dorsal displacement of the cardiac silhouette with poor visualization of its left lateral margin and pulmonary fields. Loss of definition of the right ventrolateral diaphragmatic line. (e, f) A 3.9-year-old female mixed-breed cat: loss of continuity in the diaphragmatic crura ventral and right lateral, presence of structures with soft tissue radiopacity in the right lateral, displacement of the cardiac silhouette to the left, and mild pneumothorax.

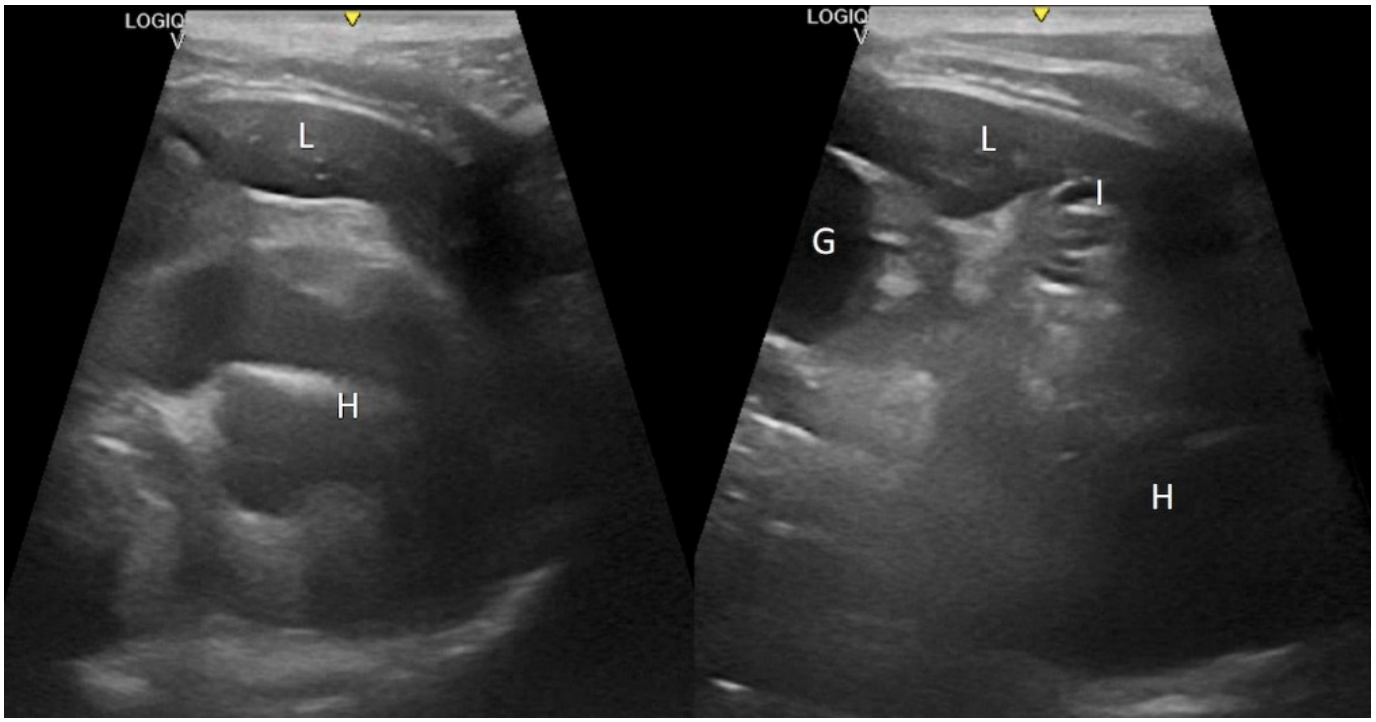

Figure 4. Longitudinal ultrasonographic images of traumatic diaphragmatic hernia in a dog. Observe the presence of abdominal organs, such as the liver (L), gallbladder (G), and intestines (I) next to the heart (H).

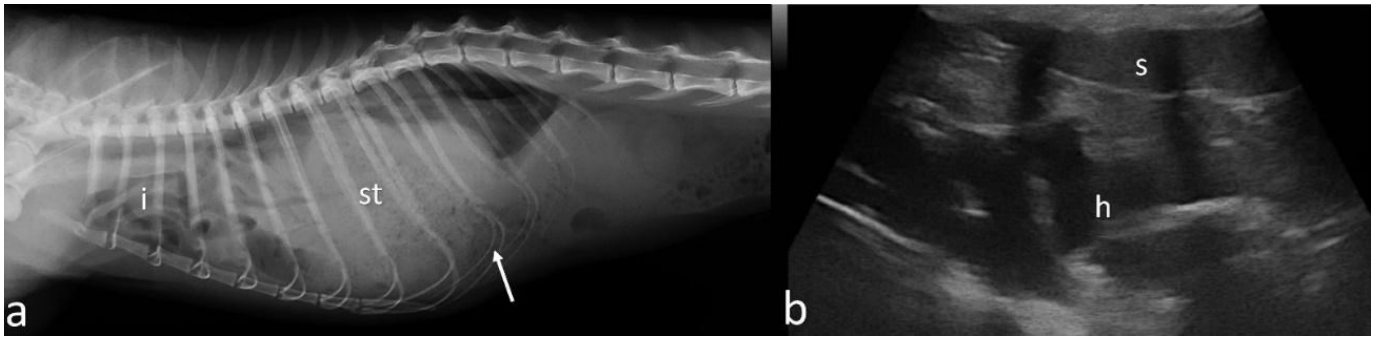

Figure 5. A 2-year-old male mixed-breed cat. (a) Right lateral view of the thorax showing loss of the diaphragmatic line (white arrow) and presence of intestinal loops (i) and stomach (st) in the thorax. (b) Ultrasound image reveals the presence of the spleen (s) next to the heart (h).

3.4 | Laboratory tests

Laboratory findings are not specific; however, biochemical analysis may show an increase in liver enzymes such as alanine aminotransferase and alkaline phosphatase, especially in cases of liver herniation (Fossum, 2019). In addition, chronic hepatic congestion may result in coagulation abnormalities and low serum protein levels (Levine, 1987).

3.5 | Differential diagnosis

The differential diagnosis of traumatic hernias includes conditions that promote respiratory changes, such as pleural effusion, pneumothorax and pneumonia (Fossum, 2019). Pleural effusion is generally verified in chronic traumatic hernias (Larson, 2024).

4 | Treatment

4.1 | Preoperative management

The treatment of diaphragmatic hernia involves surgical correction of the rupture; however, the ideal timing of the procedure is a subject of debate (Levine, 1987; Worth and Machon, 2005). Until the surgical intervention, oxygen therapy support should be provided, especially in cases of dyspnea (Baines, 2018). If the animal is decompensated, it should be held upright so that the prolapsed viscera return to

the abdomen (Worth and Machon, 2005). In animals in shock, fluid therapy and antibiotics should be administered (Fossum, 2019), but volume overload in animals with concomitant lung injuries can be deleterious and predispose them to pulmonary edema (Worth and Machon, 2005).

Drugs that have minimal respiratory depressant effects should be used, and oxygenation should be ensured before the induction of anesthesia for a safer procedure (Worth and Machon, 2005; Baines, 2018). Animal handling must be done carefully to avoid further complications (Levine, 1987). Short-acting barbiturates or propofol are used to allow rapid induction and intubation (Bellah, 2014). Controlled ventilation should be conducted with care, as high inspiratory pressure can lead to re-expansion pulmonary edema (Fossum, 2019).

4.2 | Surgical procedure

The approach through midline celiotomy has the following advantages: the side of the hernia does not need to be determined; the incision can easily be extended if needed; there is less pain in the postoperative period (Levine, 1987; Kagan, 1980). The disadvantages include difficulty performing the suture and the need to enlarge the opening of the diaphragm to remove adhesions from the viscera (Levine, 1987; Hunt and Johnson, 2018). Median sternotomy of the caudal sternebrae is a method of extending the median celiotomy, but it is associated with increased postoperative morbidity (Worth and Machon, 2005; Hunt and Johnson, 2018).

Lateral thoracotomy promotes good exposure of the herniated viscera and diaphragmatic rupture, providing visualization for the breakdown of adhesions; however, the side of the hernia must be known (Kagan, 1980; Levine, 1987; Bellah, 2014). Thus, this access is not indicated in cases of hernia with a bilateral defect or if intervention in the abdominal cavity is necessary (Hunt and Johnson, 2018). One study used thoracic access in the eighth intercostal space and diaphragmatic advancement in cases of phrenocostal tears (Raiser, 1994).

For midline celiotomy, the animal is positioned in dorsal recumbency (light reverse Trendelenburg) (McClaran, 2013). The incision is made in the ventral abdominal midline and can be extended cranially and caudally (Hunt and Johnson, 2018; Fossum, 2019). With the abdominal cavity open, the viscera located in the thoracic cavity are gently reduced back to the abdominal cavity (Levine, 1987; McClaran, 2013). Manipulation must be extremely careful with incarcerated liver and/or spleen to avoid ruptures, as these organs are generally congested and friable (Hunt and Johnson, 2018). If the herniated content is difficult to reduce, the diaphragmatic rupture can be carefully expanded, avoiding traumatizing the vessels, phrenic nerve, and caudal vena cava (Baines, 2018).

Adhesions with an evolution of less than seven to fourteen days can be disrupted manually; however, if the adhesions are old, dissection or resection is used, depending on the organ involved (Hunt and Johnson, 2018). After repositioning the viscera, a careful inspection should be carried out to assess signs of injury or unfeasibility that need to be corrected if present (Worth and Machon, 2005; Fossum, 2019). In fresh traumatic diaphragmatic hernias, the diaphragm is usually easily manipulated, with no difficulty in applying the suture (Baines, 2018). In chronic processes, fibrosis can interfere with diaphragm manipulation and needs to be released, but debridement of the edges before suturing may not be advantageous, as it may increase the size of the lesion and complicate the suturing procedure (Hunt and Johnson, 2018).

The suture is usually applied from the dorsal to ventral, especially when the rupture is near the hiatus (Levine, 1987; Baines, 2018). The suture pattern and material depend on the surgeon's preference (Bellah, 2014) (Figure 6). Simple continuous suture with absorbable synthetic material, such as polyglactin 910 and polydioxanone, or non-absorbable material can be used (Worth and Machon, 2005; McClaran, 2013). In cases of avulsion of the diaphragm from the ribs, a suture incorporating the rib can increase strength (Fossum, 2019). If the lesion is near the caudal vena cava, caution should be taken during suturing to avoid obstruction of the venous return (McClaran, 2013). The application of biological (autogenous fascia, muscle flaps, omentum) or synthetic (meshes) implants has been reported in the treatment of defects that cannot be closed with a suture (Levine, 1987; Worth and Machon, 2005; Baines, 2018).

After diaphragm repair/reconstruction, the pneumothorax should be reduced to facilitate ventilation, which can be performed by using a chest tube (Worth and Machon, 2005; Fossum, 2019).

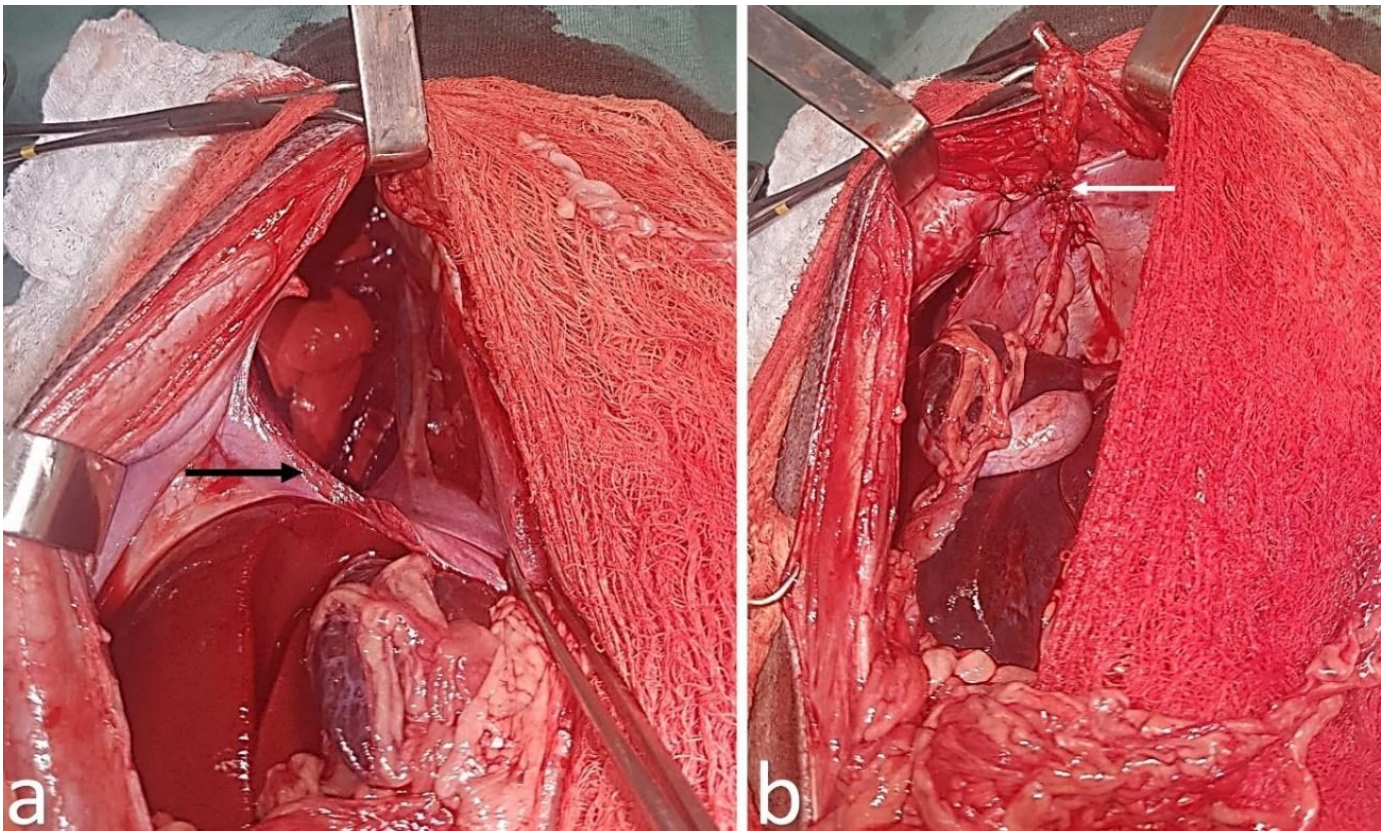

Figure 6. A 5-year-old female crossbred dog. (a) Diaphragmatic defect (black arrow) accessed through a ventral midline celiotomy. Note the combined tear. (b) Repair of diaphragmatic defect (white arrow).

Some authors suggest that pneumothorax should be relieved gradually for eight to 12 hours (Worth and Machon, 2005; Worth and Machon, 2006). Inflation of atelectatic lungs should be done carefully and gradually to avoid reperfusion injuries and the development of postoperative pulmonary edema (Hunt and Johnson, 2018). In addition, hyperinflation of the lungs can lead to rupture of the lung parenchyma, intrapulmonary hemorrhage, pulmonary edema, and eventually pneumothorax (Bellah, 2014; Hunt and Johnson, 2018). In cases of pneumothorax or continuous effusion, a chest tube should be maintained in the postoperative period until the process is stopped (Kagan, 1980; Fossum, 2019).

4.3 | Postoperative management

Animals must be maintained with adequate analgesia, as animals in pain tend to have impaired breathing (Bellah, 2014). Monitoring should be carried out in the postoperative period, so that support is provided as quickly as possible in the event of complications (Hunt and Johnson, 2018; Fossum, 2019). In cases of hypoventilation, the animal should be maintained on oxygen support (Baines, 2018). Postoperative radiographic examinations may be performed before anesthesia recovery to monitor pneumothorax or pleural effusions, collapsed lung lobes, or chest tube position (Hunt and Johnson, 2018).

The most frequent surgical complications in the immediate postoperative period are pulmonary edema due to reexpansion, pneumothorax, hemothorax, pleural effusion, shock, and cardiac arrhythmia, which can lead to death (Baines, 2018). In turn, deaths after 24 hours of the surgical procedure are usually secondary to rupture, obstruction, or strangulation of the gastrointestinal tract or due to causes unrelated to the hernia (Hunt and Johnson, 2018).

The prognosis is generally excellent, and recurrence is uncommon if the animal survives the early postoperative period of 12 to 24 hours (Hunt, 2010; Fossum, 2019). However, the prognosis has been reported as reserved in some cases, and other studies provide a survival rate after diagnosis of 51.7% (Garson et al., 1980) to 90% (Sullivan and Reid, 1990).

A study of 92 dogs and cats with traumatic diaphragmatic hernia showed a postoperative survival rate of 89.1% (Gibson et al., 2005). In another

study of 49 dogs and 48 cats with acquired diaphragmatic hernia, 6.2% died during surgery and 8.2% died after surgery (Pereira et al., 2023). Additionally, a retrospective study of 25 cats with diaphragmatic hernias found postoperative survival rates of 83.3% for acute cases and 69.2% for chronic cases (Deveci et al., 2022).

5 | Conclusion

The diaphragm is the most important inspiratory muscle composed of a muscle portion that surrounds a central tendon. Traumatic diaphragmatic hernia is commonly associated with motor vehicle accidents. The diagnosis is based on the clinical history and physical examination, but confirmation requires imaging tests, with the most frequently used being plain radiographic examination. However, an ultrasound examination is necessary in some cases. Treatment requires a surgical procedure, which in most cases is performed through a median celiotomy.

6 | References

Baines, S. Surgery of the diaphragm. In: Brockman, D.J.; Holt, D.E.; Haar, G.T. **BSAVA manual of canine and feline head, neck and thoracic surgery**. Gloucester: BSAVA, 2018. p.209-227.

Bellah, J.R. Traumatic diaphragmatic hernia. In: Bojrab, M.J.; Waldron, D.; Toombs, J.P. **Current techniques in small animal surgery**. Jackson: Tenton NewMedia, 2014. p.352-361.

Clair, L.E. Músculos do carnívoro. In: Getty, R. **Sisson Grossman anatomia dos animais domésticos**. Rio de Janeiro: Guanabara Koogan, 1986. p.1416-1441.

Deveci, M.Z.Y.; Yurtal, Z.; İşler C.T.; Emiroğlu, S.B.; Alakuş, I.; Altuğ, M.E. Herniorrhaphy and surgical outcomes of diaphragmatic hernia in cats. **Slovenian Veterinary Research**, 59(1): 47-57, 2022.

Fossum, T.W. Surgery of the lower respiratory system: pleural cavity and diaphragm. In: Fossum, T.W. **Small Animal Surgery**. Philadelphia: Elsevier, 2019. p.916-955.

Garson, H.L.; Dodman, N.H.; Baker, G.J. Diaphragmatic hernia. Analysis of fifty-six cases in dogs and cats. **Journal of Small Animal Practice**, 21(9): 469–481, 1980.

Gibson, T.W.G.; Brisson, B.A.; Sears, W. Perioperative survival rates after surgery for diaphragmatic hernia in dogs and cats. **Journal of the American Veterinary Medical Association**, 227(1): 105-109, 2005.

Hunt, G.B.; Johnson, K.A. Diaphragmatic hernias. In: Johnston, S.A.; Tobias, K.M.; Peck, J.N.; Kent, M. **Veterinary surgery small animal**. Saint Louis: Elsevier, 2018. p.4306- 4337.

Hunt, G.H. Diaphragmatic hernia. In: Bojrab M.J.; Monnet, E. **Mechanisms of disease in small animal surgery**. Jackson: Teton NewMedia, 2010. p.445-457.

Hyun, C. Radiographic diagnosis of diaphragmatic hernia: review of 60 cases in dogs and cats. **Journal of Veterinary Science**, 5(2): 157-162, 2004.

Kagan, K.G. Thoracic trauma. **Veterinary Clinics of North America: Small Animal Practice**, 10(3): 641-653, 1980.

Larson, M.M. Diseases of the mediastinum, chest wall, and diaphragm. In: Côté, E.; Ettinger, S.J.; Feldman, E.C. **Ettinger's textbook of veterinary internal medicine**. Philadelphia: Elsevier, 2024. p.3557-3581.

Levine, S.H. Diaphragmatic hernia. **Veterinary Clinics of North America: Small Animal Practice**, 17(2): 411-430, 1987.

Liebich, H.G.; Maierl, J.; König, H.E. Fasciae and muscles of head, neck and trunk. In: König, H.E.; Liebich, H.G. **Veterinary anatomy of domestic animals**. Stuttgart: Thieme, 2020. p.137-169.

McClaran, J.K. Diaphragmatic and peritoneopericardial diaphragmatic hernias. In: Monnet, E. **Small animal soft tissue surgery**. Ames: John Wiley & Sons, 2013. p.278-285.

Pereira, G.J.; Rahal, S.C.; Melchert, A.; Abibe, R.B.; Brandão, C.V.S.; Quitzan, J.G.; Mesquita, L.R.; Mamprim, M.J. Eleven-year retrospective analysis of acquired diaphragmatic hernia in 49 dogs and 48 cats. **The Canadian Veterinary Journal**, 64(2): 149–152, 2023.

Raiser, A.G. Herniorrafia diafragmática em cães e gatos. Relato de 22 casos e proposição de técnica para corrigir rupturas freno-costais. **Brazilian Journal of Veterinary Research Animal Science**, 31(3/4): 245-251, 1994.

Sullivan, M.; Reid, J. Management of 60 cases of diaphragmatic rupture. **Journal of Small Animal Practice**, 31(9): 425-430, 1990.

Worth, A.J., Machon R.G. Traumatic diaphragmatic herniation: pathophysiology and management. **Compendium on Continuing Education for the Practising Veterinarian**, 27(3): 178-191, 2005.

Worth, A.J.; Machon, R.G. Prevention of reexpansion pulmonary edema and ischemia–reperfusion injury in the management of diaphragmatic herniation. **Compendium on Continuing Education for the Practising Veterinarian**, 28(3): 531–540, 2006.