

Case Study of Traumatic Diaphragmatic Hernia Repair in a Cat at Pet First Veterinary Centre, Kuala Lumpur, Malaysia

(Studi Kasus Perbaikan Traumatic Diaphragmatic Hernia pada Kucing di Pet First Veterinary Centre, Kuala Lumpur, Malaysia)

Natalie Leong Hoi Tung^{1*}, Deni Noviana², Denny Widaya Lukman³

¹Student of the Veterinary Medicine Undergraduate Program, School of Veterinary Medicine and Biomedical Sciences

²Division of Surgery and Radiology, School of Veterinary Medicine and Biomedical Sciences

³Division of Veterinary Public Health and Epidemiology, School of Veterinary Medicine and Biomedical Sciences

*Corresponding author: deni@apps.ipb.ac.id

Submitted: 11 August 2023, Accepted: 25 June 2024

ABSTRAK

Hernia diafragma traumatis adalah cedera pada toraks akibat adanya gaya pada diafragma yang melebihi kekuatan diafragma untuk menahan tekanan. Penelitian bertujuan mengetahui cara pengobatan dan teknik pembedahan kasus hernia diafragma traumatis pada kucing. Pasien adalah kucing *domestic short hair* (DSH) betina berumur 1 tahun berbulu hitam putih dengan berat badan 2,8 kg di *Pet First Veterinary Center*. Studi kasus dimulai dengan pemeriksaan fisik untuk melihat gejala klinik dan melihat data diagnostik sebelum operasi. Hilangnya batas ventral diafragma dan bergesernya organ abdomen ke rongga toraks menjadi gambaran radiologis yang terlihat pada pasien penderita hernia diafragma. Pembedahan dilakukan di *Pet First Veterinary Center* untuk memulihkan tekanan negatif di rongga toraks dengan *thoracocentesis*. *Diaphragmatic hernia repair* merupakan teknik pembedahan untuk mengembalikan fungsi diafragma. *Intermittent positive pressure ventilation* (IPPV) merupakan teknik ventilasi yang membantu pasien agar dapat bernapas optimal selama proses bedah berlangsung. Perawatan post-operasi berlangsung dicatat dalam sistem rekam medik digital dan pemulihan pasien terjadi dalam waktu satu bulan. Penelitian menunjukkan bahwa *diaphragmatic hernia repair* adalah metode pengobatan yang efektif untuk kasus hernia diafragma traumatis sehingga dapat mempertahankan fungsi paru-paru.

Kata kunci: *diaphragmatic hernia repair*, hernia diafragma traumatis, *intermittent positive pressure ventilation* (IPPV), kucing, *thoracocentesis*

ABSTRACT

Traumatic diaphragmatic hernia is an injury to the thorax in which the forces applied to the diaphragm exceed the diaphragmatic holding strength, resulting in a defect that allows abdominal contents to protrude into the thoracic cavity. This case research aimed to investigate diaphragmatic hernia treatment and surgical repair. The patient is a 1-year old, female domestic short hair (DSH) cat, black-white hair with a body weight of 2.8 kg. Pet First Veterinary Center monitored clinic symptoms and diagnostic data before surgery. Patient state was closely checked. The loss of the ventral border of the diaphragm and the displacement of abdominal viscera within the thorax are the most prominent radiological features in patient with diaphragmatic hernias. Surgery was performed at Pet First Veterinary Centre to restore negative pressure in the thoracic cavity by *thoracocentesis*. *Diaphragmatic hernia repair* involved reconstructing the diaphragm to restore its original function. *Intermittent positive pressure ventilation* (IPPV) was performed in this surgery. The treatment with corrective surgery was recorded, followed by the recovery of the patient within one month of the surgery. This research demonstrated that diaphragmatic hernia repair was an effective method of treatment for diaphragmatic hernia to preserve pulmonary function.

Keywords: cat, diaphragmatic hernia repair, intermittent positive pressure ventilation (IPPV), thoracocentesis, traumatic diaphragmatic hernia

INTRODUCTION

The diaphragm is the muscular separation between the chest and abdominal cavities that functions as a barrier and aids in respiration. A diaphragmatic hernia (DH) is the protrusion of abdominal contents into the thoracic cavity due to a diaphragm abnormality. Traumatic diaphragmatic hernias arise when forces applied to the diaphragm surpass the diaphragmatic holding strength, resulting in a defect. (Welch 2021).

Traumatic and congenetic diaphragmatic hernias are the two forms that can arise in canines and felines. Traumatic diaphragmatic hernias arise when forces applied to the diaphragm surpass the diaphragmatic holding strength, resulting in a defect, whereas congenital diaphragmatic hernias (related to developmental failure) are further classified as peritoneal-pericardial diaphragmatic hernias (PPDH) and pleuro-peritoneal diaphragmatic hernias (PDH) (Welch 2021). Peritoneal-pericardial diaphragmatic hernia is the most common congenital defect involving the pericardium of dogs and cats (Chandrasekharan *et al.* 2017). Traumatic diaphragmatic hernia can be caused by either direct or indirect diaphragm injury.

Traumatic diaphragmatic hernias (TDHs) can be difficult to recognize at an early stage, resulting in diagnostic delays that might have life-threatening consequences (Lu *et al.* 2016). Characteristic radiographic symptoms include the disappearance of the diaphragmatic line and the cardiac silhouette, as well as the appearance of the abdominal organs, intestinal loops, gas in the thorax, or a thin abdomen (Marolf *et al.* 2002; Hyun 2004). An absolute indicator of a diaphragmatic hernia is the presence of abdominal structures in the thorax. A diaphragmatic hernia may typically be surgically corrected without much difficulty. The higher survival rate may be due to advancements in anaesthetic protocols and intensive care practices (McClaran 2012). As a result of the puncture to the cat's thoracic cavity, the lung will not function optimally during surgery, making the anaesthetic regimen essential. During surgery, manual intermittent positive pressure ventilation (IPPV) is used to maintain the saturation of oxygen in the haemoglobin (SPO₂).

The purpose of this study is to understand the correct way of treating diaphragmatic hernia and learn the correct surgical procedures to perform diaphragmatic hernia repair in Pet First Veterinary Clinic on a cat.

METHODOLOGY

Physical Examinations and Blood Examination

Diaphragmatic hernia is first diagnosed by physical examination. The patient is a 1-year old, domestic short hair (DSH) cat, black-white hair with a body weight of 2.8 kg. Patients that faced diaphragmatic hernia is not able to breath smoothly, in this case the cat shown labor breathing when presented to the veterinarian. The cat was given 2mg/kg of Robenacoxib, subcutaneous to the cat to control the pain and inflammation associated with orthopedic case. Blood is drawn from the patient for blood test. Thorax-abdomen radiograph is taken on the patient with left lateral and ventrodorsal position. Blood is drawn from the patient for blood test.

Radiography

Following a physical examination, the patient is subjected to a radiograph to obtain a radiographic confirmation result Radiographs assist confirm a diagnosis of diaphragmatic hernia and may offer information regarding the hernia's location, extent, contents, and secondary consequences. Moreover, chest radiographs aid in seeing herniated organs within the chest cavity and determining the severity of the hernia.

Implementation of Diaphragmatic Hernia repair

Reconstructive surgery of the diaphragm is recommended as the therapy for a ruptured diaphragm once the owners have been informed of the radiographic evidence of a diaphragmatic hernia, and the owner consent on surgery must be nullified. The physicians choose the operation day in accordance with the legitimate booking date, and painkillers are administered to help patients feel more comfortable as they wait for their turn to have surgery. Prior to surgery, patients are instructed to fast for at least 12 hours. During the procedure, the ruptured diaphragm is repaired.

Observation of Recovery

Patients is placed in the oxygen chamber immediately after the surgery and the recovery is observed for 2 weeks. The development of the healing is taken note until the patients are fully recovered. The patient is brought back by the owner and instructed the owner to revisit the clinic after 2 weeks to observed the recovery repaired diaphragm.

Data Analysis

Patients' secondary data were gathered and documented from the data storage program "Kreloses" at Pet First Veterinary Clinic. Before, during, and after the diaphragmatic hernia surgery, images and videos are taken. The recovery results are then compared using the radiographs obtained by evaluating the visibility of the ventral border of the diaphragm.

RESULT

The patient fell from the rooftop of a two-storey terrace house and presented to the veterinarian with sign of dyspnea and fractured tibia. The patient is also infested with fleas. Following the completion of a physical examination on the patient, the veterinarian determined that the cat is experiencing difficulty breathing and limping as there are fractures on the left tibia and fibula. On auscultation, it shows that the heart sounds and lung sounds are abnormally muffled. Most of the abdominal organs are herniated, so the abdomen may feel empty when palpating.

Blood tests and radiographs are data obtained from the patient. Table 1 shows the Complete Blood Count test result of the patient. The patient has high eosinophil count. Table 2 shows biochemistry blood test result where creatinine levels that are slightly lower than normal. Alkaline phosphatase (ALKP) and alanine aminotransferase (ALT) results are within normal range. Blood test result have shown that the kidney and liver are still functioning normally. Evaluation of blood gas values is necessary for an accurate assessment of a patient's presurgical ventilatory capacity. However, overall, this patient is a good candidate for anesthesia.

Table 1 Complete blood count (CBC) test result of the patient

Test	Results	Reference Interval
Eosinophil (10 ⁹ /L)	1.82	0.15 – 1.1 ^a

^aSource: UCDAVIS 2011

Table 2 Biochemistry blood test result of the patient

Test	Results	Reference Interval*
Creatinine (µmol/L)	66	79.6 – 194.5
Alanine Aminotransaminase (U/L)	80	25-97
Alkaline Phosphatase (U/L)	33	0-45

*Source: Latimer (2011)

Figure 1 is a comparison of radiograph images before and after surgery of a 1 year- old, 2.8 kg domestic short hair cat in right lateral and ventrodorsal view respectively. Figure 1a shows radiograph preoperatively. In this figure, the radiograph shows an abnormal position of the abdominal organ within the thorax area. The silhouette of the heart is unable to be observed, and the caudal border of the diaphragm is not visible. Figure 1b represents the radiographic images taken immediately after diaphragmatic hernia repair has performed. It can be observed that the negative pressure has recovered as there is a presence of radiolucent area in the thoracic area. Figure 1c are radiographs taken 3 after the surgery.

DISCUSSION

The patient experienced laboured respiration because the thoracic cavity was compromised, preventing the lungs from inflating and deflating normally as ruptured diaphragm results in the loss of negative pressure in the thoracic cavity. There are no pathognomonic signs of diaphragmatic hernia, most animals present with acute signs and symptoms associated with respiratory distress (McClaran 2012).

A pre-surgical blood test is done on the patient to determine the efficiency of its liver and kidneys. Table 1 shows all the parameters are in normal range except the patient show a high eosinophil count as the patient is infested with fleas. Table 2 shows biochemistry blood test result where creatinine levels that are slightly lower than normal might suggest a problem with the muscle or liver, but it could also be related to something less significant, such as decreased muscle mass. Alkaline phosphatase (ALKP) and alanine aminotransferase (ALT) results are within normal range indicates liver are functioning normally.

Radiograph are taken immediately after the surgery to establish that there is no longer any fluid in the thoracic cavity and to ensure that the negative pressure has recovered. This is an important step to determine whether the surgery has successful. In a normal thoracic radiograph, the ventral diaphragmatic surface is visualized distinctively on the lateral and ventrodorsal view. However, the patient's thoracic radiograph reveals that the diaphragm's ventral border is no longer visible, and the thorax has become radiopaque, although it was formerly radiolucent and the displacement of abdominal viscera within the thorax are the most prominent radiological features in patients with diaphragmatic hernias. (Figure 1a).

It is first starting by monitoring the physical condition and blood test is carried out to see if the health condition is suitable for the surgery. Even

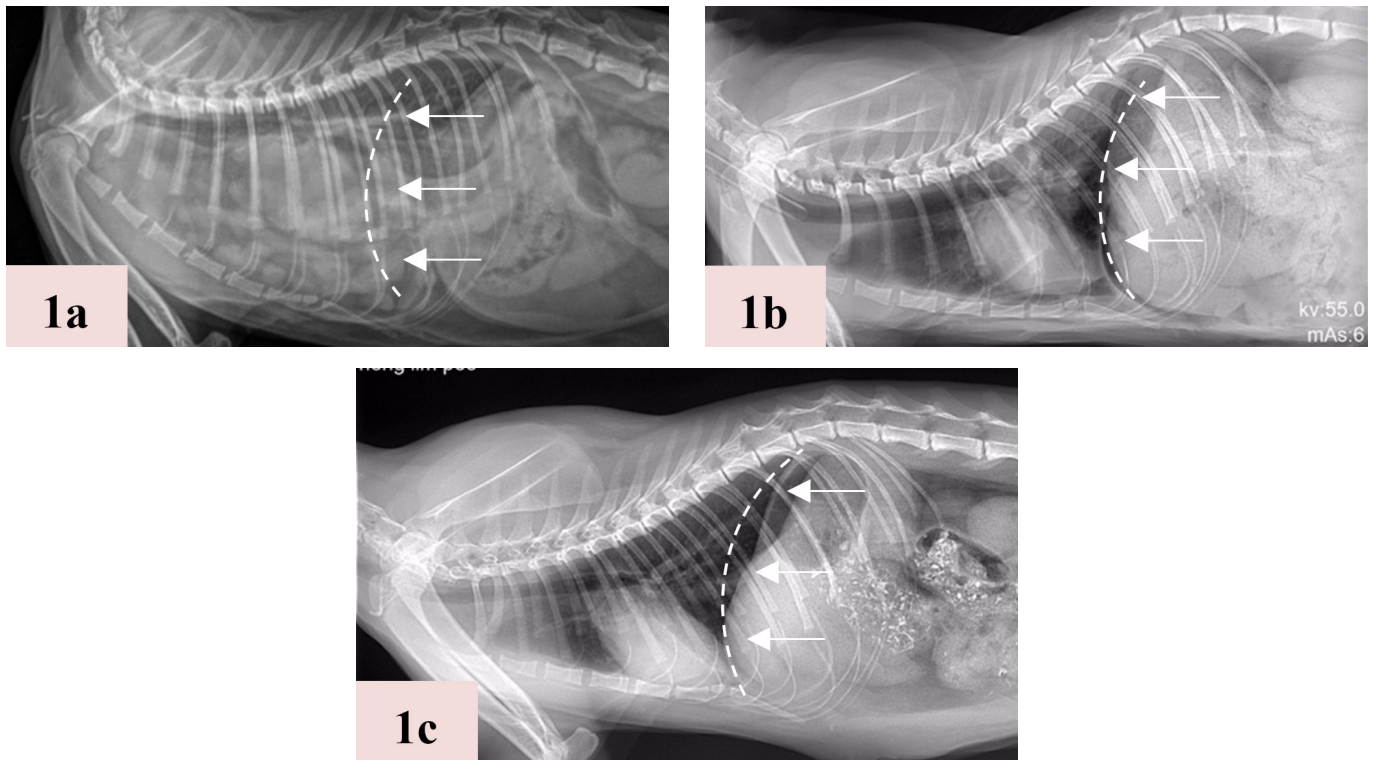


Figure 1 Right lateral view of the thorax. 1a: Preoperatively, where the abdominal organs observed in thorax region; 1b: Immediately after diaphragmatic hernia repair; 1c: 3 days after the repair. Comparison of radiograph images before and after surgery of a one-year-old, 2.8kg domestic short hair cat. White dash line showing the diaphragm. White arrow showing the caudal border of the diaphragm.

though the patient is only 1-year-old, it is required for evaluation of patient health and determination of stabilization requirements prior to anaesthesia to avoid any risk that could lead to anaesthesia related-death. The weight of the cat is taken to give accurate dosage of anaesthesia, pre-surgery and post-surgery medication. Prior to corrective surgery, patient is also fasted at least 8 -12 hours from food and water.

The cat is preoxygenated for five minutes before administering any drugs. Atropine with 0.02–0.04 mg/kg, dexamethasone, and 5 mg/kg of tramadol is administered one after another intravenously as premedication. Atropine sulfate is used as a preanesthetic to prevent or reduce secretions of the respiratory tract and increases heart rate (Plumb 2011). Dexamethasone act as an anti-inflammatory agent and a glucocorticoid agent (steroid) (Plumb 2011). This medicine is given to the patient because the lung is inflamed before the surgery due to the adhesions with the organs from the abdomen. Tramadol is useful as an analgesic or antitussive (Plumb 2011). Intravenous propofol 3-5 mg/kg sedates the cat. An IV port and three-way stopper is implanted in the hind limb.

The abdomen and caudal half to two-thirds of the thoracic cavity is aseptically prepared. The surgical site is aseptically prepared by shaving with clipper, scrubbing, washing with water, and given antiseptic

of alcohol, followed by povidone solution with 4–6 mg/kg of propofol maintenance dose. This is done with the patient standing or lateral recumbent; do not place in ventrodorsal until after intubation (Fossum 2019). This is because when the patient is place in ventrodorsal position before intubation, the patient will experience respiratory distress as the organ will cause pressure to the lungs.

The cat is preoxygenated again with oxygen mask or flow-by oxygen for five minutes in the surgery room. Preoxygenation for 5 to 7 min prior to anesthetic induction and during recovery prevents severe hypoxia during the period between induction and intubation and improves myocardial oxygenation (Fossum 2019; Grubb T 2010). Preoxygenation ensures a comfortable shield during times of apnea and hypoventilation (Danish, 2021)

Chamber or mask induction is avoided in diaphragmatic hernia patients (Fossum 2019). Patient was given induction of anaesthesia with propofol at a dose of 3-5 mg/kg and midazolam with 0.2 mg/kg, intravenously through cephalic vein, with a 24-gauge sterile IV catheter.

Propofol injection 20 ml includes propofol, which is used as an anesthetic in procedures. It operates by inducing reversible loss of consciousness. According to Kassem et al. 2019, propofol was used to cause

a quick, smooth induction, a longer duration of anaesthesia, and full muscular relaxation, which is acceptable for most surgical procedures. The clinical effect of an induction dosage of propofol will last around 10 minutes.

Inhalational anesthesia is not utilized as maintenance. However, 3-5 mg/kg of propofol is used as anesthetic maintenance. The combination of midazolam and tramadol produces a neuroleptanalgesia, which combines a powerful sedative analgesic (an opioid) with a tranquillizer or neuroleptic.

After the cat has started to lose its awareness, lidocaine splash of 2 mg/kg of 2% is applied before intubation desensitizes the cat's larynx due to its small size, unusual anatomy, and sensitive larynx (Thompson and Rioja 2016). After that, it is followed by an endotracheal tube with the size 4.0 is placed in the patient's trachea to protect the airway and administer the oxygen to ensure the cat is oxygenated throughout the procedure. The capnograph is inserted after intubation. Manual Intermittent Positive Pressure Ventilation (IPPV) is performed with 3cm H₂O.

Electrocardiogram (ECG) is placed on the cat. Two infusion pumps are used to administer adrenaline and dopamine through CRI. Adrenaline with 0.025–0.3 g/kg/min is dissolved in 50ml NaCl and is administered by CRI to the hind leg (Macintire *et al.* 2012). Dopamine with 1–3 g/kg/min is dissolved in 100 ml NaCl and administered by CRI to the forelimb (Macintire *et al.* 2012). A tongue depressor is wrapped around the hind leg to straighten it so medications can flow freely into the veins. Gelsoline 2-5ml/kg or voluven is administered if a cat's blood pressure lowers. The cat's oxygen saturation is measured with a pulse oximeter probe. Emergency adrenaline 0.01 mg/kg and atropine 0.02–0.04 mg/kg is prepared. The surgical area is then draped and fixed with towel clamps.

Ventilator is used in diaphragmatic hernia corrective surgery as it is a crucial step to maintain the respiratory rate of the patient. This is because the patient's respiratory system has already been compromised by the punctured diaphragm which results in loss of abdominal and thoracic mechanical coupling, inability to generate transdiaphragmatic pressure, and a shift in the work of inspiration to the less efficient intercostal and abdominal musculature (Worth and Machon 2005). Manual IPPV is performed in this instance due to the absence of mechanical IPPV in the clinic.

IPPV refers to a specific form of mandatory ventilation (MV) involving the use of positive pressure and an invasive airway device such as an endotracheal tube (ETT) or tracheostomy (Newsome *et al.* 2018). This

mode is used on patients who have no spontaneous respiration. Assisted or controlled ventilation via IPPV is important in patients with traumatic diaphragmatic hernias, even in those that may appear to have adequate ventilatory function (Worth and Machon 2005).

Electrocardiography (ECG) is used in the surgery as it is the most effective diagnostic method for identifying heart arrhythmias. Electrodes are placed on the skin to detect and record the electrical activity of the heart, providing crucial information about its function and any problems. An electrocardiographic examination may be helpful in identifying cardiac arrhythmias, congenital cardiac abnormalities, and myocardial injury, which could all greatly raise the risks associated with anaesthesia.

Balfour Abdominal Retractor is a self-retaining retractor utilised in laparoscopic procedures. It may also be used for specific abdominal procedures that require holding the abdomen open for examination or evaluation, in case of diaphragmatic hernia repair.

Constant rate infusion (CRI) is a medication continuously administered to a patient and is used to maintain consistent plasma levels of that medication (Brashear, 2015). Constant rate infusion (CRI) enables for more precise fluid administration via intravenous fluid devices. Drugs with a rapid onset of action and a brief half-life are optimal for constant rate infusion (CRI) administration, as the veterinarian can provide a constant, steady-state concentration of the drug and titrate it to achieve the desired effect. Proper administration of CRI drugs ideally involves the use of specialized equipment, such as infusion pumps and blood pressure monitors.

Capnography is used to measure CO₂ in exhaled and inhaled gases and display a waveform of the partial pressure of CO₂ throughout the breath cycle. Capnography minimizes the need for repetitive arterial blood gas sampling, thus providing an excellent noninvasive monitoring and diagnostic tool (Marshall M 2004). Capnography is a true respiratory function monitor and can allow anesthetists to recognize apnea, hypoventilation, equipment malfunction and endotracheal tube obstruction.

The patient is placed in dorsal recumbency. Manual IPPV method is performed throughout the surgery with 3 cmH₂O by using a reservoir bag. A ventral midline abdominal incision is made. The abdominal organs are repositioned within the abdominal cavity. There are adhesions present in the lung with the abdominal organs, the tissues are carefully separated from the thoracic structures to prevent pneumothorax or hemorrhage. Before closing the hernia, the defect's edge is debrided (Figure 2a). The diaphragmatic

defect is closed with a simple continuous sutures pattern with 3-0 nylon suture (Figure 2b).

The entire abdominal cavity is explored for associated injury and any defects found is repaired (Figure 2c and 2d) (Fossum 2019). After repairing the defect, the pleural cavity of air is evacuated by thoracocentesis procedure. Thoracocentesis is performed at the sixth, seventh, or eighth intercostal space, near the level of the costochondral junction.

The abdomen muscle is closed with polydioxanone 3-0 with simple continuous pattern while the fat is closed with subcuticular continuous suture pattern with polydioxanone 3-0. The skin is closed with subcuticular continuous suture with polyglycolic absorbable suture size 3-0. Radiographic images are taken immediately after the surgical procedure to establish that there is no longer any fluid in the thoracic cavity and to ensure that the negative pressure has

recovered through this surgery (Figure 1b). After that, the air in pleural cavity is evacuated by thoracocentesis procedure. Thoracocentesis is performed at the sixth, seventh, or eighth intercostal space, near the level of the costochondral junction.

The patient is placed in the oxygen chamber alongside the oxygen prong immediately after surgery. The patient's appetite, bowel and urine are monitored everyday after the surgery.

Trixone, omeprazole, tramadol, and dexamethasone are administered intravenously to the patient immediately following surgery, with 15 to 30 minutes between injections of each medication. Injections of 1.0 g trixone are used to treat bacterial infections. Tramadol is used to treat pain after the surgery (Plumb 2011). In patients with reduced respiratory function, pain management is particularly crucial. These patients must be able to take calm,

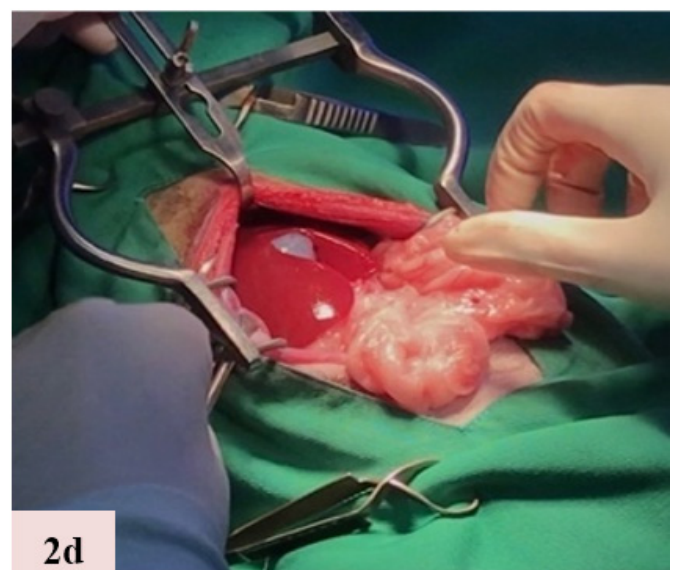
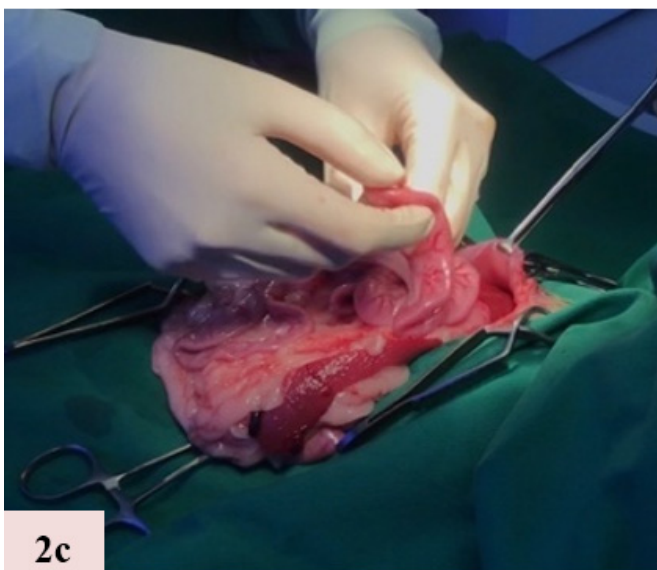
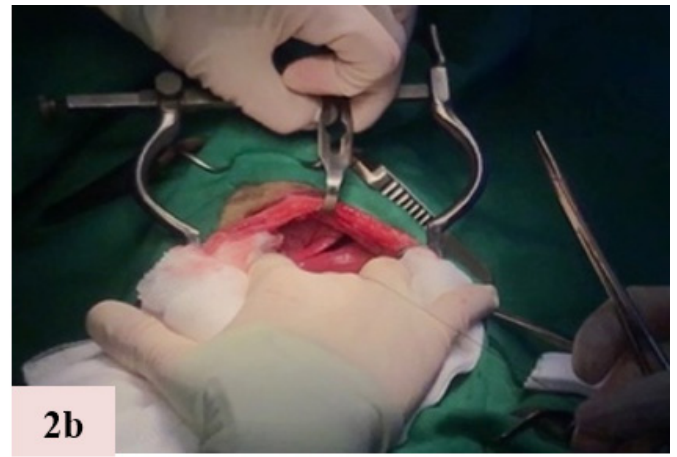
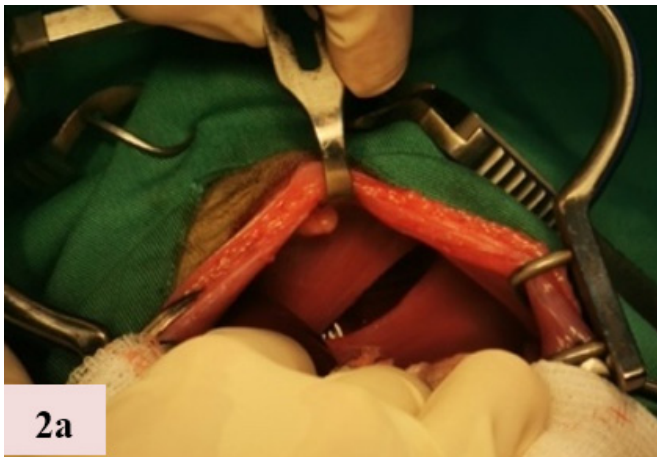


Figure 2 Diaphragmatic hernia repair. 1a: Diaphragmatic defect is located, 1b: Diaphragmatic defect is closed with a simple continuous sutures pattern. The surgical site is maintained opened by Balfour Abdominal Retractor, 1c: The abdominal organs are explored for associated injury and the intestine is being inspect and spleen is in good condition, 1d: Liver is inspected

deep breaths postoperatively; nevertheless, a patient in pain will take quick, shallow breaths (Fossum 2019). However, since the cat rely mainly on the diaphragm for breathing, any manipulation of the diaphragm during the repair results in extreme postoperative pain. Pain can also compromise thoracic expansion and ventilation. The resultant hypoventilation causes respiratory acidosis and hypoxemia which delays recovery. Dexamethasone is a steroid (corticosteroid) medicine that provide anti-inflammatory properties. Omeprazole help to reduce stomach acid and alleviate symptoms like vomiting and nausea as the patient is prescribed with steroid medicine which may cause gastric discomfort.

The patient are attached with Elizabethan collar immediately after the surgery and when they are discharged from the hospital to prevent them from licking or biting their incision areas or sutures. The patient is cage-rested for two week to restrict the patient's activity. The patient was given hot pack to maintain its body temperature for a more rapid recovery.

The patients is able to recover fully within one months postoperatively as the patient has no difficulty in breathing and sutures are removed during the revisit. After the patients are fully recover, they may resume their regular activities. Pneumothorax is the most frequent complication following surgical correction of diaphragmatic hernias.

In conclusion, diaphragmatic hernia repair has an excellent prognosis if the animal survives the early postoperative period (12–24 hours). With proper management, recurrence is unlikely. With proper preparation and care, these patients can have successful procedures despite high anesthetic risk. Traumatic diaphragmatic herniation can be surgically repaired in general practice, but it is best to refer these cases to a hospital with a specialized anesthesiologist, airway pressure monitoring, strict patient monitoring, complete equipment for IPPV and thoracocentesis to recover lung negative pressure. First-week recovery is shown. After surgery, patients breathe normally.

ACKNOWLEDGEMENT

The author faced numerous challenges and obstacles in completing this script, expressing gratitude to several parties for their guidance and support. The primary supervisor, Prof. drh. Deni Noviana, Ph.D., DAiCVIM., and the secondary supervisor, Dr. med. vet. drh. Denny Widaya Lukman, M.Si., were instrumental in the project's completion.

The author's parents and family provided constant love and support. The experienced doctors and staff

at Pet First Veterinary Centre, including Dr. Kiew, Dr. Teoh, Dr. Benedict, Dr. Lim, Dr. Ruth, June Leu, and Viki Ho, provided guidance and support. The author also thanked her batchmates for their friendship, laughter, and memories. Although the research is not perfect, the author hopes it will benefit future readers.

“Penulis menyatakan tidak ada konflik kepentingan dengan pihak-pihak yang terkait dalam penelitian ini”

REFERENCES

- Brashear M. 2015. How to calculate and manage constant rate infusions. *The Veterinary Nurse*, 6(6): 354–358.
- Chandrasekharan PK, Rawat M, Madappa R, Rothstein DH, Lakshminrusimha S. 2017. Congenital Diaphragmatic hernia - a review. *Maternal Health, Neonatology and Perinatology* 3:6. doi:10.1186/s40748-017-0045-1.
- Danish MA. 2021. Preoxygenation and Anesthesia: A Detailed Review. *Cureus*. 13(2).
- Fossum TW. 2019. *Small Animal Surgery*. 5th ed. Philadelphia (PA): Elsevier.
- Grubb T. 2010. Anesthesia for Patients with Respiratory Disease and/or Airway Compromise. *Top Companion Anim Med*. 25(2):120–132.
- Hyun C. 2004. Radiographic diagnosis of diaphragmatic hernia: review of 60 cases in dogs and cats. *Journal of veterinary science (Suwon-si, Korea)*. 5(2):157–162.
- Kassem M, Nasr M, Sadik K, Belal S. 2019. The effect of intravenous administration of propofol, thiopental, or propofol plus thiopental mixture in dogs undergoing experimentally liver insufficiency. *Damanhour Journal of Veterinary Sciences*. 2(2):19–23.
- Latimer KS. 2011. *Duncan and Prasse's Veterinary Laboratory Medicine: Clinical Pathology*. 5th edition. West Sussex: John Wiley.
- Lu J, Wang B, Che X, Li X, Qiu G, He S, Fan L. 2016. Delayed traumatic diaphragmatic hernia: A case-series report and literature review. *Medicine*. 95(32).
- Macintire DK, Drobatz KJ, Haskins SC, Saxon WD. 2012. Constant rate infusion. *Manual of Small Animal Emergency and Critical Care Medicine*. 2nd edition. West Sussex: John Wiley.
- Marolf A, Kraft S, Lowry J, Pelsue D, Veir J. 2002. Radiographic diagnosis—right kidney herniation in a cat. *Vet Radiol Ultrasound*. 43(3): 237–240.
- Marshall M. 2004. Capnography in Dogs. *Compend Contin Educ Pract Vet*. 26(10): 761–777.
- McClaran JK. 2013. Diaphragmatic and

- peritoneopericardial diaphragmatic hernias. In: Monet E, editor. *Small Animal Soft Tissue Surgery*. Philadelphia: Saunders.
- Newsome AS, Chastain DB, Watkins P, Hawkins WA. 2018. Complications and Pharmacologic Interventions of Invasive Positive Pressure Ventilation During Critical Illness. *Journal of Pharmacy Technology*. 34(4): 153–170.
- Plumb DC. 2011. *Plumb's Veterinary Drug Handbook*. 9th ed. Stockholm: John Wiley
- Thompson KR, Rioja E. 2016. Effects of intravenous and topical laryngeal lidocaine on heart rate, mean arterial pressure and cough response to endotracheal intubation in dogs. *Vet Anaesth Analg*. 43(4): 371–378. doi:10.1111/vaa.12303.
- [UCDAVIS] University of California, Davis. 2011. Clinical diagnostic laboratory CBC reference intervals. [Internet]. [Accessed on 11 July 2023]. Available at: https://www.vetmed.ucdavis.edu/sites/g/files/dgvnsk491/files/local_resources/pdfs/lab_pdfs/UC_Davis_VMTH_Hematology_Reference_Intervals.pdf
- Welch BT. 2021. Peritoneal-pericardial diaphragmatic hernia in a 6-year-old male intact pug dog. *Can Vet J*. 62 (1): 69 -72.
- Worth AJ, Machon RG. 2005. Traumatic Diaphragmatic Herniation: Pathophysiology and Management. *Compend Contin Educ Pract Vet*. 27(3): 180–191