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Scientific Report

Anesthetic management of diaphragmatic hernia repair in a dog: a case report and literature review of anesthetic techniques

Vesal, N.* **and Meimandi Parizi, A.**

Department of Clinical Sciences, School of Veterinary Medicine, Shiraz University, Shiraz, Iran

***Correspondence:** N. Vesal, Department of Clinical Sciences, School of Veterinary Medicine, Shiraz University, Shiraz, Iran. E-mail: nv1340@shirazu.ac.ir

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Summary

This case report describes the anesthetic management and ventilation technique in the surgical treatment of traumatic diaphragmatic hernia in a dog. A 5-month-old 8-kg female terrier with a history of car accident was presented for femoral fracture repair. Before anesthetic induction, marked tachypnea and dyspnea were noted. Diaphragmatic hernia was diagnosed based upon radiographic and ultrasonographic findings. Exploratory laparotomy revealed diaphragmatic rupture and herniation of spleen, omentum, parts of liver lobes and stomach into the thoracic cavity. The importance of thorough physical examination and patient assessment, anesthetic management and monitoring, provision of adequate ventilation and oxygenation during surgery using standard ventilation equipment are discussed.

Key words: Diaphragmatic hernia, Anesthesia, Trauma, IPPV, Dog

Introduction

Traumatic diaphragmatic hernia most often develops as a result of blunt abdominal trauma (particularly motor vehicle accidents), resulting in sudden increase in abdominal pressure and subsequent disruption of the diaphragm (Schmiedt *et al.*, 2003; Fossum, 2007). Herniation of abdominal organs into the thoracic cavity may result in the inability of the lung to inflate and reduced functional residual capacity (Wilson, 1992). Surgical repair of traumatic diaphragmatic hernia is necessary to replace abdominal contents, relieve respiratory compromise, and reestablish diaphragmatic function. This case report describes the anesthetic management and ventilation technique of a dog undergoing diaphragmatic hernia repair. The importance of a thorough preanesthetic examination, intraoperative monitoring and provision of adequate ventilation and oxygenation have been discussed.

Case description

A 5-month-old 8-kg female terrier dog was referred to the Veterinary Teaching Hospital, School of Veterinary Medicine, Shiraz University with a history of car accident and left femoral fracture. On admission, the dog was quiet, alert, and responsive with a marked increase in breathing effort and tachypnea (respiratory rate, 60 breaths.min^{-1}), which was attributed to stress and pain caused by femoral fracture. A complete blood cell count (CBC) was performed and the results for hematologic values were unremarkable.

The dog was scheduled for open reduction and stabilization of distal femoral fracture. Preanesthetic physical examination revealed increased respiratory rate and dyspnea. The breathing pattern was abdominal. Respiratory dysfunction associated with thoracic trauma was suspected and thoracic radiographs were taken. Thoracic radiography revealed a diaphragmatic hernia with a soft tissue opacity within the thoracic cavity (Fig. 1). Diaphragmatic hernia was confirmed by subsequent ultrasonography.

Fig. 1: Right lateral thoracic and abdominal radiographic view of a 5-month-old terrier dog with diaphragmatic hernia. Notice that the diaphragmatic line is lost and a soft tissue opacity is located within the thoracic cavity

Exploratory celiotomy with herniorrhaphy was scheduled for the day after admission. The cephalic vein was catheterized and saline-dextrose solution was administered at 10 $mL.kg^{-1}.h^{-1}$ throughout anesthesia. The dog was premedicated with morphine (0.5 $mg.kg^{-1}$, slow IV [Darou Pakhsh, Iran]) and anesthesia was induced with diazepam (0.2 $mg.kg^{-1}$ [Caspian tamin Pharmaceutical Co., Rasht, Iran]) and ketamine (4 $mg.kg^{-1}$ [Alfasan, Woerden, Holland]) combination administered to effect. Lidocaine spray was used to abolish laryngeal reflex and the dog was then intubated using a 6-mm cuffed tracheal tube and positioned in dorsal recumbency. Anesthesia was maintained with isoflurane (1.5 to 2.0%, Nicholas Piramal Limited, London, UK) delivered in oxygen via a circle system using a small animal anesthetic machine (Fabius, Drager Medical, AG and Co. KGaA, Germany). Intermittent positive-pressure ventilation (IPPV) was initiated by use of a time-cycled ventilator delivering 15 $breaths.min^{-1}$ and an inspiratory: expiratory (I:E) ratio of 1:2 to achieve a target end-tidal CO_2 between 35 to 45 mm Hg.

Laparotomy was performed via right paracostal incision and the diaphragm was visually inspected. An approximately 8-cm tear was identified in the ventral right portion of the diaphragm; spleen, omentum, parts of liver lobes and stomach were found within the thoracic cavity (Figs. 2 and 3). Herniated abdominal structures were gently retracted into the abdomen; and the diaphragmatic rent was closed with continuous pattern using 2/0 Vicryl (Ethicon, Edinburgh). A routine 3-layer closure was used for the celiotomy incision.

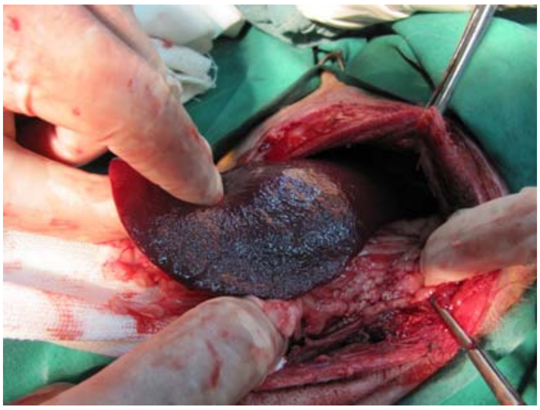

Fig. 2: Photograph of the diaphragmatic tear in the dog in Fig. 1. The spleen has been returned to abdominal cavity

Fig. 3: Photograph of the diaphragmatic tear in the dog in Fig. 1. Part of stomach is still in the thoracic cavity

The total anesthetic time was approximately 1 h and 40 min, during which time pulse rate and oxyhaemoglobin saturation (SpO2-using pulse oximetry with the probe positioned on the tongue), respiratory rate and end-tidal CO_2 concentration (via side-stream capnography) were monitored and remained within clinically acceptable limits. At the end of anesthesia, isoflurane administration was discontinued.

Reduction of the respiratory rate to 10 breaths.min^{-1} after thoracotomy closure, was followed by a return of spontaneous ventilation and IPPV was discontinued. Following extubation, the dog was allowed to receive oxygen via a face mask during recovery. Anesthetic recovery was uneventful, and the dog received Cefazolin (Exir Pharmaceutical Co., Boroogerd, Iran) 25 mg.kg^{-1}, IV and discharged after surgery. Other postoperative treatments included administration of Cephalexin (Jaber Ebne Hayyan, Pharmaceutical Mfg. Co., Tehran, Iran) 30 mg.kg^{-1}, PO, q 12 h for 5 days and tramadol (Sami Saz Pharmaceutical Co., Mashhad, Iran) 3 mg.kg^{-1}, PO, q 24 h and ketprofen (Aburaihan Pharmaceutical Co., Tehran, Iran) 2 mg.kg^{-1}, SC, q 24 h for 3 days. One week after diaphragmatic hernia repair, the dog was reanesthetized without any complication and surgery to stabilize a distal femoral fracture was performed.

Follow-up communication with the owner revealed that the dog was not having any complications or any evidence of recurrence of the diaphragmatic hernia two months after discharge from the hospital.

Discussion

Diaphragmatic hernia usually is secondary to trauma and rib fractures, pulmonary contusions, traumatic myo-carditis, hemothorax, and shock are also often present concurrently (McCullough, 2002; Slensky, 2009). Despite the displacement of abdominal organs into the thoracic cavity and impaired pulmonary expansion, animals with diaphragmatic hernias may have minimal clinical signs (Ricco and Graham, 2007); therefore, thoracic radiographs are indicated in all cases with history of trauma (Fossum, 2007). Additional imaging techniques such as, contrast radiographs (following oral administration of barium sulphate [gastrography] or injection of contrast material into the peritoneal cavity [peritoneography]), ultrasonography, computed tomography (CT) scans or magnetic resonance imaging (MRI) may be necessary since plain thoracic radiographs do not always provide a definitive diagnosis (Slensky, 2009). Undiagnosed or occult diaphragmatic hernia can be life-threatening if the patient undergoes anesthesia to treat concurrent injuries (e.g., fractures) (Ricco and Graham, 2007).

Surgical reduction of the herniated organs into the abdominal cavity and closure of the diaphragmatic tear is the only treatment (Schmiedt *et al*., 2003; Slensky, 2009). Stabilization of the cardiovascular and respiratory system should be carefully considered before attempting anesthesia and surgical repair of the diaphragm (Wilson, 1992). Other systemic abnormalities (e.g., dehydration, anemia and shock) should also be assessed during the examination (McCullough, 2002) and should be corrected before anesthetic induction. Thoracocentesis may be necessary before induction of anesthesia in patients with substantial pleural fluid accumulation or pneumothorax because severe respiratory distress may occur on induction due to reduced lung volume (Paddleford and Greene, 2007; Slensky, 2009). Arterial blood gas analysis is helpful in identifying the extent of hypoxia and respiratory acidosis. Supplemental oxygen (face mask or nasal insufflation) should be provided during preparation for anesthesia if the patient is in respiratory distress (Schmiedt *et al*., 2003; Fossum, 2007). 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, 2007; Grubb, 2010).

Tranquilization and analgesia may be required for an excited and painful patient in order to avoid an increase in respiratory effort in an already respiratory compromised patient. Because profound sedation, relaxation of the musculature of the upper airway, and decreased respiratory rate may worsen the respiratory compromise, the patient should be closely observed after the administration of preanesthetic drugs (Grubb, 2010). Although phenothiazine and benzodiazepine tranquilizers have minimal effects on ventilation at therapeutic doses, intravenous administration of higher doses should be avoided (Kushner, 2002). The α_2-adrenergic agonists may significantly depress pulmonary function, especially in patients suffering from respiratory distress caused by pneumothorax or diaphragmatic hernia; therefore, they should be given at very low doses, if necessary (Paddleford and Greene, 2007).

Opioids are generally associated with minimal changes in cardiac output, systemic blood pressure, and oxygen delivery, but their dose-dependent respiratory depressant effects cause a decrease in respiratory rate and tidal volume (Paddleford and Greene, 2007). However, respiratory depression is only a minor concern because the patient is going to be intubated and receive 100% oxygen (Grubb, 2010). In the present report, as the dog was of a placid temperament and the patient was experiencing moderate to severe pain after thoracic trauma and femoral fracture, morphine alone, which provided adequate sedation was used.

Injectable anesthetics (thiopental, ketamine and propofol) allowing rapid intubation are preferred and chamber or mask induction should be avoided in animals with diaphragmatic hernia (Fossum, 2007). Inhalation anesthetics should be used for maintenance of anesthesia in dogs with diaphragmatic hernia (Fossum, 2007; Paddleford and Greene, 2007). Nitrous oxide is not recommended in patients with diaphragmatic hernia because it rapidly diffuses into pleural cavity, exacerbating pneumothorax (Fossum, 2007; Paddleford and Greene, 2007). Ketamine-diazepam combination has been used in patients with respiratory disease (Kushner, 2002). Thiopental can cause splenic enlargement and is best avoided where the spleen may be within the thorax.

Rapid induction should be followed by tracheal intubation and IPPV (Ricco and Graham, 2007; Grubb, 2010). In the present case, a low dose of diazepam-ketamine combination was used and the larynx was sprayed with lidocaine to abolish any laryngeal and pharyngeal reflexes. Anesthesia was maintained with isoflurane in oxygen.

Muscle relaxants may be used to facilitate the surgeons' access and to control the patient's ventilation and take over ventilatory effort. In the present case, neuromuscular blocking agents were not used and the patient was mechanically hyperventilated to decrease the arterial carbon dioxide levels and decrease the stimulus for ventilation (Paddleford and Greene, 2007).

Laparotomy for diaphragmatic hernia repair always requires controlled ventilation because the pleural cavity is opened to the atmosphere during the course of surgery. IPPV should be started soon after induction and tracheal intubation (Paddleford and Greene, 2007; Grubb, 2010). If a mechanical ventilator is not available, ventilation should be maintained by manual intermittent squeezing of the reservoir bag. As a general guide, the ventilator settings for dogs are TV of 10-15 mL kg^{-1}, RR of 15-20 breaths min^{-1}, peak inspiratory pressure of 15-20 cm H_2O and I:E ratio of 1:2 to 1:3 (Hartsfield, 2007). High inspiratory pressures should be avoided during mechanical ventilation to help prevent lung damage or volutrauma (Wilson, 1992; Fossum, 2007). Adequate ventilation can be monitored by measurement of end tidal CO_2 (capnography) or arterial CO_2 (blood gas analysis) (Kushner, 2002).

The most common complication after surgical repair of diaphragmatic hernias is pneurnothorax; therefore, patients should be carefully monitored postoperatively for evidence of hypoventilation, and if necessary, thoracocentesis should be performed to restore intrathoracic negative pressure (Slensky, 2009). Reexpansion pulmonary edema (RPE) is a possible complication associated with rapid lung reexpansion, especially after repair of a chronic diaphragmatic hernia (Kushner, 2002; Fossum, 2007).

Postoperative analgesics should be provided in severely painful patients, especially if the pain is from thoracic trauma, as the pain relief considerably improves respiratory function (Grubb, 2010). In the present case, morphine (a μ and κ receptors agonist) was used preoperatively and postoperative multimodal analgesia was provided by using a combination of tramadol and ketoprofen (a nonsteroidal anti-inflammatory drug). Tramadol (ạweaḳ μ-agonist and selective serotonin and norepinephrine reuptake inhibitor) is not a scheduled drug and has been used for management of mild to moderate postoperative pain in dogs (Mastrocinque and Fantoni, 2003).

In summary, the anesthetic management of a patient with diaphragmatic hernia should include: careful preanesthetic evaluation, preoxygenation and evacuation of the pleural space via thoracocentesis, rapid induction of anesthesia and establishment of a patent airway, providing intermittent positive pressure ventilation, close intraoperative monitoring and administration of supplemental oxygen during recovery.

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