DIAPHRAGMATIC HERNIA REPAIR
Howard B. Seim III, DVM, DACVS
Colorado State University

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Key Points
• Most diaphragmatic hernias are not life threatening
• Suture the hernia from dorsal to ventral
• Use a one layer simple continuous pattern for closure
• Evacuate all thoracic air prior to closure

General Considerations and Indications
A hernia is an abnormal protrusion of an organ or a portion of it through the containing wall of its cavity, beyond its normal confines. The term is usually restricted to the abdominal cavity.

A diaphragmatic hernia is a protrusion of the abdominal viscera through the diaphragm; it may be congenital or acquired. Clinically speaking, a diaphragmatic laceration or defect may exist without protrusion of organs through it. In the cat, traumatic diaphragmatic hernias are common, whereas congenital hernias are infrequently seen. The most common congenital hernia involving the diaphragm is a peritoneal-pericardial diaphragmatic hernia. Whenever this defect is suspected, a thorough examination (i.e., physical, radiographic, cardiovascular) for evidence of further midline defects (i.e., umbilical hernia, atrial and ventricular septal defects, cleft palate) should be performed.

The diaphragm is not essential for life as the entire diaphragm can be removed in a newborn cat and the animal will survive.

Applied Anatomy
The diaphragm projects into the thoracic cavity like a dome; it attaches to the lumbar vertebrae, ribs, and sternum. Fibers arise on these skeletal parts and radiate towards the tendinous center. The diaphragm is composed of only one layer of muscle and two layers of tendon and therefore is weaker than the multilayered abdominal wall. The central tendon of the diaphragm of the cat is relatively small. In its tendinous portion, transverse fibers course from one side to the other as a reinforcing apparatus.

The muscular part is divided into the pars lumbalis, a pars costalis on each side, and the pars sternalis, all of which with the exception of the lumbar portion, have a uniform thickness of 2-3 mm in cats. The pars lumbalis of the diaphragmatic musculature is formed by the right and left diaphragmatic crura, the right crus being considerably larger than the left. Seen from the abdominal cavity each crus of the diaphragm is a triangular muscular plate whose borders give rise to the tendinous portions. The musculature of the crus mediale is the thickest (3-4 mm). The pars costalis on each side consists of fibers radiating from the costal wall to the tendinous...
The pars sternalis is an unpaired medial part unseparated from the bilateral costal portions. The diaphragm domes far into the thoracic cavity, and its costal part lies on the medial surface of the last few ribs and costal arch (when tears occur here, the costal arch can be used in the repair). The stomach and liver attach by ligaments to the concave peritoneal surface of the diaphragm.

**Diagnosis**

Diaphragmatic hernia is generally diagnosed via thoracic and abdominal radiographs. Classic findings on thoracic radiographs is loss of the diaphragmatic line, air filled visceral structures in the thoracic cavity, loss of lung fields. Abdominal radiographs may reveal a lack of abdominal viscera. Classic thoracic radiographs of a patient with a peritoneo-pericardial diaphragmatic hernia shows a large, round pericardial sac. Occasionally, air filled viscera can be identified in the pericardial sac. Patients that present with an acute traumatic diaphragmatic hernia (e.g., hit by a car) may have a massive hernia with abdominal contents replacing most of the patients respiratory capacity.

**Preoperative Considerations**

Immediate surgical intervention for the repair of a diaphragmatic hernia is rarely indicated. Emergency surgery should not be undertaken unless the surgeon and anesthesiologist are prepared to handle any complications and are confident they can maintain the animal's essential requirements while the animal is anesthetized. However, prompt surgical repair is indicated in acutely injured animals with severe dyspnea, cyanosis, and respiratory distress who demonstrate massive herniation, and in patients that present with an air filled stomach in the thoracic cavity (these patients can develop life threatening dyspnea if enough swallowed air enters the stomach).

The most commonly encountered patient with diaphragmatic hernia will fall between the two categories mentioned above and should be handled in a systematic manner that will not compromise the already reduced breathing ability. Surgery is not considered an emergency in mildly symptomatic or asymptomatic animals with congenital hernias or traumatic hernias of at least several days' duration. Remember that any stressed, dyspneic cat should be handled very carefully as further stress can produce catastrophic results.

**Anesthesia**

Patient stress must be kept to a minimum during the anesthetic induction phase as any exertion by the animal can be disastrous.

**Surgical Approaches**

A midline abdominal celiotomy (xiphoid to pubis) is the easiest and most versatile approach. Positioning the patient's head toward the top of the table and tilting the table at a 30° to 40° angle will facilitate gravitation of abdominal viscera out of the thorax. Rarely is it necessary to extend the incision into the thorax via a median sternotomy however the animal should be prepared in case this becomes necessary.

**Surgical Procedure**
See the DVD for a detailed video description of this technique. When an extra pair of hands is unavailable for retraction, a Balfour self retaining retractor is a helpful piece of equipment; large Gelpi retractors work well in cats. Using the abdominal approach, an incision is made from xiphoid to pubis. Once the peritoneal cavity is opened, the diaphragm is exposed and the situation evaluated. Some hernias, especially in the area of the dorsal attachments of the crura and the aortic hiatus are not easily visualized; therefore, this area should be carefully inspected even when another laceration is present. The herniated contents are replaced in their proper position and inspected for damage. Some of the complicating injuries that the surgeon must be prepared for are torsion of one or more liver lobes, ruptured viscus, intussusception, costal abdominal hernia, and others. If adhesions exist, they should be broken down using blunt dissection so as to avoid excess hemorrhage and inadvertent damage to a vital structure.

Using large sponges or laparotomy pads moistened with warm saline, the liver and bowel are retracted caudally. The diaphragmatic tear is now more easily visualized so that a careful examination of the thorax can be done both visually and manually. All thoracic fluid should be aspirated. The lungs should be expanded to remove atelectasis and to inspect for pulmonary tears and persistent areas of collapse. If the hernia is more than 48 hours old, the edges of the tear should be debrided. This can be done by incising the hernial edge instead of trimming a piece of the diaphragm off. It is recommended to suture the hernia from dorsal to ventral. It is much easier to visualize the dorsal structures (vena cava, aorta, esophagus) when suturing. The hernia is closed with a single layer, simple continuous suture pattern using synthetic absorbable suture material (dexon, vicryl, PDS, Maxon) or monofilament nonabsorbable suture material (nylon, prolene, novafil). Suture size recommended in cats is 3-0. It might be necessary to preplace the most dorsal sutures for better visualization of the tear during suturing. It is also helpful to reconstruct the tear with several simple interrupted sutures to facilitate visualization of the rent. When tears near the caval hiatus are sutured, care is taken to avoid constriction of the vena cava by placing sutures to close to the cava. The same principle applies to the aortic and esophageal hiati.

Air can be evacuated from the chest using several techniques.

1. Prior to tying the last knot of the hernial closure, a carmalt forceps is placed in the rent and spread open to allow visualization of the thoracic cavity. The lungs are inflated so as to fill the thoracic cavity. The carmals are removed and the last suture tied to provide an air tight-water tight seal.

2. After hernial rent closure a needle or plastic intravenous catheter is placed through the diaphragm and into the thoracic cavity. Thoracic cavity air is evacuated using a syringe.

3. Needle thoracentesis is performed after the procedure is complete.

4. A 12 - 14 French feeding tube is brought into the peritoneal cavity through a paramedian stab incision in the cranioventral body wall. The tube is passed through the rent in the diaphragm just prior to its final closure. Be sure that all fenestrations in
the tube are beyond the diaphragm. The diaphragmatic rent closure is then completed around the tube. With the use of a 3-way stop cock and 60 cc syringe, air is evacuated from the thorax until a gentle negative pressure is obtained. The celiotomy incision is closed in a routine fashion. When the celiotomy closure is complete, the tube is again aspirated. The patient should then be placed through a series of positional changes (ventral recumbency, right lateral recumbency, left lateral recumbency, and dorsal recumbency) while attempting to aspirate air. When negative pressure is obtained in all positions, the tube is gently pulled from the chest and abdominal incision. A skin suture is placed in the tube's exit wound.

5. A 12 -14 French diameter thoracostomy tube can be placed in the 7th or 8th intercostal space. The patient should then be placed through a series of positional changes (ventral recumbency, right lateral recumbency, left lateral recumbency, and dorsal recumbency) while attempting to aspirate air. The tube is removed when the patient has had a negative pressure for 12 - 24 hours.

All patients are monitored carefully for the next six to eight hours. If signs of respiratory abnormalities arise (dyspnea, tachypnea, etc), the right and left hemithorax should be tapped with a needle and syringe.

**Postoperative Care**

Postsurgical care includes systemic antibiotics and careful monitoring of the patient's breathing, temperature, and color. Cats should be kept on a warming device for at least 24 hours. Analgesics may be used to relieve patient discomfort, however care should be taken to monitor the effects of various analgesic drugs on respiratory effort. Thoracic radiographs may be taken to evaluate the chest drain and pleural space.

**Summary**

Successful repair of a diaphragmatic hernia depends on careful preoperative and postoperative care of the patient. During the surgical repair, the surgeon must work quickly and effectively to complete the procedure as efficiently as possible.