2. SURGERY OF THORAX

2.1. TREPHINING OF FRONTAL AND MAXILLARY SINUSES IN CATTLE AND HORSE

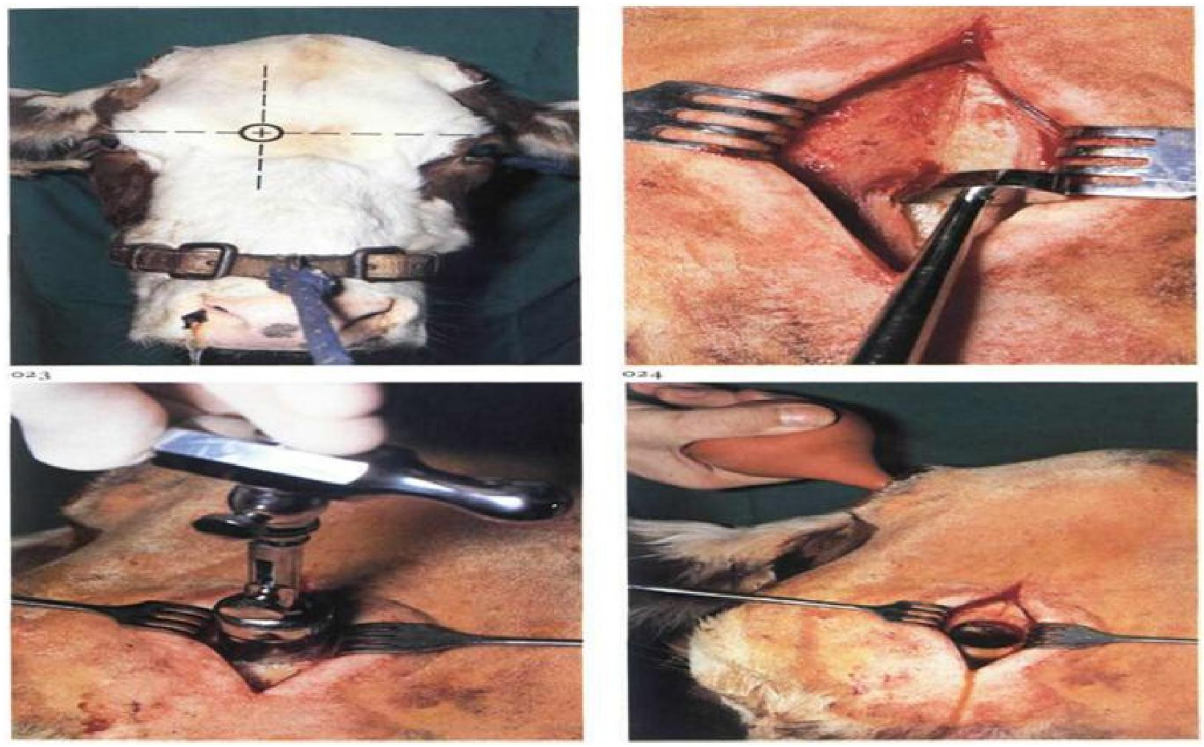
2.1.1. Trephining of frontal and maxillary sinuses in cattle

Trephination of the frontal sinus is indicated in chronic empyema, which in adult cattle is caused usually by infection of the sinus following dehorning or horn fracture. Initially the sinusitis is often confined to the caudal part of the sinus, but in long-standing cases the entire sinus may be involved. In the latter case drainage of the sinus is obtained by trephining 2 cm from the midline on a line passing through the centre of the orbits **[A].** If the original opening to the sinus at the site of the dehorning wound is narrowed or closed by granulation tissue, it is enlarged or re-opened under cornual nerve block to facilitate adequate flushing of the sinus.

Surgical approach:

Trephination is carried out on the standing animal under local analgesia. An approximately 5 cm long vertical incision is made through skin, subcutis and periosteum. The periosteum is dissected from the bone with a periosteal elevator **[B]** and drawn aside, together with the skin, with wound retractors. The point of the trephine is inserted into the bone. Trephination is performed by rotating the trephine **[C]**. After a circular groove has been cut into the bone, the point of the trephine is retracted, and trephination is continued through the full thickness of the bone. The disc is removed with a bone screw inserted into the hole made previously by the point of the trephine. Sometimes the disc must be levered out because it remains fixed to a bony sinus septum.

To remove exudate and necrotic tissue the sinus is flushed thoroughly with a disinfectant solution **[D].** To prevent premature closure of the openings they are packed with gauze bandage plugs. Postoperative flushing is repeated daily, until the sinus has healed, as evidenced by absence of purulent discharge.



2.1.2. Trephining of frontal and maxillary sinuses in horse

Trephination of the maxillary sinuses is indicated in cases of empyema, cysts or neoplasms, and for repulsion of upper molar teeth. Plate **E** represents a radiograph showing chronic alveolitis of the first upper molar.

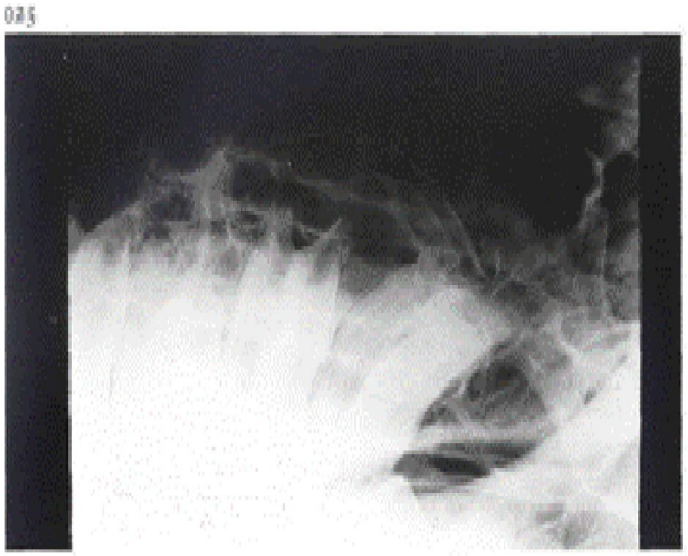
The rostral maxillary sinus is trephined about 2-3 cm dorsal to the rostral end of the facial crest; the caudal maxillary sinus is trephined 2-5 cm rostral to the medial canthus and 2-3 cm dorsal to the facial crest **[F].** Care must be taken to avoid damage to the nasolacrimal duct.

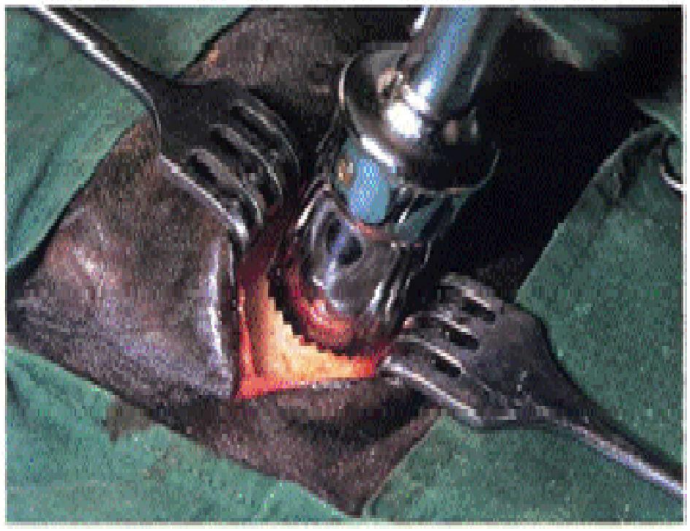
Surgical approach:

The operation may be carried out either on the standing animal under local infiltration analgesia, or on the recumbent animal **[G]** under general anaesthesia. In case of tooth repulsion general anaesthesia is required.

At the selected site an approximately 4 cm long incision is made parallel to the facial crest through the skin and subcutaneous tissue. Depending on the site of surgery it may be necessary to retract the levator labii maxillaries muscle in order to expose the periosteum. The periosteum is then incised with a scalpel and separated from the bone with a periosteal elevator. The wound edges of the skin and periosteum are drawn aside with wound retractors **[H]**.

E. F.

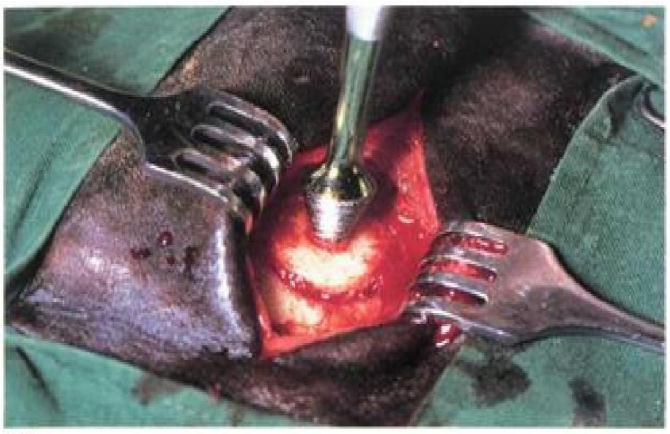


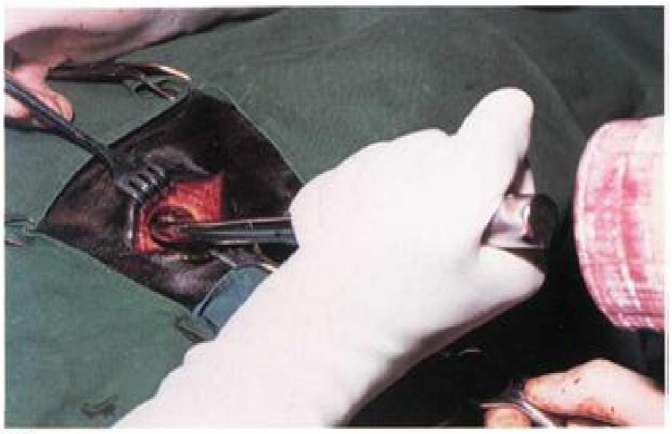


G. H.

Trephination is performed as described in trephination of the frontal sinus in cattle. The disc is removed with a bone screw **[I]**. In empyema caused by alveolitis, the sinus is flushed and the affected tooth is carefully located. A punch is then introduced into the sinus and placed upon the roots of the tooth to be repelled. To prevent damage to adjacent teeth and the maxillary bone, the punch must be placed accurately; it may thus be necessary to enlarge the trephination hole with rongeurs. The tooth is repelled from its alveolus with firm, but careful, blows **[J]**. The course of repulsion is constantly checked by the surgeon's hand in the oral cavity. After removal the tooth is examined to determine if it is complete. Any tooth or bony fragments must be removed. Intra-operative radiography is recommended to ensure that no fragments remain. The sinus and alveolus are copiously flushed with a disinfectant solution **[K]**. The alveolus and trephination hole are then packed with povidone iodine soaked gauze bandage plugs **[L].**

I. J.





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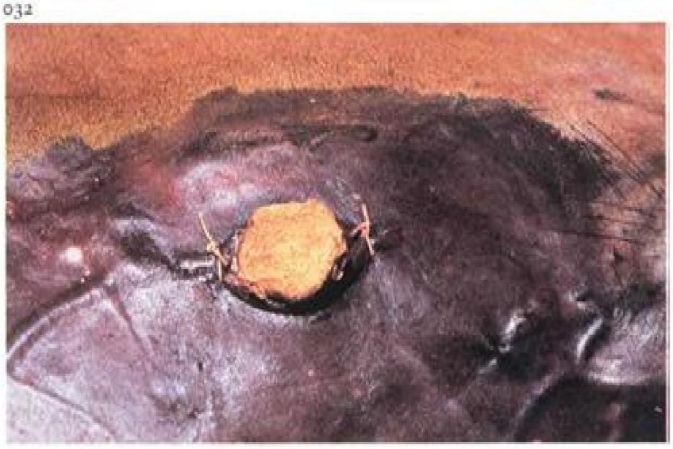


K. L.

Postoperatively the sinus and alveolus are repeatedly flushed after removal of both plugs. The plug placed in the alveolus after flushing must be somewhat smaller than the previous one, in order to enable granulation tissue to gradually fill the alveolus; the plugs in the trephination hole are of constant size. Only when the alveolus is closed off by granulation tissue and exudation in the sinus has ceased is the trephination hole allowed to close.

2.2. TRACHEOTOMY IN CATTLE AND DOG

2.2.1. Tracheotomy in cattle

Tracheotomy is an incision through the tracheal wall. It is usually an emergency procedure and is indicated to relieve dyspnoea caused by acute nasal, laryngeal or proximal tracheal obstructions.

Surgical approach:

Tracheotomy is usually performed on the standing animal under local infiltration analgesia, but may also be carried out on the recumbent patient. The head and neck of the animal are extended and an approximately 7 cm ventral midline skin incision is made in the cranial third of the neck at the level of the 4th-6th tracheal ring.

After incising the thin cutaneous muscle in the midline, the longitudinal junction of the sternohyoid muscles is divided and the trachea exposed. The muscles and skin are spread with a wound retractor.

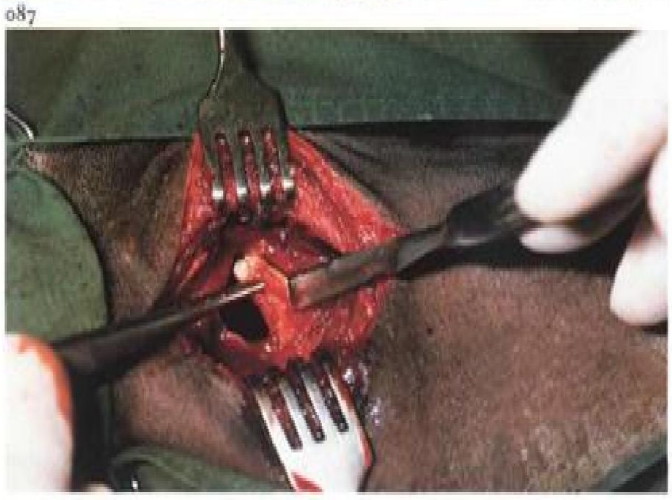
If temporary tracheotomy is indicated, a tracheal annular ligament is pierced with a scalpel and a tracheal tube (ovoid in cross-section) is inserted.

If the tracheotomy tube is to remain for a longer period, partial resection of a tracheal ring is performed; (i) A tracheal window is produced by partial resection of one tracheal ring **[M]**. The disc to be removed is grasped with forceps. (ii) To prevent the tracheal ring from collapsing, resection of a semi-disc of the tracheal rings proximal and distal to an incision through the annular ligament is recommended **[N, O]**.

After tracheotomy a self-retaining tube is inserted **[P]** and the skin edges are sutured around the tube in a simple interrupted pattern. Since there is considerable mucous secretion for the first few postoperative days, the tube must be cleaned frequently. Later on, when the discharge has reduced, air passage through the tube is checked daily, but the intervals of cleaning may be prolonged. After the tube is withdrawn, the tracheotomy wound heals by second intention.

M.

N.



O. **P**

2.2.2. Tracheotomy in dog

Preoperative management

Upper airway procedures are performed to remove, repair, or bypass areas of obstruction, injury, or disease. Affected animals may have mild to severe respiratory distress. Mild or moderately dyspneic patients initially should be examined from a distance to prevent exacerbating the condition. Open-mouth breathing, abducted forelimbs, labored breathing, and restlessness indicate moderate to severe respiratory distress that may require emergency therapy. Minimal restraint should be used with severely dyspneic patients, and they should be allowed to maintain the position in which they feel most comfortable.

Supplemental oxygen may be given by means of nasal insufflation, tracheostomy tube or catheter, endotracheal intubation, mask (including an Elizabethan collar that has had plastic wrap put over it to form a "cage" over the head), or oxygen cage. To cool dyspneic animals, a fan may be directed at the patient; ice packs may be applied to the head, axilla, inguinal area, and extremities; and/or cooled fluids may be administered intravenously.

Indications for Upper Respiratory Tract Surgery:

- ✓ Brachycephalic syndrome
- ✓ Devocalization
- ✓ Laryngeal collapse
- ✓ Laryngotracheal trauma
- ✓ Laryngeal paralysis
- ✓ Tracheal collapse
- ✓ Laryngeal masses
- ✓ Tracheal masses
- ✓ Nasal masses or infection
- ✓ Nasal trauma
- ✓ Foreign bodies
- ✓ Congenital abnormalities

Sedation of Severely Dyspneic Dogs

- Hydromorphone (0.1–0.2 mg/kg IV, IM, or SC)
- Butorphanol (Torbutrol, Torbugesic) (0.2–0.4 mg/kg IV, IM, or SC)
- Acepromazine(0.02–0.05 mg/kg, max 1 mg IV, IM, or SC)
- Diazepam (Valium)(0.2 mg/kg IV)

Diagnosis of upper respiratory disease is based on the history and clinical signs, physical examination findings, hematologic and serum biochemical parameters, radiographs, endoscopy, culture, or biopsy, or all of these. The history and clinical signs may include abnormal respiratory noises (e.g., cough, inspiratory stridor, and wheeze), exercise intolerance, hyperthermia, tachypnea, dyspnea, cyanosis, restlessness, and/or collapse. Gagging and regurgitation of secretions are common with nasopharyngeal, laryngeal, and some tracheal abnormalities. Mucopurulent or bloody discharges are common with obstructive or infectious nasal disease. Voice change may occur with laryngeal paralysis, and dysphagia may be noted with supraglottic obstructions. Subcutaneous emphysema occurs with penetrating laryngotracheal or nasal injuries.

Anesthesia

Patients with upper respiratory obstruction or disruption are extreme anesthetic risks. The periods of greatest danger are during induction of anesthesia and recovery. If the animal has already been sedated an anticholinergic drug (atropine or glycopyrrolate should be given. A combination of diazepam and ketamine is also useful for induction because these drugs maintain laryngeal function; however, exposure of the larynx in normal dogs is more readily accomplished with thiopental or propofol than with diazepam-ketamine. Oxygen should be supplemented during the examination, and oxygen saturation should be monitored with pulse oximetry (preferable) or by observation of mucous membrane color.

General anesthesia is preferred for most upper respiratory procedures because it ensures a patent airway, allows controlled ventilation, facilitates asepsis, and is less stressful for patients. Local anesthesia may allow placement of a tracheostomy tube when the patient is comatose or cannot tolerate general anesthesia.

Anesthesia should be maintained with inhalant drugs in oxygen. Tracheal procedures may require temporary retraction of the endotracheal tube from the surgical site, placing an endotracheal tube distal to the surgical site through a tracheotomy, or using injectable anesthetic drugs. During surgery the animal should be sighed (given an extra large breath) every minute or two to renew surfactant. Oxygen saturation or blood gases (or both) should be monitored from induction until recovery and until abnormalities have been corrected.

Selected Anesthetic Protocols for Use in Animals Undergoing Upper Respiratory Tract Surgery

- ✓ Premedication and induction *Diazepam (0.2 mg/kg given IV) followed immediately with thiopental (10–12 mg/kg IV) or propofol(4–6 mg/kg IV) to effect. As an alternative, give diazepam (0.27 mg/kg IV) plus ketamine (5.5 mg/kg IV) titrated to effect.
- ✓ Maintenance(Isoflurane or sevoflurane)

Surgical Anatomy

The *trachea* is a semirigid, flexible tube extending from the cricoid cartilage to the mainstem bronchi at about the fourth or fifth thoracic vertebra. Thirty-five to 45 C-shaped hyaline cartilages joined by annular ligaments ventrally and laterally and by trachealis muscle *(dorsal tracheal membrane)* dorsally, form the trachea. The tracheal vessels and nerves, which are found in the lateral pedicles, supply the trachea segmentally. Innervation is by the autonomic nervous system. Sympathetic fibers from the middle cervical ganglion and sympathetic trunk inhibit tracheal muscle contraction and glandular secretions, whereas parasympathetic fibers from the vagus and recurrent laryngeal nerves cause tracheal muscle contraction and glandular secretions.

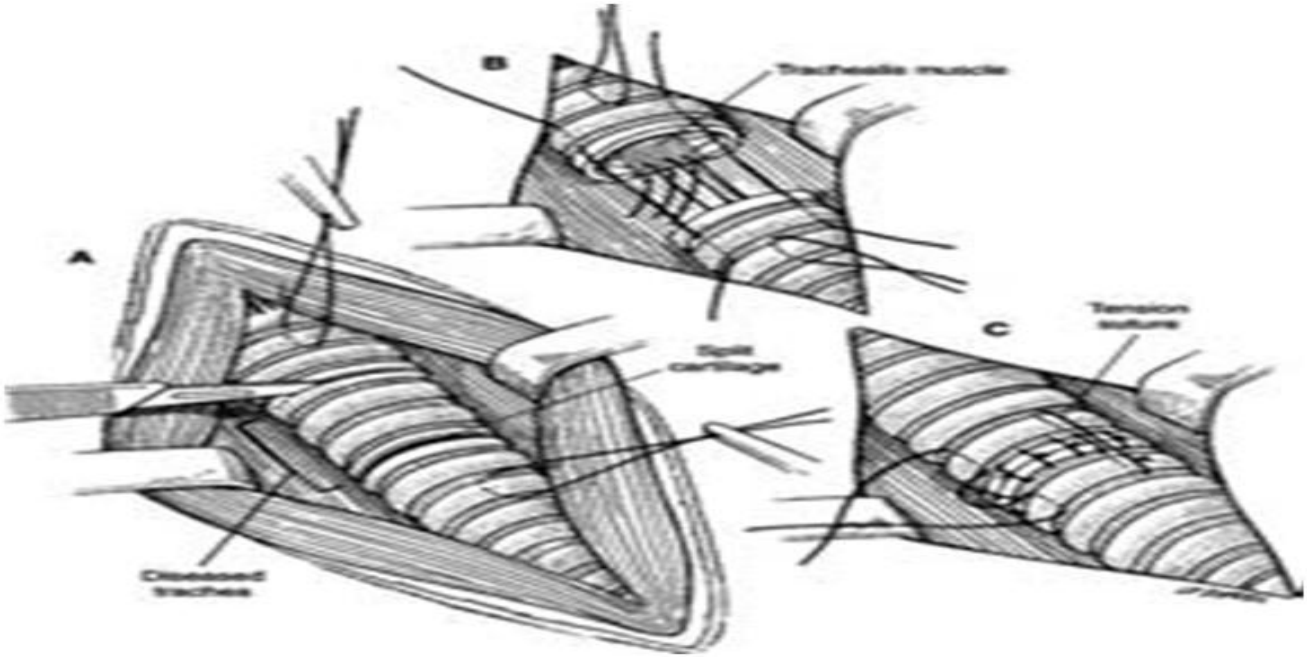
Tracheal Resection and Anastomosis

Removal of a tracheal segment may be necessary to treat tracheal tumors, stenosis, or trauma. Depending on the extent of injury, tears in the tracheal wall that occur as a consequence of bite wounds or endotracheal intubation may be closed primarily, or they may be resected and the tracheal ends anastomosed. Depending on the degree of tracheal elasticity and tension, approximately 20% to 60% of the trachea may be resected and direct anastomosis achieved. The split cartilage technique is preferred because it is easier to perform and results in more precise anatomic alignment with less luminal stenosis than many other techniques. Diseased trachea that exceeds the limits of resection and anastomosis may be managed with permanent tracheostomy, intraluminal silicone tubes, grafts, or prostheses with variable success.

- Expose the involved trachea through a ventral cervical midline incision, lateral thoracotomy, or median sternotomy. Mobilize only enough trachea to allow anastomosis without tension. Preserve as much of the segmental blood and nerve supply to the trachea as possible.
- Place stay sutures around cartilages cranial and caudal to the resection sites before transecting the trachea. Resect the diseased trachea by splitting a healthy cartilage circumferentially at each end or by incising annular ligaments adjacent to the intact cartilages.
- Use a No. 11 blade to split the tracheal cartilages at their midpoint. Transect the dorsal tracheal membrane with Metzenbaum scissors.
- Preplace and then tie three or four simple interrupted sutures (3-0 or 4-0 polypropylene) in the dorsal tracheal membrane.
- Retract the endotracheal tube into the proximal trachea during resection and placement of sutures in the dorsal tracheal membrane. Remove blood clots and secretions from the lumen and advance the tube distal to the anastomosis after placing dorsal tracheal membrane sutures. Complete the anastomosis by apposing the split cartilage halves or adjacent intact cartilages with simple interrupted sutures beginning at the ventral midpoint of the trachea. Space additional sutures 2 to 3 mm apart. Place three or four retention sutures to help relieve tension on the anastomosis.

- Place and tie these sutures so that they encircle an intact cartilage cranial and caudal to the anastomosis, crossing external to the anastomotic site.
- Lavage the area and appose the sternohyoid muscles in a simple continuous pattern. Close the subcutaneous tissues and skin routinely.

Fig.1: Tracheal resection and anastomosis. **A,** Place stay sutures cranial and caudal to the resection sites. Split the cartilages with a No. 11 blade and transect the trachealis muscle with Metzenbaum scissors. **B,** Appose the trachealis muscle with three or four interrupted sutures, and then approximate the split cartilages. **C,** Place three or four tension-relieving sutures around cartilages adjacent to the anastomosis.



If tension-relieving sutures do not adequately relieve tension at the anastomosis, further mobilize the trachea, make partial-thickness incisions through annular ligaments proximal and distal to the anastomosis, or restrict head and neck movement after surgery. Maintain the muzzle for 2 to 3 weeks.

2.3. DIAPHRAGMATIC HERNIA IN DOG

A **diaphragmatic hernia** occurs when the continuity of the diaphragm is disrupted such that abdominal organs can migrate into the thoracic cavity.

General considerations and clinically relevant pathophysiology

Diaphragmatic hernias are commonly recognized by small animal clinicians and may be congenital or may occur secondary to trauma. Most diaphragmatic hernias in dogs and cats are caused by trauma, particularly motor vehicle accidents. The abrupt increase in intra abdominal pressure accompanying forceful blows to the

abdominal wall causes the lungs to rapidly deflate (if the glottis is open), producing a large pleuroperitoneal pressure gradient. Alternately, the pressure gradient that occurs between the thorax and the abdomen may cause the diaphragm to tear. The tears occur at the weakest points of the diaphragm, generally the muscular portions. Location and size of the tear or tears depend on the position of the animal at the time of impact and the location of the viscera.

Diagnosis

Signalment

There is no breed predisposition for traumatic diaphragmatic hernias. Young males were historically thought to be more commonly affected; however, a recent study of traumatic diaphragmatic hernias identified no sex predilection.

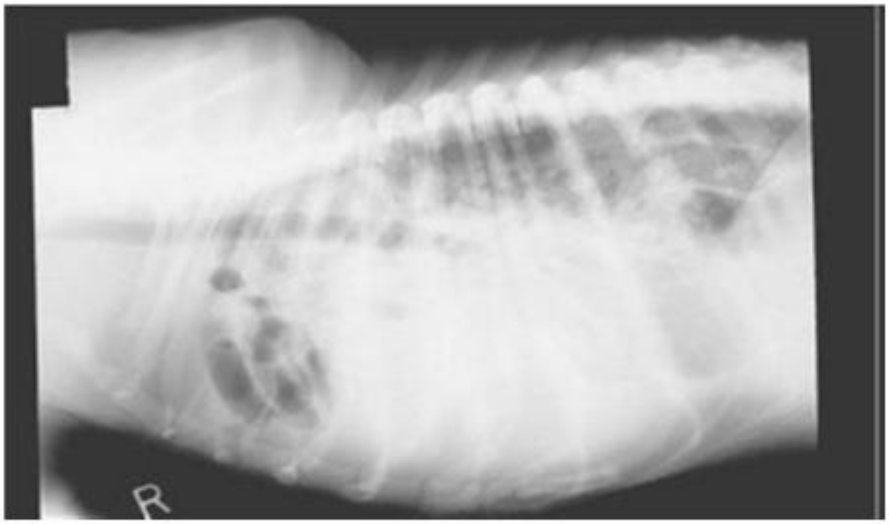
History

The duration of a diaphragmatic hernia may range from a few hours to years. Many (15% to 25%) are diagnosed weeks after the injury. The animals may be presented in shock acutely after the trauma or the hernia may be an incidental finding. Animals sustaining trauma often suffer from associated injuries (e.g., fractures). With a chronic diaphragmatic hernia, the clinical signs most often are referable to either the respiratory (i.e., dyspnea and exercise intolerance) or the gastrointestinal systems (i.e., anorexia, vomiting, diarrhea, weight loss, and pain after ingestion of food) or they may be nonspecific (e.g., depression). Many animals with chronic hernias are not dyspneic at the time of diagnosis.

Physical Examination Findings

Animals with recent traumatic diaphragmatic hernias frequently are in shock when presented for treatment; therefore, clinical signs may include pale or cyanotic mucous membranes, tachypnea, tachycardia, and/or oliguria. The liver is the most commonly herniated organ, a condition that often is associated with hydrothorax caused by entrapment and venous occlusion.

Fig. 2: Lateral thoracic radiograph of a dog with a diaphragmatic hernia. Note the air-filled intestinal loops in the thoracic cavity.



Diagnostic Imaging

Definitive diagnosis of pleuroperitoneal diaphragmatic hernia usually is made by radiography or ultrasonography. If significant pleural effusion is present, thoracentesis may be necessary for diagnostic radiographs. Radiographic signs of diaphragmatic hernia may include loss of the diaphragmatic line, loss of the cardiac silhouette, dorsal or lateral displacement of lung fields, presence of gas or a barium-filled stomach or intestines in the thoracic cavity, pleural effusion, and/or failure to observe the stomach or liver in the abdomen (Fig. 2).

Ultrasound examination of the diaphragmatic silhouette may help when herniation is not obvious radiographically (i.e., hepatic herniation and pleural effusion). Ultrasonography may be particularly difficult if severe pulmonary contusions are present, which make the lung appear ultrasonographically similar to liver, if only omentum is herniated or if adhesions between the liver and lung are present.

Surgical treatment

Chronic diaphragmatic hernias may have a higher mortality rate than acute diaphragmatic hernias; however, the prognosis with both groups is good to excellent with surgery. If pulmonary contusions are severe, surgical repair of diaphragmatic hernias should be delayed until the patient's condition has been stabilized; however, herniorrhaphy should not be delayed unnecessarily. Animals with gastric herniation should be evaluated carefully for gastric distention and should be operated on as soon as they can safely be anesthetized because acute gastric distention within the thorax may cause rapid, fatal respiratory impairment.

Note: Do not delay surgery unnecessarily in animals in stable condition. If the stomach has herniated into the thoracic cavity, perform surgery as soon as possible (i.e., on an emergency basis).

Note: Be prepared to perform organ resection (i.e., partial lobectomy, intestinal resection, and anastomosis) if the hernia is chronic. Be aware that reexpansion pulmonary edema may occur in patients with chronic diaphragmatic hernias, but is rare.

Preoperative Management

Prophylactic antibiotics should be given before induction of anesthesia in animals with hepatic herniation. Massive release of toxins into the circulation may occur with hepatic strangulation or vascular compromise.

Anesthesia

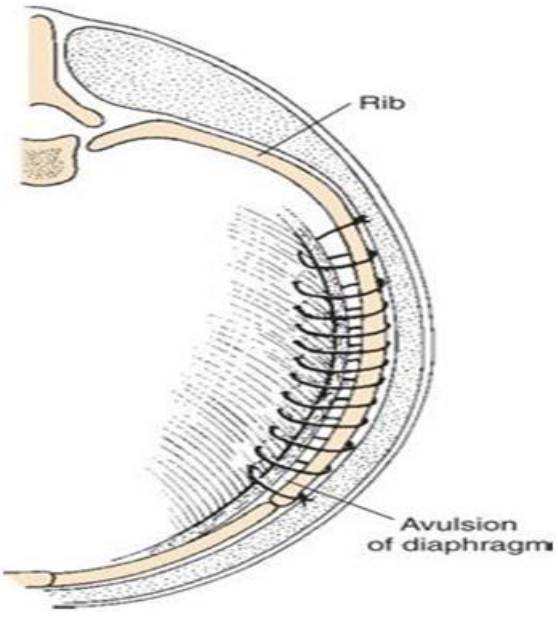
Chamber or mask induction should be avoided in animals with diaphragmatic hernia. Supplementing oxygen before induction improves myocardial oxygenation. Because of the animal's already compromised ventilation, drugs with minimal respiratory depressant effects should be used.

Injectable anesthetics allowing rapid intubation are preferred. Inhalation anesthetics should be used for maintenance of anesthesia. Intermittent positive pressure ventilation should be performed, and high inspiratory pressures should be avoided to help prevent reexpansion pulmonary edema. The lungs should be allowed to expand slowly after surgery.

Positioning

The animal is placed in dorsal recumbency for a midline abdominal incision. The entire abdomen and caudal one half to two thirds of the thoracic cavity should be prepared for aseptic surgery. Because acute ventilatory compromise may occur during positioning, these animals should be carefully monitored during this period.

Fig.3: To repair a diaphragm avulsed from the thoracic wall, incor-porate a rib in the suture line.



Note: Be sure to prep an adequate area so that the incision can be extended into the caudal sternum for thoracic access if necessary.

Surgical technique

- Make a ventral midline abdominal incision; if greater exposure is needed, extend the incision cranially through the sternum.
- Replace the abdominal organs in the abdominal cavity (if necessary, enlarge the diaphragmatic defect).
- If adhesions are present, dissect the tissue gently from the thoracic structures to prevent pneumothorax or bleeding. With chronic hernias, débride the edge of the defect before closure.
- Close the diaphragmatic defect in a simple continuous suture pattern.
- If the diaphragm is avulsed from the ribs, incorporate a rib in the continuous suture for added strength. Remove air from the pleural cavity after closing the defect.
- If continued pneumothorax or effusion is likely, place a chest tube. Explore the entire abdominal cavity for associated injury (i.e., compromise of the vasculature to the intestine or splenic, renal, or bladder trauma) and repair any defects.

Note: If the diaphragmatic defect is particularly large, synthetic material such as Silastic sheeting can be used to close it; however, this is seldom necessary.

Suture materials and special instruments

To close the diaphragm, use either a non absorbable (e.g., polypropylene) or an absorbable (e.g. polydioxanone or polyglyconate) suture.

Postoperative care and assessment

Patients should be monitored postoperatively for hypoventilation, and oxygen should be provided if necessary. Reexpansion pulmonary edema (RPE) is a possible complication associated with rapid lung reexpansion after repair of a diaphragmatic hernia.

Complications

The most common complication after surgical repair of diaphragmatic hernias is pneumothorax, especially if the hernia is chronic and if adhesions are present.

Prognosis

If the animal survives the early postoperative period (i.e., 12 to 24 hours), the prognosis is excellent, and recurrence is uncommon with proper technique. Reported mortality rates for animals with traumatic diaphragmatic hernia have varied from 12% to 48%.