SURGICAL MANAGEMENT OF BRACHYCEPHALIC SYNDROME

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Key Points

- English bulldogs are significantly over-represented.
- Light general anesthesia is required for accurate evaluation of laryngeal function and defects.
- Limited use of crushing clamps and cautery results in less postoperative swelling.
- Overall prognosis for dogs with brachycephalic syndrome is favorable.

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Definition: Brachycephalic syndrome is a combination of upper airway disorders commonly seen in brachycephalic breeds (e.g., English bulldog, Boston terrier, Pugs). Disorders associated with this syndrome include stenotic nares, elongated soft palate, and everted laryngeal saccules. Occasionally patients present with laryngeal collapse. Patients may present with any combination of the above listed disorders.

Diagnosis
Clinical presentation:

Signalment: Brachycephalic breeds are most commonly affected (i.e., English bulldog, French bulldog, Boston terrier, Pug, Pekingese). The age at presentation ranges from less than one year to 11 years. The majority of patients present between 1 and 4 years with English bulldogs presenting at a younger age than other breeds. There is no apparent sex predisposition.

History: Historical findings are generally related to upper airway obstruction and include noisy respiration, heat intolerance, exercise intolerance, cyanosis, and occasionally syncopal attacks. Gagging, retching, and vomiting may also be reported. Historical findings may vary depending upon the number of abnormalities present (i.e., stenotic nares, elongated soft palate, and/or everted laryngeal saccules). Generally, the more abnormalities present the more severe the historical and clinical findings.

Clinical signs: The most frequently reported clinical signs in patients with brachycephalic syndrome include noisy respirations and exercise and/or heat intolerance. Moderate to severely affected patients or patients with multiple defects may present with cyanosis and/or syncope.

Physical examination: Physical examination is generally normal except for patients with stenotic nares. In patients with stenotic nares the wings of the nostril (i.e., dorsolateral nasal cartilage) obstruct airflow resulting in turbulent airflow and resultant noise.

Examining the patient after exercise may exacerbate clinical signs (i.e., noise and exercise intolerance) making diagnosis of brachycephalic syndrome more likely. Oral examination of the awake patient is generally unrewarding as the laryngeal apparatus

and related abnormalities cannot be seen without light general anesthesia.

Radiography: Diagnosis of brachycephalic syndrome is based on signalment, history, physical examination, and direct visualization of the laryngeal apparatus with the patient under light general anesthesia. Thoracic radiographs are generally recommended to rule out lower airway disorders such as tracheal hypoplasia and pulmonary abnormalities.

Differential diagnosis: Any disorder causing noisy respirations, exercise intolerance, cyanosis, and syncope. Included are laryngeal mass, laryngeal collapse and laryngeal paralysis.

Medical management: Medical management is directed at decreasing airway turbulence and subsequent inflammation and edema. Strict confinement, anti-inflammatory medications (e.g., steroids, NSAIDS), and a cool environment are recommended. Obese patients should be placed on a weight reduction diet plan. As medical management does nothing to change the anatomic deformity of the disorder, it is considered palliative but not curative.

Surgical treatment: The objective of surgical treatment is to provide an adequate airway by relieving any anatomic obstruction.

Preoperative management: Use of anti-inflammatory medication preoperatively is generally recommended. Patients are given intravenous steriods (dexamethasone 0.5 - 1 mg/kg IV) at the time of anesthetic induction.

Anesthesia: Anesthetic management is somewhat dependent upon the severity of clinical signs at presentation and degree of airway abnormality.

Patients with mild signs may be anesthetized with the clinicians' standard anesthetic protocol. Careful evaluation of the laryngeal apparatus is performed prior to intubation and while the patient can still breath on its own (i.e., light general anesthesia). Laryngeal function is carefully evaluated during inspiration and expiration.

Patients with moderate clinical signs may need to be preoxygenated prior to induction. Induction should be performed quickly, the laryngeal anatomy and laryngeal function examined thoroughly, and the patient intubated to establish an open airway.

Patients with severe clinical signs should be preoxygenated 5 - 10 minutes prior to induction. A vagolytic agent (i.e., atropine) should be considered 10 - 15 minutes prior to induction because vagal tone is generally increased and cardio-inhibitory reflexes are enhanced. Induction should be quick, examination of the laryngeal anatomy and function performed, and the patient intubated to establish an open airway.

Laryngeal examination: Once the patient is under a light plain of anesthesia laryngeal function is evaluated. Care is taken to observe for evidence of laryngeal collapse, elongated soft palate, and everted laryngeal saccules.

Surgical anatomy: The soft palate in the dog forms a long and broad movable partition between the oral and nasopharynx. The cranial border is attached to the bony palate; the caudal margin forms the dorsal border of the opening from the mouth into the pharynx. This portion of the palate is in contact with the epiglottis during normal

inspiration; during deglutition, the epiglottis moves away from the soft palate to protect the opening of the glottis. At the same time the soft palate moves dorsally to close the nasopharynx and prevent regurgitation of material into the nasal cavity. The dorsal nasopharyngeal surface has a mucous membrane lining continuous with that of the nasal cavity and a slightly convex contour. The mucous membrane of the ventral concave surface is a continuation of the lining of the hard palate and is referred to as the oral surface of the soft palate.

Relevant pathophysiology: Protrusion of an elongated soft palate into the laryngeal inlet during respiration significantly obstructs air passage into the glottis. Stenotic nares, when present, contribute to the severity of the occlusion by increasing the inspiratory effort (and subsequent negative pressure) thus drawing the soft palate deeper into the larynx. Edema and inflammation result from friction against the epiglottis during each respiration. The resultant thickening further lessens airflow. As increased inspiratory effort continues, increased negative pressure in the airway encourages laryngeal saccules to evert.

Positioning: Patients may be positioned in ventral or dorsal recumbancy.

Stenotic nares: The author prefers ventral recumbancy with the head supported on towels so the head position is normal and functional.

Elongated soft palate and everted saccules: Patients can be operated in either ventral or dorsal recumbancy. In dorsal recumbancy, the maxillary canine teeth are taped securely to the operating table. The mandibular canine teeth are taped to an ether stand situated over the patients' head. The mouth is opened wide to enhance visualization. This positioning is critical as oral cavity exposure is key to adequate visualization and instrumentation.

In ventral recumbancy, the maxillary canine teeth are 'hooked' over the bar of an ether stand. The mandibular canine teeth are then taped to the operating table in such a fashion that the mouth gapes open. The tongue is grasped with tongue forceps and gently pulled from the mouth.

Surgical technique: The surgical technique varies depending upon the defect to be repaired.

Stenotic nares: This technique is illustrated on the Respiratory Surgery I surgery video available via www.videovet.org.

Stenosis is decreased by removing a horizontal wedge of alar cartiladge from the wing of the nostril. The flap created is sutured to remaining tissue of the wing of the nostril using 3-0 or 4-0 Dexon or Vicryl in a simple interrupted suture pattern. Two or three sutures is all that is generally required to complete the nasoplasty.

An alternate technique gaining popularity in Shih Tzu and Boston breeds is to completely excise the alar cartilage. Bleeding is controlled by wedging a gauze sponge in the patient's nostril for 5 minutes by the clock.

Presurgical temporary tracheostomy?: Use of a presurgical tracheostomy facilitates exposure and visualization of the soft palate and laryngeal saccules. However, it is not

necessary in the majority of patients. The author considers use of a tracheostomy in patients that present with severe clinical signs (i.e., cyanosis, syncope) and have a combination of defects to repair. Tracheostomy is preferred over exiting the endotracheal tube through a pharyngostomy as the tracheostomy can be used in the postoperative management of the patient if necessary. In our hospital, regardless of the severity of the airway obstruction, the patient is recovered in a critical care environment and instruments necessary to perform an emergency tracheostomy are readily available.

Elongated soft palate: This technique is illustrated on the Respiratory Surgery I surgery video available via www.videovet.org.

When the patient is anesthetized for surgery, light general anesthesia is performed so the surgeon can visualize the relationship of the soft palate with the epiglottis prior to intubation. Using a skin marker a single 'dot' is placed on the location of the elongated soft palate that touches the tip of the epiglottis (see the video for Soft Palate Resection on the Respiratory Surgery I surgery video www.videovet.org). Once the soft palate is marked the patient can be intubated and anesthetized for surgery.

The patient is placed in ventral (the author prefers ventral recumbacy) or dorsal recumbancy with the mouth opened widely (see positioning). A broad malleable retractor can be used to retract the tongue caudally or a tongue clamp can be used to retract the tongue ventrally; either technique greatly facilitates visualization of the soft palate and laryngeal structures. A headlamp also facilitates visualization but is not necessary.

Since postoperative edema and swelling are of major concern following soft palate surgery, it is important to keep surgical trauma to a minimum. Use of clamps and electrocautery may cause excessive surgical inflammation and should be avoided. Use of a laser has been shown to be an atraumatic alternative to excision and suturing.

When suturing, a 3-0 or 4-0 synthetic absorbable braided suture is recommended (Dexon, Polysorb or Vicryl). Dexon, Polysorb or Vicryl is chosen because of its soft supple nature; Maxon, Biosyn or PDS are much to stiff and may cause irritation to the oral cavity postoperatively.

First, a stay suture is placed in the soft palate on each lateral margin of the proposed soft palate excision. A mosquito hemostat is placed on the stay sutures to apply tension to the palate thus facilitating exposure. The mark on the soft palate is used to help determine stay suture location. A third stay suture is placed on the margin of the central portion of the soft palate. This stay suture allows the surgeon to manipulate the palate during resection. The soft palate incision is begun from the left or right margin (stay suture) and one-third of the soft palate is incised using the 'dot' to determine extend of resection. The incised nasal mucosa is then sutured to the incised oral mucosa using a simple continuous suture pattern. Hemorrhage is controlled by suture pressure. No attempt is made to cauterize or clamp bleeding vessels. Once the first 1/3 of the palate excision is sutured the next 1/3 of the palate is cut and sutured. Staging the excision facilitates the surgeon's ability to visualize the oral and nasal mucosal cut surfaces for suturing. When the palate excision and suturing are complete, the stay sutures are cut and the remaining soft palate replaced and evaluated once again for extent of resection.

Everted laryngeal saccule resection: There is some suggestion that if the stenotic nares and elongated soft palate can be successfully treated (see above), the lateral saccules

will return to their normal location in the larynx and no longer cause airway obstruction without the need for surgical resection. The author only removes lateral saccules in patients that present with severe respiratory signs (i.e., severe cyanosis, syncope).

When removing laryngeal saccules, the patient is placed in dorsal recumbancy with the mouth opened widely. Everted laryngeal saccules appear as edematous, translucent tissue 'balls' lying in the ventral aspect of the glottis and obscuring the vocal folds.

If the patient had a tracheostomy tube placed prior to surgery, the saccules are easily visualized and excised as described above. If the patient has an endotracheal tube exiting the laryngeal apparatus, the tube is temporarily removed while the saccules are excised.

Surgical removal is performed using a sharp long-handled laryngeal cup biopsy forceps (or similar long handled biopsy instrument) or a long-handled Allis tissue forceps and #15 BP scalpel blade. If a laryngeal cup biopsy forceps is used the everted saccule is grasped and amputated with the biopsy forceps. Any remaining tags are grasped with a long-handled DeBakey forceps and trimmed with a #15 BP blade or scissors. If an Allis tissue forceps is used the laryngeal saccule is grasped with the Allis forceps and a long-handled scalpel with a #15 BP blade is used to excise the saccule at its base.

Suture material/special instruments:
Malleable retractors or Young tongue retractor (JorVet.com), head lamp, long-handled laryngeal cup biopsy forceps (or similar instrument), long-handled Allis tissue forceps, long-handled scalpel handle, long-handled DeBakey forceps, 3-0 or 4-0 Dexon, Polysorb or Vicryl with a cutting or sharp taper needle.

Postoperative care and assessment: Any patient requiring surgery to relieve airway obstruction should be monitored carefully (preferably in a critical care environment) for the first 24 hours postoperatively. The degree of care may vary depending upon the patients presenting signs and surgical manipulations required to correct the airway obstruction. Examples of the authors' degree of postoperative care based on patient presentation and surgery performed are listed below:

Stenotic nares only: These patients are generally held for observation 12 – 24 hours postoperatively and discharged from the hospital the day following surgery.

Soft palate resection only: Patients that present with mild clinical signs (i.e., noise, mild exercise or heat intolerance) and are bright and alert 24 hours after surgery can be discharged that day. Patients that present with moderate to severe clinical signs (i.e., severe exercise intolerance, episodes of cyanosis, syncopal attacks) are monitored in a critical care environment until signs resolve. Immediate postoperative gagging and coughing are observed in about 13% of patients. Patients requiring a tracheostomy prior to surgery, or an emergency tracheostomy, remain in a critical care environment until the tracheostomy can be removed.

Combined nares, palate, saccule repair: These patients are treated similarly to patients with soft palate resection and are based on presenting clinical signs. Patients with multiple defects tend to present with moderate to severe clinical signs and may require more intensive care. Immediate postoperative gagging and coughing are observed in about 80% of patients.

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Prognosis: Prognosis for patients with brachycephalic syndrome is generally dependent upon the defects found at presentation.

Stenotic nares only: About 96% of dogs with stenotic nares will improve postoperatively.

Soft palate resection only: About 85 – 90% of dogs with soft palate resection only will improve postoperatively. Young dogs (i.e., less than 2 years of age) are more likely to improve (90%) than dogs greater than 2 years of age (70%).

Stenotic nares and soft palate resection: Dogs having a combination of stenotic nares repair and soft palate resection are more likely to have a favorable outcome (96%) compared to those that did not (70%).

Soft palate and everted saccule resection: Dogs having this combination of defects repaired will have an 80% chance of significant improvement postoperatively.

CHEST DRAIN PLACEMENT AND MANAGEMENT

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If you would like a copy of a video of this surgical procedure go to www.videovet.org or contact videovet@me.com.

Key Points

- The most common types of intrapleural pathology requiring chest drain placement are air and fluid.
- Careful handling of severely dyspnic patients during diagnostic work-up can be life saving.
- Careful attention to providing a sub q tunnel during chest drain placement prevents exit point leak.
- Chest drain removal is based on quantity and character of fluid.

Definition: Pneumothorax is defined as the abnormal accumulation of air in the interpleural space. The most common cause of pneumothroax is trauma.

Pleural effusion is defined as the abnormal accumulation of fluid (i.e., blood, pus, water, chyle, pseudochyle) in the interpleural space. As the accumulation of fluid increases, the mechanical restriction of the lungs to normal ventilation may result in significant hypoxia. Pleural absorption of certain exudates (e.g., pus) may result in systemic toxic effects. Closed chest drainage alone (i.e., as for accumulations of blood, water, chyle, or pseudochyle) or closed chest drainage and lavage (i.e., pus) may be necessary to return the patient's pulmonary status to normal.

Synonyms: Thoracostomy tube, chest tube

Diagnosis
Clinical presentation:

Signalment: Patients that present with disorders requiring the use of chest drain management may be of any age, sex, or breed.

History: Historical findings in patients requiring chest drains are acute dyspnea or chronic dyspnea with an acute exacerbation of severe dyspnea. A history of trauma is common in patients that present with severe respiratory difficulty (i.e., pneumothorax).

Clinical signs: The most frequently reported clinical signs in patients requiring chest drain placement is dyspnea. Signs may be mild, moderate, or severe depending upon the amount of interpleural pathology. Occasionally patients present with a chronic history of mild dyspnea then suddenly have an acute and severe attack requiring urgent care.

Physical examination: Physical examination should be done with care. Over manipulation of severely dyspnic patients can result in enough stress to cause respiratory decompensation resulting in a catastrophic outcome. Minimal manipulation and pre-oxygenation can go a long way in preventing the above scenario.

Laboratory findings: Results of a complete blood count, serum chemistry profile, and urinalysis are dependent upon the patients underlying disorder.

Radiography: Diagnosis of interpleural disease can be established with thoracic radiographs. It is important to remember that the stress of positioning can be enough to cause significant decompensation in a severely dyspnic patient. Pre-oxygenation and careful handling are important

prerequisites to ensure patient safety. Evidence of air or fluid density in the interpleural space is diagnostic for pneumothorax or hydrothorax, respectively.

Differential diagnosis: Any fluid or air accumulation in the interplerual space causing severe dyspnea is a potential candidate for chest drain placement and management.

Medical management:
Pre-examination management: Patients can have a significant amount of pulmonary atelectasis and ventilatory compromise, yet appear relatively normal. However, the least amount of stress (i.e. physical examination, chest radiographs, ultrasound) can rapidly push them into a respiratory decompensation. It is important to handle dyspneic animals with minimal stress. Generally, a needle thoracentesis can be performed to relieve the immediate respiratory distress. Go to www.videovet.org for a detailed video description of performing a needle thoracentesis. Supplemental oxygen should be provided with a mask during the thoracentesis procedure. Once the majority of fluid has been removed and the patient is relieved of its life-threatening dyspnea further workup can commence and, if indicated, an indwelling chest drain can be inserted.

Surgical treatment: The objective of chest drain placement is to provide an avenue for removal of contents (i.e., air, fluid) that have accumulated in the interpleural space.

Preoperative management: Supplemental oxygen should be provided with a mask, and needle thoracentesis performed to remove as much air or fluid as possible. Once the majority of air or fluid has been removed and the patient is relieved of its life-threatening dyspnea, anesthetic management can be considered.

Anesthesia: Chest drain placement is an easy and quick procedure; local or general anesthesia may be considered. General anesthesia offers a more controlled situation; intubation and gentle positive pressure ventilation are then available to expand constricted or atelectatic lung lobes.

Surgical anatomy: The lung surfaces are covered with visceral pleura and the thoracic walls with parietal pleura. The parietal and visceral surfaces are held in intimate contact by negative pressure coaptation and fluid exchange.

Positioning: Patients are positioned in lateral recumbancy with the most affected hemithorax uppermost.

Surgical technique:
Chest tube placement using a percutaneous chest tube placement device (MILA):
The site of chest tube placement is clipped, aseptically prepared and a local anesthetic placed. An over the needle plastic catheter is placed at the 7th of 8th intercostal space. Once the needle and catheter have entered the pleural space the needle is removed thus leaving the plastic catheter in place. A quide wire is then passed through the plastic catheter and into the pleural space. Make certain the wire is passed at least 8-12 inches in the pleural space. Once the wire has been adequately advanced remove the plastic catheter being careful to maintain placement of the quide wire. Now grasp the exposed end of the quide wire and pass it into the tip of the chest tube. Advance the chest tube along the quide wire until it passes into the pleural space. Continue to advance the chest tube to its marked hub. Now remove the guide wire from the the chest tube and attach a syringe to the chest tube to begin evacuating air or fluid. The chest tube is secured to the chest to prevent premature removal.

Chest tube placement using a feeding tube or trocar thoracostomy tube:

The surgical site is clipped and aseptically prepared. A stab incision is made over the 9th or 10th intercostal space. A subcutaneous tunnel directed cranioventral is made over two intercostal spaces with the aid of a curved Mosquito hemostat. Once an adequate tunnel has been developed the hemostat is removed and is clamped at the tip of the feeding tube. If a trocar thoracostomy tube is being used, the long metal trocar is placed in the lumen of the drain so the tip just protrudes from the end of the tube. The hemostat (feeding tube) or trocar (trocar thoracostomy tube) is used to place the drain in the tunnel previously dissected. The hemostat or stylet and drain are then carefully punctured through the intercostal muscles of the 7th intercostal space and into the thoracic cavity. The intercostal vessels located on the caudal aspect of the rib are avoided. If a hemostatic forceps is used, once the drain enters the thoracic cavity, the hemostat is opened and the drain advanced into the pleural space before removing the hemostat. The drain is gently advanced in a cranioventral direction until about 4 to 6 inches are within the pleural cavity. The tube will usually make a gentle curve and rest on the ventral thoracic floor. Generally, sterile, disposable rubber feeding tubes of size #14 – 16 French (cats) or 18 – 20 French (dogs) can be used. These tubes have a large enough inside diameter to preclude obstruction with exudate, yet soft enough to be nonirritating to the pleural surfaces. All chest tube fenestrations must be within the chest cavity to prevent iatrogenic pneumothorax or leakage of pleural contents into the subcutaneous space. Several simple interrupted sutures are placed to close the skin snugly around the tube. A Chinese finger-trap friction suture is used to secure the tube to the patient. A deep simple interrupted suture is placed in the skin and around the subcutaneous portion of the chest drain to incorporate lattisamus dorsi muscle, and exited on the opposite side of the tube. This suture helps ensure a air tight and water tight seal around the exit point of the chest drain.

Suture material/special instruments: #14 to 20 French silastic or red rubber feeding tubes, pointed stylet to fit in tube lumen

Postoperative care and assessment: An antibiotic ointment is applied to the skin incision and a comfortable bandage applied around the chest to secure and cover the tubing. Initially, all fluid or air is withdrawn from the chest. Assisted respiration is then administered to expand the lungs. In cases with constrictive pleuritis, full expansion cannot be achieved initially. After all fluid is aspirated, radiographs are taken to confirm proper drain placement and possibly provide further evidence of etiology (i.e. congestive heart failure, foreign bodies, neoplasia). Kinks in the tubing may be seen on radiographs and can be corrected by gently maneuvering the tube in and out of the chest. When not in use, the tubing should be double-clamped and a sterile 3 cc syringe taped to the end. In addition, all tube connections should be reinforced using orthopedic wire to engage all parts that could potentially be pulled apart by animal or man. Here is an illustration of how the author secures all tube connections. All drain tubing is then covered with the bandage to insure a closed system.

Tube removal: Tube removal is dependent upon the change in volume and character (i.e., cytology) of the fluid over a period of time. Generally, as the fluid volume decreases and the cytology is consistent with the irritation caused by the presence of the drain, tube removal can commence. A gauze sponge with an oil base ointment is placed over the exit wound, and the tube gently pulled. The gauze sponge remains on the wound to help seal against possible leaks. A bandage is placed to hold the gauze sponge in place. The bandage can be removed in 3 to 4 days.

Prognosis: The short term prognosis for patients that require chest drain placement is generally favorable. If the preoperative management is performed as directed above, drain placement should be successful and will aid in determining the ultimate cause of the pleural pathology. The long term prognosis is dependent upon the underlying disorder.

DIAPHRAGMATIC HERNIA REPAIR

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If you would like a copy of the video of this surgical procedure on DVD, go to www.videovetorg.

Key Points

- Not all diaphragmatic hernias are life threatening
- Suture the hernial rent from dorsal to ventral
- Use a one layer simple continuous appositional suture pattern for hernia closure
- Evacuate all thoracic air prior to abdominal closure

General Considerations and Indications

Three classifications of diaphragmatic hernia may be diagnosied: acute traumatic, chronic traumatic and congenital diaphragmatic herna.

Acute Traumatic

This is the most common type of diaphragmatic heria in dogs and cats. It is generally caused by vehicular trauma but can be caused by any form of trauma.

Chronic Traumatic

This classification of diaphragmatic hernia is seen when a patient has an acute traumatic hernia that was undiagnosed at the time of occurence. Later (months to years) the hernia is diagnosed due to sudden or chronic onset of respiratory difficulty.

Congenital

The most common congenital hernia involving the diaphragm is a peritonealpericardial diaphragmatic hernia. Whenever this defect is suspected, a thorough examination (i.e., physical, radiographic, cardiovascular) for evidence of further midline congenital defects (i.e., umbilical hernia, atrial and ventricular septal defects, cleft palate) should be performed.

Applied Anatomy

The diaphragm projects into the thoracic cavity like a dome; it attaches to the lumbar vertebrae, costal arch, 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 pars costalis on each side consists of fibers radiating from the costal

wall to the tendinous center. 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 diaghragmatic 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 further compromise the patients already reduced breathing ability. Surgery is not considered an emergency in mildly symptomatic or asymptomatic animals with congenital hernias or chronic 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 abdominal retractor is a helpful piece of equipment; large Gelpi retractors work well as abdominal retractors in cats and small dogs. Using the abdominal approach, an incision is made from xiphoid to pubis. Once the peritoneal cavity is opened, the falciform ligament is removed and the Balfour or Gelpi abdominal retractors placed. The diaphragm can now be visualized 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.

Using large sponges or laparotomy pads moistened with warm saline, the liver and bowel are retracted caudally. Visualization of the cranial quadrant of the abdomen can be facilitated by removing the viscera from the abdominal cavity and placing it on a moistened laparotomy sponge. 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.

In acute traumatic diaphragmatic hernia, the lungs should be expanded to remove atelectasis and to inspect for pulmonary tears and persistent areas of collapse.

In chronic traumatic hernias care is taken not to inflate the lungs. When lung paranchyma is atelelectatic for such a long period of time the alveoli collapse. If they are suddenly expanded with air the tight junctions of the normal alveoli are damaged and the infated alveolus fills with fluid. This is referred to as re-expansion pulmonary edema. This is a life threatening disorder and should be avoided.

It is recommended to suture the hernia from dorsal to ventral thus making it 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, Biosyn 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 hernial rent between two sutures and gently spread open to allow access to the thoracic cavity. The lungs are inflated so as to fill the thoracic cavity. The carmalts are removed and the last suture tied to provide an air tight and 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 diaphragmatic rent between to sutures just prior to its final closure. Make certain 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.

5. A 12 -14 French diameter thoracostomy tube can be placed at the level of the 9th or 10th intercostal space, tunneled to the level of the 7th or 8th intercostal space and placed through the intercostal muscle and into the thoracic cavity. The patient is then 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 plerual 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.

Management of Esophageal Foreign Bodies and Esophageal Surgery Techniques
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Key Points

- The esophagus has unique anatomic characteristics
- Regurgitation is the major sign of esophageal dysfunction
- 90% of esophageal foreign bodies (FB) can be removed without surgical intervention
- Early and aggressive medical treatment of 'post FB removal' esophagitis may prevent stricture
- Esophageal surgery requires careful attention to surgical technique

Anatomy: The esophagus is divided into three portions: cervical, thoracic, and abdominal esophagus. The cervical esophagus generally lies dorsal to the trachea but gradually goes to the left of the trachea as it enters the thoracic inlet. The thoracic esopahgus is on the left at the thoracic inlet, but is to the right of the aorta as it passes distal to the heart, then returns to the left as it enters the esophageal hiatus of the diaphragm. The abdominal esophagus begins at the esophageal hiatus as it blends with the cardia of the stomach. The lower esophageal sphincter (LES) located in the abdominal cavity.

Blood Supply: The blood supply to the esophagus is segmental. Generally, the blood supply is good but it lacks the number of collaterals that are found in the small bowel. The cervical esophagus is supplied by the caudal and cranial thyroid arteries, the thoracic esophagus by the bronchoesophageal arteries and branches of the internal intercostal arteries and the abdominal esophagus by branches of the left gastric artery. Nerve supply comes from vagus and recurrent laryngeal nerves.

Layers of the Esophagus: The esophagus has four distinct layers: outer adventitia, muscular layer, submucosa, and mucosa. The outer adventitia is not a true serosal layer and therefore does not have the early "sealing" effect by exuding fibrin as is noted in the small bowel. The muscular layer consists of two oblique layers of striated muscle that cross over each other and blend with the cardia. Cats have a predominance of smooth muscle while dogs have skeletal muscle. The submucosa consists of collagen and loose connective tissue that holds blood vessels, nerves and mucous glands. This is the strongest layer of the esophagus, and must be incorporated in any esophageal closure. The mucosa consists of stratified squamous epithelium.

The proximal esophageal sphincter is composed of the cricopharyngeal muscle and circular proximal esophageal muscles. This sphincter dilates when food is pushed against it to allow normal swallowing. Achalasia can develop if there is asynchronous dilatation of the sphincter (i.e., crico-pharyngeal achalasia).

The LES or cardia is a blend of esophageal and gastric muscle as the esophagus enters the stomach.

Function: The esophagus has primary and secondary peristaltic waves. Primary peristalsis is stimulated by pharyngeal swallowing while secondary peristaltic waves begin in the esophagus itself. Some patients with idiopathic megaesophagus are devoid of normal primary and secondary peristalsis.

Clinical Presentation: Patients with esophageal disease may present with a variety of signs depending upon the duration of pathology. Initially drooling, gagging, retching, and regurgitation are common signs. Some patients may exhibit dysphagia, distress, or slow continual swallowing. Later, these signs may disappear, and become more nonspecific (i.e., depression, anorexia, weight loss).

Clinical Evaluation: When esophageal disease is suspected, plain radiographs of the cervical and thoracic esophagus should be performed. Often this will give the clinician a diagnosis, especially if the patient has a radiopaque esophageal foreign body (it is reported that 50% of esophageal FB's are radiopaque) or megaesophagus. If survey radiographs are normal, contrast media should be given to further evaluate the esophagus (i.e., stricture, megaesophagus, radiolucent esophageal FB, or persistent right aortic arch). Definitive diagnosis may require a "dynamic" study using a barium swallow with fluoroscopic visualization. Further evaluation can be accomplished by use of rigid or flexible fiberoptic endoscopy. This allows visualization of the esophagus as well as esophageal biopsy.

Esophageal Foreign Body

Clinical presentation: The presenting complaint is often suggestive, but rarely diagnostic for esophageal foreign body. In the early phase of the disease, patients generally present with drooling, gagging, retching, and regurgitation. Occasionally, the owner may have seen the patient eat a bone or some other foreign object. In more chronic cases (i.e., several days to weeks) the patient may present with non-specific signs such as depression, anorexia, and weight loss. It is important to dig into the history for prior signs of esophageal disease as the information may not be given unless asked specifically. The patient may be able to ingest liquids but refuse or regurgitate solid food. Clinical signs may also vary with the completeness of the obstruction. Complete esophageal obstruction may present with severe fulminating signs including excessive drooling, regurgitation, dehydration, anorexia, and depression.

Location of obstruction: Esophageal foreign bodies generally become lodged at one of four locations: pharyngeal, thoracic inlet, heart base, or esophageal hiatus.

Clinical Evaluation: The history may point toward esophageal disease. Physical examination may be helpful in palpation of cervical esophageal foreign bodies. Auscultation in patients with perforations may reveal increased pleural friction rubs. Definitive diagnosis requires further evaluation as described previously (i.e., thoracic radiographs, esophagram, endoscopy). Thoracic radiographs may reveal a radiodense mass or accumulation of air within the thoracic esophagus. Mediastinitis or pleuritis may be seen in patients with a perforated esophagus. Contrast radiography should be performed if there is reasonable doubt about the diagnosis. If your index of suspicion is high that a perforation exists, organic iodide contrast media should be used instead of barium products. Rarely are cervical radiographs needed for 'diagnosis' of cervical esophageal foreign bodies as the majority are palpable at physical examination, however, radiographs should be taken to assess the exact location and size of the esophageal foreign body. Rigid or flexible fiberoptic esophagoscopy is an excellent method to definitively diagnose esophageal FB's and is the first step in therapeutic management.

Management of Esophageal Foreign Bodies: Approximately 90% of esophageal foreign bodies can be successfully removed by nonsurgical means. In the proper sequence of therapeutic management, nonsurgical techniques should be attempted first. Nonsurgical removal of an esophageal foreign body includes rigid or flexible endoscopic retrieval through the oral cavity, advancement of the foreign body into the stomach, or removal via the use of Foley catheters. If the radiographic examination reveals an esophageal perforation, early surgical treatment may be warranted.

Rigid Esophagoscopy: When performing esophagoscopy, the patient should be placed under general anesthesia and intubated with a cuffed endotracheal tube. This gives the clinician control of the patient and the airway, decreasing the chance of fluid or lubricant being aspirated. The patient is

placed in left lateral recumbency with the head and neck extended. When using a rigid esophascope, the largest size diameter that will easily pass the proximal sphincter should be used. As the scope is passed toward the heart base it should be slightly elevated, as the esophagus travels just to the right of the aorta. Slight continual rotation will allow easy passage of the scope. The esophagus has a tremendous ability to dilate. As the esophascope is passed, the esophageal wall will gently be pulled away from any sharp points of the foreign body which are embedded in the esophageal wall. Once the esophageal foreign body is located an alligator, probang, or biopsy forcep can be used to grasp, gently rotate and loosen the embedded foreign body. The preferred method is to deliver the foreign body into the esophascope and remove the two as a single unit. This protects the orad esophagus from damage during removal. If this cannot be safely accomplished, the foreign body should be gently pushed into the stomach. If removal is still impossible without significant damage to the esophageal wall resulting in perforation, a surgical approach should be considered.

Flexible Fiberoptic Endoscopy: A flexible fiberoptic endoscope can also be used for removal of esophageal foreign bodies. The technique is similar to that described for the rigid endoscope, however you do not have the advantage of orad esophageal dilatation. The use of a protective latex covering that slips over the foreign body after it is grasped protects the esophagus during removal. In addition, if using this technique the endoscopist should be careful to monitor respirations. If the FB has caused a small perforation, the air used to inflate and expand the esophagus will leak into the pleural space causing a life threatening tension pneumothorax. If this occurs, an emergency chest drain must be placed.

Foley Catheter Technique: An alternate method for removal of esophageal foreign bodies is the Foley catheter technique. This technique is accomplished by passing a 20-26 French Foley catheter with a 30 cc bulb beyond the esophageal foreign body and inflating the bulb. Inflating the bulb with liquid contrast (i.e., Hypaque) and taking a lateral thoracic x-ray will definitively determine the bulb's location). Then, a second Foley catheter with the same size bulb is placed cranial (orad) to the esophageal FB and the bulb inflated thus dilating the esophagus cranial to the FB. The two catheters are withdrawn simultaneously. The orad Foley catheter dilates the esophagus ahead of the foreign body while the aboral Foley catheter pushes the foreign body orad. This technique is best utilized with soft, blunt esophageal foreign bodies that do **not** have embedded points (e.g., cartilage, gristle, plastic, soft food, rubber, cloth).

Post-removal Therapy: Post-removal Examination: After removal of the esophageal foreign body, the esophascope or fiberoptic endoscope should be reintroduced and esophageal mucosa evaluated for evidence of esophagitis, erosions, ulcerations, or perforation. If a scope is not available, contrast radiography is recommended.

It has been shown experimentally in the dog that esophagitis leads to a reduction in tone of the lower esophageal sphincter and decreases esophageal motility. These factors may enhance reflux of gastric acid and its contact time on esophageal mucosa. This, along with post traumatic esophagitis secondary to the presence of a foreign body, may enhance the possibility of developing severe esophagitis with resulting stricture.

Management of Post-traumatic Esophagitis: The recommended therapy for esophagitis secondary to foreign body removal is:

Carafate
Acid blocker

Metaclopramide
Dietary restriction (3-5 days NPO) or use of a gastrostomy feeding tube
Antimicrobials
Steroids (tapering dose over a four day period)

The rationale for therapy is as follows:

Carafate acts as a 'bandaid' to cover the denuded or erosive surface of the esophagus thus preventing further acid contact.

Acid blocker is used to decrease acid content of the stomach, thus decreasing the possibility of acid rich gastric juice refluxing into the esophagus.

Metaclopramide is used for its anti-emetic effects, ability to increase LES tone and its prokinetic effect on GI motility.

Dietary restriction is recommended simply to decrease mechanical irritation of food contacting esophageal mucosa. In severe cases a gastrostomy feeding tube should be considered. Nasoesophageal and esophagostomy feeding tubes are contraindicated due to their irritating effect on esophageal mucosa.

Antibiotics are given to protect the patient against bacterial infection and possible abscessation that may be associated with deep esophageal ulceration/erosion that may occur post FB removal. Antimicrobials are particularly useful when small undetectable perforations exist.

Steroid use is somewhat controversial. It has been shown clinically that steroid use in the treatment of esophagitis decreases the incidence of stricture formation. Although steroids do not significantly alter the fibrous protein synthesis in other organs (e.g., such as skin wounds), the esophagus seems to be "different". The most plausible explanation is that a transient inhibition of fibrous protein synthesis permits cellular healing to proceed to an extent that stimulation of fibrous protein synthesis does not occur. The esophagus is unique from other organs in that it has a stratified squamous epithelium, without an organized dermis, lying directly on submucosal loose connective tissue. Healing may therefore be more simple and rapid than in complex organs such as skin, and early retardation of fibrous protein synthesis with corticosteroid treatment could make a significant difference in the quality and quantity of the final scar.

Esophageal Perforation: Patients suspected of having esophageal perforation post FB removal should have an organic iodide esophagram. Small perforations (1-3 mm) should be treated conservatively as for esophagitis (see discussion above). Placement of a gastrostomy feeding tube should be considered. Use of nasoesophageal, esophagostomy or phayngostomy feeding tubes are contraindicated.

Large perforations (> 3 mm) should be surgically explored, debrided, and closed. These patients should be managed with a chest drain postoperatively and thoracic lavage as needed. Complications associated with esophageal perforation secondary to foreign body removal are mediastinitis, pleuritis, pyothorax, and pneumonia. Placement of a gastrostomy feeding tube should be considered.

Surgical Removal of Esophageal Foreign Bodies: Surgical intervention (i.e., thoracotomy and esophagotomy) is indicated if there is either radiographic evidence of mediastinitis or pleuritis,

endoscopic evidence of severe pressure necrosis of the wall of the esophagus, or significant resistance to the movement of the foreign body during nonsurgical attempts at removal.

Surgical Approaches to the Esophagus
Surgical removal techniques and approaches differ with the location of the foreign body.

Cervical: Cervical esophageal foreign bodies can be approached via a midline cervical incision. The esophagus is found just to the left of the trachea. Further attempts at gently milking and teasing the foreign body to encourage oral removal may be done. If this fails, a longitudinal esophagotomy is performed in a relatively healthy portion of the esophagus and the foreign body removed. Esophageal mucosa should be examined prior to closure. Any perforation should be debrided and sutured. Esophageal closure technique is discussed under esophageal surgery.

Thoracic Inlet: Foreign bodies at the thoracic inlet may require a median sternotomy. Fortunately this is an unusual location for esophageal FB's requiring surgical intervention.

Heart Base: Foreign bodies at the base of the heart can be approached through a left fourth or fifth intercostal thoracotomy. The exact interspace is dictated by the location of the foreign body on a lateral x-ray. It is important to pack off thoracic viscera prior to the esophagotomy incision. Esophageal closure technique is discussed under esophageal surgery. Thoracic closure is routine, and a chest drain should be placed to facilitate postoperative management.

Lower Esophageal Shpincter: Foreign bodies located cranial to the diaphragm should be approached through a left eighth intercostal thoracotomy. Two options are available to the surgeon at this point: 1) esophagotomy and foreign body removal as discussed above or, 2) transdiaphragmatic removal or 3) ceilotomy and gastrotomy.

Transdiaphragmatic Approach:
Transdiaphragmatic approach requires incision into the abdominal cavity through the diaphragm. The stomach is located and a gastrotomy performed. Extraluminal esophageal manipulation of the foreign body from the thoracotomy along with luminal manipulation of the foreign body through the gastrotomy incision facilitates removal without the need for esophagotomy. Advantages of this technique include: gastrotomy instead of esophagotomy, esophageal visualization, and early alimentation. If the esophagus is severely contused or perforated, a gastrostomy feeding tube can be placed without repositioning the patient.

Celiotomy/Gastrotomy: Another technique that can be considered in distal esophageal foreign bodies is ventral midline celiotomy and gastrotomy. The disadvantage here is not being able to visualize the esophagus, and the difficulty in releasing some foreign bodies without esophageal manipulation. In addition, if the technique is unsuccessful in removal of the FB, the patient will require a thoracotomy.

Postoperative Care: Postoperative care of esophagotomy is similar to that used in nonsurgical removal of esophageal foreign bodies. Patients are treated with systemic antimicrobials, gastric acid blockers, carafate, metaclopramide, feeding tube, and NPO for 5-7 days. Periodic aspiration cytology of thoracic fluid from the chest drain will help monitor possible breakdown and/or leakage. If leakage is suspected, an organic iodide esophagram can be done. In cases of severe mediastinitis, pleuritis, or pyothorax, thoracic lavage two to three times a day with body temperature polyionic isotonic fluid is indicated. Periodic thoracic fluid cytology should be evaluated to determine success of therapy and

proper timing for removal of the chest drain. Feeding should commence in five to seven days with water and blenderized food. Soft foods are fed for approximately one to two weeks, then the patient can be worked back onto a normal diet. Clients should be warned of the possibility of esophageal stricture at 2 - 4 weeks after foreign body removal.

Esophageal Surgery: Esophageal surgery has been considered a challenge in veterinary medicine for a long time. The most common complications involve leak and dehiscence. In order to prevent these complications, special considerations must be given to surgical intervention of the esophagus, including:

a) The esophagus lacks an outer serosal surface which would help limit leakage by exuding fibrin.
b) The esophagus has a segmental blood supply.
c) Constant motion of the esophagus through respirations, visceral movement, diaphragmatic movement, and swallowing contradicts one of the basic principles of wound healing; namely tissue immobilization during healing.
d) The esophageal wall poorly tolerates stretching and tension and may result in postoperative strictures.
e) The esophageal layers must be sutured meticulously to maximize suture holding power and minimize interference with blood supply and wound healing.
f) There is no omentum to help seal or localize a leak.

Principles of Esophageal Surgery: Several principles of esophageal surgery are mentioned below. Adhering to these principles will increase the chance of a successful outcome.

a) Conserve blood supply with atraumatic surgical technique and careful exposure. Suturing must be technically perfect to decrease vascular compromise.
b) The submucosal layer of the esophagus is the layer of strength and must be engaged a minimum of 3 mm from the cut edge of the outer adventicia. Sutures should be no further apart than 2 – 3 mm.
c) Place the esophagus at rest for 5-7 days postoperatively. This means NPO and proper postoperative nutritional support with a gastrostomy or jejunostomy feeding tube. Naso-esophageal, esophagostomy, and pharyngostomy feeding tubes are contraindicated due to the esophagitis induced by the presence of the tube.
d) Suture lines must be tensionless when completed as the esophagus does not respond favorably to linear stretching.

If these principles cannot be met, the consequences are either breakdown and leakage or esophageal stricture.

Indications for Esophageal Surgery:
Esophageal surgery may be indicated subsequent to obstruction by a foreign body, perforation secondary to a foreign body, perforation secondary to a diagnostic procedure (i.e., esophogoscopy), stricture removal, resection of a benign esophageal tumor (i.e., leiomyoma) or rarely, removal of an esophageal diverticulum.

Suture Materials and Suture Patterns:
The suture pattern and material of choice for esophageal anastomosis and esophagotomy closure are controversial in the veterinary or human literature. The most common patterns and materials include:

1) Simple interrupted or simple continuous full thickness using 3-0 or 4-0 synthetic absorbable suture such as Dexon, Vicryl, Polysorb, Biosyn, Monocryl, PDS or Maxon with a swaged-on taper needle. This technique is the authors' preference and Biosyn or Maxon the authors suture of choice.

2) Also described is placement of a row of simple interrupted sutures in the mucosa and submucosa with the knots tied into the lumen using 3-0 or 4-0 absorbable suture (i.e., Dexon, Vicryl, Polysorb, Biosyn, Monocryl, PDS or Maxon) and a row of simple interrupted sutures in the muscle and outer adventicia (suture size and type is the same as above).

3) Another technique is placement of a single row of full thickness interrupted horizontal mattress sutures (Dexon, Vicryl, Polysorb, Biosyn, Monocryl, PDS or Maxon).

Regardless of the suture pattern chosen it is of vital importance that the surgeon engage at least 3 to 4 mm of the collagen laden submucosa on each side of the esophageal defect with every suture bite. In addition, sutures should not be placed any further apart than 2 – 3 mm. Careful attention to detail is important in order to increase the chance of a strong and successful leak proof suture line.

In situations where tension remains a problem with anastomotic closure, several techniques to relieve tension have been described: crush the phrenic nerve to decrease diaphragmatic movement and its influence on the distal esophageal segment, traction sutures from 1 cm caudal to the anastomosis to the prevertebral fascia, or circular myotomy of the **outer** longitudinal muscle layer.

Esophageal Replacement: Elaborate techniques for esophageal replacement in man include pedicled GI segments (i.e., stomach, colon, jejunum). In the dog, successful esophageal replacement has been done with pedicle inverse tubed skin grafts, diaphragmatic pedicle grafts, and esophageal patching using the sternothyroideus muscle.

Muscle Patch: Sternothyroideus muscle is used as a patch by suturing it over the esophageal defect**.** Squamous epithelium will eventually fill the defect and normal function can be expected.

The sternothyroideus muscle is elevated and placed over the defect to judge the surface area necessary to cover the defect. A mattress suture is placed full thickness through the sternothyroideus muscle and esophageal wall. The far side of the patch is sutured first to allow adequate visualization.

Once the far side of the patch is sutured along the entire length of the defect, the leading edge of the patch is grasped and pulled over the defect to completely cover it. The leading edge of the defect is sutured as previously described.

Postoperative management: Postoperative management of esophageal surgical procedures are similar to that previously described for the postoperative management of esophageal foreign bodies.

Esophageal Stricture: Esophageal strictures are an infrequent problem in veterinary medicine. The most common causes are: chemical burns (lye), secondary to esophageal foreign body removal, secondary to esophageal surgery (particularly anastomosis), and secondary to esophageal reflux of gastric acid in anesthetized patients.

Esophagitis: The development of esophagitis resulting from reflux or regurgitation is puzzling. Two factors that encourage reflux and regurgitation are airway occlusion and increased intra-abdominal pressure. Both of these conditions occur during anesthesia, abdominal surgery, and recovery. It is

possible that patients susceptible to reflux of gastric contents into the esophagus prior to anesthesia, are more likely to reflux during surgery and immediately postoperatively.

Esophageal Stricture: Patients with esophageal stricture present with chronic regurgitation of undigested food with the ability to hold down liquids. The signs are similar to a patient with esophageal foreign body causing partial obstruction. Cause can generally be determined from the patient's past history (e.g., lye ingestion, recent esophageal foreign body, recent surgical procedure). A definitive diagnosis can be made by contrast radiography and endoscopy.

The best treatment for esophageal stricture is **prevention**. Whenever a patient regurgitates or vomits during an anesthetic episode, vigorous esophageal lavage should be instituted immediately. The esophageal mucosa is very sensitive to the effects of gastric acid, and relatively short contact times (3-4 hours) at low pH (2-3) can result in significant esophagitis. Also, after removal of esophageal foreign bodies or after esophageal surgery, patients should be treated aggressively for esophagitis (i.e., NPO, antibiotics, cimetidine, antacids, alternate feeding avenues).

Management of Esophageal Stricture: Treatment of esophageal strictures can be either nonsurgical or surgical. Nonsurgical treatment is preferred and generally requires periodic bougienage and steroid therapy. Frequent bougienage is necessary to properly manage patients to a state at which oral alimentation results in little or no regurgitation.

Surgical correction requires accurate localization of the stricture. Contrast radiography should be used in each case. Frequently it is not possible to identify the stricture on the external surface of the esophagus at the time of surgery, and the wall is not usually grossly dilated proximal to the stricture. This localization will also help dictate the approach necessary to expose the esophagus surgically.

Three techniques have been advocated for surgical correction of esophageal strictures:
1) longitudinal esophagotomy followed by transverse closure.
2) resection and anastomosis
3) esophageal reconstruction with a diaphragmatic pedicle, segment of gastrointestinal tract, skin, or sternothyroideus patch.

The procedure performed is generally dictated by the type of stricture present in the esophagus.

Postoperative management is similar for any patient with esophageal surgery (see above).

Esophagomyotomy for the treatment of mural (muscular) strictures is also reported. Success of this technique is dependent upon the anatomic location of the stricture. The tissues involved may include adventitia, muscularis, or submucosa. Mucosal strictures cannot be successfully treated by esophagomyotomy.

Technique: Make a longitudinal incision through the effected tissue layers (i.e., adventitia, muscularis, submucosa) until the mucosa bulges. The mucosal layer is dissected approximately 180° of the esophagus to allow appropriate mucosal bulging. A biopsy of the muscle layers should be done to help determine the cause of the stricture.

FELINE PERINEAL URETHROSTOMY

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Key Points

- Patients with cystic and urethral calculi present with stranguria
- Retropulsion of urethral calculi into the urinary bladder simplifies management of urethral calculi
- Aggressive lavage of the urethra and bladder should be performed during cystotomy
- Permanent urethrostomy is an acceptable method of managing chronic stone formers

Definition: Cystic and urethral calculi have various compositions (i.e., oxalate, struvite, urate) and may be present in the urinary bladder or lodged in the urethra, respectively. They may be multiple or single, may cause partial or complete obstruction (i.e., urethral), and may require surgical manipulation for removal.

DIAGNOSIS

Clinical presentation:

Signalment: There is no age, sex or breed predisposition.

History: Patients generally present with a history of urinary obstruction and/or signs of urinary tract infection. Common complaints include difficulty urinating, straining to urinate, hematuria, blood tinged urine in the litter pan, and/or a distended abdomen. Patients that present several days after complete obstruction may have a distended and painful abdomen and a history of anuria. These patients may be so compromised that they present in shock.

Clinical signs: The most frequently reported clinical signs in patients with cystic and urethral calculi include unproductive straining to urinate, blood tinged urine seen in the litter pan, hematuria, and/or polakiuria. Severity of clinical signs may vary with the degree of urethral obstruction and duration of obstruction prior to presentation. Patients with complete obstruction for several days may show signs of post-renal azotemia (i.e., severe depression, recumbant, shocky).

Physical examination: Abdominal palpation may reveal a full urinary bladder; occasionally, calculi within the bladder may be palpable. Patients with severe clinical signs (i.e., presented several days after complete obstruction) may show azotemia, shock, and/or severe depression. Abdominal palpation generally reveals a large, turgid urinary bladder and may result in discomfort to the patient.

Laboratory findings: Results of a complete blood count and serum chemistry profile are generally normal in patients presenting acutely; urinalysis may show evidence of urinary tract infection and and/or crystalluria. Patients presenting after several days of complete obstruction may have significant changes in their biochemical profile including increased BUN, increased creatinine, metabolic acidosis, and severe electrolyte abnormalities. Urine is generally grossly hemorrhagic and urinalysis may show signs of urinary tract infection and crystaluria.

Radiography: Survey radiographs may show presence of radiodense calculi in the urethra and/or urinary bladder as well as a distended urinary bladder. Occasionally, radiolucent calculi occur and can only be visualized using retrograde contrast cystourethrography. Careful radiographic evaluation of the kidneys and ureters should be done to rule out renal and ureteral calculi.

Ultrasonographic examination of the bladder, ureters, and kidneys may be helpful in diagnosis of cystic, ureteral, or renal calculi.

Differential diagnosis: Any disorder causing urinary obstruction, including urethral neoplasia, granulomatous urethritis, urethral stricture, and urethral trauma. Definitive diagnosis is based on clinical signs, inability to pass a catheter, and evidence of calculi on survey or contrast radiographs.

MEDICAL MANAGEMENT:

Immediate care: In animals with complete obstruction long enough to cause azotemia, temporary urinary diversion is provided by performing a prepubic cystostomy (see technique described below) or frequent cystocentesis (i.e, tid to qid). Azotemia is treated with crystalloid IV therapy prior to calculus removal.

Urethral catheterization of a female cat:

- Female urethral catheterization is easier than male
- Use a closed ended tom cat catheter
- Ventral recumbancy is recommended
- Pass the catheter with no evidence of resistance

RETROGRADE HYDROPULSION OF LODGED URETHRAL CALCULI

Calculus removal: Retrograde hydropulsion: This technique should result in an 80-85% success rate for retropulsing urethral calculi into the urinary bladder!

Thoroughly mix 20 cc of sterile saline and 5 cc of Surgilube or K-Y Jelly in a 35 cc syringe and attach the syringe to a 3.5 - 5.0 French soft rubber catheter/feeding tube.

Anesthetize the patient, extrude the penis and pass the lubricated urinary catheter in the urethra up to and against the calculus. Place a dry gauze sponge around the extruded tip of the penis and occlude the penis around the catheter by squeezing it with thumb and finger.

Using a back and forth action on the catheter, simultaneously inject the saline/lubricant mix under extreme pressure.

a) During injection, the calculi and urethra are lubricated by the saline/lubricant mix while the viscosity of the mixture (i.e., KY jelly and saline) encourages the calculus to dislodge and become retropulsed into the urinary bladder.

b) This technique is attempted, and generally successful, regardless of how many stones are in the urethra and no matter where they are lodged.

If the above technique fails, use a stiffer catheter (i.e., open or closed ended tomcat catheter) and repeat the above maneuvers. Use care when manipulating these stiffer catheters against the calculus.

SURGICAL TREATMENT:

The objective of surgical treatment is to remove all retropulsed calculi from the urinary bladder and any remaining urethral calculi that were unable to be retropulsed. Bladder calculi are removed via cystotomy, urethral calculi are removed via urethrotomy, and patients that are frequent stone formers may benefit form a permanent urethrostomy to allow continual passage of small urethral calculi.

Preoperative management: Patients that present acutely can be anesthetized immediately and retropulsion attempted (see above described technique). If urinary tract infection is suspected, preoperative treatment with antibiotics may be instituted.

Patients that present after several days of complete obstruction should be treated medically until the azotemia resolves, blood gas abnormalities resolve, and electrolytes return to normal. The patients' electrocardiogram should be monitored if hyperkalemia is present preoperatively. Medical treatment may consist of intravenous fluids, systemic antibiotics, continuous ECG monitoring, and bladder decompression. Bladder decompression may be accomplished via multiple cystocentesis (i.e., tid or qid), or placement of an antepubic cystostomy tube (described in detail below).

Anesthesia: Routine general anesthesia is performed in patients that present acutely without signs of azotemia. Azotemic, shocky patients with moderate to severe biochemical abnormalities should be treated as described above until these abnormalities return to normal.

Surgical anatomy: The male feline penile urethra consists of urethral mucosa (i.e., urothelium) surrounded by corpus cavernosum urethra, which is in turn surrounded by tunica albuginea. Because of the blood filled corpus cavernosum urethra and the tough fibrous connective tissue tunica albuginea, the urethra can withstand tremendous pressure (e.g., as with aggressive retropulsion) without the fear of urethral rupture.

The urinary bladder consists of the following layers; serosa, muscular, submucosa and mucosa. The bladder is lined with transitional epithelium.

Positioning: Patients are positioned in dorsal recumbancy for retropulsion, cystostomy tube placement and routine cystotomy.

Urethrostomy: Urethrostomy is generally performed in patients that are recurrent stone formers. It provides a permanent opening that is large enough to accommodate passage of most urethral calculi, crystals and mucoid debris.

Perineal urethrostomy; perineal approach: The perineal urethra is the location of choice for urethrostomy in cats. It is a convenient location for surgical manipulation, the urethral diameter will accommodate passage of most urethral calculi and there is less urine scald postoperatively.

Prior to surgery a urethral catheter is passed, if possible. After a routine castration, an elliptical incision is made around the scrotum and penis. Then the subcutaneous tissues are dissected to expose penile urethra. The penile urethra is dissected free from surrounding connective tissue. The ventral attachment of the pelvic urethral to the pubis (i.e., ishiocavernosus m.) is identified and transected. The penile urethra is freed from its connective tissue attachments to the pelvic floor using

blunt digital dissection. The retractor penis muscle is identified on the dorsal aspect of the penis and is dissected from its attachment on the penis. The dissected retractor penis muscle is then used to develop the dorsal plane of dissection to separate the pelvic urethra from its dorsal connective tissue attachments. Once the urethra is dissected enough to visualize the dorsolaterally located bulbourethral glands penile dissection can stop. The penis is catheterized and the urethral orifice identified. An incision is made from the penile urethra to the pelvic urethral to the level of the bulbourethral glands using a Stevens tenotomy scissor or Iris scissor. The urethral orifice at the level of the bulbourethral glands is generally of large enough diameter to accept the flange of a tomcat catheter.

After incision of the urethra, the glistening urethral mucosa is identified. 5-0 nonabsorbable monofilament suture with a swaged on cutting or taper-cut needle is recommended by the author. The first urethrostomy suture is placed at the dorsal aspect of the urethrotomy incision on the right or left side at a 45o angle to include urethral mucosa and skin (suture split thickness of skin). The suture is tied and cut leaving the ends 3-4 cm long to act as a stay suture. A mosquito hemostat is placed on this suture to provide traction and countertraction to enhance visualization of the urethral mucosa. The second suture is placed opposite the first suture and tied as described for the first. A stay suture is also placed here. A third urethrostomy suture is placed directly on the dorsal midline to hold the dorsal margin of urethral mucosa to the dorsal margin of the skin incision. Alternating sutures from dorsal to ventral are placed until approximately one half of the penile urethra has been sutured to skin. The remainder of the penis is amputated and the subcutaneous tissue and skin are closed routinely. Fine ophthalmic instruments make tissue handling and suturing easier. Use of a 2X magnifying loupe and headlamp light source enhances visualization of the urethral mucosa and facilitates accurate suturing. It is critical for the surgeon to recognize the glistening urethral mucosa and carefully suture it to skin. This will decrease (or eliminate) the chance of urethral stricture.

Perineal urethrostomy; dorsal approach: Perineal urethrostomy can be performed with the patient placed in dorsal recumbancy. This positioning is more ergonomic for the surgeon and allows easy access of the urinary bladder for concurrent cystotomy. When positioning the cat tie the hind limbs cranially until the pelvis is slightly elevated off the surgery table. Place a folded towel under the pelvis to support this slightly elevated position. The surgical technique is as described above for the perineal urethrostomy performed using a perineal approach.

POSTOPERATIVE CARE AND ASSESSMENT:

Perineal Urethrostomy: An Elizabethan collar should be considered, especially in patients that may be prone to self-mutilation. Patients should be kept quiet and away from other animals. An indwelling urinary catheter placed routinely postoperatively is NOT necessary following an uncomplicated urethrostomy.

PROGNOSIS

The prognosis for surgical management of urethral and cystic calculi is dependant upon preoperative management of azotemic patients prior to anesthesia, success of retropulsion of urethral stones into the urinary bladder, care in removing all stones via cystotomy, and care of ensuring urethral mucosa to skin apposition during urethrostomy.

Patients that have successful retropulsion of urethral calculi and do not require urethrostomy have an excellent prognosis. If careful attention is paid during cystotomy to ensure that no calculi are left behind (see discussion on cystotomy technique), the prognosis for cure is excellent. Long term prognosis is dependant on evaluaiton of calculus composition, dietary management, management of urinary tract infection, and attention to urine pH.

Patients that have an elective perineal urethrostomy have a favorable prognosis if attention is paid to proper surgical technique (i.e., urethral mucosa is sutured to skin). Occasionally, chronic stone forming patients will form a calculus that is too large to pass through the urethrostomy stoma.

PRACTICAL TECHNIQUES FROM THE NAVC INSTITUTE

FELINE PERINEAL URETHROSTOMY VENTRAL APPROACH

Feline Friendly Article

Clara S.S. Goh, BVSc, MS, Diplomate ACVS, and Howard B. Seim III, DVM, Diplomate ACVS
Colorado State University

Welcome to the first article in our new ***Practical Techniques from the NAVC Institute*** *column. Each year, the NAVC Institute takes place in Orlando, Florida, and specialists in select areas of veterinary medicine provide hands-on, one-on-one continuing education to the Institute attendees.*

The ***NAVC*** *and* **Today's Veterinary Practice** *have partnered together to present information from the NAVC Institute 2014 courses. For those unable to attend, this column provides the opportunity to experience the excellent education provided at the Institute. Visit* ***navc.com/institute*** *for further information.*

Over the past decade, advances in the medical management of feline lower urinary tract disease (FLUTD) have decreased the requirement for surgical intervention of the blocked male cat.

Perineal urethrostomy (PU) is still the surgical treatment of choice for patients with:

- Repeated urethral obstruction despite medical management
- Obstruction that cannot be relieved by urethral catheterization
- Catheterization that has resulted in significant urethral trauma and/or stenosis.[1]

INITIAL MEDICAL MANAGEMENT

Prior to anesthesia for an elective PU, manage the patient medically with IV fluid therapy and bladder decompression (via retropulsion of urethral crystal/mucus plugs or calculi, catheterization, repeat cystocentesis, or a temporary cystostomy tube) until all renal, metabolic, and electrolyte parameters are within normal limits.

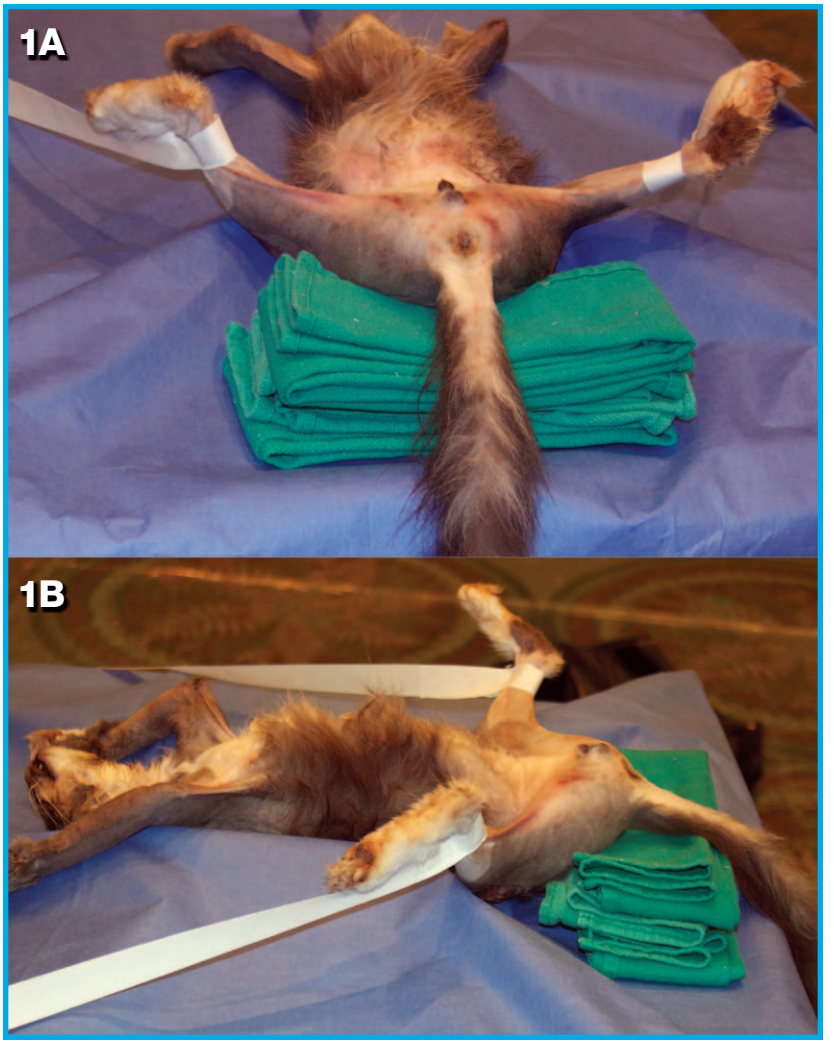
FELINE PERINEAL URETHROSTOMY (DORSAL RECUMBENCY)

Our preferred technique is a slight variation on the traditional PU described by Wilson and Harrison in 1971.[2] In this variation, the cat is placed in dorsal recumbency instead of the standard perineal approach. This positioning is more ergonomic for the surgeon, and allows access to the ventral abdomen for concurrent cystotomy if indicated.

The Essentials for Perineal Urethrostomy

- Standard general surgery pack, including needle holders, thumb forceps (preferably Debakey forceps), mosquito forceps, scalpel handle, Metzenbaum and Mayo scissors
- Stevens tenotomy scissors (4" straight)
- 2 Gelpi retractors (3.5" size)
- Suture (4-0 to 5-0 monofilament synthetic absorbable, on a taper or taper-cut needle)
- Suction device and small Frasier suction tip

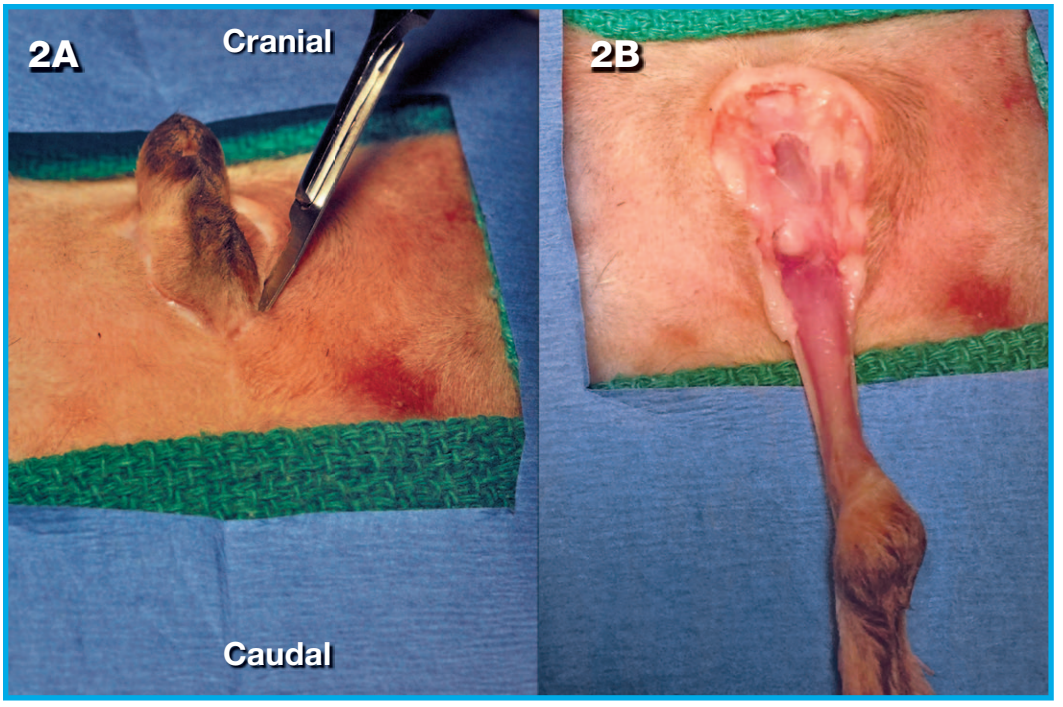
1 Position the cat in dorsal recumbency (see **Surgical Insight: Penile Orientation**) with the hindlimbs tied cranially until the pelvis is slightly elevated off the surgery table. Place a folded towel under the pelvis to support the patient (**A** and **B**) and place a purse string suture in the anus. Clip and aseptically prepare the perineal region ± ventral abdomen (if a cystotomy is indicated).



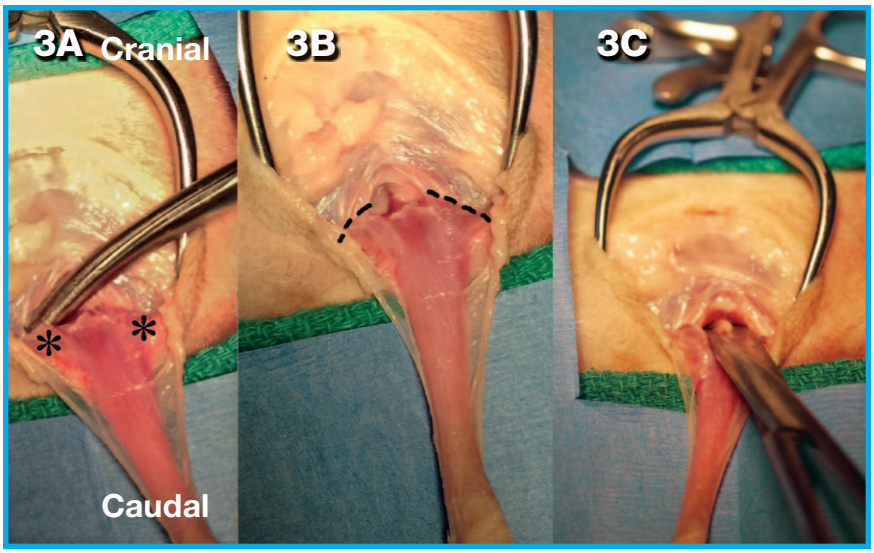
SURGICAL INSIGHT: PENILE ORIENTATION

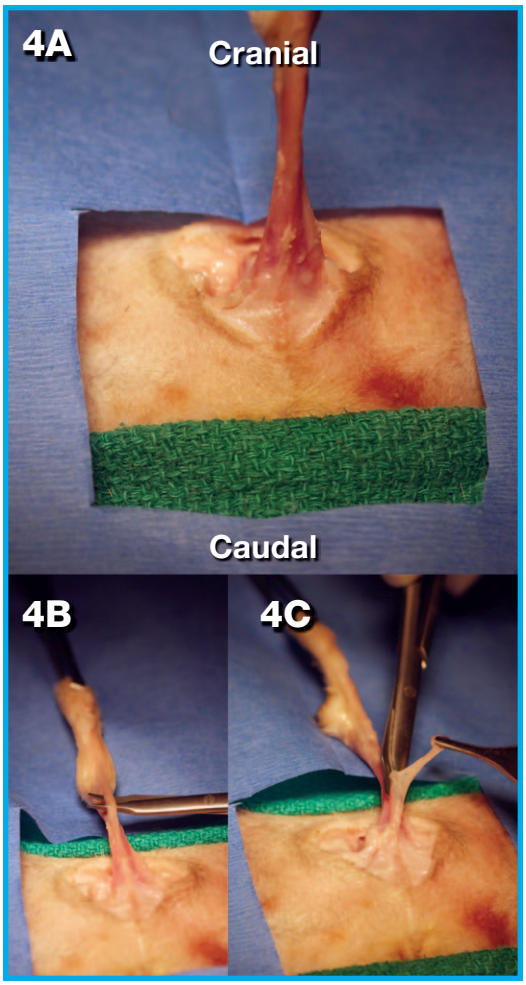
- Pay close attention to penile orientation in this technique (ie, dorsal versus ventral side).
- When the penis is pulled **caudally**, toward the tail, the surgeon is working on its **ventral aspect**.
- When the penis is reflected **cranially**, toward the cat's head, the surgeon is working on the **dorsal aspect**.
- Minimal delicate peripenile dissection is carried out on the **dorsal aspect** of the penis, as this is where the primary neurovascular supply is located.[3]
- When dissecting the **dorsal aspect** of the penis, the surgeon is also in close proximity to the rectum, which is undesirable because it increases the risk of rectal perforation

2 If the cat is intact, perform a routine castration. The urethra can be catheterized with a Tomcat catheter to aid identification and manipulation. Make a symmetric, elliptical incision around the scrotum and penis (**A**) at the junction of the perineal and scrotal skin. Perform a circumferential dissection of the subcutaneous connective tissues to isolate the penis (**B**).



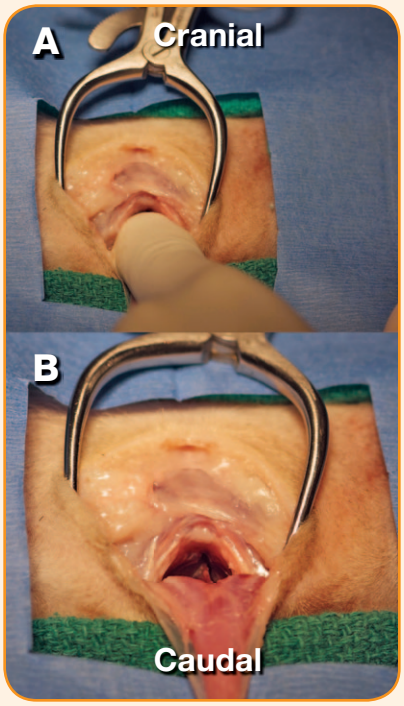
3 With the penis pulled caudally, dissect the ventral connective tissue to isolate the paired ischiocavernosus muscles (**A, asterisks**), which attach the penis to the pelvis (see **Surgical Insight: Ischiocavernosus Muscles**). Transect these muscles at their attachment to the ischium (**B, dotted line**); then sharply and bluntly dissect the ventral penile ligament until the penis can be freely retracted caudally from any ventrolateral pelvic attachments (**C**).





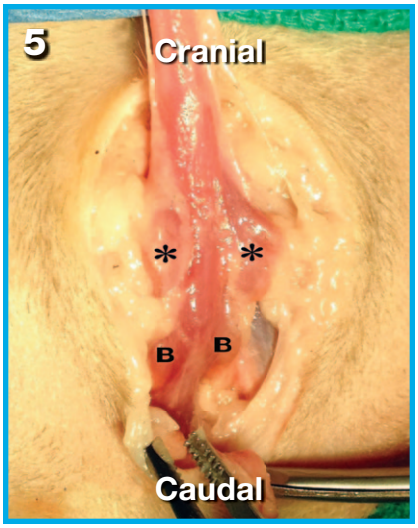
4 The penis is now reflected cranially, allowing the surgeon to work on its dorsal aspect (**A**). Identify the thin retractor penis muscle on the dorsal midline directly overlying the urethra (**B**). Carefully isolate it, and use a combination of blunt and sharp dissection with Metzenbaum or Stevens tenotomy scissors to free and transect its attachment to the penis (**C**).

5 Use the transected and isolated retractor penis muscle as a guide for continued careful dorsal dissection in the same tissue plane, which exposes the urethra to the level of the paired bulbourethral glands. Dorsal dissection is complete once the paired bulbourethral glands (**B**) are identified dorsolateral to the transected ischiocavernosus muscles (**asterisks**). Do *not* carry out any further dorsal peri-penile dissection once these glands are visualized.



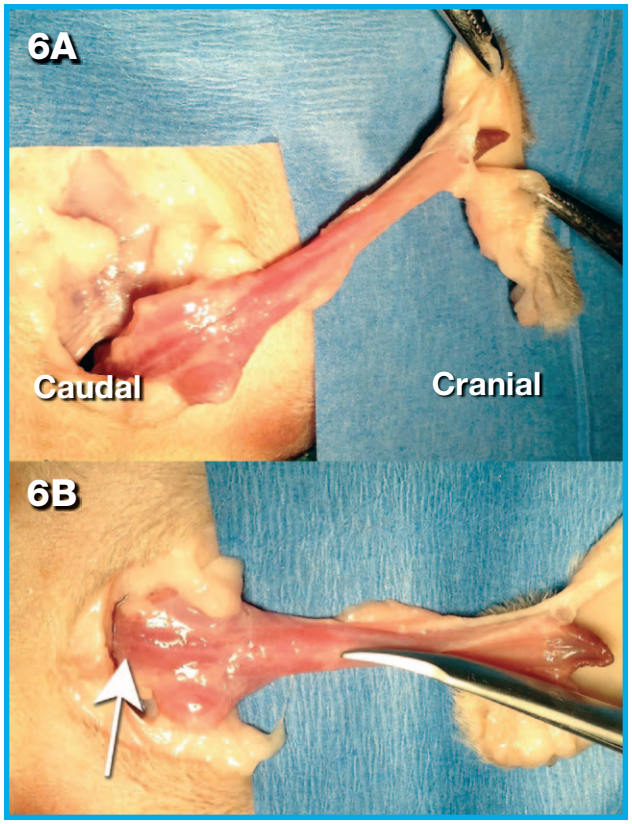
SURGICAL INSIGHT: ISCHIOCAVERNOSUS MUSCLES

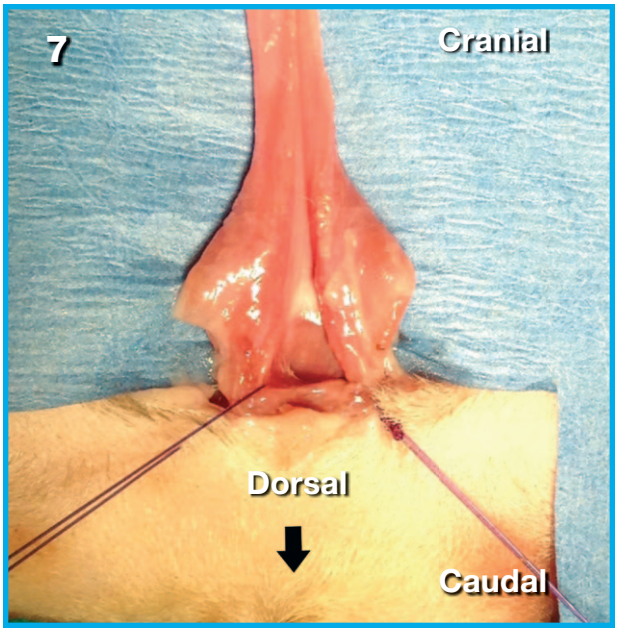
- Sharp transection of the ischiocavernosus muscles close to their ischial attachment limits hemorrhage from the body of the muscle.
- Ventral dissection is considered sufficient when the surgeon can place a finger between the penis and ischium within the pelvic canal. Palpate the space between the penis and ischium to confirm sufficient ventral dissection (**A and B**).



Collaboration on Continuing Education
Turn to page 6 to read this issue's **Editor's Note** in which Editor in Chief, Dr. Lesley King, and NAVC Conference Coordinator, Dr. David Senior, provide more details about this collaborative column and how it meets the goals of both ***Today's Veterinary Practice*** and the **North American Veterinary Community** with regard to providing the highest quality continuing education for veterinary professionals.

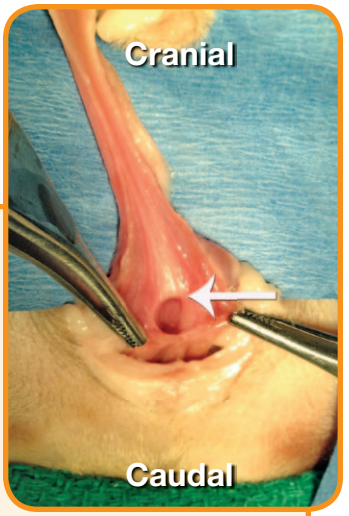
6 Transect the scrotal and preputial skin to expose the tip of the penis (**A**), and remove the urethral catheter. Use Stevens tenotomy scissors to make a longitudinal incision into the urethral lumen, starting distally and continuing on the dorsal midline to the level of the bulbourethral glands (**B, black arrow**). See **Surgical Insights: Bulbourethral Glands** and **Urethrotomy Incision**.



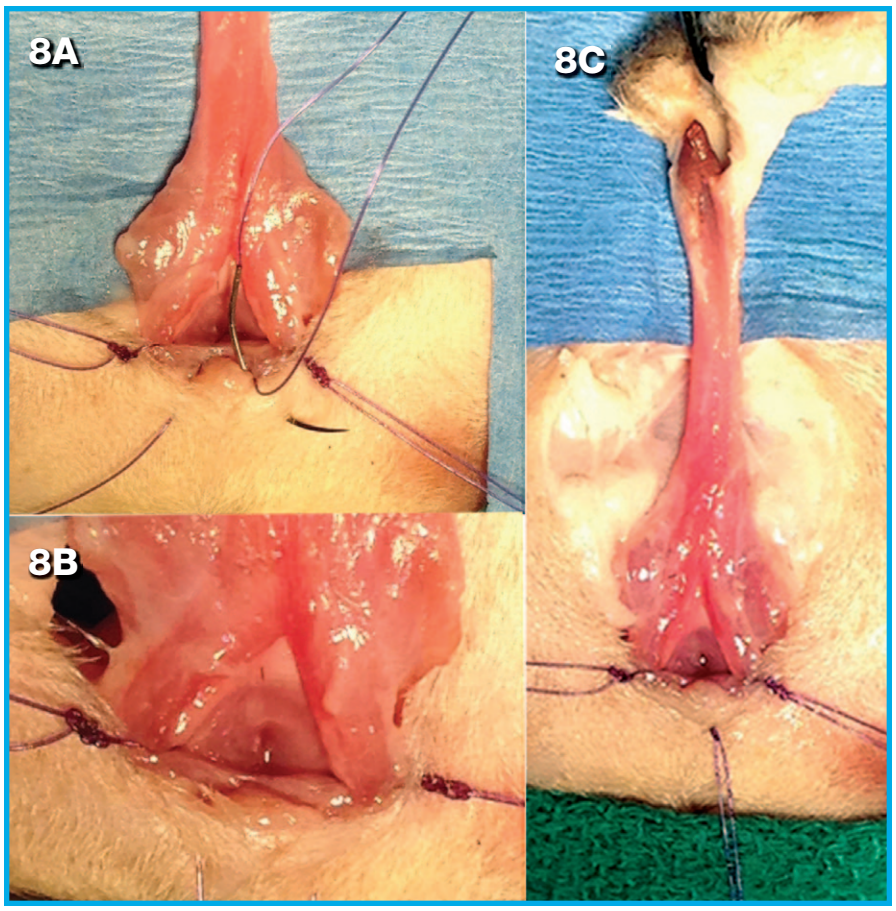


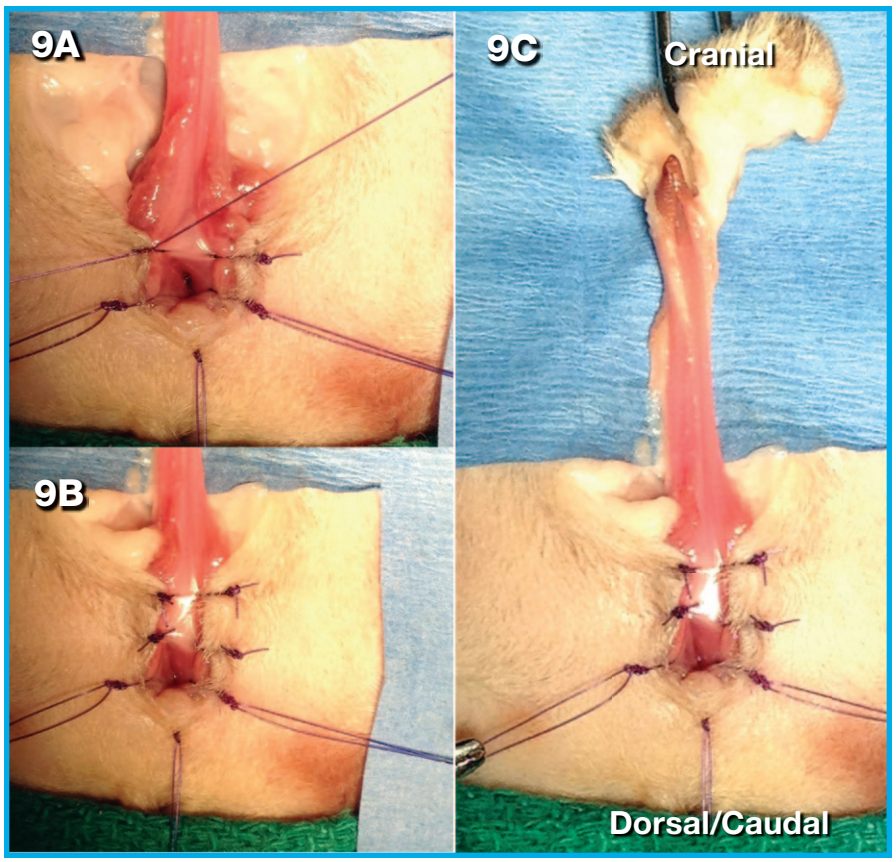
7 If the urethrostomy opening is thought of as a clock face (with the dorsal aspect pointing toward the anus at 6 o'clock), the most critical sutures are at the 6, 4, and 8 o'clock positions. The 4 o'clock and 8 o'clock interrupted sutures are placed first, leaving the suture ends long as stay sutures to aid in retraction of the tissues.

SURGICAL INSIGHT: BULBOURETHRAL GLANDS
- The transected paired ischiocavernosus muscles are sometimes misidentified as the bulbourethral glands.
- These paired glands typically lie adjacent and just proximal to the transected muscles, lending a "butterfly" appearance to the penis and surrounding structures.
- Identify these glands because they serve as key landmarks for the junction of the more narrow penile urethra and wider membranous pelvic urethra.



SURGICAL INSIGHT: URETHROTOMY INCISION
- Make sure the urethrotomy incision is on the dorsal midline and is carried out to the level of the bulbourethral glands (ie, the widest point of the penile urethra).
- Identify this junction by a visible pale line in the urethral mucosa at the level of the bulbourethral glands (**white arrow**).
- If the urethrotomy is *not carried far enough*, the urethrostomy lumen will be too narrow.
- If the urethrotomy is *carried too far*, there will be excessive tension on the PU site.
- The ideal urethrostomy site lies 2 to 3 mm proximal to the penile urethra within the wider membranous urethra.





8 A mattress suture can be placed in the 6 o'clock position (see **Surgical Insights: Sutures** and **Tissue Handling**). This tissue bite sequence has 4 steps. The needle:

1. Engages split thickness skin (**A**)
2. Penetrates the urethral mucosa (into urethral lumen) (**B**)
3. Passes back through the urethral mucosa (from lumen out) (**C**)
4. Passes split thickness skin.

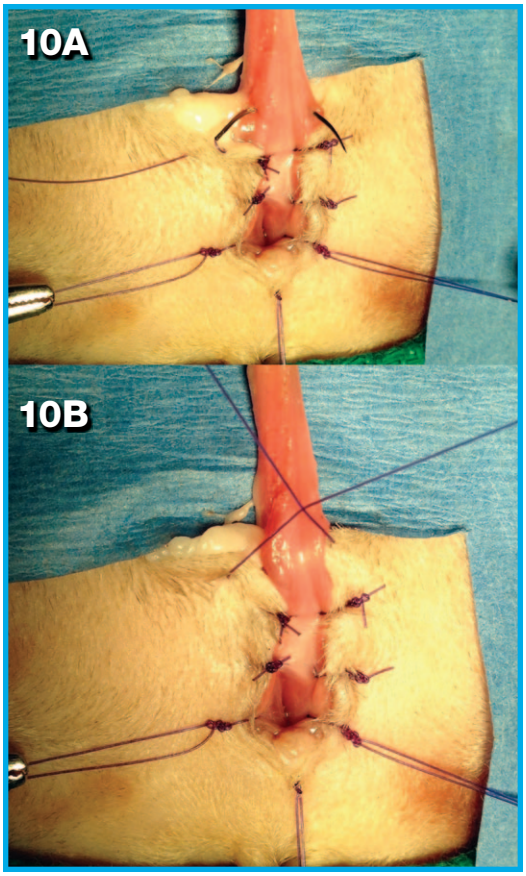
SURGICAL INSIGHT: SUTURES

- It is critical to identify the cut edge of the urethral mucosa (glistening pale tissue plane medial to the adjacent red cavernous tissue) and achieve perfect apposition of mucosa to skin.
- A 5-0 synthetic absorbable monofilament suture on a taper-cut needle is ideal.
- Encompass 2 to 3 individual tissue bites during each suture pass:
  1. Urethral mucosa
  2. Fibrous tunica albuginea (this bite may be included with the first)
  3. Split thickness skin.
- Absorbable suture material does not require removal, which makes its use advantageous.

9 The remaining interrupted sutures of the PU site are placed in a dorsal to ventral sequence (**A through C**).

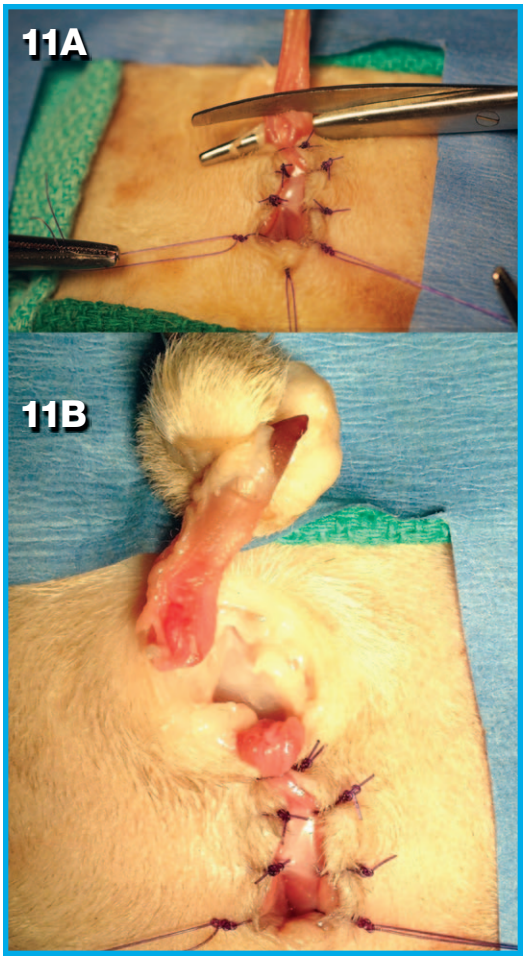
SURGICAL INSIGHT: TISSUE HANDLING

- Do not grasp the fragile urethral mucosa or skin with forceps.
- Instead, grasp only the adjacent fibrous tunica albuginea and hypodermal layer of the skin.
- Dissipating mild hemorrhage with saline lavage and suction will facilitate visualization of tissue planes.

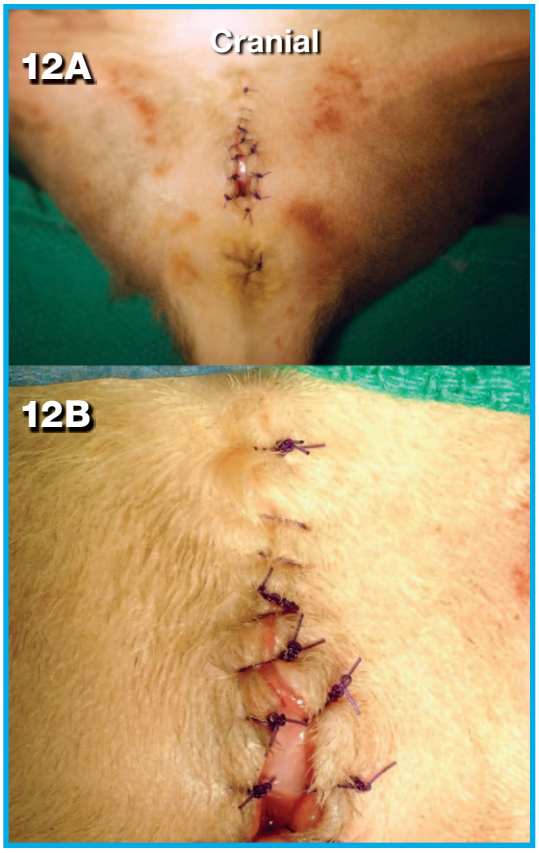


10 Following transection of the penis, the most ventral suture (**A**) should act as an encircling suture to ligate the penile stump (**B**); thus, controlling penile hemorrhage. Alternatively, a separate encircling suture can be placed around the penile stump.

11 The penis is amputated (**A and B**).



12 Complete the PU by closing the remaining skin incision using a simple continuous or interrupted pattern (**A and B**).



POSTOPERATIVE MANAGEMENT

Postoperative management includes:

- Appropriate pain management
- Monitoring urine output
- Continuation of IV fluid diuresis (at least 24 H postsurgery)
- Ensuring the patient cannot damage the repair (eg, E-collar, litter that will not adhere to the surgery site).

A postoperative indwelling urethral catheter is not indicated in a routine PU.

COMPLICATIONS

Educate owners about potential acute complications, such as hemorrhage, re-obstruction, urine dissection into the subcutaneous tissues, incisional dehiscence, urinary tract infection, urine scald, incontinence, and stricture.[1,4,5]

Although the management of such complications is beyond the scope of this article, adhering to the basic surgical principles of delicate tissue handling, careful dissection, tension-free closure, and perfect mucosa-to-skin apposition should minimize occurrence of such complications.

Recurrent bacterial cystitis is the most common late complication, and appropriate ongoing medical management of the underlying FLUTD helps prevent it.[4,5]

PROGNOSIS

The overall prognosis following PU is good, with around 90% of clients reporting a satisfactory long-term quality of life.[4,5]

FLUTD = feline lower urinary tract disease; PU = perineal urethrostomy

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GALL BLADDER MUCOCELE

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Colorado State University

Introduction: Patients diagnosed with gall bladder mucocele are often candidates for surgical exploratory. This decision is generally based on history, physical examination findings, response to medical therapy and results of serial ultrasonographic findings of the gall bladder and liver.

Presurgical Considerations: Preoperative treatment of patients with gall bladder mucocele is dependant upon the patients presenting signs and results of physical and ultrasonographic findings. If the patient is stable and there is no evidence of gall bladder rupture the patient can be pretreated with fluid and antimicrobial support prior to exploratory laparotomy. However, if there is a high index of suspicion that the mucocele is ruptured the patient is treated as an urgent care case, stabilized as best as possible with fluid and antimicrobial support. An exploratory laparotomy should be scheduled as an emergency procedure.

Biliary Surgery Facts: Normal bile is sterile. In cases of cholecystitis and cholangitis, however, bile frequently contains bacteria. Bile leakage can induce chemical peritonitis resulting in tissue irritation and permeability changes that may result in subsequent bacterial growth. Administration of preoperative and postoperative antimicrobials is indicated in the preoperative treatment of these patients. Antibiotic therapy should be based on culture and susceptibility testing, however empirical use of biliary antibiotics include ampicillin, cephalosporins, and chloramphenicol because they are excreted in the bile.

In cases of prolonged obstructed biliary disease, a deficiency of prothrombin and vitamin K-dependent coagulation factors can develop. Administration of vitamin K or a fresh whole blood transfusion may be indicated.

Suture Materials and Patterns: Suture materials best suited for biliary surgery include synthetic monofilament absorbable suture (i.e., Maxon, Biosyn, Monocryl, PDS) or synthetic monofilament nonabsorbable suture (i.e., nylon, polypropylene, Novafil). Multifilament synthetic absorbable sutures (i.e., Vicryl, Dexon, Polysorb) can be used but their braided nature may result in excessive tissue drag.

Suture needles recommended are similar for those used in intestinal surgery; fine taper, taper cut, or reverse cutting needles. The recommended suture pattern is single layer simple continuous apposition; each bite penetrates all layers of gallbladder wall. Single layer simple interrupted appositional suture pattern can also be used. Inverting suture patterns should be avoided as they tend to create unacceptable lumen compromise. Suture size is dependent upon the species and structure being sutured.

Gall Bladder: cats: 4-0 or 5-0
small dogs: 4-0 or 5-0
large dogs: 4-0

Surgical Anatomy: Biliary tract surgery is generally limited to the extrahepatic biliary system including hepatic ducts, common bile duct, cystic duct, and gallbladder. In the dog, hepatic ducts enter the cystic duct and common bile duct separately. The cystic

duct extends from the neck of the gallbladder to its junction with the first hepatic duct. Distal to this, the duct continues to the duodenum as the common bile duct. The common bile duct empties into the duodenum at the major duodenal papilla. Blood is supplied to the gallbladder via the cystic artery, which originates from the left branch of the proper hepatic artery. The extrahepatic biliary tract is most often approached via a midline xyphoid to pubis celiotomy.

Cholecystectomy: Indications for cholecystectomy include gall bladder mucocele, irreparable damage to the gallbladder or cystic duct, neoplasia, calculi, and necrotizing cholecystitis.

Technique: The liver and gallbladder are exposed via cranial ventral midline celiotomy. The gallbladder is adhered to the right medial and quadrate lobes via peritoneal attachments. These visceral peritoneal attachments are incised along the junction of the gallbladder and liver. While applying gentle traction, the gallbladder is freed from the liver by blunt dissection. The gallbladder and cystic duct are freed to their junction with the common bile duct, being careful not to damage the common bile duct or hepatic ducts. The cystic duct and cystic artery are clamped and double ligated with 2-0 monofilament absorbable or nonabsorbable suture. The duct is transected between ligatures and the gallbladder removed. Bleeding from the raw surface of the liver is controlled by direct pressure from a gauze sponge, a hemostatic substance such as Gelfoam or Vetspon, or by incorporating an omental pedicle flap. A sample of bile and gallbladder wall is taken for culture and susceptibility testing and the remainder of the gallbladder submitted for histopathologic examination.

Patients presenting with gall bladder mucocele rupture should have a xyphoid to pubis exploratory laparotomy. Mucocele contents are often thick and tenacious. After gall bladder rupture these contents are disseminated throughout the abdominal cavity. Careful exploratory of all areas of the abdomen are essential in order to retrieve all contents of the ruptured mucocele.

Remnants of the gall bladder wall are excised from their attachments on the liver lobes. The cystic ducts' communication with the common bile duct is identified and ligated. The abdomen is generously lavaged with sterile physiologic saline solution until the fluid is clear and devoid of any evidence of bile staining.

In order to provide continued abdominal drainage postoperatively, one or two Jackson-Pratt drains are placed in the abdomen to provide postoperative abdominal drainage. In patients over 25kg two drains are used; one is placed in the cranial abdomen between the liver and diaphragm and the second is placed in the caudal abdominal quadrant. The drains are exited at a point distant from the primary abdominal incision. Drains remain in place postoperatively until the character of the fluid cytology/quantity returns to normal (i.e., healthy neutrophils, no bacteria, decreasing fluid quantity)

Postoperative management: Patients presenting with an intact gall bladder (i.e., early surgery) require careful postoperative observation for the first 12 – 24 hours after surgery. These patients can generally be discharged from the hospital within 24 to 36 hours after surgery.

Patients presenting with a ruptured gall bladder mucocele (i.e., late diagnosis/surgery) should recover in a critical care unit that can offer 24hr/day close observation to access

patient progress. Intravenous fluids, antimicrobial therapy, abdominal drain management, and close CBC and electrolyte evaluation should be available.

Prognosis: The prognosis for patients presented prior to gall bladder rupture is favorable to excellent. Patients' presented with gall bladder rupture generally have a guarded prognosis, however the sooner these patients are explored the better the overall prognosis.

INTESTINAL ANASTOMOSIS

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If you would like a copy of this surgical procedure go to www.videovet.org.

Key Points

• Pay attention to basic surgical principles
• Submucosa is the layer of strength
• Use synthetic absorbable suture materials
• Appositional techniques are best
• Intestinal sutures should engage at least 3 - 4 mm of submucosa
• Intestinal sutures should be no further apart than 2 - 3 mm
• Always handle bowel wall using atraumatic technique
• Examine the integrity of your anastomsis visually
• 50 - 60% of the 'small intestine' of dogs and cats can be resected

General principles of small intestinal surgery

1) Incorporation of the collagen laden submucosal layer in the surgical closure.
2) Minimize trauma and contamination.
3) Maintain good blood supply to the surgical site.
4) Avoid tension across the suture line as this may increase the possibility of leak and/or breakdown.
5) Pay attention to your established criteria when suturing intestinal defects.

Operative Considerations

1) Proper **"packing off"** of the surgical field using moistened laparotomy pads should be performed around the **exteriorized** bowell to prevent accidental abdominal contamination from intestinal contents.
2) Keep abdominal contents warm and **moist** throughout surgery with a warm, balanced electrolyte solution.
3) Handling abdominal viscera should be kept to a minimum. **Gentle manipulation** of intestine with moistened gloves or stay sutures is helpful in preventing unnecessary tissue trauma. **DeBakey** forceps are the most atraumatic forceps for handling abdominal visceral organs.
4) The collagen laden, tough **submucosa** is the layer of strength in the small intestine; this layer must be incorporated into any small intestinal closure**.**
5) It may be difficult to visualize the submucosal layer due to **mucosal eversion**. Visualization of submucosa may be enhanced if everted mucosa is trimmed away.
6) Intestinal contents should be "milked" away from the anastomosis site. **Intestinal clamps** (e.g., Doyen intestinal clamps, Alice tissue forceps with a rubber feeding tube interposed, hair clips, or Penrose drains) may be used to prevent intestinal contents from contaminating the surgical site whilst manipulating intestine during anastomosis.
7) The anastomosis should be **irrigated** prior to its return to the abdominal cavity and instruments and gloves changed prior to abdominal closure.
8) **Abdominal lavage** with 2-3 liters of body temperature, sterile, physiologic saline solution should be accomplished prior to closure. The objectives of repeated abdominal lavage include dilution of bacteria and endotoxin and mechanical removal of fibrin and necrotic debris. The fluid of choice is body temperature, sterile, physiologic saline solution with no additives (i.e. betadine solution, chlorhexidine, antibiotics, etc). Lavage solution is poured into the abdominal cavity using a sterile stainless steel bowl, the abdominal viscera gently aggitated, and fluid and debris suctioned out with a suction device and a Poole suction tip. Injecting antimicrobials or other products into the abdominal cavity is not recommended.

Suture Material

Absorbable suture
Catgut. Catgut is **NOT** recommended for any visceral organ surgery. Its unpredictable absorption and rapid loss of tensile strength in such situations may result in an unacceptably high number of anastomotic leaks and /or breakdowns. Use of catgut suture in gastrointestinal surgery is not recommended.

Dexon, Polysorb, and Vicryl. Synthetic absorbable braided suture (i.e., polyglactin, polyglycolic acid) have become very popular. The braided nature however does result in increased tissue drag and difficult knotting ability.

Biosyn and Monocryl. These sutures have similar properties to Dexon, Polysorb and Vicryl however they are monofilament. They were developed to overcome the problem of tissue drag and knot slipping found in the braided synthetic absorbables. Their predictable hydrolytic absorption is unaffected by their immediate environment (i.e., infection, contamination, hypoproteinemia). They retain high tensile strength for a long period of time (2-3 weeks) and have very good handling characteristics. These suture materials are ideal for use in gastrointestinal surgery. These sutures are the authors choice for gastrointestinal surgery.

PDS and Maxon. PDS and Maxon, are synthetic absorbable monofilament suture materials with similar properties to that of Dexon and Vicryl. They have been shown to retain approximately 70% of their tensile strength at 3-4 weeks, and are absorbed by hydrolysis (unaffected by infection, contamination, hypoproteinemia). These suture materials are ideal for use in gastrointestinal surgery. Possible disadvantages include stiffness, a tendency to kink and prolonged absorbtion time.

Nonabsorbable suture
Nylon, Polypropylene. Monofilament, nonabsorbables are excellent suture materials for use in contaminated or infected surgical sites. They have a high tensile strength, are relatively inert in tissue, noncapillary, and do not act as a nidus for infection. These materials pass through tissue with essentially no tissue drag and have excellent knot tying security at sizes 3-0 to 5-0.

Silk, Mersilene, Bronamid, Vetafil. Multifilament nonabsorbable sutures should **NEVER** be used in gastrointestinal surgery. They may harbor infection for years and may result in suture related abdominal abscesses or draining tracts.

Suture size
For the majority of small intestinal surgical procedures in dogs, 3-0 or 4-0 size suture material is adequate; in cats, 4-0 is recommended. The tensile strength of this size suture is greater than the tensile strength of the tissues that are being sutured (i.e., intestinal wall). Larger size suture may contribute to anastomotic failure by increased trauma to tissues and its effect on the blood supply of tissue margins.

Needles
Swaged-on "atraumatic" reversed cutting, narrow taper point, or fine taper-cut needles can all be used for gastrointestinal surgery. The author prefers a narrow taper point needle. Needle diameter should approach the diameter of the suture.

Suture Placement
When suturing intestine, sutures should be placed 3 - 4 mm from the cut edge of the intestinal **serosa** and no more than 2 - 3 mm apart. It is important to recognize everted mucosa and be sure the 3 - 4 mm bite in the intestinal wall is not just in mucosa but engages all layers of the intestinal wall. Measure your intestinal wall bite from the cut edge of the serosa.

Suture Patterns

There is considerable controversy regarding specific suture pattern for use in small intestinal surgery. Everting, inverting, and appositional suture patterns have been used experimentally and clinically for suturing enterotomies and anastomoses. Appositional patterns are recommended as they cause little lumen compromise postoperatively.

Everting: Everting patterns (i.e., horizontal mattress) have been shown to encourage adhesions and result in lumen stenosis. This technique is **NOT** recommended. The everting technique is not to be confused with the mild eversion of mucosa that occurs in the appositional techniques described below.

Inverting: In small animals adequate lumen diameter is an important consideration with any technique. Inverting patterns result in substantial lumen compromise of the small intestine and are **NOT** recommended in dogs and cats.

Apposition: Anatomic apposition of individual layers of the bowel wall (i.e., mucosa, submucosa, muscularis, and serosa) result in primary intestinal healing. This technique is superior to inverting or everting techniques because apposition of intestinal margins eliminates lumen compromise. This is the authors preferred technique for suturing all hollow viscus organs in the abdominal cavity. Suture patterns of choice include:

1) Simple interrupted apposing. This technique involves suturing **all** layers of the intestinal wall and tying the knots on top of the serosa to approximate cut edges. The sutures should be tied tight enough to effect a watertight seal, yet not so tight as to blanch the tissue and cause ischemia of intestinal margins. This technique is simple, fast, reliable, and does not result in lumen compromise**.**

2) Simple continuous apposing. This technique is similar to the simple interrupted appositional technique however, a continuous suture pattern is used rather than an interrupted pattern. Advantages include a more efficient anastomosis, equal suture tension over the entire anastomosis, airtight-watertight seal, and mucosal eversion is minimized. This is the authors preferred suture pattern for suturing all hollow viscus organs in the abdominal cavity.

INTESTINAL ANASTOMOSIS: Intestinal anastomosis is indicated for resection of nonreducible intussusception, necrotic bowel wall secondary to complete intestinal obstruction, intestinal volvulus, stricture secondary to trauma, linear foreign body with multiple perforations, and intestinal neoplasia (e.g., leiomyoma, leiomyosarcoma, adenocarcinoma).

After a complete abdominal exploration, the affected length of bowel is delivered from the peritoneal cavity and isolated with the use of moistened laparotomy pads and crib towels. If possible, the intestinal anastomosis should be performed on a water resistant surface (e.g., plastic drape, crib towel) to prevent ‘strike’ through contamination.

Once the level of resection has been determined, the appropriate mesenteric vessels are identified and ligated, and the portion of intestine to be resected is isolated by clamping the bowel at a 60° angle away from the mesenteric border. This angle ensures adequate blood supply to the antimesenteric border.

Everted mucosa: Occasionally when the segment of intestine to be removed is amputated mucosa ‘everts’ from the cut edge of the intestinal wall making it difficult to visualize the cut edge of the serosa. If this occurs it is ‘highly’ recommended to excise the everted mucosa to enable the surgeon to easily visualize the cut edge of the intestinal serosa. It is vital that the surgeon engage at least 3 – 4 mm of intestinal wall with each suture to guarantee adequate bites in the collagen laden submucosa.

Bowel lumen diameters: In cases where the oral end of the bowel is dilated and the aboral end is normal size, several options exist to create intestinal lumens of equal diameter:

1) Increase the angle of resection on the smaller diameter segment of bowel (i.e., aboral segment). This will increase the orifice size by 5-10 mm depending upon bowel diameter (e.g., dog vs cat).
2) In larger lumen size discrepancies the antimesenteric border of the smaller diameter stoma can be incised longitudinally to enlarge the lumen diameter.
3) An end-to-side anastomosis can be performed by closing the larger diameter stoma of the intestinal resection with a single layer continuous apposing suture pattern then anastomosing the smaller diameter segment of bowel to an appropriate size enterotomy made in the antimesenteric border of the larger diameter segment of bowel.
4) The larger diameter segment of bowel can be made smaller in diameter by suturing its cut edge until its lumen is equal in size to the smaller diameter intestine (this technique is often used for subtotal colectomy in cats).

Intestinal Anastomosis Technique:
See the Practical Techniques on GI Surgery I surgery video for a detailed illustration of this technique (www.videovet.org).

When suturing an anastomosis, atraumatic handling of bowel wall and perfect anatomic apposition of incised margins is important. It is recommended to begin suturing at the mesenteric border as this allows adequate visualization of mesenteric vessels and helps prevent encircling these vessels when placing the first few sutures. Any of the appositional suture patterns previously described (i.e., simple continuous or interrupted) will result in a high success rate, both in the short-term (i.e., leakage, breakdown) and long-term (i.e., stricture, stenosis).

The following tips may prove helpful when performing an intestinal anastomosis (see the anastomosis video clip at www.videovet.org for detailed illustration of the surgery tips below):

1) First, place a stay suture to hold the mesenteric border of each segment of bowel in apposition. Tie this suture, leave the ends long, and place a hemostat on the suture end without the needle.
2) Place a second stay suture in the antimesenteric borders of each segment to be sutured to bring the ends of the intestinal segments into apposition. Place a hemostat on the ends of this suture.
3) Place gentle traction on the mesenteric and antimesenteric stay sutures to bring the two intestinal segments into apposition. Make certain the lumen diameters of each bowel segment are identical.
4) Using the needled segment of suture from the mesenteric stay suture, begin a simple continuous appositional anastomosis being careful to get a 3 - 4 mm bite relative to the cut edge of the serosa and placing each suture no more than 2 - 3 mm apart (2 mm apart in cats). When the anastomosis is complete, tie the suture to the mesenteric stay suture.
5) If a simple interrupted apposing suture pattern is used, be careful to get a 3 - 4 mm bite relative to the cut edge of the serosa and place each suture no more than 2 - 3 mm apart.
6) Evaluate the integrity of the anastomosis. The author's preference for evaluating the integrity of the anastomotic closure is to **visually** examine each suture to be certain that suture placement has met your strict criteria (i.e., sutures are no more than 2 - 3 mm apart and have a 3 - 4 mm bite in the submucosa).

Postoperative care
Intravenous fluids to maintain hydration and ensure renal function are continued postoperatively, until the patient begins to eat and drink. Intravenous fluids should then be tapered over a 24 to 48 hour period.

Feeding: Early return to enteral feeding is best for the overall health of the intestine. Feeding the postoperative gastrointestinal surgical patient is generrally based on the following criteria:
a) preoperative condition of the patient

b) the condition of the bowel at the time of surgery
c) surgical procedure performed (i.e., enterotomy, anastomosis, pylorectomy)
d) presence or absence of peritonitis
e) postoperative condition of the patient.
The earlier patients can be returned to oral alimenation the better.

Complications
The most common postoperative complication of small intestinal surgery is leakage; leak is either associated with breakdown of the anastomosis or improper surgical technique (i.e., improper suture placement, inappropriate suture material, knot failure, sutures to far apart, inappropriate bite in the collagen laden submucosal layer, suturing nonviable bowel).
A presumptive diagnosis may be accomplished by the following:
1) Body temperature (may be up if acute or down if moribund).
2) Abdominal palpation: periodic, gentle abdominal palpation for pain (gas or fluid?).
3) General attitude (depression-anorexia).
4) Incision: examination of the patients incision for drainage (look at cytology if drainage is present)
5) CBC: leukocytosis followed by leukopenia (sepsis), or a degenerative left shift may imply breakdown.
6) Glucose: low glucose generally implies sepsis (this occurs early in sepsis and may be used as a screening test).
7) Abdominal radiographs: generally not helpful, they are difficult to critically assess due to the presence of postoperative air and lavage fluid. It can take 1 - 3 weeks for peritoneal air to diffuse from the abdominal cavity after routine abdominal surgery. Time variation is dependant upon the amount of air remaining in the abdominal cavity postoperatively (i.e., large deep chested animal vs a small obese animal).
8) **Abdominal tap** (paracentesis): a four quadrant abdominal tap is accomplished by aspirating fluid using a 5cc syringe and 20 gauge needle or placing a plastic IV catheter into the peritoneal cavity and allowing fluid to drip onto a slide. This may be the most sensitive diagnostic test for determining the presence or absence of intestinal leak.
9) Peritoneal lavage (if paracentesis is not productive): infuse 10-20cc/kg of sterile physiologic saline solution into the abdominal cavity, then gently palpate the abdomen and repeat the four quadrant paracentesis. This technique increases the sensitivity of paracentesis to 90%.
Once fluid has been obtained, a smear should be stained and evaluated microscopically. Depending upon the cell types seen, a determination of the presence of leakage can be made.

Below are examples of expected cytology in patients with and without leak.
1) Healthy PMNs with few degenerate PMNs and a moderate number of red blood cells: This cytology may be expected in any postoperative abdominal procedure (e.g., OHE, abdominal exploratory, cystotomy). Your index of suspicion for anastomotic breakdown should be low. However, if clinical signs continue to deteriorate, repeat paracentesis (2 - 3 times daily, if necessary) to determine the "trend" of the abdominal fluid cytology is recommended.
2) Healthy polymorphonuclear leukocytes with bacteria located intra or extracellularly, degenerate PMNs with intracellular bacteria, free bacteria, or food particles--imply breakdown. Exploratory laparotomy is indicated.

In a recent morbidity/mortality study of patients undergoing intestinal surgery it was found that animals requiring a second abdominal surgery to treat intestinal disorders were less likely to survive than patients requiring only one laparotomy. Also, the longer it took to determine whether or not intestinal leakage had occured the less likely the patient would survive reoperation. **The take home message is:** pay attention to detail during the first surgery and if a leak occurs, diagnose it and treat it as soon as possible.

Prognosis The overall prognosis for uncomplicated GI surgery is excellent. The surgeon must pay attention to detail when suturing any hollow viscus organ with liquid contents.

UROABDOMEN

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If you would like the video DVD of this surgical procedure, go to **www.videovet.org** or contact **videovet@me.com**.

Ruptured Bladder

Trauma to the urinary bladder is relatively common in veterinary patients. It often results in uroperitoneum (uroabdomen) that is associated with severe metabolic and multisystemic disturbance which can be fatal if not treated urgently but appropriately.

Blunt abdominal trauma (vehicular is the most common cause) and direct injury from pelvic fractures are the most common reasons for injury to the bladder in dogs. In cats, blunt abdominal trauma, injury during catheterization and rupture during bladder palpation are the most common causes of urethral and bladder rupture. Other reasons include urethral obstruction, erosive neoplastic lesions, or penetrating abdominal wounds. The most common site of urinary tract trauma is the bladder. The apex is most often the site of rupture although any part of the bladder can be affected especially when pelvic fractures are the cause.

Patients with a ruptured bladder often do not show clinical signs immediately after injury. However over the subsequent 24-48 hours patients often become dehydrated and begin to develop metabolic and electrolyte disturbances that can become severe and life threating. As urine accumulates in the peritoneal space a chemical peritonitis ensues which, if sterile, is not immediately life-threatening but causes abdominal pain and ileus. Urine is hyperosmolar to the extracellular fluid. This results in a net flux of fluid across the peritoneal membrane. Third-spacing of fluid in the peritoneal cavity along with decreased intake and often increased losses due to vomiting leads to severe dehydration. Hyperkalemia and azotemia develop as peritoneal potassium and urea equilibrate rapidly with extracellular fluid. Metabolic acidosis often develops due to decreased excretion of hydrogen ions in urine and progressively worsening hypovolemic shock.

Rapid diagnosis of urinary tract injury is vital. Aggressive emergency management of associated metabolic abnormalities to stabilize the patient should be performed prior to definitive surgical repair.

DIAGNOSTIC CRITERIA

History

Gender predisposition: Male dogs are predisposed to traumatic bladder rupture because the longer, less distensible male urethra is more able to withstand elevated intravesicular pressure. In cats there is no sex predisposition. There are no known age or breed predispositions

Physical Examination Findings

Lethargy, anorexia, dehydration, abdominal pain, ascites, hypothermia, other signs of traumatic injury

Laboratory Findings
azotemia, hyperkalemia, metabolic acidosis, hyperalbuminemia, increased hematocrit, neutrophilia

Fluid analysis: Samples of abdominal fluid can be obtained by abdominocentesis or diagnostic peritoneal lavage.

Collection of Peritoneal Fluid Sample:
Abdominocentesis – this technique is successful in the majority or cases.
The patient is positioned in lateral recumbency
An area is clipped and aseptically scrubbed along the ventral midline approximately 10x10cm
Insert a 20 or 22 gauge 1½ inch needle on a 3 or 6ml syringe 1cm caudal to the umbilicus and just off the midline (avoiding the falciform ligament)
Aspirate gently and collect samples for fluid analysis, cytology and microbial culture and sensitivity testing
Multiple quadrant abdominal taps can be performed if the above is unsuccessful
If one site yields a fluid sample the other taps are abandoned.

The fluid recovered can be a transudate, modified transudate or exudate depending on the chronicity and whether concurrent sepsis is present. Comparison of creatinine and potassium concentrations in peritoneal fluid and serum are the most reliable tests for confirming uroabdomen in dogs and cats. Because of the large molecular size of creatinine it diffuses only slowly across the peritoneum into the extracellular fluid. A significant gradient is established between abdominal fluid and serum, detection of which is a sensitive and specific test for uroabdomen. A similar gradient exists with potassium. Patients with creatinine and potassium levels in their abdominal fluid that are slightly to markedly higher than in their serum are very likely to have a uroabdomen. Reported ratios of abdominal fluid to serum creatinine concentrations in dogs with uroabdomen are a mean of 5:1 and in cats a mean of 2:1. The same ratio for potassium in dogs is reported to be a mean of 2.5:1 and in cats a mean of 1.9:1

Plain abdominal radiography: The bladder may or may not be visible in patients with bladder rupture as small leaks will still allow distension of the bladder to some degree. Loss of abdominal detail will occur due to fluid accumulation which will worsen with time. Evidence of an underlying cause may be obvious such as pelvic fractures or cystic or urethral calculi.

Contrast radiography: Care should be taken administering contrast agents to dehydrated or azotemic patients as renal insult can result. Patients should be fully stabilized before undergoing these studies. Positive contrast retrograde urethrocystography is the contrast study of choice in patients with bladder rupture and should be the first radiographic study performed. It is easy to perform and allows confirmation of the diagnosis and location of the site of leakage in the lower urinary tract in most cases. Fluoroscopic visualization during contrast injection is helpful as it aids in early detection of the site of leakage. If not available plain radiography can confirm

leakage but dispersal of contrast material may obscure the origin of the leakage somewhat. If sufficient intravesicular pressure is not achieved during contrast injection false negative results may be seen especially with small tears and in unusual cases where the lesion has self sealed. As leakage of urine from the upper urinary tract cannot be detected with a retrograde cystourethrogram an intravenous urogram should be performed especially if no lesions were found during the first study.

Abdominal ultrasonography: Ultrasound examination should detect fluid accumulation in the peritoneal space and can be used to guide abdominocentesis. It may also help identification of underlying bladder pathology, calculi and other possible causes of uroabdomen such as renal, ureteral and urethral lesions.

Differential Diagnoses

Leakage or urine from a location other than the bladder can usually be ruled out with contrast studies of the upper and lower urinary tract such as a retrograde urethrocystogram and an intravenous urogram.

Other causes of acute abdomen can usually be ruled out by abdominocentesis, radiographic and/or ultrasonographic examination.

TREATMENT RECOMMENDATIONS

The aim of initial treatment is pre-surgical patient stabilization. Principal areas of concern are azotemia, electrolyte and acid-base disorders, and cardiac arrythmias that result from severe hyperkalemia.

Drainage of urine from the abdomen is the next most important step. This can be achieved with a percutaneous placement of a peritoneal lavage catheter (feeding tube, Jackson Pratt drain, etc). Use of an indwelling urethral catheter or tube cystostomy is helpful in decreasing the amount of urine entering the peritoneal space from the bladder.

Surgical management is ultimately required in most cases. However, uroabdomen is a medical and not a surgical emergency. Patients operated on prior to adequate stabilization are likely to experience life threatening intraoperative and post operative complications.

Initial Treatment

Intravenous fluid therapy: Fluids should be administered upon admission. An isotonic saline solution (0.9% NaCl) is the fluid of choice. Volume of fluid given is judged by degree of hypovolemia and is made on a case by case basis.

Treatment of hyperkalemia: Mild hyperkalemia will often resolve with fluid diuresis alone. More severe hyperkalemia (> 7mEq/L) may be associated with cardiotoxicity and specific treatment should be considered.

Cardiac monitoring: Continuous ECG monitoring is recommended. Most cardiac abnormalities are related to hyperkalemia and will resolve once normokalemia is re-

established. Typical changes are absent or flattened P waves, prolongation of the P-R interval, widened QRS complexes, spiked T waves and bradyarrythmias. ECG abnormalities however are not consistent and it should not be assumed that hyperkalemia is absent if the ECG is normal or vice versa.

Analgesia: Pain relief should be instituted early as chemical peritonitis is very painful. Opioid analgesics are most commonly used such as morphine, hydromorphone, or buprenorphine.

Antibiotics: Intravenous antibiosis should be instituted. A first generation cephalosporin such as Cefazolin is an appropriate empirical choice.

Surgical Management

Exploratory Laparotomy: A xyphoid to pubis exploratory laparotomy is performed. Patients that present with a ruptured bladder have sustained enough trauma to result in concurrent visceral organ injury thus a complete abdominal exploratory is recommended. Any rents in the bladder are identified and the area debrided of necrotic or damaged tissue. The bladder is sutured with one layer simple continuous or simple interrupted suture pattern using a synthetic absorbable suture (such as 3-0 or 4-0, Capryson, Monocryl, Biosyn Dexon, Vicryl, Polysorb) in an appositional pattern. No attempt is made to invert the incision. Copious lavage of the peritoneal cavity is performed with body temperature sterile physiologic saline solution followed by routine abdominal closure. If bladder wall integrity is of concern post-operatively an indwelling urethral catheter can be left in place for 24-48 hours to allow decompression but is not mandatory.

Supportive Treatment

Intravenous fluid therapy with an isotonic saline solution should be administered post-operatively depending on the patient's hydration status. This should be maintained until the patient is drinking.

Antibiotic therapy: If the abdominal effusion was sterile it is not necessary to continue antibiotic therapy beyond the intraoperative period. However if septic effusion was detected antibiotic therapy based on the results of culture and sensitivity should be continued for at least two weeks.

Analgesia: Appropriate opioid analgesia should be continued post-operatively for at least 48 hours.

Gastric protectants: Uremic gastritis may cause vomiting and ulceration. Treatment with an H2 receptor antagonist or proton pump blocker should be considered.

Patient Monitoring

Repeat serum biochemical analysis should be performed post-operatively to demonstrate resolution of azotemia, electrolyte imbalances and acid-base abnormalities. Urinary leakage post-operatively is a potential complication and should be diagnosed promptly if present. Failure to recover from surgery uneventfully, persistence of azotemia or hyperkalemia and recurrence of abdominal distension should alert the clinician to a possible problem.

Continuous ECG monitoring should be performed until complete resolution of all cardiac abnormalities.

PROGNOSIS
In general prognosis after bladder rupture is excellent if diagnosis and treatment are prompt.

Favorable Criteria
Simple rents in the apex of the bladder are easy to close. In cases where bladder wall damage is extensive or in ruptures secondary to avascular necrosis of the bladder wall prognosis is less favorable.
Patients systemically stable prior to surgery that can be taken promptly to surgery are likely to make an excellent recovery.

Unfavorable Criteria
Surgical intervention prior to reversal of the patients metabolic derangement.
Presence of septic peritoneal effusion.
Significant delay in time to diagnosis and treatment may adversely affect outcome.
Severe concurrent traumatic injuries.

Recommended Reading

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