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Table of Contents

Geraldine Hunt     University of California, Davis

Esophageal Surgery ........................................................................................................... Page 4
Anatomy Worth Knowing: Avoiding complications in the Thorax and Abdomen ............. Page 7
Extrahepatic Portosystemic Shunts ................................................................................ Page 9
Lung Lobe Resections: Staple, Suture or Scope ............................................................... Page 12
Urethral Surgery: Stones, Strictures and Salvage ......................................................... Page 16
The Retroperitoneum: The Forgotten Space ................................................................. Page 19
Gastric Surgery ................................................................................................................ Page 21
Liver Biopsy ........................................................................................................................ Page 25
The Sick Gallbladder: When to Cut? .............................................................................. Page 27
Surgery of the Biliary Tree .............................................................................................. Page 30
Ovariecotmy versus Ovariohysterectomy: Open versus Closed .................................. Page 34

Bryden J. Stanley     Michigan State University, East Lansing, Michigan, USA.

Do Internal Obturator Flaps ever fail? .......................................................................... Page 38
Urethral Sphincter Mechanism incompetence – Anything other than Colposuspension?... Page 43
Better News for Chylothorax? ........................................................................................ Page 48
Tips and Tricks for Perineal Urethrostomy ................................................................. Page 51
Kidney and Ureteral Stones – What are the Options? ................................................. Page 53
Relaparotomy – When to go back in? .......................................................................... Page 56
Principles of Intestinal Surgery .................................................................................... Page 61
Complications of Intestinal Surgery .............................................................................. Page 64
What Drain for the Septic Abdomen? ......................................................................... Page 67
Abdominal Bite Wounds and Penetrating Trauma Cases ............................................ Page 69
Caesarian .......................................................................................................................... Page 75
Maurine Thomson     Veterinary Oncology Specialists, VSS, Brisbane.

Chest wall, Pleural Space, and Mediastinal Challenges ..................................................Page 79
Complications with Routine Bladder Surgery .................................................................Page 86

Abstracts

Septic Peritonitis in a Dog involving Candida albicans.  Katie Petrie.........................Page 89
Results of Surgical Treatment Intervertebral Disc Disease.  W Park, D Cook, P Moses....Page 90
Coarse Fractionated Radiation Therapy for the Treatment of Microscopic Canine
Soft Tissue Sarcoma.  M Kung, V Poirier, M Dennis, D Vail, R Straw...............................Page 91
Developmental Anogenital Abnormality: A Case Report of Hypospadias and Bifid
Scrotum in a 16 week old British Shorthair  William Basuki........................................Page 92
Temporary Transarticular Stifle External Fixation in Dogs and Cats: 20 Cases
JM Kolichis, CA Preston ......................................................................................................Page 93
Small Intestinal Foreign Bodies: A Retrospective Study of 212 Cases.  JSM Kim............Page 95
Association between Clinical Outcomes with Epidural Methoprednisolone Infiltration
And Magnetic Resonance Imaging Findings in Dogs with Lumbosacral Degenerative
Stenosis.  J King, D Cook, P Moses, P Gilbert, J Lunn, S Davies ........................................Page 96
Contouring Standard Tibial Plateau Leveling Osteotomy Plate and Proximal Load Screw
Effect of TPLO on Patellar Tendon Angle: A Prospective Clinical Study.
S Sathya, P Gilbert, J Campbell.............................................................................................Page 99

Glenn Edwards     School of Animal and Veterinary Sciences, Charles Sturt
University, NSW.

Intestinal Resection: Small vs Large..................................................................................Page 100
Pyometron: Successful Post-op Care ................................................................................Page 105

Peter Gilbert     Veterinary Specialist Services, Brisbane, Queensland.

Abdominal Wall Hernias .....................................................................................................Page 107
Prostatic Cysts and Abscesses ..........................................................................................Page 108
ESOPHAGEAL SURGERY

GB Hunt

University of California – Davis

The esophagus is frequently involved in disease processes, but surgeons are traditionally reluctant to tangle with it, due to its relative inaccessibility and reputation for poor wound healing. This reputation is probably based more on theoretical concerns about its blood supply, wall structure and intrathoracic location than on a large body of clinical experience. Diseases that may warrant esophageal surgery include foreign bodies (including stick injuries), masses, strictures, esophageal compression secondary to vascular ring anomalies, and megaesophagus. The main goal of this lecture is to describe the ways in which anatomy impacts the surgical approach and repair of the esophagus, and discuss tips for maximizing success.

The following includes quotes (in italics) and modifications from Miller's Anatomy of the Dog (3rd ed) ed. Howard E. Evans, Saunders.

“The esophagus traverses most of the neck and all of the thorax, and ends on entering the abdomen, it is divided into cervical, thoracic, and abdominal portions. It begins dorsal to the cricoid cartilage. A plicated ridge of mucosa, the limen pharyngoesophageum, most prominent ventrally, denotes the junction between the pharynx and the esophagus.”

This ridge can be seen on careful pharyngoscopy, and can be over-developed in some dogs, leading to dysphagia and intermittent respiratory obstruction.

The cervical esophagus travels between the longus colli muscles and the trachea in the cranial neck, then trends to the left (in most cases) until it reaches the thoracic inlet. In some brachycephalic dogs, the esophagus forms a distinct sacculation at the thoracic inlet. On the left side, the left common carotid artery, vagosympathetic nerve trunk, internal jugular vein, and tracheal duct run in the angle between the esophagus and the longus capitis muscle.

The thoracic esophagus extends from the thoracic inlet to the esophageal hiatus of the diaphragm. At first, it usually lies within the cranial mediastinum to the left of the trachea. For this reason, the cranial-most portion of the thoracic esophagus is best approached from a left lateral thoracotomy. In some brachycephalic dogs, the esophagus forms a distinct sacculation at the thoracic inlet. On the left side, the left common carotid artery, vagosympathetic nerve trunk, internal jugular vein, and tracheal duct run in the angle between the esophagus and the longus capitis muscle.

The aorta (if normally positioned) ascends the left side of the esophagus between the fifth and ninth thoracic vertebrae, and then progressively separates from it so that the two structures are about 3 cm as they approach the diaphragm. In a dog with a vascular ring anomaly such as persistent right aortic arch, the aorta ascends on the right hand side of the esophagus, with the ligamentum arteriosum present on the left side. Due to the often voluminous esophageal sacculation orad to the vascular ring, it can be difficult to distinguish the ligamentum arteriosum as it is indented into the wall of the esophagus, and sometimes even incorporated within its layers.

The left and right vagal nerves pass on either side of the esophagus until the tracheal bifurcation, where they each split into dorsal and ventral branches. The two dorsal branches (left and right) pass dorsocaudally along the sides of the esophagus and unite with each other dorsally, 2 to 4 cm cranial to the esophageal hiatus, and run into the abdomen as a single trunk. Similarly, the right and left ventral branches of the vagi unite immediately caudal to the
root of the lungs to form the ventral vagal trunk. This trunk is initially in contact with the esophagus, then moves ventrally in a fold of mediastinum as it passes through the esophageal hiatus just below the esophagus.

The **abdominal portion** of the esophagus ends at the cardia of the stomach, approximately level with the last thoracic vertebra.

**Esophageal Wall**

The esophagus varies in both diameter and wall thickness along its course. It is thicker in the cervical portion (about 4 mm in thickness) than in the thoracic portion, 2.5 mm. It is thickest in the abdominal portion (about 6 mm where it joins the stomach).

The least distensible parts occur at both its beginning and its end, and as it passes through the thoracic inlet.

The esophagus has four distinct layers: fibrous, muscular, submucosa, and mucosa. “In the cervical region, the **fibrous coat, or adventitia** (tunica adventitia), blends with the deep cervical fascia (prevertebral fascia) dorsally and on the left, and with the fascia which forms the carotid sheath on the right. The adventitia of the thoracic and abdominal portions of the esophagus blends with the endo Thoracic and the transversalis fascia, respectively. It is largely covered by pleura in the thorax and with peritoneum in the abdomen. Where the esophagus is not covered by serosa, its adventitia blends with that proper fascia of the organs with which it comes in contact.”

The lack of serosa for much of its length is postulated as a reason for poor esophageal wound healing, possibly because the tissue does not hold sutures as securely as other portions of bowel, or because the serosal layer is not present to take tension away from the muscular and submucosal suture layers.

The **muscular layer of the esophagus** is essentially two oblique layers; the external and internal and form a spiral. They continue onto the stomach.

The **submucosa** loosely connects the mucous and the muscular coats. It allows the relatively inelastic mucous coat to be thrown into heavy longitudinal folds when the esophagus is contracted. The **mucosa** is composed of a superficially cornified, stratified squamous epithelium. The combined mucosa/submucosa is a thick, tough layer that holds sutures well.

**Vasculature of the Esophagus**

The vasculature of the esophagus is another (and perhaps more likely) reason for its variable wound healing in comparison to the small bowel, for instance.

The arteries to the cervical portion of the esophagus are primarily twigs from the cranial and caudal **thyroid arteries**. There is potential communication between these small vessels in the mid-portion of the cervical esophagus, but in the even that one is damaged, the esophagus is dependent on blood supply from the other. If this is quite distant to the site of injury, that portion of esophagus is at risk of poor perfusion (and hence poor wound healing).

The cranial two-thirds of the thoracic esophagus is dependent on perfusion from the esophageal branch of the **bronchoesophageal artery**. The remaining part is supplied by esophageal branches of the aorta and/or **dorsal intercostal arteries**, and the terminal portion is supplied by the esophageal branch of the **left gastric artery**. Damage to, or obstruction of the bronchoesophageal artery may therefore render a portion of the esophagus avascular, leading to a disastrous surgical result.
Esophageal Innervation

The cricopharyngeal muscle and the cervical portion of the esophagus are supplied with motor fibers from the small **pharyngoesophageal nerve**, a branch of the vagus. There may be some innervations from the recurrent laryngeal nerves.

“It is probable that the recurrent laryngeal nerves carry the afferent (Chauveau, 1886) and some motor fibers to the cervical portion of the esophagus as well as providing both the motor and sensory nerve supply to the thoracic part as far caudally as the heart. The dorsal and ventral branches of the vagi and the vagal trunks they form supply the esophagus caudal to the heart.”

This anatomical feature highlights the importance of evaluating esophageal function in patients with laryngeal paralysis, especially if a laryngeal tieback is being considered.

Surgical Tips And Tricks

1. Try to avoid extensive dissection around the esophagus that might damage either nerve or blood supply.
2. Remember that the esophagus is very distensible (like the stomach) so that the distance between individual single interrupted sutures might stretch considerably and allow for leakage. A continuous suture might be preferable for this reason, although it would not be a good option for a 360 degree repair, as it would impede distention of the esophagus during passage of a food bolus.
3. The esophagus’s distensibility is also helpful, as it allows for placement of more than one suture layer, and allows room for placement of an inverting layer in the muscularis (such as a Cushing suture), if you desire a more robust closure.
4. Making longitudinal esophageal incisions may be better than transverse ones for the above reason.
5. In addition to its wall layering, and somewhat tenuous blood supply, the final feature of the esophagus that may impact wound healing is the fact that, being extra-abdominal, the omentum is not available to support the repair. Bringing the esophagus through a small diaphragmatic defect might be helpful in some cases, particularly with lesions in the caudal portion of the thorax.
6. Be proactive about postoperative support like gastrostomy tube feeding in a patient with esophagitis or ulceration following foreign body retrieval, for instance. Prophylactic administration of antacids and gastroprotectants. Lavage the esophagus with saline if there is any evidence of intraoperative regurgitation/reflux.
ANATOMY WORTH KNOWING: AVOIDING COMPLICATIONS IN THE THORAX AND ABDOMEN

GB Hunt

University of California, Davis

We often take our knowledge of anatomy for granted. We learned anatomy at Vet school, we’ve been in practice for years, but we can still be surprised (sometimes unpleasantly) when we run into something we can’t identify or find ourselves in territory that we don’t know very well. The goal of this lecture is to highlight some anatomical features of the thorax and abdomen that might come in useful one day.

Thorax

The sternum starts with the manubrium and ends with the xiphoid. The sternocleidomastoid muscles insert onto either side of the manubrium. Splitting between these allows easy access to the trachea and esophagus at the base of the neck. The cranial mediastinum can also be explored through this approach, especially if the manubrium is separated. However, when dissecting deep (dorsal to the manubrium) in this area be cautious of the paired common carotid arteries that arise from the brachiocephalic trunk. Likewise, the external and internal jugular veins coalesce in the cranial thorax to form the brachiocephalic vein. This can become quite compressed if the surrounding tissues are stretched apart, and appear like a fascial shelf. Needless to say, dissecting through this “fascia” can have serious consequences.

As you move caudally in the chest, remember the main relationships between the esophagus, trachea, aorta and pulmonary arteries. A normally-positioned aortic arch sweeps up the left side of the mediastinum, with the trachea and esophagus situated to the right. The paired pulmonary arteries divide on either side, and the pulmonary veins likewise travel on either side at the base of the heart. This somewhat complex arrangement means that a surgical approach to the trachea or esophagus should be carefully planned and is not always totally intuitive.

The accessory lung lobe can be a little misleading. It is a lobe of the right lung, but is positioned on the midline in the caudal thorax and thus sits between the left atrium and the diaphragm. Although masses of the accessory lobe may appear to sit more towards the left, they must be accessed through a right thoracotomy approach.

The costo-diaphragmatic recess is the potential space in the caudal thorax between the thoracic wall and the diaphragm, and is lined by pleura. The lungs protrude partially but not completely into the recess, which means that the thoracic cavity can be entered at a site that is not normally occupied by lung. The presence of the costo-diaphragmatic recess is exploited when removing masses of the caudal ribs, and the diaphragm can easily be advanced and sutured in a more cranial position without much compromise of lung volume and hence ventilation.

At the junction between the thorax and abdomen, the rectus abdominus muscles (and linea alba) connect with the caudal sternum. It seems intuitive to think that the linea alba inerts onto the xiphoid, but this is not the case. The linea fuses with the caudal extent of the deep pectoral muscle, and is anatomically separate from the xiphoid. Thus it is possible to completely divide the linea alba ventral to the xiphoid without cutting the cartilaginous caudal edge of the xiphoid, or interfering with the attachments of the diaphragm on either side of the xiphoid. In this way, the cranial abdominal incision can be widely opened without risk of perforating the diaphragm. Conversely, if the cranial abdominal incision is extended by cutting lateral to the xiphoid, it is easy to accidentally enter the thorax.

Abdomen

The diaphragm consists of two muscular portions (crurae) that attach by tendinous ligaments to the spine and epaxial muscles on either side of the aorta (this will be described more completely in the lecture on the Retroperitoneal Space. The crus of the diaphragm attach to the costal arch and lateral xiphoid. The esophagus passes between the
crura of the diaphragm (ventral to the aorta). The portion of diaphragm between the two muscular crurae is tendinous, and the caudal vena cava passes through it’s own foramen in the right portion of the tendinous diaphragm.

Close to these tendinous origins of the crurae, bilateral fascial sheets (the triangular ligaments) attach the left lateral and right lateral lobes of the liver to the diaphragm. The diaphragm is more closely attached to the liver on the right and centrally, due to the location of the caudal vena cava. The left lateral lobe can be mobilized by dividing the left triangular ligament, allowing access to the left crus of the diaphragm and esophageal hiatus.

The gastrohepatic ligament is another region of the abdomen that contains a number of structures and might therefore be confusing. It consists of the loose tissue of the lesser omentum, and also contains the common bile duct, the portal vein and the hepatic artery. These can be identified and distinguished from one another. Because of their close association, it is also possible to temporarily occlude all blood flow into the liver by clamping the vessels as they travel toward the porta hepatis (hilus of the liver).

Another attachment within the abdomen that can be both helpful and frustrating is the duodeno-colic ligament. It does not contain blood vessels and can be divided in order to mobilize the caudal duodenal flexure, which is otherwise quite difficult to evaluate and manipulate. Due to the fact that the small intestine is suspended from the root of the mesentery, it is also possible to lift the entire small bowel and relocate it to visually follow the duodenum all the way from the descending portion, through the caudal flexure, into the ascending portion and its attachment to the jejunum.

The ileum has an important role in absorption of cobalamin (Vit B12). Dogs and cats with serious disease or resection of the ileum require parenteral supplementation and cobalamin levels should be checked in these patients.

Other important associations that can be important include the proximity of the cranial mesenteric artery and left adrenal gland. The cranial mesenteric artery should be identified and protected during dissection of adrenal gland tumors, or other masses in that region (such as foreign body granulomas). The cranial mesenteric artery is the sole arterial supply to the jejunum.

The caudal mesenteric artery is found within the mesocolon just cranial to the pubis. It branches into the left colic artery (which supplies the distal colon) and the cranial rectal artery. Ligation of the caudal mesenteric artery when resecting the distal colon reduces blood flow to the anastomotic site substantially, and may predispose to stricture formation, dehiscence or necrosis in the dog.

Although practicing veterinarians need little reminder of the anatomy of the ovary and uterus, it can be helpful to remind students or new graduates that the suspensory ligament and ovarian blood vessels occupy different portions of the mesovarium. The suspensory ligament is a thickening of the cranial edge of the mesovarium and runs craniodorsally to the retroperitoneum, whereas the vessels ascend in the loose fat more caudally within the pedicle. If the ovary is drawn ventrally (out of the incision) and caudally, the suspensory ligament is separated from the ovarian vessels. The more dorsally the suspensory ligament is broken (ie deeper within the abdomen), the less likely it is to also damage the ovarian vessels. Remember that there is a small vessel that communicates between the uterine artery and the ovarian artery. One end of this vessel is usually ligated with the ovarian pedicle, but when the vessel is transected as the mesometrium (broad ligament) is cut, it may back-bleed substantially from the ovarian end of the uterine horn before the uterine arteries are also ligated.

Reference

EXTRAHEPATIC PORTOSYSTEMIC SHUNTS

GB Hunt

University of California-Davis

Congenital portosystemic shunts (CPS) occur as a result of an error in embryonic development where primordial vessels either develop abnormal connections, or fail to undergo atresia. Many breeds have been reported as predisposed around the world, the most notable being a number of terriers (Yorkshire, Cairn, Maltese, Jack Russell), Chihuahuas, miniature schnauzers, pugs, toy poodles, Australian cattle dogs, Labrador and Golden retrievers and Irish Wolfhounds. In general, extrahepatic shunts are more common in terriers and other small breed dogs, whereas intrahepatic shunts are more common in medium to large-breed dogs. However, exceptions occur (eg Toy and Miniature poodles) and some form of shunt imaging is recommended prior to surgical exploration. Patients from breeds that are not known to be predisposed to CPS are more likely to “break the rules”, and should be evaluated especially carefully.

Surgical Therapy

The goal of surgery is to identify the shunt and attenuate it. As most patients have poorly developed hepatic portal circulation, and relatively high portal vascular resistance, total immediate occlusion of the shunt is highly likely to result in life-threatening portal hypertension. Therefore, surgical methods aim either to provide partial occlusion (which may be increased in stages by subsequent procedures) or application of a device to promote slow occlusion. The goal of slow or stage occlusion is to allow the intrahepatic portal circulation time to regenerate, with reduction in vascular resistance, at the same time as the shunt is being slowly or incrementally occluded. The main techniques used for slow occlusion of extrahepatic shunts are cellophane bands and ameroid constrictors. Cellophane bands promote occlusion by stimulating a foreign body reaction and fibrosis between the band and the shunt wall. Ameroid constrictors produce some mechanical occlusion as the ameroid clay takes up fluid, but also cause local inflammation with fibrosis and thrombosis of the shunt vessel. Recent reports have described the use of a variety of other clear films for shunt occlusion in dogs and cats, including polypropylene and polyethylene. These seem to be as effective as cellophane, probably due to the chemicals incorporated during the manufacturing process.

Peri-operative Monitoring and Treatment

Serum glucose concentration should be monitored regularly due to the tendency for hypoglycemia. Albumin levels may drop markedly when intravenous crystalloid is administered at surgical rates, and plasma transfusion is often required. Hemodynamic parameters should be measured regularly during and following surgery to gauge trends, and allow early detection of developing portal hypertension. Patients can be severely polyuric prior to surgery and may require increased maintenance fluid rates to avoid dehydration postoperatively. Potassium supplementation may be required.
Complications of surgery

The major life threatening complications are portal hypertension and postligation neurological dysfunction. The incidence of portal hypertension has been greatly reduced by adoption of the slow occlusion techniques, and publication of guidelines for safe shunt attenuation. Mild to moderate portal hypertension may not cause life-threatening problem; affected patients may have inappetance or diarrhea for a short period of time, or develop ascites. Assuming they are able to compensate hemodynamically for the reduced central venous return, and the bowel does not become critically hypoxic, they will eventually develop acquired shunts and a consequent return of portal pressure towards normal. Early published reports suggest that up to 20% of patients can be expected to develop acquired shunts, but more recent studies, in which patients underwent postoperative evaluation using DPCTA, showed that the incidence is probably less than 10%, with an additional 10% of patients experiencing ongoing shunting as a result of malplacement, or failure of the attenuating device to promote complete occlusion. Postoperative neurological sequelae range from blindness or muscle twitching, through disorientation, to generalized motor seizures and status epilepticus. Hypoglycemia and hepatic encephalopathy may also produce signs that can be difficult to distinguish from true postligation neurological dysfunction (PLND). In addition, patients experiencing seizures preoperatively may continue to have seizures postoperatively if the seizures were caused by something other than their CPS.

Hypoglycemia, hepatic encephalopathy and the seizures of idiopathic epilepsy should be manageable by evaluating the patient and relevant blood work, and treating accordingly. Post-ligation neurological dysfunction seizures and status epilepticus constitute a much more serious problem with a guarded prognosis. Pre-operative treatment with phenobarbitol and levetiracetam (Keppra, UCB pharmaceuticals Inc, GA) has been shown to significantly reduce the incidence of seizures, although published reports and anecdotal experience suggest that the risk is not completely abolished.

Hepatic disease is a risk factor for abnormal wound healing, with a delay in development of wound strength. Skin sutures should be left if for at least 2 weeks following major surgery in these patients to reduce the risk of late dehiscence.

Therapeutic Decision-making

In light of the fact that many patients have mild clinical signs, and surgical shunt attenuation has a significant morbidity/mortality rate, owners are sometimes faced with a difficult choice between long-term medical management and surgical correction. Some dogs live apparently normal lives with no management at all, whereas others develop severe clinical signs within the first few months of life. On risk-benefit analysis, a young puppy with obvious hepatic encephalopathy is more clearly a candidate for surgery than an 8 year old dog in which CPS is detected on a routine wellness check. An exception would be the older male dog in which CPS is diagnosed following urethral obstruction with ammonium urate calculi. Medical management in these patients may not control stone formation, and as urethral obstruction is, in itself, potentially life-threatening, many owners will opt for surgical correction of the CPS. Likewise, patients with severe polyuria/polydipsia may be generally happy, but present unacceptable management issues, making surgery an attractive option.
Many dogs with severe clinical signs will become near-normal on medical management, prompting the owners to question the necessity for surgery. The choice then is between lifelong dietary management and other therapies, weighed against a high probability for return of liver function to normal following CPS attenuation.

**Prognosis**

The mortality rate following correction of CPS is less than 5%. Up to 80% of patients receiving slow occlusion devices for extrahepatic CPS can be expected to regain normal liver function, with a median survival of 152 months. (Falls etc). The mortality and morbidity rate are higher for surgical correction of intrahepatic shunts, and for cats with CPS of any anatomical type, and the chance of return to liver function is lower than for dogs with extrahepatic CPS.

The prognosis for patients undergoing PTCE has not yet been established definitively, however, early reports suggest that the mortality and morbidity rate is low, and patients are highly likely to show substantial clinical improvement, although complete closure of the shunt is unlikely.

Regardless of the technique used, the clinical impact of residual flow through the original shunt has yet to be determined. Intuitively, a reduction in shunt fraction should improve hepatic function, however, the actual shunt fraction at which a patient might resume a normal diet and not show clinical signs is not known.

Approximately 10% of patients will never return to normal liver function even following complete shunt occlusion and will likely require lifetime medical management, although interestingly they are often less severely affected clinically once acquired shunts have developed than they were with a single shunt.

**Reference**

LUNG LOBE RESECTIONS: STAPLE, SUTURE OR SCOPE?

GB Hunt
University of California, Davis

Lung lobe resection is indicated in a number of different circumstances, including spontaneous pneumothorax, migrating foreign bodies, neoplasia, pneumonia and lung abscessation, lung lobe torsion, trauma and bullous emphysema. Radiographic features may be very similar regardless of etiology and hence it is important to have a logical plan to decision-making, which includes signalment, history, results of diagnostic testing, and a knowledge of the most likely diseases and outcomes.

Diagnosis is based on clinical signs, results of diagnostic imaging (including observations at surgery), and histopathology. Published evidence shows that while radiography has excellent specificity for detecting spontaneous pneumothorax and lobar lung diseases, it is less sensitive for identifying lung lesions than CT, which is now considered the diagnostic imaging modality of choice.\(^1\) CT is also very helpful in identifying additional lesions (eg metastases to lung and tracheobronchial lymph nodes) and differentiating disease of the thoracic wall and mediastinum from lesions situated within lung lobes. The success of radiography and CT is dependent on inflation of the lung lobes. Atelectasis can mask a variety of disease processes. Despite its reported utility, there remain many situations in which CT is of limited assistance, where visualization at surgery and histopathology is required to characterize the type of lung disease. Thoracic sonography can be helpful in patients with masses that directly abut the chest wall, and in patients with thoracic effusion, but it is of limited utility if the mass is surrounded by inflated lung or the patient has pneumothorax.

Pertinent surgical anatomy

The dog and cat have 7 lung lobes, divided into right and left sections. The left lung includes the cranial and caudal portion of the left cranial, and the left caudal lung lobe. The right lung includes the right cranial, right medial, right caudal and accessory lung lobe. It is possible to remove the entire left lung, however, removal of the entire right lung is likely to result in pulmonary hypertension and hypoventilation. Removal of any functional lung lobes needs to be considered carefully in any patient with disease of its other lung lobes.

The cranial and middle lung lobes are mobile, and are suspended at their hilus from the pulmonary artery, pulmonary veins and bronchi. All must be ligated when the lung lobe is removed. The left and right caudal lung lobes are also attached to the dorsal mediastinum by the pulmonary ligaments. These are flat, elongated folds of fascia that must be divided in order to isolate the lobe and mobilize it enough to divide its hilus and remove the lung lobe.
Surgical approach

In light of the variable sensitivity of radiographs for detecting some lung lesions, it seems prudent to examine all the lung lobes in patients that do not have a pre-operative CT. This is not usually performed in patients undergoing lung lobectomy for a solid mass, but is important when evaluating patients for spontaneous pneumothorax, for instance.

Surgical exploration is usually performed via median sternotomy or lateral thoracotomy (caudal lobar lesions can be examined in a limited fashion through a diaphragmatic incision, but not easily removed), but thoracoscopy provides a minimally-invasive alternative. Regardless of approach, surgeons should be cautious examining the lung lobes with a patient in dorsal recumbency, due to the difficulty of inspecting the hilar region. The surgeon should work closely with the anesthetist during exploration. The lungs should be adequately inflated when checking for air leaks. Conversely, the anesthetist should be careful with ventilation pressures, as high pressures may cause additional ruptures in dogs with generalized lung disease, or following lobectomy. The anesthetist should always inform the surgeon if they are if they are experiencing problems with pulmonary compliance and are considering using positive end-expiratory pressure or increased inspiratory pressures.

In patients with clear evidence of a disease process involving a single lung lobe, a lateral approach is sufficient. However, this does not allow for examination of the contralateral thorax and hence other affected lobes may be overlooked.

In discrete diseases affecting a single lung lobe, total or partial lung lobectomy may be performed using either sutures, surgical staples, or vascular clips (Hemolok, Weck Systems: Dr P Mayhew, personal communication). In patients with diffuse, emphysematous lung disease, the pleura is often fragile and continued air leakage may occur even after stapling. In these cases, it is preferable to perform a total rather than a partial lobectomy. Recent work has shown that partial lobectomy can be effectively and safely performed using a vessel sealing device (Ligasure, Covidien). Anecdotally, the lungs of these patients often have an abnormal appearance, with obvious sub-pleural air accumulation forming small blebs, and a crackling feeling when the lung is palpated. The lungs must be manipulated gently, as even minor trauma can result in leaks that are resistant to suturing and may require lobectomy.

Flooding the thoracic cavity with saline may allow identification of a leaking lesion either before or after surgery. These lesions should be removed. Saline contained within the thorax, especially in a patient in dorsal recumbency, will apply pressure to the lung lobes and may reduce the tendency for the lesion to leak air. Therefore, lung integrity should also be tested by dripping saline onto the pleura while the lung is being maximally inflated with a controlled inspiratory pressure.

In patients with confirmed or suspected neoplasia, the tracheobronchial lymph nodes should be identified and ideally biopsied. Until recently, biopsy was rarely performed when lobectomies were undertaken using a minimally-invasive approach. However, recent work has identified a safe and effective method for biopsying the tracheobronchial lymph nodes thoracoscopically.

All patients undergoing lung lobe removal should have a thoracostomy tube placed, and a balanced plan for postoperative analgesia developing (we usually use fentanyl infusion for the first 12 hours, local intercostal
nerve block or intrathoracic bupivacaine, with transitioning to intermittent hydromorphone or oxymorphone (see your regular practice reference book for doses). When the patients are ambulatory and eating, oral medication such as tramadol and/or an NSAID is commenced. This is continued for 5 to 7 days after surgery.

**Advantages and Disadvantages of different approaches**

All approaches to the thorax require a fairly high level of anesthetic management and perioperative monitoring, so as long as these are available in a practice, the main advantages and disadvantages of the different techniques come down to the equipment and skill required, the amount of postoperative morbidity, and the ability to adequately explore the thorax.

**Lateral thoracotomy versus median sternotomy:**

Lateral thoracotomy is a simpler approach. May be less painful than sternotomy. More direct approach to the tracheobronchial lymph nodes than sternotomy. Easier to position an effective thoracostomy tube after surgery. Cannot explore the contralateral side effectively.

**Thoracoscopic versus open approach:**

Advantages of thoracoscopy: Less morbidity and quicker recovery. Excellent visualization. Maybe shorter hospital stays with thoracoscopy. High level of client satisfaction (some owners will only proceed if we can do the case thoracoscopically).

Disadvantages: requires specialized equipment, anesthetic protocols (one-lung ventilation) and skill. Often takes longer. If working space not adequate there is poor visualization of the affected lung and surrounding tissues. Harder to gauge the surgical margins if a partial lobectomy is to be performed. Removal or biopsy of tracheobronchial lymph nodes requires additional surgical skill.

**Stapling versus suturing versus other**

Stapling of the lung at its hilus has been the standard method for many years. Surgeons prefer to use a thoracoabdominal (TA) or endoGIA stapler (Covidien) than suturing, because it is very quick and has proven to be safe in the vast majority of patients. The use of Ligasure is evolving and needs to be evaluated in clinical patients.
before safe recommendations can be made. The hilar blood vessels may exceed the maximum safe diameter for ligation (7 mm) and ligasure is unlikely to be effective for the bronchus, so Ligasure is likely to only be used for lung biopsy or partial lung excision. Endoloops (Ethicon) are used for lung biopsy in children, and liver lobectomy in dogs, so also have potential. The main disadvantage of any technique is that the equipment required to place the device is reasonably bulky, and precludes use of the TA and endoGIA stapler thoracoscopically in small patients. For this reason, techniques such as the Hemolok clip and Endoloop will probably become more popular in time.

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URETHRAL SURGERY: STONES, STRICTURES AND SALVAGE

GB Hunt

University of California, Davis

Start by considering two cases:

1: “Tebow”, a 7 yo male intact Australian Heeler
2: “Magic”, a 7 yo male neutered Himalayan cat

Presenting complaint: Straining and seemingly unable to produce urine.

What do these cases have in common?
What are the likely differences?
What steps should we take to make a diagnosis and resolve their problem?
At what point do we stop treating medically and consider surgical intervention?

The blocked dog and cat present a common problem. It is usually a medical emergency and immediate steps must be taken to re-establish urethral patency and decompress the bladder. However, urethral blockage can occur for a variety of reasons and it is impossible to accurately predict prognosis and consider treatment options until a diagnosis has been made. In addition to considering the possible underlying etiologies, attending veterinarians must also consider the possibility of iatrogenic trauma, and perform diagnostic procedures as carefully as possible to avoid exacerbating urethral injury.

Treatment of a patient with urethral blockage should be as follows:

Careful history and physical examination, including rectal palpation in dogs.
Blood collection for electrolytes and renal function tests, in addition to a general biochemical and hematological screen.
Placement of an IV catheter and delivery of low-potassium intravenous fluids (until potassium level is known).
Analgesia (including topical lidocaine for urinary catheter placement).
Sedation if required for urinary catheter placement.
Careful catheterization of the urethra.
Plain abdominal/pelvic radiographs.
If urethral obstruction encountered, catheterization is attempted again under heavy sedation or anesthesia, using continuous flushing with saline to dislodge stones or “sand”. Avoid undue force as it is easy to tear the urethra.
Consider cystocentesis for bladder decompression if the bladder is turgid. Urine should be collected for microscopy and culture.
Urethral hydropulsion with an assistant occluding the pelvic urethra, enabling the distal urethra to be distended with saline, thereby dislodging calculi and flushing them back into the bladder.
Sonographic examination of the kidneys, bladder, prostate and caudal abdominal structures.
If urethral obstruction persists despite dislodging stones, or if the animal presents for multiple recent episodes of obstruction, perform a retrograde urethrogram to check for urethral stricture or tearing. Mucosal tears can act as valves, preventing passage of the urinary catheter even when expression of the bladder is possible, or vice versa.
Definite treatment which might consist of stone removal, repair of urethral trauma or some form of urinary diversion system.

Causes of urethral blockage in the dog

Urethral calculi
Benign prostatic hyperplasia
Prostatic neoplasia (more common in neutered animals)
Bladder retroflexion into a perineal hernia
Iatrogenic (following cryptorchidectomy)
Transitional cell carcinoma
Granulomatous urethritis  
Pubic trauma  
Reflex dysynergia  
Fracture of the os penis  
Urethral stricture  

**Causes of urethral blockage in the cat**  
Feline lower urinary tract disease  
Inflammation  
“Sand”  
Stones  
Urethral stricture (iatrogenic)  
Preputial stricture (kittens)  
Prostatic disease is reported, but more often causes tenesmus and constipation  
Iatrogenic occlusion of urethra post ovariohysterectomy  

**Methods for re-establishing urinary flow**

Clearly the patient’s survival is based on being able to re-establish urine flow. Ideally this should be through normal pathways. Dislodgement of urethral calculi should be followed by removal using surgery, endoscopic retrieval or lithotripsy. Urethral tumors may be debulked using endoscopically-guided laser or dilated with urethral stents. Strictures may be removed using laser, or undergo balloon dilation or stenting. Preputial stricture in the kitten responds well to preputioplasty, whereby the prepuce is opened and the mucosa sutured to the skin with fine absorbable sutures to reduce the risk of re-stricture. Urethral trauma may be treated conservatively by placement of a closed-system indwelling urinary catheter. However, if leakage is obvious during contrast urethrography it is likely that the defect will require surgical repair. Extravasated urine is very irritant and can cause serious cellulitis and necrosis of tissues.

Not all patients will be good candidates for the definitive procedures listed above, the procedures may not be available in a certain area, the clients may not be willing to pursue referral, the treatment may not be successful, or medical management may fail to prevent disease recurrence. In these cases, it is necessary to consider some form of salvage procedure.

Salvage procedures aim to preserve urine output while avoiding urine extravasation. The most commonly performed salvage procedure is the perineal urethrostomy for cats with recurrent urethral obstruction. Perineal urethrostomy became common-place in the early 1970s but later fell out of favor due to the incidence of postoperative complications such as stricture and recurrent urinary tract infections, and the development of dietary options for managing the underlying disease. Nevertheless, some cats cannot be effectively managed medically, and others suffer iatrogenic trauma to the distal urethra as a result of multiple unblocking procedures. Cats presenting for recurrent episodes of urethral obstruction should undergo contrast urethrography prior to treatment. Some cats demonstrate severe narrowing of the prostatic urethra and this should be interpreted carefully, as it often represents a dynamic, rather than a fixed, obstruction. Perineal urethrostomy remains a good salvage procedure as long as it is performed using good surgical principles, the stoma is created at the level of the wide pelvic urethra, and care is taken to establish a good mucosal to cutaneous anastomosis, reducing the risk of stricture. Preputial stricture in kittens can be treated by preputioplasty; opening the prepuce and carefully suturing mucosa to skin.

In dogs, urethrostomy is usually required secondary to obstruction or trauma to the urethra at the level of the os penis. Scrotal urethrostomy (following castration) is more commonly performed than perineal urethrostomy, as this better accommodates the normal posture for urination. Prescrotal urethrostomy is also feasible in an intact male dog, but is very likely to result in urine scalding and scrotal dermatitis, which can be difficult to manage. Prepubic urethrostomy is reserved for patients with intrapelvic urethral disease where other options are not feasible. Prepubic urethrostomy is associated with a high complication rate, including ascending urinary tract infection and incontinence. Although good results can be obtained in some patients, the high risk of an unsatisfactory result means that it should only be considered as a last resort.

Urinary diversion may also be established by means of in-dwelling cystostomy catheters. These can be maintained for long periods of time and may be well accepted by clients, although it can be hard to prevent self-removal by the patient. The main disadvantage of in-dwelling catheters is the high likelihood of ascending urinary tract infections that can be almost impossible to eradicate while the foreign body remains in situ.
Balloon dilation is useful for treating benign urethral strictures, and placement of urethral stents can provide palliation in patients with urethral neoplasia although the results are variable and the prognosis is always uncertain in such patients. Finally, various other surgical options for bladder and urethral reconstruction using native tissues (such as the vagina and vestibule) have been reported and might be considered on a case-by-case basis.
THE RETROPERITONEUM: THE FORGOTTEN SPACE

GB Hunt

University of California – Davis

The retroperitoneal space (retroperitoneum) is the anatomical space (sometimes a potential space) in the abdominal cavity behind (retro) the peritoneum. It has no specific delineating anatomical structures. Organs are retroperitoneal if they have peritoneum on their visceral side only. Structures that are not suspended by mesentery in the abdominal cavity and that lie between the parietal peritoneum and abdominal wall are classified as retroperitoneal. The retroperitoneal space is a continuum with the caudal mediastinum by means of the aortic hiatus between the crura of the diaphragm. The paired diaphragmatic crura have a broad muscular attachment to the costal arch, and a tendinous attachment to the epaxial musculature at the thoracolumbar junction. Therefore, the diaphragm can be separated from the dorsal body wall by incising these tendons, giving access to the cranial retroperitoneal space.

For the purpose of this lecture, we will consider retroperitoneal structures that have a covering of peritoneum on one side only, or those situated within the retroperitoneal fat, and associated with the epaxial musculature. Organs that often (although not necessarily commonly) require surgical intervention include:

Kidneys
Adrenal glands
Ovaries
Cisterna chyli
Ureters
Hypogastric and medial iliac (sublumbar) lymph nodes
Psoas and quadratus lumborum muscles
Prostate
Vagina

The retroperitoneal vascular anatomy is quite complex, with the aorta and caudal vena cava, and their lumbar branches (associated with each of the lumbar vertebrae). The sympathetic chain runs through the retroperitoneal space, with sympathetic ganglia situated around the main arterial branches (celiac, cranial mesenteric, caudal mesenteric). Mesenteric lymphatic vessels drain into the cistern chyli, which continues cranially as the thoracic duct.

Due to the fact that it is relatively inaccessible in the dorsal part of the abdomen, and occupied by the large abdominal vessels (aorta and caudal vena cava), the retroperitoneal space is not usually explored thoroughly during a routine exploratory laparotomy. Even when a patient is known to have retroperitoneal disease, the surgical approach is not always straightforward.

Retroperitoneal abscesses, or draining tracts associated with migrating foreign bodies, are a common reason for surgical exploration. In addition, hematomas, abscesses or cysts associated with the kidneys and adrenal glands can present surgical challenges.
Surgical Approaches to the Retroperitoneal Space

Ventral midline celiotomy

This approach is useful for most renal and ureteral lesions. It is also feasible for drainage of retroperitoneal abscesses situated in the mid to caudal abdomen. The hypogastric and medial iliac lymph nodes can be accessed from this approach.

Paracostal

The paracostal approach is useful for accessing the adrenals, and lesions of the epaxial musculature in the cranial portion of the abdomen. It is particularly helpful for lesions on the right hand side, and allows exploration of the tissues dorsal to the caudal vena cava, which are not accessible from a ventral approach. It can be helpful in deep-chested dogs.

The approach is made caudal to the last rib, by either dividing or splitting the muscles of the lateral abdominal wall: external abdominal oblique, internal abdominal oblique and transversus abdominus.

Combined thoracoabdominal approach

A single paracostal approach to the cistern chyli has been described by Staiger, Stanley and others. This approach allows division of either the left or right crus of the diaphragm, allowing access to the retroperitoneum of the cranial abdomen, and also the caudal mediastinum. Although described for cistern chyli ablation and thoracic duct ligation, this approach is potentially useful for any lesions in this vicinity.1

Laparoscopy

The minimally-invasive approach is becoming standard for nephrectomy and adrenalectomy, and techniques for resecting the sublumbar and hypogastric lymph nodes. Cisterna chyli ablation has also been performed laparoscopically.

Reference

GASTRIC SURGERY

GB Hunt

University of California, Davis

Some procedures of the stomach are performed commonly in veterinary practice; these include gastrotomy for foreign body removal, and gastropexy for treatment or prophylaxis of GDV.

The stomach is forgiving with respect to surgery as it has very good suture holding capacity due to the collagen content of the submucosa, and excellent blood supply. However, diseases of the pyloric region pose more challenges, especially when they require extensive resection and anastomosis. Likewise, gastric necrosis necessitating gastric resection in dogs with GDV imparts a significantly worse prognosis. For these reasons, veterinary surgeons are justifiably nervous about performing gastric resections.

There are a variety of diseases that cause gastric outflow obstruction, including gastric adenocarcinoma, chronic hypertrophic pylorogastropathy, gastric polyps. The prognosis for these conditions is very different and hence it is important to try and clarify the nature of the disease process before surgery if at all possible. This might be done in a minimally-invasive manner by means of endoscopy and endoscopic biopsy, ultrasound and fine needle aspiration biopsy. Gastric tumors such as adenocarcinoma and benign polyps may not exfoliate well. Laparoscopy is not particularly effective at evaluating the gastrointestinal tract and hence has limited application: however, if the presence of a gastric lesion can be confirmed, a video-assisted approach might be helpful in permitting exteriorization of the affected portion of stomach with subsequent biopsy. Computed tomography does not provide many extra advantages unless it seems important to evaluate the blood supply to the stomach and the spleen using angiography.

In cats, gastric masses are most commonly caused by neoplastic conditions such as adenocarcinoma or lymphoma, however inflammatory conditions such as eosinophilic sclerosing fibroplasia have also been reported. Gastric dilation and volvulus occurs infrequently in cats and has been reported in association with diaphragmatic hernia. Cats can present with perforated gastric ulcers resulting from stress and non-steroidal anti-inflammatory medications.

Recent publications have also cast light on risk factors for GDV in dogs, response to therapeutic and prophylactic gastropexy, the efficacy of incisional gastropexy versus endoscopic and laparoscopic-assisted gastropexy, the role of plasma lactate levels in predicting outcome in dogs with GDV, and the effect of pyloric surgery on gastric emptying. The results of these reports and others will be discussed during this session.

Recent Publications Pertinent To Gastric Surgery


Sartor, A. J. Bentley, A. M. Brown, D. C.

151 dogs treated surgically for GDV and 302 control dogs with no history of GDV. Two control dogs were matched with respect to age, body weight, sex, neuter status, and breed to each dog with GDV.

6 (4%) dogs in the GDV group and 3 (1%) dogs in the control group had a history of previous splenectomy. The odds of GDV in dogs with a history of previous splenectomy in this population of dogs were 5.3 times those of dogs without a history of previous splenectomy (95% confidence interval, 1.1 to 26.8).

Conclusions and Clinical Relevance - For the patients in the present study, there was an increased odds of GDV in dogs with a history of splenectomy. Prophylactic gastropexy may be considered in dogs undergoing a splenectomy, particularly if other risk factors for GDV are present.
Gastric foreign body as a risk factor for gastric dilatation and volvulus in dogs.
Battisti, A. de Toscano, M. J. Formaggini, L.

118 large- or giant-breed dogs treated surgically for an episode of GDV and 342 large- or giant-breed dogs (>12 months old) that underwent abdominal surgery for reasons other than GDV. Procedures: During exploratory celiotomy, all dogs underwent palpation and visual examination of the entire gastrointestinal tract. A foreign body was defined as nondigestible or slowly digestible material palpated during gastrointestinal tract examination that was causing clinical signs or was >10 cm in length or >2 cm in width. Results: The incidence of gFBs was significantly higher in the group of dogs with GDV. The presence of a gFB, age, weight, and purebred status were significant risk factors for GDV. Odds ratios were calculated for gFB (OR, 4.920), age (OR, 1.157), weight (OR, 0.958) and purebred status (OR, 4.836). Conclusions and Clinical Relevance: Gastric foreign body was found to be a significant risk factor for GDV in dogs. The study findings suggested that a large- or giant-breed dog with a gFB was approximately 5 times as likely to develop GDV as a similar dog with no gFB. Results indicated that there was a strong correlation between gFB and GDV in dogs. However, further cohort studies are needed to determine whether there is a causal relationship between the presence of a gFB and the development of GDV in dogs.

Evaluation of plasma lactate concentration and base excess at the time of hospital admission as predictors of gastric necrosis and outcome and correlation between those variables in dogs with gastric dilatation-volvulus: 78 cases (2004-2009).

Gastric necrosis was identified in 12 dogs at the time of surgery and in 4 dogs at necropsy. Sixty-five (83%) dogs survived to hospital discharge, whereas 13 (17%) dogs died or were euthanized. Of the 65 survivors and 8 nonsurvivors that underwent surgery, gastric necrosis was detected in 8 and 4 dogs, respectively. Via receiver operating characteristic curve analysis, an initial plasma lactate concentration cutoff of 7.4 mmol/L was 82% accurate for predicting gastric necrosis (sensitivity, 50%; specificity, 88%) and 88% accurate for predicting outcome (sensitivity, 75%; specificity, 89%). Among all dogs, the correlation between initial plasma lactate concentration and base excess was significant, although base excess was a poor discriminator for predicting gastric necrosis or outcome (area under the receiver operating characteristic curve, 0.571 and 0.565, respectively).

Conclusions and Clinical Relevance: In dogs with GDV, plasma lactate concentration at the time of hospital admission was a good predictor of gastric necrosis and outcome. However, despite the correlation between initial base excess and plasma lactate concentration, base excess should not be used for prediction of gastric necrosis or outcome in those patients.


Medical records of 102 dogs were reviewed retrospectively to examine relationships between plasma lactate concentration and gastric necrosis and between plasma lactate concentration and outcome for dogs with gastric dilatation-volvulus (GDV). 69 of 70 dogs (99%) with plasma lactate concentration <6.0 mmol/litre survived, compared with 18 of 31 dogs (58%) with plasma lactate concentration >6.0 mmol/litre (1 dog killed for economic reasons was not included). Gastric necrosis was identified in 38 dogs (37%). Median plasma lactate concentration in dogs with gastric necrosis (6.6 mmol/litre) was significantly higher than concentration in dogs without gastric necrosis (3.3 mmol/litre). Specificity and sensitivity of using plasma lactate concentration (with a cutoff of 6.0 mmol/litre) to predict which dogs had gastric necrosis were 88 and 61%, respectively. 62 of 63 dogs (98%) without gastric necrosis survived, compared with 25 of 38 dogs (66%) with gastric necrosis. It is concluded that pre-operative plasma lactate concentration is a good predictor of gastric necrosis and outcome for dogs with GDV and that pre-operative measurement of plasma lactate concentration may assist in determining prognosis of dogs with GDV.
Efficacy of incisional gastropexy for prevention of GDV in dogs. Benitez, M. E. Schmiedt, C. W. Radlinsky, M. G. Cornell, K. K. Journal of the American Animal Hospital Association; 2013. 49(3):185-189. Medical records of 61 dogs undergoing IG following either gastric derotation for treatment of GDV or as a prophylactic procedure were evaluated retrospectively. Median follow-up time for all dogs was 717 days (range, 49-2,511 days). Of the 61 dogs, 27 had prophylactic IG performed. The remaining 34 dogs presented for GDV and had an IG performed during surgical treatment of GDV. No dog experienced GDV after IG. Recurrence of gastric dilatation (GD) alone was noted in 3 of 34 patients (8.8%) undergoing IG during surgery for GDV and in 3 of 27 patients (11.1%) treated prophylactically with IG. This study confirmed the efficacy of IG for the long-term prevention of GDV in dogs.

Evaluation of short- and long-term complications after endoscopically assisted gastropexy in dogs. Dujowich, M. Keller, M. E. Reimer, S. B. Journal of the American Veterinary Medical Association; 2010. 236(2):177-182. 24 dogs. Endoscopically assisted gastropexy was performed on each dog. Dogs were evaluated laparoscopically at 1 or 6 months after surgery to assess integrity of the gastropexy. Long-term outcome was determined via telephone conversations conducted with owners >=1 year after surgery. Results - In all dogs, the gastropexy site was firmly adhered to the abdominal wall at the level of the pyloric antrum. Long-term follow-up information was available for 23 dogs, none of which had any episodes of gastric dilatation-volvulus a mean of 1.4 years after gastropexy. Conclusions and Clinical Relevance - Endoscopically assisted gastropexy can be a simple, fast, safe, and reliable method for performing prophylactic gastropexy in dogs. This technique appeared to be suitable as an alternative to laparoscopic-assisted gastropexy.

Prospective evaluation of laparoscopic-assisted gastropexy in dogs susceptible to gastric dilatation. Rawlings, C. A. Mahaffey, M. B. Bement, S. Canalis, C. Journal of the American Veterinary Medical Association; 2002. 221(11):1576-1581. 23 dogs susceptible to GDV were referred as candidates for elective gastropexy. These dogs had a history of treatment for gastric dilatation, clinical signs of gastric dilatation, or family members with gastric dilatation. Laparoscopic-assisted gastropexy was performed. One year after surgery, abdominal ultrasonography was performed to evaluate the attachment of the stomach to the abdominal wall. Two dogs with GDV were also treated with laparoscopic-assisted derotation of the stomach and gastropexy. Results - None of the dogs developed GDV during the year after gastropexy, and all 20 dogs examined ultrasonographically had an intact attachment. Another dog was euthanatized at 11.5 months for unrelated problems. Two dogs with GDV successfully underwent laparoscopic-assisted gastropexy after the stomach was repositioned. Conclusions and Clinical Relevance - Laparoscopic-assisted gastropexy resulted in a persisting attachment between the stomach and abdominal wall, an absence of GDV development, and few complications. Dogs with a high probability for development of GDV should be considered candidates for minimally invasive gastropexy. Carefully selected dogs with GDV can be treated laparoscopically.

Comparison of the effect of laparoscopic and conventional pyloric surgery on gastric emptying in dogs. Sanchez-Margallo, F. M. Ezquerra-Calvo, L. J. Soria-Galvez, F. Uson-Gargallo, J. Veterinary Radiology & Ultrasound; 2005. 46(1):57-62. The effect of a laparoscopic approach and pyloric surgery on canine gastrointestinal activity, particularly gastric emptying time. The purpose of this study was to compare the effect of laparoscopic and conventional pyloric surgery, in Ramstedt pyloromyotomy and Heineke-Mikulicz pyloroplasty, on complete gastric emptying time in 20 clinically normal dogs. Dogs were divided into four groups of five animals: dogs with laparoscopic Ramstedt pyloromyotomy, conventional Ramstedt pyloromyotomy, or laparoscopic Heineke-Mikulicz pyloroplasty, and the conventional Heineke-Mikulicz pyloroplasty group. Gastric emptying time using barium sulfate mixed with dry kibble dog food was measured fluoroscopically before and 1 month after surgery. Gastric emptying of solids was significantly enhanced in the pyloroplasty groups in the postoperative period compared with preoperative emptying. Just as after conventional pyloromyotomy, gastric emptying time after laparoscopic pyloromyotomy was not statistically different as compared with preoperative values. This study indicates that the fluoroscopic test meal is a valuable tool for defining complete gastric emptying time in normal dogs. We conclude that pyloromyotomy was less
effective in decreasing complete gastric emptying time than Heineke-Mikulicz pyloroplasty in normal dogs. The possibility of decreasing complete gastric emptying time by laparoscopic surgery suggests a potential clinical application for this technique in small animals.


Four cats with feline gastrointestinal eosinophilic sclerosing fibroplasia (FGESF) are described. Clinical signs included decreased appetite, weight loss, vomiting and diarrhea. Bloodwork abnormalities included mild neutrophilia (n=2) and hyperglobulinemia with concurrent hyperproteinemia (n=2). Ultrasonographically, a total of five solitary masses with mural thickening and loss of layering were identified in the stomach, duodenum, jejunum and colon. In one cat a second, separate lesion was diagnosed 3 weeks following surgical resection of one mass. Histopathologically, lesions were characterized by collagen trabeculae and mixed inflammatory cell infiltrates, predominantly eosinophils. Multiple areas of necrosis were also noted, which contained bacteria in 2/4 cats. In two cats, changes consistent with FGESF were also noted in the liver. All cats had surgical resection of their lesions. Two cats are still living at time of publication (43 and 24 months post-surgery). FGESF should be considered as a differential for intestinal masses in cats.


This report describes the historical and physical findings, as well as the treatment and outcome, in three cats with spontaneous gastric perforation that were receiving anti-inflammatory medication immediately prior to presentation. It highlights the importance of thorough patient evaluation in any cat presenting with non-specific clinical signs and a history of anti-inflammatory drug administration.


Three cats were examined because of acute dyspnoea and sudden abdominal enlargement. In all cats, radiographs revealed gastric dilatation-volvulus (GDV) and diaphragmatic hernia. Cardiovascular shock and dyspnoea were treated by intravenous fluid-therapy, oxygen administration and relief of diaphragmatic pressure by means of stomach decompression and in one case placing the patient in an inclined position. Gastric decompression was performed by needle gastrocentesis, placement of a rhino-gastric tube, or a combination of these. Diaphragmatic herniorrhaphy was performed in either case; one cat also underwent gastropexy. The immediate postoperative period resolved uneventfully and the cats were doing well at follow-up. Feline GDV is a rare event in which diaphragmatic hernia may be a predisposing factor.
LIVER BIOPSY

GB Hunt

University of California, Davis

Liver biopsies are usually taken to establish a diagnosis and guide treatment, and therefore the amount of liver taken, the way in which it is to be stored and processed, and the tests that are to be requested is important to consider prior to biopsy.

One piece of liver is usually placed in formalin for histopathology and another piece is kept fresh (in a plain tube or urine container) for culture. Additional pieces of liver may be harvested for metal testing. The site from which the biopsy is to be taken may also be important. If diffuse changes are expected (e.g. congenital vascular disease or cholangitis), choose the lobe that is most accessible. If focal changes are present (eg liver cysts or nodules), biopsies should be taken from the lesions, and also from normal liver. Bile should also be collected for cytology and culture if bacterial cholangitis is considered likely. Consider performing a preoperative coagulation panel in patients with hepatopathies.

Surgical Technique

Biopsies may be obtained using a Tru-cut needle under ultrasound guidance, or using a skin biopsy punch at surgery. Biopsies in patients that might have a coagulopathy should be taken using a technique that uses suture hemostasis such as a wedge biopsy.

The guillotine technique for liver biopsy is appropriate for diffuse lesions in a liver lobe that has a projecting part of its free edge, which allows suture ligation across its base. The tip of the quadrate lobe usually provides a convenient projection for biopsy in patients with normal appearing livers or diffuse liver disease. A monofilament absorbable suture of 4-0 or 3-0 is preformed into a ligature and placed around a protruding piece of liver and then tightened. Be careful not to apply too much traction to the suture when tying or cutting it, as it can easily pull through the liver parenchyma. After the ligature is tied, the protruding tip of the liver lobe is amputated using scissors, leaving at least 3 mm between the cut edge and the suture to avoid cutting the ligature.

With the punch technique, a 4 mm skin biopsy punch is used to obtain a core of liver tissue. The core may be separated from the base by either turning the biopsy punch on its side to cut across, or carefully lifting the tissue core and cutting its base with fine scissors. Haemostasis is then achieved by digital pressure for at least 2 minutes. If bleeding continues, a plug of gelfoam (see below), muscle or fat may be placed into the deficit, and, if this does not halt the hemorrhage, a single mattress or cruciate suture of 4-0 monofilament absorbable suture will usually control it. The main aim of a suture is to exert gentle pressure from one side of a defect to the other, pressing the cut edges together and assisting haemostasis. Thicker sutures or ligatures are only effective when applied to the hilus of a liver lobe during lobectomy, or when amputating the tip of a liver lobe.

The wedge biopsy technique is used for focal lesions deep within the liver lobes, when larger pieces of liver are required (eg for metal analysis), or patients with a coagulopathy. A wedge is removed from the liver using sharp excision. A continuous mattress suture of 4-0 or 3-0 monofilament absorbable suture material is placed, in a through-and-through pattern if at the liver edge (i.e. entering the capsule of the liver on one side of the lobe and exiting through the capsule on the other side of the lobe), or taking large bites of tissue on either side of the defect if it is closer to the hilus. Once the suture has traversed the defect in one direction, it is reversed and continued back to its origin. The suture arms at the beginning and end may then be tied to one another in a square and gently tightened until the edges are apposed and the haemorrhage is controlled.

If bile is required, it is collected using a fine needle (no greater than 22 gauge) inserted through liver parenchyma and into the gall bladder. Insertion through the liver parenchyma reduces the risk of leakage from the gall bladder following aspiration. Ask your pathologist how much bile they require for cytology (likely needed in an EDTA tube) and microbiology (plain tube).
Laparoscopic Liver Biopsy

Liver biopsy is the simplest laparoscopic procedure we perform, requiring the least amount of specialized equipment. With the patient in dorsal recumbency, following CO2 insufflation, the liver falls away from the diaphragm and the diaphragmatic surface and edges of the liver lobes can be inspected. The caudate lobes are not visible using this approach, and it is difficult to evaluate the more dorsal portions of the other liver lobes. Once the portion of liver to be biopsied has been selected, laparoscopic biopsy forceps are advanced under the edge of the liver lobe in the closed position. They are then opened and gently withdrawn, allowing the edge of the liver to fall between the jaws. The forceps are closed, and held closed for 60 seconds to assist hemostasis. The laparoscopy port may be advanced towards the liver to provide resistance to removal of the biopsy and thus avoid the lobe being pulled too far towards the body wall when the forceps are drawn back and before the biopsied tissue disengages from the liver lobe. In most cases, blood loss is negligible following biopsy, or clots within a few seconds. Bile can be collected under laparoscopic visualization using a spinal needle, but be careful not to advance the needle too far as it can perforate the diaphragm and the lung, causing a pneumothorax.

Disposable products are available to assist with haemostasis after liver biopsy (open or laparoscopic), and are mainly composed of cellulose, including gelfoam (a cellulose product that can be packed into defects or laid on top of them) and Surgicel a cellulose fabric that can be wrapped over a bleeding site of the liver. Small pieces of fat or muscle can be cut from the body wall and used to similar effect. Surgical staples are also useful for haemostasis.
Surgery for the gall bladder is usually performed for the purpose of removing a biliary mucocele, in patients with spontaneous or incipient rupture of the gall bladder, usually as a result of cholangitis and occasionally for neoplasia or trauma. Indications for surgical exploration include clinical signs such as abdominal pain, inappetance, vomiting along with elevated alkaline phosphatase, sonographic evidence of biliary mucocele, gall bladder distention or cholelith formation, edema or discontinuity of the wall of the gall bladder, and peritoneal fluid containing high levels of bilirubin or microscopic evidence of bile crystals.

**Gall bladder mucocele** is a specific condition that results from dysfunction of mucus-secreting cells within the gallbladder mucosa. According to Pike et al (2004), “these cells undergo cystic hyperplasia, and the cysts and individual glands become dilated by mucus with a similar histologic appearance to that within the gallbladder lumen. The inciting cause of mucus hypersecretion is unknown and may be multifactorial.” The diagnosis may be made incidentally during evaluation for other problems, or may be based on presence of abdominal pain, elevated liver enzymes and abnormalities on abdominal ultrasound. The sonographic features of gall bladder mucocele have been well-described and include evidence of organizing mucus accumulation within the gall bladder, showing a stellate or finely striated appearance and lacking the gravity-dependent movement of bile sludge. Thickening and edema of the gall bladder wall and peritoneal fluid accumulation suggest a more advanced stage of the disease. Overt bile peritonitis, hyperbilirubinemia and systemic signs of disease indicate a surgical emergency. Cocker spaniels and Shetland sheep dogs are over-represented amongst reported breeds. The odds of dogs with hyperadrenocorticism having a gall bladder mucocele have been reported as being 29 times higher than dogs without hyperadrenocorticism. Results from Pike’s retrospective study of 30 dogs suggest that surgical cholecystectomy is an effective treatment for gall bladder mucocele. Early reports show that the mortality rate for emergency cholecystectomy in patients with gall bladder rupture is higher than that for elective surgery (68% versus 32%) leading many specialists to recommend cholecystectomy in all dogs diagnosed with gall bladder mucocele. An alternative in the asymptomatic dog with minimal or no signs is cautious observation with serial biochemistry and sonography. If the gall bladder wall thickens, or the liver enzymes become elevated, elective surgery should be scheduled prior to gall bladder rupture or biliary obstruction.

**Necrotizing Cholangitis** may be seen as a peracute phenomenon or as a chronic result of bacterial cholangiohepatitis. The gall bladder may appear edematous and inflamed, overtly necrotic or fragmented. Bile staining of peritoneal tissues around the gall bladder or bile ducts suggests impaired integrity of the
wall and impending biliary rupture. In some instances, the gall bladder has already suffered an explosive rupture. Removal of the gall bladder and ligation of the cystic duct is indicated in these cases.

There may sometimes be an indication for surgical exploration and lavage of the biliary tract for cholestasis due to bile sludging. The cause of this is not well understood, although in some instances it may result from cholangitis. While the gall bladder does not necessarily appear diseased in these patients, it seems sensible to remove it to avoid future issues with gall bladder inspissation or rupture, and to reduce the concentration of bile and perhaps reduce the tendency towards sludge formation.

**Surgical Anatomy**

The gall bladder resides in a fossa between the quadrate and right medial liver lobes. The gall bladder is partially embedded in the liver parenchyma. Its major arterial supply is via the cystic artery, that runs up along the cystic duct from the hepatic artery at the liver hilus. The cystic duct is tortuous, and connects to the lobar hepatic ducts before continuing caudally within the hepatogastric ligament as the common bile duct, to the duodenum.

**Surgical Technique**

The ventral midline laparotomy should extend cranially to the xiphoid cartilage to allow access to the diaphragmatic surface of the liver. Moistened laparotomy sponges are positioned around the gall bladder. Placement of a laparotomy sponge between the diaphragm and the liver may push the quadrate lobe caudally and provide easier access. The gall bladder is dissected bluntly from the liver. A combination of suction, dissection and cautery facilitates visualization. Occasionally, large venous sinuses are present on either side of the gall bladder: these connect to the hepatic vein(s) and need to be sutured. In many cases, bleeding can be controlled by temporary packing with guaze sponges, or application of gelatin foam or cellulose sheeting. The cystic artery (and its branches) are ligated or cauterized and the cystic duct dissected to the level of the hepatic ducts. The cystic duct may then be ligated using a non-absorbable suture. Transfixing sutures are not recommended due to the potential for bile leakage where they perforate the cystic duct. If bile sludging is present, or there is clinical evidence of bile duct obstruction, the common bile duct should be checked for patency by passing a catheter or guide wire orthogradely into the duodenum. Alternatively, the bile duct can be cannulated retrogradely via a duodenotomy (see “The Biliary Tree” lecture).

Laparoscopic cholecystectomy was one of the first minimally invasive procedures performed in humans, and is becoming more widespread for treatment of gall bladder disease in dogs. A recent report showed
laparoscopic cholecystectomy to be successful in a series of dogs with gall bladder mucoceles. The main disadvantage of a laparoscopic approach is that it does not allow the patency of the common bile duct to be easily checked. Adhesions in dogs with chronic disease can also make visualization and safe dissection difficult.

References


Surgery for the biliary tract is considered amongst the most technically challenging of the intra-abdominal procedures and hence is not routinely performed by practitioners. However, there are some basic principles of biliary tract surgery that all experienced veterinarians should be familiar with. In addition, it is necessary for vets in practice to be comfortable with the decision-making process for patients with biliary tract disease in order to provide their clients with the best possible advice about management.

Anatomy of the biliary tree

Bile ductules coalesce in each liver lobe to produce a lobar duct. The lobar ducts converge at the hilus of the liver to join the cystic duct and proceed towards the duodenum as the common bile duct. Flow through the common bile duct is controlled by the duodenal sphincter (sphincter of Oddi). When the sphincter is contracted, dilute bile flowing from each liver lobe is diverted retrogradely into the gall bladder, and concentrated. After eating, the sphincter relaxes and the gall bladder contracts, enabling flow of concentrated bile into the duodenum to aid digestion. In the cat, the pancreatic duct and bile duct enter the duodenum together, which is an important factor when considering the most appropriate form of biliary diversion to pursue. In the dog, the pancreatic and bile duct are separate, and there is an accessory pancreatic duct also. The gall bladder is supplied by the cystic artery, a branch of the hepatic artery, that follows the cystic duct from the porta hepatis.

Biliary trauma

The most common presenting sign for biliary trauma is bile peritonitis that may not be diagnosed for some days following injury. The bile duct most commonly ruptures at the junction between the cystic ducts and hepatic lobar ducts, although damage can be seen at any level. While preoperative diagnosis of biliary rupture is relatively straightforward, determination of the level of leakage can be extremely difficult and surgeons exploring patients with bile peritonitis should be prepared to carefully evaluate all segments of the biliary tree and be equipped to perform a repair at potentially any site. Facilities must be available for supportive treatment of these patients before and after surgery, as this is a significant prognostic factor for survival.³

Bile duct obstruction and biliary diversion
Obstruction of the bile ducts may occur at any level from the liver lobe to the duodenal papilla. Bile duct obstruction amenable to surgical correction usually occurs at the level of the pancreas or duodenum, and results from extraluminal pressure (acute or chronic pancreatitis) or intraluminal choledoliths or bile sludge.

A range of biliary diversion techniques are available, depending on the nature and level of obstruction. The most common traditional method is cholecystoduodenostomy, where an end to side anastomosis is created with the descending duodenum. This technique can be life saving, but is associated with a high complication rate, including ascending cholangiohepatitis. For obstructions occurring at the level of the duodenum, sphincterotomy is an option that preserves normal biliary anatomy and function, while facilitating bile flow into the duodenum. Repositioning of the bile duct into the duodenum by means of biliary neostomy is possible for very distal obstructions, but requires surgical magnification and advanced skills to avoid stricture formation. Placement of stents for biliary obstruction has been reported, using either self-securing expandable stents or red rubber catheters sutured to the duodenal mucosa.

**Surgical Technique**

The abdomen is opened by a ventral midline laparotomy extending cranially to the xiphoid sternum. Surgical retractors, a surgical assistant and good lighting that can be focused deep in the body cavity is essential. Useful instruments include malleable (ribbon) retractors for atraumatically retracting viscera, atraumatic forceps (Debakkey) and right-angled dissection forceps (eg Lahey bile duct forceps). The unsheathed interior tube of a Pool suction cannula (small size) is very useful because it allows simultaneous suction and blunt dissection. Depending on the chronicity of the disease process, it may be necessary to break down adhesions between the stomach, duodenum, pancreas and liver in order to adequately inspect the bile ducts. An incision should be made in the antimesenteric surface of the duodenum and the major duodenal papilla identified. An intravenous cannulae or red rubber tube is passed through it and advanced carefully into the bile duct. The bile duct can now be lavaged and the integrity of the biliary tree assessed. This can also be used for leak checking if a biliary perforation is identified and closed. If temporary stenting is desired (for instance during treatment for pancreatitis, or to palliate non-resectable neoplasia) the red rubber tube can be left in situ, the end cut off, and the tube sutured in place with an absorbable suture.

Cholecystoduodenostomy is performed by mobilizing the gall bladder from its fossa without disrupting its blood supply and drawing it and the duodenum together to choose a site for anastomosis that does not result in undue tension. Make a generous incision (at least 2 cm) into both the gall bladder and the duodenum and suture the two together in two layers using continuous 3-0 or 4-0 polydioxanone suture. The goal is to create a wide stoma that allows easy drainage of bile and also ingesta from the gall bladder into the intestine should reflux occur.
Bile duct repairs are usually performed using 4-0 or finer suture. Polypropylene (on a small taper needle) has good handling characteristics, excellent knot security and very little tissue drag and is an ideal choice for surgery of all vessels. Simple interrupted or continuous sutures are used for longitudinal defects. Small perforations may be closed using a cruciate suture spanning the defect, as long as the bile duct lumen is not unduly compromised when it is tightened.

A closed suction drain (such as the Jackson-Pratt drain) is usually placed following biliary surgery to enable monitoring of peritoneal fluid for postoperative bile leakage.

**Keys to surgical success**

The most important factors that dictate success when performing biliary tract surgery in dogs and cats are:

1. Good surgical decision-making. Is this the appropriate procedure for this patient?
2. Careful perioperative monitoring and support, including blood products.
3. Excellent lighting.
4. Surgical assistant and retraction.
5. Sound knowledge of surgical anatomy.
6. Correct surgical instruments (atraumatic grasping and dissecting forceps, long-handled instruments for deep-chested patients, probes and catheters to test bile duct patency and act as stents during biliary repair).

**References**


OVARIECTOMY VERSUS OVARIOHYSTERECTOMY: OPEN VERSUS CLOSED

GB Hunt

University of California, Davis

There has been understated debate for many years about virtually all aspects of sterilizing female dogs and cats. Most veterinarians, however, have never really engaged in these debates because we tend to learn a procedure and stick with it if it seems safe, effective, efficient and not too costly. When questioned, we refer to our extensive practical experience as evidence that our approach is a good one and that there is no reason for change. Until evidence emerges regarding safety or outcomes that clearly favors one approach over another, the factors that influence decision-making usually revolve around cost, convenience, the necessity for specialized equipment, and client demand.

The focus of this presentation is to highlight the main debates centering on sterilization of female dogs and cats, the current evidence that exists to support the various positions, and some anecdotal observations about the various issues. Some of these debates have more significance in a Veterinary School than in general practice while others are more pertinent to specialist than general practice. However, they all have a potential impact on “standard of practice” and development of community and client preferences. Considering the issues outlined below may also help you decide what is right for your practice.

The main debates:

1. Should you perform an ovariohysterectomy (OVH), or is an ovariectomy (OVE) sufficient?
2. Is a laparoscopic procedure better than an open one?
3. Should you spay female dogs at all?
4. What about just doing a hysterectomy, rather than removing the ovaries?
5. What about tubal ligation?
6. Flank versus ventral approach.
7. How large an incision, and when to use a spay hook?
8. When/how to break the suspensory ligament.

Factors to consider when addressing each of the above:

What is your main goal in performing the procedure? ie reproductive control, reducing risk of mammary neoplasia or pyometra, behavioral modification, eliminating the unwanted signs of estrus, resolving a disease process (eg pyometra).

Are there features of your population/clientele that favor one approach versus another? Eg nursing queens/bitches, inability to restrict activity or remove sutures.

Do you have the equipment necessary to perform, say, laparoscopic ovariectomy and do you have the staff and the time available to master the procedure?

What are the complications of performing one procedure versus another?
Known complications:

Ovariectomy: surgical hemorrhage, incomplete removal of the ovary leading to ovarian remnant syndrome, inadvertent ligation of the ipsilateral ureter, flank abscess/draining sinus from non-absorbable ligatures.

Hysterectomy: surgical hemorrhage, infection (especially if pyometra), inadvertent ligation of the ureter at the trigone.

Either OVE or OVH: retained surgical sponge, urethral sphincter mechanism incompetence. Inadvertent ligation of ureter. Retained sponges. Ligature foreign body reaction.

Open procedure: surgical wound dehiscence, pain, seroma, infection. Damage to abdominal organs during use of the spay hook.

Laparoscopic procedure: poor visualization of entire abdomen, damage to spleen or other organs during entry to the body cavity or instrument manipulation.

Postulated (anecdotal) complications:

Risk of pyometra when the uterus is not removed.
Damage to urethral sphincter due to excessive traction on the uterus through a small midline incision.
Poor visualization through limited incisions.
Increased risk of trauma when inexperienced surgeons using the spay hook with minimal visualization.

What are the relative advantages of one procedure versus another?

Open procedure:

Advantages: Ability to explore urogenital tract and abdomen.
Quick access to control hemorrhage if a pedicle is dropped.
No need for special equipment.
This is how most of us are trained.

Disadvantages: Increased postoperative pain (see References).
Larger incision and risk of incision complications.
Greater need for postoperative exercise restriction.

Laparoscopy:

Advantages: Less postoperative pain and easier postoperative management.
Better visualization IF the equipment works and you can isolate the ovary from the surrounding viscera.
High level of demand from certain clientele.
Provides an opportunity to train for more advanced procedures (an advantage for future patients?).

Disadvantages: Specialized equipment and expertise required.
 Likely to be more expensive.
Does not allow full exploration.
Likely to take longer than a conventional spay.

FREQUENTLY ASKED QUESTIONS

Why bother with ovariectomy rather than a complete spay?

If you are doing laparoscopy, an OVE is easier and quicker than an OVH. This is probably the main reason that the OVE versus OVH debate has gained traction in the US and Australia. OVE has been standard in European countries for many years. OVE may result in less traction/damage to the neck of the bladder than OVH if being performed open. However, it would almost certainly still require isolation and exteriorization of the uterine horns to gain access to the ovary. Probably less painful postoperatively (see References).
Wouldn’t ovariectomy predispose to pyometra if the uterus is not removed?

This does not seem to be the case under most situations (see References). Most reports of pyometra in “spayed” bitches result from ovarian remnant syndrome or the use of exogenous progesterational agents. There are no confirmed reports of pyometra in patients where the ovaries are known to have been completely removed.

How often is the uterus completely removed in a traditional “spay”.

This is a really good question, because anecdotal evidence from surveys suggests that many practitioners do not remove the uterus completely when performing an OVH. The uterine horns might be ligated very close to their bifurcation, leaving most of the uterine body in the patient. Some practitioners remove only a portion of the uterine horn (indeed, in many ovariectomies, the cranial portion of the uterine horn is removed along with the ovary to ensure the entire ovary is taken out). If many patients that have undergone an “OVH” actually have remnants of their uterus remaining, it is hard to make a case that OVH eliminates the possibility of pyometra.

Is it better to use a spay hook, or your fingers?

Depends how good you are with the spay hook, and how big your fingers are!

Conclusion

In most cases, the decision as to which procedure to perform is based on clinical experience, comfort level, client demand, equipment and infrastructure. There is little evidence to strongly recommend one procedure versus another, as long as the ovaries are being removed. Retention of the ovaries is known to have health implications, predisposing to pyometra and mammary neoplasia. However, there is emerging evidence that early OVE may predispose to other diseases (see References).

If laparoscopy is being used, there is no evidence that OVH is safer than OVE, and hence OVE is becoming the procedure of choice in young animals with no evidence of uterine disease.

Where is the evidence? See References (with their Conclusions quoted) below.

The question that remains to be answered is: **Which procedure should we teach to veterinary students?**

We will debate this during the session, and hopefully draw some conclusions.
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“A total of 1728 cases of pyometra were recovered from a female dog outpatient caseload of 78,469 animals, giving a total prevalence of 2.2 per cent over the study period. There was an annual increase in the incidence of pyometra within the population, while elective ovariohysterectomy caseload has declined. Bullmastiffs (P<0.0001), golden retrievers (P=0.001) and dogue de Bordeaux (P=0.008) were over-represented in the pyometra population when compared with the female dog outpatient caseload. Mean age at presentation was 7.7 years. Some breeds presented at a significantly lower age, including dogue de Bordeaux (mean age 3.3 years) and bullmastiffs (mean age 3.4 years), while others presented as older dogs, including Yorkshire terriers (mean age 9.4 years) and border collies (mean age 10.3 years).”

Making a rational choice between ovariectomy and ovariohysterectomy in the dog: a discussion of the benefits of either technique.
Goethem, B. van Schaefers-Okkens, A. Kirpensteijn, J.
Veterinary Surgery; 2006. 35(2):136-143.
“OVH is technically more complicated, time consuming, and is probably associated with greater morbidity (larger incision, more intraoperative trauma, increased discomfort) compared with OVE. No significant differences between techniques were observed for incidence of long-term urogenital problems, including endometritis/pyometra and urinary incontinence, making OVE the preferred method of gonadectomy in the healthy bitch. Clinical Relevance - Canine OVE can replace OVH as the procedure of choice for routine neutering of healthy female dogs.”

Neutering dogs: effects on joint disorders and cancers in golden retrievers.
Riva, G. T. de la Hart, B. L. Farver, T. B. Oberbauer, A. M. Messam, L. L. McV. Willits, N. Hart, L. A.
There were no cases of CCL diagnosed in intact males or females, but in early-neutered males and females the occurrences were 5 percent and 8 percent, respectively. Almost 10 percent of early-neutered males were diagnosed with LSA, 3 times more than intact males. The percentage of HSA cases in late-neutered females (about 8 percent) was 4 times more than intact and early-neutered females. There were no cases of MCT in intact females, but the occurrence was nearly 6 percent in late-neutered females. (CCL – cranial cruciate ligament rupture, LSA – lymphosarcoma, MCT – mast cell tumor).
DO INTERNAL OBTURATOR FLAPS EVER FAIL?

Bryden J. Stanley

Michigan State University, East Lansing, Michigan, USA

Introduction:
Perineal herniation appears to occur as the pelvic diaphragm muscles weaken. The condition occurs almost always in older, intact male dogs. A definitive, single etiology eludes us, although it is generally accepted that hormonal imbalance (or different expression of androgen and/or relaxin receptors) plays an important part in the initiating pathology, with exacerbation from chronic constipation, tenesmus and sometimes urinary obstruction. Neurogenic atrophy has also been identified but not clearly explained. This seminar will not address the cause(s) or pathogenesis of the condition further, but rather, as the title suggests, discuss the most common herniorrhaphy technique and its complications.

Anatomy of the ischiorectal fossa and function of the pelvic diaphragm:
Regardless of the herniorrhaphy technique employed, the importance of reviewing the anatomy of these structures and the benefit of performing an anatomical prosection and practice procedure on a cadaveric specimen cannot be over-emphasized. Familiarity with the ischiorectal fossa will definitely and positively affect surgical outcome.

A. external anal sphincter
B. levator ani muscle
C. coccygeus muscle
D. sacrotuberous ligament
E. internal obturator muscle
F. pudendal neurovascular bundle
G. Caudal rectal branches
H. ischiatic nerve/caudal gluteal vessels
I. semitendinosus muscle
J. superficial gluteal muscle

The pelvic diaphragm comprises the coccygeus and levator ani muscles. The thick and generally robust coccygeus arises from the ischiatic spine and spreads out to attach to the transverse processes of the 2nd – 5th caudal vertebrae. The levator ani lies medial to the coccygeus, adjacent to the rectum. It arises from the medial ilium and pubic symphysis and attaches to the 7th caudal vertebra. These muscles have a number of functions:
1) support the lateral wall of the rectum
2) aid in elimination of feces from the rectum
3) prevent caudal herniation of abdominal structures during times of increased abdominal pressure
4) wag the tail (acting unilaterally)
5) tucks the tail between the legs (acting bilaterally)

The failure of this support from the pelvic diaphragm allows:
1) stretching, dilation or pouching of the rectum. Feces will not be eliminated and will dehydrate and accumulate in the caudal rectum. This constipation (or any other reason for straining such as prostatomegaly) will cause the dog to strain to defecate which, with time, will allow
2) herniation of abdominal contents caudally into the ischiorectal fossa.

Perineal herniation can occur unilaterally (66%) or bilaterally, and strangely, appears to be more common on the right (80%). Although the levator ani is often difficult to identify in the affected dog, the coccygeus is usually still evident and able to be used in the repair.

Clinical Signs and Diagnosis:

Tenesmus and perineal swelling ventrolateral to the anus are the most consistent presenting signs. Mostly the herniated mass is soft and easily reducible, although bladder can be retroflexed or caudally displaced into the ischiorectal fossa, which can cause variation in the size of the swelling. If a retroflexed bladder is incarcerated or strangulated, stranguria and severe metabolic imbalances can ensue. Digital examination of the rectum nearly always reveals a lateral deviation or pocket. It may be impacted with feces which must be manually removed to enable thorough examination. Always check both sides of the rectal wall, as herniation may be imminent on the non-affected side, and weakness of the musculature evident. Check also for a ventral pocket, as a significant ventral component may require additional management. This condition is fairly easy to diagnose, but differentials include neoplasia, abscess and cyst.

Pre-surgical Treatment:

Unless the bladder is strangulated in the hernia, surgical treatment is not an emergency. If the bladder is retroflexed, an attempt to catheterize and empty it should be made. If this is unsuccessful, it can be drained by cystocentesis, attempted manual reduction and then catheterized. Surgical management of the “complicated perineal hernia”, with bladder retroflexion, will be discussed below. A thorough clinical evaluation, laboratory workup and appropriate supportive therapy are recommended as affected dogs are generally older animals.

The patient should be fasted for 24 hours before surgery and warm water enemas administered the evening prior to surgery. Perioperative antibiotics are recommended. Following anesthesia, the anal sacs are expressed and the rectum manually evacuated if fecal material has arrived. A purse string suture placed in the anus, and appropriate signage placed on animal. The animal is placed in a modified Kraske position - sternal recumbency with the hind limbs hanging over the elevated end of the table and the tail pulled craniodorsally. The inguinal area should be padded and operating table may be tilted to elevate the hindquarters - take care not to compromise respiratory function.

Herniorrhaphy techniques:

Typically, at time of herniorrhaphy, castration is performed. The rationale for this is several-fold - it may reduce the possible hormonal influence on the pelvic diaphragm muscles, and it will decrease the size of the prostate, which can exacerbate the straining and subsequent herniation. A perineal castration can be performed with the dog in the Kraske position, or following re-positioning into the traditional dorsal recumbency.

Following aseptic preparation of the surgical site, a curved incision is made adjacent to the anus in a dorso-ventral direction. The hernial sac is opened and the hernial contents reduced before the herniorrhaphy is started. Typically, when the hernial sac is entered, fluid will emanate and a variety of consolidated fat and fibrous strands will be encountered, obscuring the view. (This is why it is so important to know your anatomy!) . The contents are best reduced by freeing up the adhesions and pushing them gently back towards the abdomen, typically medial to
the coccygeus. They can be held in reduction with an instrument. The landmarks of the ischiorectal fossa can then be identified. Frequently, only remnants of the levator ani muscle are found, due to muscular deterioration.

With all herniorrhaphy techniques, some tips include:

- Use 0 or 2-0 monofilament non-absorbable or slowly absorbable interrupted sutures - preplaced, and only tied when they have all been placed.
- Avoid the pudendal nerve and internal pudendal vessels ventrally when suturing, and the caudal rectal branches.
- Avoid the caudal gluteal vessels on the lateral aspect of the ischiorectal fossa.
- Avoid penetrating the rectum or anal sacs when placing sutures into the external anal sphincter.
- Care not to incorporate the sciatic nerve if placing sutures through the sacrotuberous ligament (place sutures through, not around, the ligament if using this structure).
- There is sometimes a thick enough hernial sac to place another row of supporting sutures before closing the subcutaneous layer and skin routinely.

**Traditional herniorrhaphy:**
During my residency, shortly after electricity was invented, the traditional technique for performing perineal herniorrhaphy was to suture the coccygeus m. (and levator ani, if evident) to the external anal sphincter, and then secure the ventral aspect with sutures from the external anal sphincter and coccygeus to a partially elevated internal obturator. Tension was often high at the ventral aspect of the herniorrhaphy, and recurrence rates from this technique are higher than the subsequently described internal obturator flap.

**The internal obturator muscle transposition:**
This technique has significantly better results with a much lower recurrence rate than the traditional technique, and is most probably the procedure of choice of surgical specialists. One or two sutures are placed dorsally between the coccygeus and external anal sphincter, and then the caudal border of the internal obturator is incised and elevated from the ischiatic table to the level of the obturator foramen. Its tendon is transected as it crosses over the lesser ischiatic notch of the ischium, taking care to avoid the sciatic nerve coursing laterally. The muscle flap is then swung dorsally and sutured to the external anal sphincter medially, and the coccygeus. At the most dorsal point of the flap, the internal obturator is sutured to the external anal sphincter and coccygeus muscles, with one suture incorporating all 3 muscles. The sacrotuberous ligament can be incorporated laterally if appropriate.

**Issues with the internal obturator technique:**

- **Technical error.** Failure to accurately identify anatomical structures will lead to failure of any technique, including the internal obturator transposition. Experience of the surgeon has been shown to play a role in recurrence rates, and lack of anatomical knowledge leading to a poorly performed procedure is likely the most common cause of “failure” of this technique.
- **Tension.** Too much tension will result in suture cut out from pressure causing ischemia and subsequent necrosis. This is not common when using the internal obturator transposition compared to the standard technique, but can occur if there is a small internal obturator, if the angle of the ischial plateau is steep, or in cases of significant herniation of abdominal contents into the area (see Complicated perineal hernia).
- **Atrophied coccygeus.** Occasionally, the coccygeus muscle may not be adequate to hold sutures
- **Small internal obturator.** Rarely, the internal obturator may be inadequate to hold sutures.
- **Loss of internal obturator.** Over aggressive elevation of the internal obturator will damage its nerve and blood supply and result in atrophy of the muscle.
- **Ventral pocket.** In some cases, usually in bilateral perineal herniation, there is a significant ventral component to the hernia. This ventral weakness is not corrected by the internal obturator technique.
animals will function well with dietary management following internal obturator transposition, but if a significant ventral pocket leads to ongoing fecal accumulation, a semitendinosus transposition should be considered.

**Superficial gluteal muscle transposition:**
This technique actually dates back to the 1980s, but has not been widely reported as the preferred technique for first surgical intervention. The approach requires a longer incision, and takes slightly longer to perform, but can contribute significant support with a thick muscle pad. Superficial gluteal transposition can be combined with internal obturator transposition, when the coccygeus is not robust. It can also be used when the internal obturator transposition has failed for one of the above reasons.

The usual perineal incision is extended dorsally over the hip and the superficial gluteal is readily identified lateral to the sacrotuberous ligament. Its broad aponeurotic tendon of insertion is transected as low as possible on the lateral femur. A little more dissection allows the muscle to be reflected (or just caudally rotated if using it with the internal obturator transposition) into the ischiorectal fossa and the tendon sutured to the external anal sphincter caudally and the internal obturator (or whatever tissues remain) ventrally.

This technique is well-tolerated by the animal and is a good use of an adjacent muscle. It is valuable to know as it can provide a strong support to cases with significant herniation of abdominal contents in addition to the rectal dilation or acculation.

**Semitendinosus muscle transposition:**
The semitendinosus is long muscle arising from the caudolateral ischiatic tuberosity, extending down the back of the thigh to insert in fascia of tibia. This Type III muscle has a two dominant vascular pedicles (the caudal gluteal vessels proximally and the distal caudal femoral distally), and can survive on either one of these. Section of the semitendinosus muscle up to two thirds of its length allows it to be swung 90 to 180 degrees to aid in hernia repair.

The most common use in perineal herniation is to support the ventral component of this condition following bilateral internal obturator or superficial gluteal transposition. The muscle can be swung in from the ipsilateral or contralateral side and sutured to the sacrotuberous ligament, coccygeus, external anal sphincter and internal obturator muscles.

Although very effective in eliminating the ventral component and bringing support into the area, this technique carries some morbidity with a transient lameness for a day or two. A closed-suction drain is recommended.

**Meshes and other scaffolds:**
Polypropylene meshes, fascia lata and a variety of decellularized collagen matrices have been used to provide support to the pararectal area, being sutured to the external anal sphincter, coccygeus, sacrotuberous ligament and internal obturator. These appear to be quite effective, although no randomized, comparative studies have been published. These could also be used as adjunctive support to one of the muscle flaps. In my experience, due to the availability of local muscles, meshes are not commonly used. Foreign material also carries the potential for causing irritation or rejection, inflammation and infection with the subsequent development of draining tracts.

**Complicated perineal hernia:**
Up to 20-30% of perineal hernias can involve substantial abdominal contents such as a retroflexed or caudally displaced bladder, prostate or intestines. These cases can be accompanied by significant metabolic derangement including azotemia, acidosis, hyperkalemia, etc., and will require stabilization before any surgical intervention. These severe cases also benefit from an abdominal approach prior to herniorrhaphy, at which time the herniated contents are reduced and secured within the abdomen. The advantages of doing this before hernia repair are several – It immediately makes the patient more comfortable; it makes the definitive herniorrhaphy much easier to perform as much of the contents have been reduced, and it prevents strain on the repair itself, as the contents are now fixed within the abdomen and will not translocate caudally when intra-abdominal pressure is raised. Following careful reduction of all herniated contents to their anatomically correct locations, procedures performed include:

- Vas deferens pexy – secures the prostate and bladder within the abdomen by securing each vas deferens to the lateral or ventral body wall (done following open castration).
- Cysto pexy – secures the bladder within the abdomen by suturing to the right body wall
- Colopexy – will minimize rectal dilation and/or prolapse in a subsequent bilateral herniorrhaphy. The colon is pexied to the left body wall following scarification.
Whether the castration, abdominal approach and the herniorrhaphy are staged by several days, or done under one procedure is largely dependent on the condition of the dog and the preference of the surgeon. The same holds true for staging bilateral herniation, or doing both sides under one anesthetic event.

DON’T EVER FORGET TO REMOVE THE PURSE STRING
URETHRAL SPHINCTER MECHANISM INCOMPETENCE – ANYTHING OTHER THAN COLPOSUSPENSION?

Bryden J. Stanley, Heather S. Hadley

Michigan State University, East Lansing, MI, Blue Pearl Veterinary Specialists, Minneapolis, MN

Anatomy
The urinary tract consists of four functional anatomic parts including the kidneys, the ureters, the bladder, and the urethra. Normal micturition requires intricate and coordinated interaction of the nervous system, the urinary bladder, and the urethra. The key anatomic components of the lower urinary tract include:

• The bladder body and neck which are comprised of detrusor smooth muscle
• The proximal urethra or internal urethral sphincter (IUS) which is also composed of smooth muscle
• The distal urethra or external urethral sphincter (EUS) which consists of striated muscle.

The urethral closure mechanism consists of the bladder neck and the urethral smooth and striated musculature. Functionally, the urinary cycle is divided into two phases, the storage phase and the voiding phase.

Storage: Sympathetic input is responsible for the storage phase of urination and is supplied to the bladder and IUS via the hypogastric nerve. The hypogastric nerve stimulates detrusor beta receptors in the bladder, inducing smooth muscle relaxation and permitting bladder filling under low pressure. The hypogastric nerve also stimulates alpha-1 receptors of the bladder neck and the internal urethral sphincter inducing smooth muscle contraction. This closes the outlet flow tract and maintains continence. During the storage phase, additional input through the pudendal nerve stimulates nicotinic cholinergic receptors in the EUS, causing contracture and additional closure of the outlet when needed (during barking, coughing, sneezing, or to over-ride the urge to void when inappropriate). During the storage phase, urethral resistance must exceed intravesicular pressure to maintain continence.

Voiding: As bladder filling progresses, sensory receptors embedded in the bladder wall relay stretch information via the pelvic nerve to the spinal cord. The information is relayed to the brainstem, where the impulse to empty the bladder is sent down the spinal cord. Parasympathetic pelvic nerve stimulation of muscarinic cholinergic receptors in the detrusor muscle results in bladder contraction and a sharply increased intravesicular pressure. Simultaneously, parasympathetic inhibition of sympathetic input to the IUS and voluntary inhibition of EUS contraction causes passive relaxation of the outflow tract and allow voiding. Conscious control to the striated urethral musculature of the EUS travels via the pudendal nerve again.

Urinary incontinence is defined as the involuntary escape of urine during the storage phase of the urinary cycle. Clinically, patients present with intermittent or continuous urine dribbling. However, it is important to note that normal voiding may also occur. Causes of urinary incontinence are traditionally divided into neurogenic and non-neurogenic disorders, with the latter group divided into anatomic anomalies, acquired abnormalities, and functional abnormalities. Anatomic anomalies includes ectopic ureters, and acquired abnormalities of the lower urinary tract that cause incontinence are inflammatory or infiltrative diseases of the bladder or urethra such as cystitis, urethritis, neoplasia, urolithiasis, and prostatic disease. A functional disorder exists when the bladder and urethra are structurally normal but fail to perform properly.

Urethral Sphincter Mechanism Incompetence:
The most common functional abnormality causing incontinence is urethral sphincter mechanism incompetence. In addition to the urethral smooth and striated muscle tone, a complex mechanism of factors contributes to overall urethral resistance and thus continence. These include:

• urethral elasticity
• urethral physical properties such as length and diameter
• intra-abdominal pressure acting on the outer surface of the urethra
• and the degree of engorgement of suburothelial venous plexuses
These combined factors compose the urethral sphincter mechanism. Therefore, urinary incontinence as a result of abnormal function of the urethral sphincter mechanism is termed urethral sphincter mechanism incompetence or USMI. USMI can present in dogs and cats, males and females, and may be a congenital or acquired condition. It is generally an acquired condition in spayed female dogs; however, in some medium to large breed dogs and rarely in cats, it may precede ovariohysterectomy or be considered congenital in nature.

**Congenital USMI**
In the congenital form of the disease, clinical signs are typically observed in the young, sexually intact dog and are often associated with other anatomic malformations (such as a short, wide, or absent urethra, bladder hypoplasia, or ectopic ureters). Leakage observed with congenital USMI is typically greater than with ectopic ureters. It should be noted that 50% of these dogs are reported to become continent after their first heat cycle.

**Acquired USMI**
Acquired USMI is the most common form of adult canine incontinence. Although it has been reported in males, the incidence is much higher in females, affecting 5-10% of spayed dogs. If only large breed dogs are considered, the incidence approaches 12.5% of spayed females. The onset of incontinence usually starts 2-3 years after an uneventful spay, making most dogs middle-aged at the time of presentation. Owners typically describe urine dribbling that is most noticeable when the animal is recumbent or sleeping. The exact abnormality leading to USMI and the region of the urethra in which it occurs are unknown. It appears to be a multifactorial problem and various factors are suspected to contribute to its clinical manifestation. These factors include:

- **Urethral tone:** The introduction of urethral pressure profilometry has confirmed that poor urethral tone is present in USMI. Urethral tone is maintained by a complex interaction of neuromuscular, vascular and passive elastic components, and it is unclear which of these is deficient in sphincter mechanism incompetence.

- **Urethral length:** Considerable variation exists in urethral length among dogs of different sizes, however, dogs with USMI tend to have shorter urethras than continent animals.

- **Bladder neck position:** Several authors have reported the radiographic finding of a pelvic bladder in incontinent animals. The role of bladder neck position with USMI is thought to be due to changes in the transference of abdominal pressures to the urethra, which typically acts as an external occluding force.

- **Body size:** Large breed dogs appear to be particularly at risk for USMI.

- **Breed:** Dobermans, Old English Sheepdogs, Rottweilers, Weimaraners, Springer Spaniels and Iris Setters appear to be over-represented.

- **Ovariohysterectomy/ovariectomy status:** There is a well-documented association between spaying and urinary incontinence. This is theorized to be due to a lack of circulating estrogens as estrogen exerts a permissive effect of the alpha receptors of the internal urethral sphincter, removal of estrogen results in decreased responsiveness of the muscle to sympathetic stimulation and decreased internal sphincter tone.

- **Body condition score:** Although not a cause of the condition, it is thought that obesity worsens the condition of USMI.

The diagnosis of USMI is largely based upon patient signalment, history, physical examination, and the exclusion of other causes of incontinence. A minimum database including a urinalysis with culture and sensitivity should be performed in all patients. Additional diagnostics may include ultrasound, contrast radiography, contrast CT and cystoscopy. Because of the prevalence of USMI in middle-aged spayed female dogs, the typical clinical presentation, and the relative safety of the drugs used to treat this condition, some clinicians advocate diagnosing the condition by therapeutic trial of suspected cases. However, a definitive diagnosis can be obtained only by a urethral pressure profile, using specialized equipment.

**Medical management of USMI:**
USMI may be fully, partially, or transiently responsive to medical management. The mainstays of medical management include phenylpropanolamine or PPA and estrogen therapies. PPA is an alpha adrenergic agonist that
increases urethral tone by stimulating alpha adrenergic receptors in the urethra. Adverse effects of PPA include hypotension, tachycardia, restlessness, irritability, increased intraocular pressure, and gastrointestinal signs. Diethylstilbestrol (DES) is a synthetic estrogen that increases smooth muscle contractility and the sensitivity of alpha adrenergic receptors in the urethra. Adverse effects of DES include behavioral changes, bone marrow toxicity, signs of estrus, and alopecia. Around 75-90% of female patients will respond very well to one or a combination of these therapies. Males, however, are less likely to respond to medical therapy, with less than 50% seeing improvement.

**Surgical treatment of USMI**

Surgical intervention is typically reserved for patients in which appropriate medical management has failed, that have experienced adverse reactions to medications, that have comorbidities that preclude the use of medical therapies, or where the owners no longer wish to medicate long-term. The goal of surgical treatment is to increase urethral resistance to prevent the outflow of urine during the storage phase, but to allow it to flow during detrusor activation. Various interventions focus on:

1) Cranial translation of the bladder to increase intra-abdominal forces acting on the urethra
2) Reducing the diameter of the urethral lumen
3) Improving functional urethral length

It is obvious from the list of surgical techniques and interventions that have been described that there is not one clear and proven procedure that provides consistent improvement with low recurrence rates. However, it does appear that techniques are improving, especially with respect to long-term signs. The following list covers some commonly performed procedures:

**Colposuspension**

Through a caudal ventral midline celiotomy, the bladder and bladder neck are cranially advanced, and the urethra compressed against the pubic brim with two mattress sutures from the vaginal wall to the prepubic tendon.

**Urethropexy**

Using the same approach to that of the colposuspension, the urethra is pexied to the ventral abdominal wall during closure, thus kinking the urethra at the site of urethropexy. Some surgeons have reported combining this technique with colposuspension.

**Urethral lengthening**

The proximal urethra is elongated by resecting two full-thickness V-shaped flaps in the ventral bladder wall, in an aim to increase functional urethral length and cranially advance the bladder.

**Sling urethroplasty**

Seromuscular flaps are created from the ventral bladder neck, reflected laterally and secured together on the dorsal aspect of the bladder neck. This aims to reduce the urethral diameter via circumferential compression, and the closure of the partial thickness bladder incision. This technique also claims to somewhat increase the functional length of the urethra.

**Minimally invasive techniques**

Endoscopically-guided implantation of various bulking agents such as medical-grade collagen, PTFE (Teflon), at several submucosal sites in the proximal urethra has been undertaken at several institutions.

**Transobturator vaginal tape**

Polypropylene tape is passed from a retropubic approach, via episiotomy, dorsal to the urethra and secured ventral to the vagina. This technique aims to reduce urethral diameter via compression from the tape. Retropubic sling systems are now commonly employed in women with stress incontinence, and these techniques warrant further investigation.

Overall, the outcomes of these interventions have not been uniformly successful. Many appear to have good short-term efficacy but poor long-term results with restoration of continence in only 14-56% of patients. For some techniques, such as the retropubic tape, there are limited long-term data. This current lack of a consistently effective surgical technique is important, as failure may ultimately lead to euthanasia. The continued need for successful
treatment options is also clearly evident in human medicine. The cost of urinary incontinence to the US health care system is estimated to be as high as 19.5 to 32 billion dollars per year.

**Artificial urethral sphincters**

In humans, the artificial urethral sphincter (or AUS) is currently considered the gold standard for patients with refractory USMI. The first AUS was described in 1947 by Foley. Foley’s AUS consisted of an externally worn urethral cuff that was attached to a pump kept in the patient's pocket. In 1972, the first AUS to resemble the current model was developed by Scott. This device consisted of a fluid reservoir, an inflatable cuff with 4 unidirectional valves, an inflation pump, and a deflation pump. Scott’s design was modified over the next decade and in 1983, the AMS 800 was introduced. It is currently the most widely used and successful artificial urinary sphincter available for patients with severe USMI. (Severe USMI is defined as the inability of the urethra to maintain effective closure pressure sufficient to keep the patient clinically dry during stress (such as coughing, sneezing, or laughing) or during reasonable physical activity). To date, ~100,000 patients have been treated with the AMS 800.

At MSU we transitioned from colposuspension (occasionally with urethropexy) to endoscopic placement of collagen in the proximal urethra, with similar long-term results – many animals requiring repeat intervention after several months. However, based upon encouraging results from Adin, we started placing hydraulic urethral sphincters in 2009 and have currently placed 12 devices.

**HUS placement:** A caudal ventral midline celiotomy is performed. Cranial retraction of the bladder with a stay suture and the periurethral fat carefully dissected away from the proximal urethra. A variably sized silicone vascular occluder is selected and carefully primed to ensure no air is within the system. The system is temporarily connected to the port and the volume to full occlusion is recorded. All fluid apart from prime fluid is removed. The cuff is placed around the urethra and sutured together with 3-0 or 2-0 polypropylene. The infusion line is tunneled through the body wall and into a lateral flank area, where it is secured to the primed port. The port is sutured to the body wall through the appropriate holes. Closure is routine.

Currently all dogs are continent, but it has definitely been a learning curve and a variable degree of ongoing management is required. The silicone occluders are not designed to be permanently implanted (they are designed for short-term vascular occlusion), although they are probably adequately durable for this procedure. The devices designed for permanent implantation in humans are obviously much more costly, which tends to preclude their use in veterinary medicine.

**Learning curve from using the HUS in 12 dogs:**

- Implanted a larger size cuff than you think you will need (we hardly ever put smaller than a 10mm cuff). We initially measured the urethral diameter and placed a cuff that was half the size measured. But due to apparent constriction from fibrosis we have replaced 3 dogs with a larger cuff. We think there is less chance of erosion of the urethra and stricture due to fibrosis. One of the additional advantages of having a larger cuff is that there is more volume to titrate, which is much easier when you are dealing with 0.1 ml “tweaks” at a time.
- Use Hetastarch rather than saline. We suspect that with time, there may be some diffusion of saline or buffered saline from the cuff.
- Place the subcutaneous injection port in a convenient area, easy to stabilize. We initially placed the port on the ventral abdomen. We now place it in the flank area.
- Wait a month before starting inflation of the cuff. Based upon experience with the AUS in humans, a 4-6 week delay in inflation of the cuff is recommended to allow revascularization of the dissected portion of the urethra and to decrease the incidence of urethral atrophy. Adin reported that he had no longer been waiting this prolonged period in his patients, but we have found that waiting this period allows for a more consistent course to continence.
- Some cases do not require filling, but become continent with just the implantation of the primed device. Slowly and consistently add small volumes (e.g., 0.1 ml), waiting a week between injections. There appears to be a very fine line between too much and too little volume for the cuff, hence the need for patience.
- Be careful not to inadvertently depressurize the system (ensure the Huber needle is firmly attached to the syringe).
• When animal becomes continent, test for residual volume following voiding (usually by performing a quick post-voiding ultrasonography).
• If incontinence returns, perform urinalysis and culture before doing anything else.
• We have used urethroscopy to evaluate urethral closure at the site of the HUS. Priming the urinary system at 40 cm of H20 will be an indication of whether the cuff is holding appropriately. This is approximately the threshold pressure for initiation of the micturition reflex. If urethral dilation is observed at this pressure, it suggests that there isn’t adequate resistance to maintain continence and that the cuff could be further filled.
• The HUS system can was also be imaged via contrast fluoroscopy, to check for leakages if a sudden return to incontinence occurs. Contrast is injected into the subcutaneous port.
• In 2 dogs, we have noted that the minimal volume required to attain functional continence also left a small residual volume in the bladder following voiding. We suspect these dogs to have a weakened detrusor muscle – in these cases the bladder often appears flaccid, even when empty. These dogs subsequently did well with the additional of bethanechol to stimulate detrusor contraction. Bethanechol is a long-acting parasympathomimetic that is selective for muscarinic receptors without any effect on the nicotinic receptors.

Based upon these 12 dogs, we have learned that although the surgical placement of the HUS is not technically demanding, post-operative management requires infinite patience and clear communication with the owner. Manage the owners’ expectations - they are often impatient and keen for more frequent injections, or larger volumes per injection. We recommend the owner keep a diary for the first few months. Overall, results are encouraging and indicate that HUS is a valid, and most likely first choice, treatment option for dogs with refractory USMI at this time. As additional cases are accumulated, the outcomes for short and long-term efficacy of the HUS, the reliability of the implants, and associated complication rates will become more clear.
BETTER NEWS FOR CHYLOTHORAX?

Bryden J. Stanley

Michigan State University, East Lansing, Michigan, USA

Anatomy of the lymphatic vascular system:
The lymphatic system consists of a tissue component and a vascular component. The tissue portion plays a major role in immune defense mechanisms, whilst the vascular component of the lymphatic system really acts as an auxiliary to the venous part of the vascular system. The vascular component includes lymph capillaries, larger vessels and lymph transporting ducts. As blood flows through capillary beds, significant amounts of fluid and proteins (up to 50% of the total circulating protein) escape into the interstitial compartment. This fluid (generally clear and colorless) readily enters the lymphatic capillaries and returns slowly via the lymphatic ducts to the systemic venous system cranial to the heart. Lymph typically contains proteins and cells (polymorphonuclear cells, mononuclear cells and red blood cells), but lymph from each region of the body has a characteristic composition. Lymphatic villi in the intestines absorb emulsified fat and thus the lymphatic vessels (called lacteals) appear milky or “chylous”. Small lymphaticovenous communications have been demonstrated to nearly all the veins of the body, especially in the renal area. When a major duct such as the thoracic duct is ligated, the lymphatic system opens up lymphaticovenous anastomoses proximal to the obstruction. The small lymphatic capillaries are simple, transparent endothelial tubes, but the larger lymphatic vessels are surrounded by poorly organized smooth muscle and a thin fibrous adventitia. Upon gross inspection however, even the larger vessels appear incredibly thin and difficult to identify. Flow of lymph depends mainly upon movement of adjacent muscles, although some weak intrinsic contractions have been noted. Large lymphatic vessels contain valves, and when obstructed, lacteals can show a ‘string of beads’ appearance.

Lymphatic drainage of the thoracic limbs and head and neck is via the lymph nodes to the right and left tracheal trunks. The right tracheal trunk usually terminates into the venous junction of the external jugular and the right subclavian. The left tracheal trunk usually terminates into the thoracic duct. Lymphatic drainage of the pelvic limbs (via the iliac lymph nodes) and the abdominal viscera (via the mesenteric lymph nodes) is to the cisterna chyli. The cisterna chyli is a bipartite structure that lies in the retroperitoneum, closely associated with the abdominal aorta. The part that lies ventral to the aorta is plexiform, and extends from the caudal pole of the left kidney to cranial mesenteric artery. It communicates via are variable network of connections to the more cranial part that lies dorsal to the aorta. This part is saccular, and extends from the left renal hilus to the celiac artery – but can be quite erratic in location, and sometimes even extends through the aortic hiatus of the diaphragm before it narrows into the thoracic duct. The thoracic duct is the main channel for the return of lymph from the caudal body and abdominal viscera; it is the cranial continuation of the cisterna chyli. Its exact point of origin is variable, depending on the rather erratic location of the cisterna chyli. It seems to begin mostly as a single duct, but can then become quite plexiform in nature - most notably in the caudal thorax. It is closely associated with right dorsal aspect of the thoracic aorta until the level of the sixth thoracic vertebra, where it traverses to the left side, running cranioventrally to terminate in the junction of the left external jugular vein and the cranial vena cava.

Etiologies of chylothorax:
Chylothorax is defined as the accumulation of chyle within the pleural cavity. It does not occur commonly, but is seen on a regular basis in referral institutions, and can be devastating for both animal and owner. Reported etiologies for free chyle collecting in the thorax in both dogs and cats include right-sided cardiac failure (cardiomyopathy, congenital anomalies), pericardial disease, diaphragmatic malformation, diaphragmatic hernia, mediastinal neoplasia (lymphoma, thymoma, heart based masses), granulomas, lymphangiectasia, lung lobe torsion, jugular venous thrombosis, dirofilariasis, blastomycosis, and traumatic or iatrogenic rupture of the thoracic duct. Generally when the thoracic duct has been lacerated (trauma or surgery) the resulting chylothorax tends to resolve with simple drainage, as the duct heals rapidly.

In most presentations, no specific underlying cause is identified and the condition is termed “idiopathic”. Very little is known about the underlying pathology of “idiopathic” chylothorax. It is suspected that some type of mediastinal lymphangiectasia causes a lymphatic obstruction, possibly associated with a transmural insufficiency that allows chyle to leak through the thin endothelial walls of the thoracic duct. Breeds of dogs reported to be predisposed are Afghan hounds, Borzois, Salukis, and Mastiffs. However, it can be seen in any breed or mixed breed, including
Labrador Retrievers, Golden Retrievers, Shelties, German Shepherd dogs, etc. Chylothorax is also seen in cats - there may be a predisposition to Oriental breeds. Cats tend to develop fibrosing pleuritis more readily than dogs with chylothorax, although with chronicity the pleurae become thickened in all animals.

**Diagnosis of idiopathic chylothorax**

Clinical signs of pleural effusion include increased respiratory rate (sometimes with abdominal effort), restrictive breathing pattern, lethargy, inappetence, exercise intolerance, coughing and occasionally vomiting. Physical examination typically reveals muffled heart sounds, decreased lung sounds ventrally and increased dorsally, and occasionally cyanosis (depending on severity). There is a lack of resonance upon thoracic percussion. Weight loss occurs with chronicity.

Differential diagnosis of pleural effusion includes hydrothorax, hemothorax, pyothorax and chylothorax. A thorough work up (which is largely to rule out an underlying cause) includes complete blood count, serum biochemistry, heartworm test, thoracic and abdominal radiography, abdominal ultrasonography, echocardiography, pleural fluid cytology and analysis, pleural fluid culture. Thoracocentesis is required to obtain pleural fluid sample for definitive diagnosis and will often provide relief of respiratory distress if a significant volume of fluid is removed. The technique is typically performed through the right 5th intercostal space, with the animal in sternal recumbency, using a butterfly or veress needle, extension tubing and a 3-way stopcock. Aseptic technique is indicated. Chyle is classed as a modified transudate (protein > 2.5 g/dL, cell count 6,000-7,000), with predominant cell types lymphocytes and non-degenerate neutrophils. With chronicity, more macrophages can be present. The fluid has a characteristic milky white or milky pink appearance to it and special staining will reveal the presence of chylomicrons. Definitive confirmation of chyle is obtained by demonstrating increased fluid triglyceride concentration compared to the serum levels. Thoracic CT will provide a more thorough assessment of intrathoracic structures, and is typically performed using lymphangiographic CT before definitive surgical intervention is undertaken.

**Management options**

This condition can be extremely challenging to manage successfully. Failure to resolve the pleural effusion is frustrating to client and clinician, and potentially devastating to the animal. Over the years several numerous medical and surgical interventions have been employed, with varying degrees of success. Medical management consists of dietary modification (to decrease fat absorption into the lymphatic system), and pharmaceutical intervention (to decrease chyle volume and thoracic duct flow) such as rutin or octreotide. Corticosteroids and diuretics have also been used. During medical management protocols, the thorax must be repeatedly drained to maintain comfort. Typically, idiopathic chylothorax is refractory to medical management, and major surgical intervention is frequently required. The goal of surgical intervention is to divert chyle flow away from the thoracic duct system, drain pleural accumulation of chyle, or facilitate flow into the systemic venous system through pressure changes. Many different procedures have been described including passive or active pleuroperitoneal shunting, pleurovenous shunting, pleurodesis, thoracic omentalization, cyanoacrylate instillation, pericardectomy, thoracic duct ligation and cisterna chyli ablation.

Although the most effective choice of surgical intervention has yet to be definitively validated, individual or en bloc ligation of the thoracic duct and all identifiable collaterals has been at the core of surgical treatment. Thoracic duct ligation is typically performed through a right caudal intercostal approach in the dog, and left caudal intercostal approach in the cat. Complete resolution of chylothorax with thoracic duct ligation alone is reported in ~ 60% of cases, even when pre- and post-ligation lymphangiography and vital staining (using methylene blue) is performed to identify anatomic variations of the thoracic duct network. In a low percentage of animals, a non-chylosus effusion can continue.

Over the past decade, several adjunctive surgical procedures to thoracic duct ligation have been reported that appear to have improved outcomes. These include cisterna chyli ablation and pericardectomy. The aim of cisterna chyli ablation is to destroy the cisterna chyli (the collecting reservoir into which the intestinal lymphatics drain, and from which chyle drains into the thoracic duct) which completely disrupts the flow of chyle into the thoracic duct. The aim of pericardectomy is to decrease right-sided venous pressure, thus facilitating drainage of the chyle into the venous system. When either of these techniques is performed concurrently with thoracic duct ligation, success rates for resolution of chylothorax increase. Recent comparison of outcomes after various combination of these procedures suggest that thoracic duct ligation + cisterna chyli ablation will have a superior outcome compared to thoracic duct ligation + pericardectomy. Many surgeons will undertake all of these procedures (i.e., thoracic duct ligation, cisterna chyli ablation and pericardectomy) in an effort to optimize outcome for their patients.
Each of the previously mentioned procedures has been described with separate approaches - typically a right 9th or 10th intercostal thoracotomy for thoracic duct ligation (left in cats), followed by median celiotomy for cisterna chyli ablation, and a 4th or 5th intercostal thoracotomy for the pericardectomy. Procedural modifications have now been developed which decrease operative time and patient morbidity, without compromising outcome. Such modifications that include endoscopic approaches (either transdiaphragmatic through the abdomen or thoracoscopic), and a single, paracostal approach to provide surgical access to both the cisterna chyli and the thoracic duct. These techniques appear to substantially decrease postoperative discomfort and hospitalization time.

In the paracostal approach, dogs are positioned in left lateral recumbency with the thoracolumbar region elevated by a rolled towel bolster. A right-sided, dorsal, paracostal approach allows access to the dorsocranial right abdomen and the retroperitoneum – where the cisterna chyli is located. From this approach, the diaphragm can be retracted caudally, then incised parallel to its costal attachment. By placing stay sutures into the pars costalis, the diaphragm can be manipulating to expose the right caudal thorax and retropleural space – and thus the thoracic duct. Also from this single approach, the mesenteric lymphatics (either lymph node or vessel) can be accessed to introduce dye to highlight the cisterna chyli and thoracic duct. This vital staining is essential before undertaking any dissection near the thoracic and abdominal aorta, as the nearly invisible thoracic duct and cisterna chyli are closely associated with the aorta. Once the cisterna chyli and thoracic duct are identified by their blue coloration from the vital staining, careful dissection around the thoracic duct can be performed, and the duct and any collaterals can be ligated close to the diaphragm. At this stage, the cisterna chyli tends to plump up and the structure can be more clearly exposed with careful dissection, before its destruction by tearing it gently away from the underlying aorta. Closure of the diaphragm and abdomen is routine. The paracostal approach, with its low morbidity, can be performed bilaterally under one anesthesia, or staged if chylous effusion persists due to the presence of a right-sided thoracic duct collateral. Pericardectomy is usually performed through a right 5th intercostal thoracotomy or thoracoscopically. It appears better to remove as much pericardium as possible, which is usually to the heart base on the right and to the phrenic nerve on the left.

Another technique that has decreased the morbidity associated with repeated thoracic drainage is the placement of a subcutaneous pleural port, leading to a fluted or fenestrated thoracic catheter. Placement of this device eliminates the need for a post-operative thoracic drain, and allows for early discharge from critical care into either the ward or into the home. Drainage is then accomplished by the transcutaneous insertion of a 19 gauge Huber needle into the port, and 3-way stopcock. Chylous effusion can sometimes persist for up to a month in some cases of chylothorax, before finally resolving (continued leakage through the aortic hiatus?), so the ability to repeatedly drain the pleural cavity with virtually no discomfort to the animal is most valuable.

Overall success rates are probably around 80-90% when all three procedures (thoracic duct ligation, cisterna chyli ablation, pericardectomy) are performed. If chylous effusion persists, we recommend reoperation on the left side through a paracostal approach, or intermittent drainage through the pleural port on a long-term basis. A few animals will develop a non-chylous effusion. All animals with pleural effusion are susceptible to lung lobe torsion.

**Summary points**

1. “Idiopathic” chylothorax is a serious condition that is poorly understood.
2. Further basic research is indicated to elucidate the underlying etiology and pathophysiology.
3. Further clinical research is indicated to validate the best combination of interventions to maximize outcomes, including the cost-effectiveness of various lymphangiographic procedures.
4. Although we have improved management over the last decade, we need to strive for better outcomes.
5. It is prudent to provide means of regular, intermittent drainage (i.e., subcutaneous pleural ports)
TIPS AND TRICKS FOR PERINEAL URETHROSTOMY

Bryden J. Stanley

Michigan State University, East Lansing, Michigan, USA

The technique of feline perineal urethrostomy (PU) is an effective way of reducing signs of urethral obstruction in many cases of feline lower urinary tract disease (FLUTD). It is critical that urethral obstruction component be accurately diagnosed, and not confused with conditions of similar presentation such as feline idiopathic cystitis or feline encrusting cystitis. Surgical intervention will not resolve clinical signs associated with these other conditions, although presenting clinical signs may be similar.

PUs were commonly performed in the 70s and 80s due to the high incidence of struvite urolithiasis. As dietary formulations were improved and cats were less prone to struvite formation, the need for the procedure declined. However, in recent years, PUs are more frequently performed again for the increasing incidence of calcium oxalate urolithiasis. It can also be performed for other reasons such as distal penile cicatrix formation, neoplasia, polyps or trauma.

The PU procedure consists of resecting the penile portion of the feline urethra, which has an extremely small luminal diameter, and creating a permanent opening from the wider pelvic urethra to the skin. The stoma is created at the level of the ischium, ventral to the anus, hence the term perineal urethrostomy. Because the pelvic urethra is so much wider than the penile urethra, a well-developed urethrostomy gives the cat a wider and shorter urethra, far less prone to obstruction from calculi or urinary grit.

Complications and outcome: When performed correctly and for the right indication, PU has an excellent prognosis for resolution of clinical signs. Cats are at higher risk of cystitis, but this is due to the underlying FLUTD pathology rather than attributable to the PU technique. (Normal cats undergoing PU do not have increased risk of cystitis). Despite veterinary urban mythology, permanent urinary incontinence has not been reported, even with extensive periurethral dissection (as far as the author is aware). Complications that have been reported include stricture formation at the stoma site (most commonly), bruising due to extravasation of urine, hemorrhage and wound dehiscence. Most of these complications can be avoided by meticulous technique, including accurate apposition of tissues. The three most critical aims to ensure a successful outcome in a PU are to ensure that:
1) the urethra is well mobilized
2) the urethral incision extends into the pelvic urethra
3) accurate apposition of mucosa to skin is obtained.

Tip 1: Use binocular loupes.

Perineal urethrostomy technique: The procedure is typically performed with the cat in sternal recumbency with perineal elevation. The cat is placed in a modified Kraske position - sternal recumbency with the hind limbs hanging over the elevated end of the table and the tail pulled craniodorsally. The inguinal area should be padded and operating table may be tilted to elevate the hindquarters - taking care not to compromise respiratory function. A purse string suture placed in the anus, and appropriate signage placed on animal.

• An elliptical incision is made around the prepuce and vestigial scrotum, and the subcutaneous tissues dissected keeping the urethra centralized and untwisted. A catheter can be placed if possible.
• The penile urethra is elevated and the firm ventral ligament transected. The ischiocavernosus muscles are located and visualized.

Tip 2: The ischiocavernosus muscles should be cut with scissors or judicious electrocautery close to the ischium, as they provide a good landmark for later tension suture placement.

• Ensure that the urethra is completely free from its ischial attachments by finger palpation.

Tip 3: Complete release of the urethra, 360 degrees around the urethra is undertaken with firm finger dissection, to a depth of 4-5 cm into the pelvic canal.
Tip 4: Keep the retractor penis muscle on the urethra at this stage as a landmark to locate the dorsal aspect of the urethra as it is mobilized. Once the bulbourethral glands are identified, continue freeing the urethra from its pelvic attachments with firm finger or blunt dissection. Dissection is adequate once the bulbourethral glands sit at the level of the skin, without any traction being placed on them.

- The retractor penis muscle can be excised and the urethra transected just proximal to the penis (still leaving about 2 cm of penile urethra). If a catheter is in place, then the cut can proceed around the catheter.
- The lumen is located and tenotomy scissors are used to very carefully incise the dorsal midline of the urethra.

Tip 5: Stay on dorsal midline as you proceed proximally.

- The urethra is incised until the level of the bulbourethral glands is reached. The tips of a pair of mosquito forceps can be carefully introduced to the level of box hinge, as confirmation that the wider pelvic urethra is present.

Tip 6: A tension-relieving suture of 4-0 PDS is placed through each bulbourethral gland/ischiocavernosus and secured to the hypodermis at the 10 and 2 o’clock positions. This takes tension of the primary suture line dorsally.

- A continuous suture of 5-0 is started on either side, starting at the dorsal aspect. It is critical to ensure that the mucosa is grasped, as the splayed bulbospongiosus can be confused for mucosa. This is why loupes are so good here.
- The penile urethra is transected about 1.5 – 2.0 cm from the stoma (a mattress suture will prevent any hemorrhage from the corpus), and suturing is continued until both sides meet at the ventral aspect. This provides an elongated area of mucosa distal to the stoma, which can act as a drainage board.
- Two or three interrupted sutures can be placed to close the dorsal aspect of the stoma.

Tip 7: Sometimes the urethral mucosa is damaged from repeated catheterization attempts and reblockage events. I call this “trashed mucosa syndrome”. A trashed urethral mucosa can be difficult to identify and suture accurately, and thus there is a higher chance of subsequent dehiscence and stricture. If you suspect a trashed mucosa, try to delay the surgery for 5 days while cat has a catheter in place. If you come across a trashed mucosa in surgery, or it has split longitudinally into the pelvis, place sutures down the sides as much as possible. Often the dorsal 2-3 sutures are under a little tension, and will not hold in a trashed mucosa. These cases need to have a 6Fr Foley silastic catheter left in place for about 5 days. This will prevent extravasation of urine and the extreme discoloration and discomfort associated with urine leakage. The mucosa heals rapidly and the catheter can typically be removed in about 5 days.

PU Revisions
Most referral institutions will see a fair number of failed PUs, mostly strictured. In nearly all of these cases, either inadequate initial mobilization was performed or the mucosa was not identified and sutured accurately. Revising these PUs is similar to performing an initial PU, except that the penile tip is missing. In rare cases there truly is not adequate length of pelvic urethra available at the level of the caudal ischium. We have seen this in a few cases with marked scarring and also in perineal trauma cases. For these cases, the described transischial approach by Bernarde (Vet Surg 33:246-252, 2004) is recommended and has had excellent results thus far.

Tip 8: Transischial urethrostomy: The cat is placed in dorsal recumbency with the pelvic limbs pulled gently cranially. A ventral midline approach to the ischium is made. The caudal 1.5 cm of the ischium is removed with a high speed burr or rongeurs, and the periurethral tissues dissected away. The catheterized pelvic urethra is mobilized quite easily and gently retracted ventrally through the ostectomy. A longitudinal incision is made
KIDNEY AND URETERAL STONES – WHAT ARE THE OPTIONS?

Bryden J. Stanley

Michigan State University, East Lansing, Michigan, USA

Anatomy of the ureter in cats and dogs

The healthy feline ureteral lumen is tiny – less than 0.4 mm – although the muscular and elastic wall can be quite thick. The normal ureteral lumen in the dog is more reasonably sized at about 2.5 mm, but still with a thick wall. The ureters lie retroperitoneally and course down from each renal hilus, heading medially and caudally before they curve ventrally within the lateral ligaments of the bladder to enter the wall of the bladder at an angle. They travel obliquely intramurally and open into the bladder lumen through slits (vesicoureteral junctions). Each ureter has a not insignificant ureteral artery with which it is closely associated in the ureteral adventitia. The ureters in both cats and dogs have 3 layers of muscle and are highly peristaltic in nature. They also can produce an exuberant granulation tissue when healing, which makes them prone to subsequent stricture. The mucosa has longitudinal folds which can be challenging when attempting to suture accurately in ureteral surgery.

Nephrolithiasis

Many stable nephroliths do not appear to cause issues, and can be monitored or managed medically without surgical intervention. Indications for removal of kidney stones include when:
- Significant obstruction is present (associated with partial or complete obstruction),
- The renal pelvis is dilated,
- If the calculus is enlarging over time, or
- If the calculus is thought to be acting as a nidus for persistent urinary tract infections.
If the kidney is completely hydronephrotic, without flow or urine production on scintigraphy (or no evident parenchyma on ultrasound), then ureteronephrectomy is likely the best choice. In the face of underlying renal disease, owner counseling is advised.

Renal calculi can be removed either by nephrotomy or by a pyelotomy approach (if the pelvis is significantly dilated). A bisection nephrotomy is performed by incising longitudinally on the greater curvature of the kidney. The kidney is initially mobilized by digital dissection, to release it from its retroperitoneal attachment, in a similar fashion for nephrectomy. Atraumatic vascular occlusion clamps such as Debakey bulldog clamps can be placed upon the renal artery and vein(s), but are not mandatory, and care should be taken not to traumatize the renal vessels. The kidney is incised with a scalpel and the cut continued down to the pelvis. Gentle suction is applied through a Frazier tip and the stone(s) removed with forceps. Each calyx should be rinsed with saline through a syringe and catheter, and further stones or debris removed or suctioned. Once all calculus material is cleared from the area, a catheter should be passed down the ureter. In cats, 2-0 nylon or polypropylene can generally be passed, or a fine guidewire. It is probably wise to take a sliver biopsy of the kidney before closure, especially in cats.

Closure of a nephrotomy is surprisingly simple – digital pressure for a few minutes will generally hold the parenchyma together, and then a continuous pattern of fine (4-0), rapidly absorbable suture material such as polyglecaprone is placed. The use of a more slowly absorbable material such as polydioxanone may act as further nidus for stone formation or re-infection, and is not recommended. Mattress sutures are not recommended for closing bisection nephrotomies, as they can compromise glomerular filtration rate (GFR).

Once the kidney has been returned to its retroperitoneal home, a couple of sutures should be placed to pexy it to the body wall to prevent subsequent torsion around its pedicle. Lavage and closure is routine.

Although it is much more common to perform a bisection nephrotomy, a vertical pyelotomy can be performed to retrieve a large stone when the pelvis is markedly dilated. This is more common in dogs than cats. The kidney is mobilized in the same way as for the nephrotomy, but renal blood flow does not need to be occluded. The incision always seems to extend into the proximal ureter and/or the renal parenchyma. Flushing is similar as for the nephrotomy, and closure is with 5-0 absorbable monofilament.

When performing renal surgery in small animals, a meticulous and gentle hand is required. There are many factors that affect renal blood flow and traumatizing a diseased kidney, or its vessels, on top of anesthetic drugs, may make
a significant and negative impact to recovery. Although the effects of nephrotox in GFR are equivocal, it is often the more functional kidney that forms the calculus. Following nephrotox, especially in cats, renal function and hydration status should be monitored carefully.

**Ureterolithiasis**
Cats and dogs are both affected with ureteral obstruction, although cats are more likely to have bilateral renal disease. The debate is always about how long to manage medically before surgical intervention, in order to save as many functional nephrons as possible. The more chronic the ureteral obstruction, the less likely the kidney will return to its former function. Four days of ureteral obstruction will likely not result in permanent damage, but 2 weeks of obstruction will drastically and permanently reduce the GFR of the ipsilateral kidney. If there is no evidence of bilateral kidney disease then the question is less pressing, but if renal values are elevated in the face of unilateral obstruction, then bilateral kidney disease must be present. Both the veterinarian and the owner need to know that ongoing medical management will be needed, for an overall guarded long-term prognosis. Despite this, many owners are prepared to intervene for the chance of improving quality of life for 6 – 24 months.

Always assume that the contralateral kidney is not as functional as the ureter (or kidney) with the stone. Many cats have experienced previously unrecognized episodes of obstruction, damaging the contralateral kidney. It is only when the remaining, more functional side obstructs with a urolith that the animal is tipped over the uremic edge. Often these cats need every nephron they have.

**Diuresis and amitryptiline:** We now have more options available to us for managing ureteral obstruction, compared to several years ago. Most cats are started on medical management of an aggressive diuresis protocol, amitryptiline and pain medications, with daily monitoring of the position of the calculus. The most common feline ureterolith, calcium oxalate, can be monitored easily by fluoroscopy, still radiography and/or ultrasonography. If there has been no movement of an obstructed ureter in 2-3 days, surgery or interventional radiology to relieve the obstruction is indicated. Medical management can be extended if hemodialysis is available. Stabilization is critical before anesthesia and surgery.

**Ureterotomy:** Performing ureterotomy in a cat requires at least 5x binocular loupes, but preferably an operating microscope, and appropriate microvascular instrumentation and training. For dog ureterotomy, 2.5x or 3.6x loupes will suffice. Suturing ureters is, in my opinion, more difficult than stripping and suturing an artery and even a vein. The thickness of the wall and the rich perfusion make visualization difficult. Additionally, one is often working with an assistant untrained in microvascular techniques, which can be extremely frustrating. Most ureteroliths in cats appear to lodge about 2 cm from the renal hilus. A cystotomy is initially performed and 2-0 or 3-0 suture material (or guidewire, or catheter in a dog) is passed up from ureterovesical junction (UVJ) to the level of the obstruction. It can be fiddly to pass the suture through the curve of the ureter as it comes into the lateral ligament, but gentle caudal traction on the bladder helps. The area of obstructed ureter should be isolated from its surrounding retroperitoneal fat and a background placed. Try not to damage the ureteral artery that runs adjacent to the ureter in the adventitia – judicious use of microtip bipolar forceps is useful. The ureter is stabilized and a longitudinal incision placed over the stone, with a beaver blade. The assistant should be ready with gentle no-touch suction and an irrigation cannula, as hemorrhage can occlude the microsurgical field. When the stone has been removed and secured, the suture material or guidewire should be passed proximally to the renal hilus, as this greatly facilitates suturing and avoids inadvertently incorporating the back wall when suturing. Usually urine flow is copious once the urolith has been removed. The ureter is sutured with 10-0 nylon, either in a transverse orientation or longitudinally. The last two sutures are placed before tying. A transverse closure creates a wider lumen, but is more likely to leak post-operatively. In any case, a percutaneous nephrostomy catheter (pigtail) can be placed before closure for temporary urinary diversion – although sometimes they leak as well, or pull out. A closed-suction abdominal drain is also placed following removal of the guide suture, closure of the cystotomy and abdominal lavage.

**Ureteroneocystostomy:** If the calculus is closer to the bladder than the kidney, then ureteral transection and a ureteroneocystostomy is preferred, even if it means descending the kidney (renal descensus) to relieve tension. Reimplanting is much easier than ureteral surgery alone, although magnification is still highly recommended. A diamond incision is created in the bladder mucosa and forceps are tunneled through the wall of the bladder to grasp the stay suture attached to the tip of the sectioned ureter. Once the ureter has entered the lumen of the bladder, the tip is cut off and the last centimeter of the ureter is spatulated and sutured to the bladder mucosa with 5-0 (dogs) or
7-0 (cats) suture material. A stabilizing suture can be placed on the outside of the bladder wall to secure the ureteral wall to the bladder. The terminal ureteral remnant is ligated close to the bladder.

**Interventional techniques:** In recent years, with the advent of interventional radiology (IR), most of the feline and many of the canine cases of ureterolithiasis are managed with placement of ureteral stents or subcutaneous ureteral bypass (SUB) devices using fluoroscopic or endoscopic guidance. Outcomes are excellent, although numbers are still small to provide long-term evaluations. Ureteral stenting is performed by our interventional radiologist working with an internist (if placed via cystoscopy) or a surgeon (if placed via the renal pelvis and an open abdomen is required).

**Double pigtail ureteral stents:** To place a ureteral stent in cats, a guide wire is passed percutaneously or via laparotomy under fluoroscopic guidance, through the kidney into the renal pelvis, and then twiddled normograde down the ureter, past the stone and into the bladder. A dilator is then passed over the guide wire and then the double ended pigtail catheter introduced over the guide wire and positioned until one end is in the bladder lumen and the other end in the renal pelvis. The dilator and guide wire are carefully removed and each end of the pigtail released. To place a ureteral stent with endoscopic guidance, cystoscopy is performed and the guide wire passed through the UVJ and into the ureter. It is wiggled past the obstruction and into the renal pelvis with fluoroscopic confirmation. The pigtail catheter is then introduced over the guide wire and under fluoroscopic guidance it is placed so that one end is in the renal pelvis and the other end in the urinary bladder.

**Subcutaneous ureteral bypass:** SUBs are composed of a nephrostomy catheter, a cuffed bladder catheter, and a subcutaneously placed, one way access port to connect the two. Implantation of a SUB involves the placement of a locking loop nephrostomy catheter in the renal pelvis during ventral midline laparotomy, with fluoroscopic guidance. The urinary bladder catheter is then inserted into the apex of the bladder and secured with its Dacron cuff. Both unsecured ends of the nephrostomy and bladder catheter are passed through the body wall and attached to the port in the subcutaneous tissues. The urine flows one way through the port from the kidney to the bladder. The shunting port has an access window which can allow flushing, imaging and urine collection with a 22g Huber needle. It is recommended that the system is flushed and checked every 3-6 months.

Decision-making and managing kidney and ureteral stones can be challenging, especially in cats. Recent techniques such as ureteral stenting and implanting SUBs greatly facilitate our management and improve short- to medium-term outcomes.
“Second look laparotomy” is a term that has been rather loosely described for many types of re-explorations of the abdomen, including revisional procedures. Today in human surgery, however, the term appears restricted to advanced ovarian cancer, with the rigorous definition: “a systematic surgical re-exploration in asymptomatic patients who have no clinical evidence of tumor following initial surgery and completion of a planned program of chemotherapy.” The second look laparotomy has declined over the last 40 years with the development of advanced imaging such as CT, PET-CT and MRI, as well as the increased usage of second look laparoscopy.

The term “relaparotomy” was initially coined for liver trauma patients with severe and uncontrolled bleeding. The abdomen would be systematically packed with laparotomy sponges and closed, providing sufficient intraabdominal pressure to attenuate the hemorrhage. The critical patient would be stabilized and the abdomen would subsequently be inspected several days later, or whenever the patient was considered to be hemodynamically stable. The packed sponges would be carefully removed and the traumatized tissues definitively addressed at that stage. The other main indication for relaparotomy is in cases of secondary peritonitis. Secondary peritonitis results from gastrointestinal tract perforation or dehiscence, strangulation or other loss of integrity of infected visceral organs, and is the most common type of peritonitis in dogs. In both human and veterinary patients with severe secondary peritonitis, an initial emergency laparotomy is performed to:

• control the source of infection,
• perform peritoneal washout, and
• provide drainage (typically closed-suction drains, but sometimes open abdominal drainage, and more recently vacuum-assisted abdominal drainage).

Relaparotomy is quite commonly performed in human patients with severe secondary peritonitis. In both humans and small animals severe secondary peritonitis carries a high mortality and morbidity, and a second surgery can offer advantages over single definitive procedure. The controversy in human emergency medicine lies in whether to perform a planned relaparotomy or an “on-demand” relaparotomy.

A planned relaparotomy is performed 36–48 hours after the emergency laparotomy, for inspection, drainage and peritoneal lavage. It is performed regardless of the clinical condition of the patient. It can be repeated several times until the findings are negative for ongoing peritonitis. The more conventional, on-demand relaparotomy is only performed when the patient’s condition warrants re-exploration, i.e., continued clinical deterioration or persistent lack of improvement. Decision-making is often made with the help of an objective risk stratification score such as the APACHE II Score (http://www.globalph.com/apacheii.htm) or the Multiple Organ Dysfunction Score (http://reference.medscape.com/calculator/mods-score-multiple-organ-dysfunction). Randomized clinical trials on human patients with severe secondary peritonitis have
compared planned relaparotomies with on-demand relaparotomies with respect to patient outcome (survival), morbidity and cost. There is no significant difference in outcome between planned and on-demand relaparotomies, with about 30% of patients dying in both groups. Morbidity is also similar in both groups. However, about a third of on-demand relaparotomies are considered negative, while two-thirds of planned relaparotomies are considered negative. Additionally, an on-demand relaparotomy policy typically incurs lower medical costs and shorter ICU stays. More recent studies, therefore, have concentrated on establishing the diagnostic and clinical criteria for on-demand relaparotomy.

In veterinary medicine, we do not have robust comparative data, and the debate appears to be over relaparotomy vs. no relaparotomy, regardless of whether it is planned or on-demand. For many valid reasons, it is difficult for veterinary clinical researchers to undertake studies on experimentally-induced peritonitis in dogs and cats, and even so, such research would not provide us with the same variety of conditions that we are faced with in practice (with respect to comorbidities, age, severity, etc.). However, the advantages of relaparotomy per se have been well established in human medicine.

The main questions with regard to relaparotomy in veterinary medicine are:
1. What are the clinical and diagnostic criteria to decide to perform on-demand relaparotomy in peritonitis?
2. What are the other indications for planned relaparotomy?
3. What is the optimal time interval for a planned relaparotomy?
4. What is the easiest way to perform relaparotomy?

1. **What are the clinical and diagnostic criteria to decide to perform on-demand relaparotomy in peritonitis?**

Apart from some obvious emergent criteria such as ongoing hemorrhage, portal vein thrombosis, bile leakage or retained surgical sponge, the decision to re-explore the post-operative peritonitis patient has been largely left in the hands of the criticalist or the surgeon, and sometimes a battle between the two. More recently, two scores have been developed and validated for use in dogs, providing **objective measures of illness severity** (Hayes G, et al, 2010). The Acute Patient Physiologic and Laboratory Evaluation (APPLE) scores comprise the APPLEfull and the APPELfast scores. The APPLEfull score is based on 10 variables and the APPELfast score is based on 5 variables, and used where clinical information is more limited or time is more critical. The criteria included in the APPLEfull score are: creatinine, WBC count, albumin, SpO2, total bilirubin, a mentation score, respiratory rate, age, a fluid score and lactate. The APPELfast score criteria are: glucose, albumin, lactate, platelet count and mentation score. These objective risk stratification models are more sensitive and accurate than the SIRS criteria (which are based on rectal temperature, heart rate, respiratory rate and WBC count) and should become more widely used as specialists become familiar with them. It is important to remember, that although these severity scores are certainly valuable, they do not definitively prove that the peritoneal cavity is the source of the declining condition.

Other changes that are consistent with ongoing or relapsing septic peritonitis include: return of lethargy and inappetance after an initial improvement. Increased abdominal pain is not always evident, however, and young animals with high GI perforations or leaks can very effectively mask their clinical signs. Repeat CBC every two days can give an excellent progressive clinical profile of the body’s response to an inflammatory focus, and is much more informative than a single CBC at a single time point. Toxic changes in the neutrophils are an early sign of sepsis, even before the
left shift occurs with bands appearing. An increased WBC or a drastically reduced ($<5 \times 10^9$) WBC are also signs of declining condition. Biochemical changes are also noted in deteriorating patients: decreased albumin and pH, increased BUN, creatinine, bilirubin, lactate and liver values (GGT and ALT). However, like SIRS criteria and signs of shock (increased heart rate, respiratory rate, decreased oxygenation, prolonged refill time, etc), these signs do not point the finger specifically at the abdomen. It may also be that by the time many of these parameters are abnormal, the ideal window for relaparotomy has closed.

The criterion that mostly clearly guides the decision toward relaparotomy is **cytology of the abdominal fluid**. If the volume of the peritoneal effusion increases, or maintains at a high level, the appearance becomes cloudy or turbulent, cytology is indicated, including a gram stain. Following an emergency laparotomy, it is normal to expect some sort of inflammatory response, so the presence of WBC up to 5,000/ul with non-degenerate neutrophils is not of concern. However, with higher counts, the presence of degenerate leucocytes and intracellular bacteria, there is a strong indication to proceed to relaparotomy. Abdominal fluid glucose can also be low in these septic cases ($< 50 \text{mg/dl}$).

Another consistent sign of ongoing peritonitis is lack of **borborygmi**. Dogs do not have the same tendency towards ileus that humans and horses do, and a silent abdomen should be taken very seriously as it is generally a sign of serious abdominal disease. It does not appear that abdominal auscultation is commonly performed, but it can be an extremely valuable tool, especially if there is a marked change (i.e., decline) in gut sounds. The silent abdomen is screaming at you.

Although analysis of peritoneal effusion is the single most useful diagnostic test, other diagnostics can also be useful. **Abdominal radiography** may reveal an inadvertent retained foreign body or widespread ileus (in case you did not perform abdominal auscultation!). Air can remain in the abdomen for several days (up to a week) following surgery and the finding of free peritoneal gas is considered normal during this period. If a contrast study is performed, iodinated contrast should be used – barium is more irritant and extremely difficult to lavage from the abdomen when mixed with fibrin. **Abdominal ultrasonography** is useful for determining surgical pancreatitis, other parenchymal disease such as liver abscessation and intussusceptions which can occur post-operatively with increased gut motility. **Abdominal CT** is routinely performed in human medicine for abdominal assessment, but rarely in veterinary medicine in the post-operative peritonitis patient. More investigation is required to fully evaluate the benefit of abdominal CT as a diagnostic tool for decision-making.

2. **What are the other indications for planned relaparotomy?**

There are times when it is difficult to make a decision during an abdominal exploration. Examples of these include conditions that involve the pylorus or proximal duodenum (which could mean the difference between performing a Bilroth II or not), and a large section of bowel or stomach with questionable viability (where resection could significantly impact lifestyle of the animal). At these times, waiting several days may avoid an invasive procedure that is ultimately unnecessary. A planned relaparotomy, decided at the time of the first laparotomy, allows a second assessment and final decision to be made and gives the tissues time to recover or declare itself.
Another indication for a planned relaparotomy is if the patient’s condition under anesthesia does not warrant a long surgical procedure. Hemodynamic instability, electrolyte dyscrasia, anemia are all conditions that could be stabilized over several days while the abdominal issue (e.g., liver hemorrhage) is temporarily addressed.

In general practice, one can be confronted with condition that is not within the skill set of the surgeon or the tools are not available to perform a certain procedure. At these times, it is feasible for the practitioner to close the animal for a planned relaparotomy at a specialist facility.

3. What is the optimal time interval for a planned relaparotomy?
When an on-demand relaparotomy protocol is in place, the time interval between the first and second surgeries is dictated by the patient’s condition. In planned relaparotomy protocols in human medicine, the time interval is within 48 hours of the initial emergency laparotomy. Further delays have been associated with increased mortality and morbidity. In dogs and cats, the optimal time interval is unknown, with reports of 15 –24 hours. We have waited 48–72 hours in cases, at which time one can separate the weak fibrinous adhesions during copious lavage. It seems that the best protocol is to be prepared to perform relaparotomy, but watch closely the clinical condition of the patient. If using vacuum-assisted abdominal drainage, the relaparotomy is typically performed in 48 hours.

4. What is the easiest way to perform relaparotomy?
If a planned relaparotomy is contemplated in high-risk peritonitis patients, then the decision has to be made whether to close the abdomen completely, close it with drains or leave it open between the laparotomies. Primary closure of peritonitis without abdominal drain placement is not recommended, as mortality is higher. It also removes the ability to regularly observe the amount and character of the peritoneal fluid, the most important criterion for relaparotomy. The most common method of abdominal closure for peritonitis is to close routinely (3 layers) with several closed-suction drains in place. However, this means that the secure closure will have to be removed again within a few days. Open abdominal drainage has been performed over the years by many surgeons in practices where high level CCU nursing is provided. However, there are no clear data through a randomized, controlled clinical trial to document its superiority or inferiority over conventional closure with drains. Nursing intensity is significantly elevated with open abdominal drainage, and patient morbidity higher. Strike-through of the bandages is a serious complication, and the daily anesthesia can impede the early mobilization and enteral nutritional support of the patient.

One of the more recent options for closing severe peritonitis cases and also facilitating relaparotomy, is vacuum-assisted abdominal drainage, or vacuum-assisted laparostomy. The caudal third of the linea is closed in the usual, secure method, but the cranial two-thirds of the linea is closed loosely with continuous 0 polypropylene, leaving about 2 -3 cm between the edges of the linea. A layer of fenestrated petrolatum impregnated wide weave gauze is placed over the loose sutures, and then the foam dressing of a NPWT device fashioned to fit over the gauze. The adhesive drape is placed and the evacuation tubing connected to the NPWT pump, set at -125 mmHg. This creates a closed drainage system with a large contact area, and no chance of strike-through. The animal can be ambulatory, and not require frequent re-dressing of the abdominal surgical incision, while the abdomen is being efficiently drained. The advantage of this technique is that not only is the abdomen more efficiently drained, but
the second inspection and copious lavage of the abdominal cavity simply requires anesthesia and removal of the dressing in the OR. Commercial systems are available for human medicine, which are even more sophisticated.

It is clear that more solid data are needed to objectively compare the effect of relaparotomy on outcomes such as survival in cases of severe secondary peritonitis. The profession should also further validate the objective scores that have been developed to most reliably indicate that relaparotomy will improve outcome. Until these studies are performed, however, relaparotomy should be considered as one of the alternatives of management for such high-risk cases. The possibility of relaparotomy and the financial implications should always be discussed with the owner before the initial laparotomy.
The best way to deal with complications is to avoid them. With gastrointestinal surgery, many potential post-operative crises can be avoided by adequately preparing your patient for surgery, adhering to basic intestinal surgery principles, and recognizing the high-risk patient beforehand.

1. Preparing your patient

When to operate? For lower or partial obstructions, surgery can usually be delayed for a few hours allowing time for fluid, acid-base and electrolyte corrections. Nevertheless, surgery should be performed within 12 hours of diagnosis. For complete gastric outflow obstruction, proximal intestinal obstruction, displacement, intestinal perforation, strangulation, or penetrating abdominal wounds, immediate surgical intervention is indicated and cardiovascular restorative therapy instituted simultaneously.

Fluid therapy Many patients requiring gastrointestinal surgery are dehydrated and often have acid-base and electrolyte disorders. Instigation of intravenous rehydration with a buffered saline solution is of paramount importance before surgery. Correction of acid-base and electrolyte imbalances are addressed if they are severe. The hypotension associated with anesthesia, as well as evaporation from the open abdomen and the anesthesia circuit will compound the fluid deficit, so aggressive fluid therapy is generally continued throughout surgery and into the post-operative period. As a rule, 10 ml/kg/hour of an appropriate crystalloid should be administered during surgery (unless cardiac failure or renal failure is evident). Oncotic support with colloids and/or blood products may be indicated in critical cases.

Fasting Fasting the patient before surgery is recommended - it will decrease the incidence of gastroesophageal reflux, decrease ingesta volume in the intestinal tract, and will also decrease bacterial numbers. A 12-hour fast is normal for adult patients, and a 6-hour fast for pediatric patients (measuring blood glucose before anesthesia). Of course, many intestinal surgery patients are vomiting and are effectively fasted upon presentation to the clinic.

Anesthesia and monitoring Most careful anesthetic protocols are suitable for small intestinal surgery. Some anesthetists will premedicate with atropine or glycopyrrolate to counter vagal effects of handling the bowel. If there is evidence of gas-filled loops of bowel, or free gas in the abdomen, then nitrous oxide should be avoided. Critical cases will require more intensive monitoring under anesthesia and into the post-operative period, such as urinary catheterization, triple lumen central line, and arterial line.

2. Intestinal surgery principles

Keeping patient warm Hypothermia is a huge concern with any open cavity surgery. Circulating water heating blankets should be routinely used, and other safe forms of warming (e.g., warm air huggers, warmed intravenous fluids) are warranted in smaller dogs and cats. It is desirable to keep core temperatures above 35 degrees Celsius.

Antibiotic prophylaxis / antibiotic therapy In most cases of abdominal surgery where a hollow organ is entered, prophylactic antibiotics are indicated. A first generation cephalosporin is commonly used for gastric and small intestinal surgery, administered as a slow intravenous bolus around induction. The dose is repeated every 2 hours until the end of surgery. If infection is present, this broad-spectrum therapy should be continued into the post-operative period, until the results of culture and sensitivity provide an effective choice of antibiotic. A second generation cephalosporin (such as cefoxitin) is preferred for the colon or rectal procedures. In cases of gross contamination, an exit culture may be warranted.

Instrumentation Appropriate instrumentation greatly facilitates surgery of the gastrointestinal tract:
• Self-retaining abdominal retractors (such as Balfours, Gossets, or Nelsons) are essential.
• Hand-held retractors to expose deeper structures (e.g., malleable, Faraboeufs, Army-Navy).
• Doyen non-crushing intestinal forceps are useful for occluding the lumen of the bowel without compromising perfusion of the bowel wall.
• Suction connected to continuous regulated suction is also a great asset in surgery. A Poole suction tip is preferred when draining abdominal fluid, while Yankeur and Frasier tips will facilitate finer procedures.
• Metzenbaum scissors and Babcock forceps, should routinely be included in the surgery pack.
• Fine, multitoothed forceps such as Debackey or Cooley are the least traumatic for handling bowel edges - avoid large toothed forceps.
• Intestinal stapling equipment, automatic ligating staplers are quick, fun and secure. Moderately expensive.
• Ceiling-mounted, double-lighting system is invaluable. Fully mobile articulated arms are preferred, or track mounted.

**Assistance** Surgical assistance is a great asset and facilitates many gastrointestinal procedures. Having an assistant scrubbed-in will enable enhanced exposure due to accurate retraction, improved apposition of bowel ends, decreased contamination and shorter surgical times.

**Sponges** The use of large laparotomy sponges is highly recommended, rather than traditional small gauze squares. Moistening the sponges in sterile saline renders them less abrasive to the delicate tissues within the abdomen. If smaller sponges are used, they should have a radio-opaque stripe. Sponges should always be counted before opening the abdomen and the sponge count reconciled before closure of the abdomen.

**Surgical technique** Always handle bowel gently. Excessive handling and drying of the intestines can cause a vagal response and postoperative ileus; the serosa also becomes irritated and inflamed. Keep the abdominal contents moistened with warm, sterile saline at all times, as they have a tendency to dry out under the operating room lights. Hands are excellent for examining the intestines and occluding the bowel lumen. Correctly placed Doyen forceps can also be used to occlude lumen, if used carefully, watching where the tips of the forceps are. Electrocautery should not be used on the bowel wall – haemorrhage from transected or incised bowel will soon clot with gentle pressure from moistened gauze. Likewise, bleeding from vasa recti or arcuate vessels should be attenuated with fine ligatures of 5-0 monofilament suture, not electrocautery. When suturing bowel, use a simple interrupted or continuous suture pattern, quite snug. The tension on the suture line in an intestinal anastomosis should be minimal.

**Assessment of intestinal viability** A decision to resect bowel requires an accurate assessment of its viability. The standard subjective criteria for viable intestine are, colour, arterial pulsations, peristalsis and bleeding from a cut edge. The bowel should be moistened and warm when assessing these characteristics. These are not all completely accurate, but it is advisable to err in favor of resecting too much, rather than leaving non-viable bowel behind. Other tests of perfusion used clinically include intravenous fluorescein dye injection, Doppler ultrasonic flow probes and pulse oximetry. If viability is questionable, resection is the prudent choice. Around 75 - 80% of the small intestines can be resected before permanent short bowel syndrome is seen.

“Packing off” Following initial exploration of the abdomen, the affected area of bowel should be isolated and packed off from the remaining abdominal contents. Four (or more) large laparotomy sponges moistened with warmed sterile saline are placed around the affected area. These sponges act to protect the packed off abdomen from contamination in case of inadvertent leakage from an enterotomy or enterectomy site; they will also keep abdominal contents moistened and decrease heat loss. By using a double top layer of exclusion draping, the top sponge can be whisked away if spillage occurs, minimising further contamination.

**Stay sutures** Stay sutures are loops of suture material passed through the bowel wall, and held with forceps. They areatraumatic and can be used to provide traction and reposition the bowel as needed. Stay sutures are removed by snipping one end of the suture close to the bowel, so that drag through the tissues is minimized.

**Suture material** A monofilament, absorbable suture material with a consistent, known rate of absorption and minimal reactivity is suitable for use in the small intestine. Polydioxanone and polyglyconate are most commonly used. Non-absorbable monofilament sutures such as nylon, polypropylene and polybutester are also suitable choices. Braided sutures are not recommended – they harbour bacteria from the intestinal lumen and they also cause more trauma as they pass through the tissue. Chromic gut is not indicated due to its unpredictable rate of absorption,
especially in the presence of inflammation. Gut will also incite a significant inflammatory response. A fine suture material is always indicated, usually 4-0 or 5-0, and occasionally 3-0 in size.

**Suture patterns** Single layer, direct apposition of the bowel is preferred for rapid healing, rather than an inverting, evverting or two-layered suture pattern. This is true for small and large bowel, but stomach wall is usually sutured in two layers – a simple continuous full thickness layer, followed by an inverting layer in the serosa and muscularis. Gastrointestinal sutures need to be tied snugly. Accurate apposition is difficult to obtain, due to the tendency for the redundant mucosa to bulge outward from the lumen. Mucosal eversion can be minimized by trimming the mucosa before suturing, modifying the bite to a modified Gambee bite, and also using a simple continuous pattern.

**Abdominal lavage and suction** Copious quantities of warm, sterile saline followed by suctioning before closure is essential following GI surgery. Thorough abdominal lavage will reduce contaminating bacteria and debris, removes residual blood, warms the abdomen, moistens all organs and enables a final check of the cavity. Obviously, water-impermeable barrier draping should be consistently used as part of the draping protocol. The addition of antibiotics or antiseptics to the final lavage solution has no proven benefit, and can be irritating to serosal surfaces.

**Checklists** It has been well documented in human surgery that complications are decreased by adherence to checklists. Checklists should be mandatory in large, busy hospital settings, and are even useful in smaller clinics. Checklists will ensure that the correct patient is in the Operating Room, the procedure is appropriate to that patient, informed consent has been granted by the owner, and costs have been discussed. They will also confirm that antibiotics have been given when indicated, what tissues are submitted for histopathology and other laboratory testing. The checklist should be read out before the procedure and following the procedure.

3. **Recognizing the high-risk patient**

Although complications of gastrointestinal surgery can occur in any patient, there are some patients at increased risk. Patients with pre-existing peritonitis, hypoproteinemia, uraemia, hyperadrenocorticism, immunosuppressed state, advanced liver disease, negative nitrogen balance, coagulopathies, septic, etc, may not heal as quickly or effectively, and carry a greater risk of dehiscence. These patients should be aggressively prepared for surgery and may require intensive post-operative care. Intestinal suture lines should be augmented with a serosal overlay or an omental wrap, thus bringing in blood supply, a source of macrophages and mesothelial cells to the sutured area. High-risk patients should be considered for feeding tube placement before leaving the abdomen. The abdominal wall closure needs to be secure and long lasting in these cases. An interrupted or continuous, carefully spaced linea closure with a monofilament (slowly absorbable or nonabsorbable) suture should be placed. Subcutaneous and skin layer should follow.
COMPLICATIONS OF INTESTINAL SURGERY

Bryden J. Stanley
Michigan State University, East Lansing, Michigan, USA

Although serious complications following gastrointestinal surgery are not common, they certainly occur, and it is a rare surgeon who can say they have never been faced some kind of major post-operative crisis following entering the bowel. One of the most important considerations in avoiding complications is recognizing patients with comorbidities and those that carry an increased risk of dehiscence. In these high-risk patients, delayed healing should be expected and heightened preparations taken. The following discussion covers some of the more common complications, both minor and major in nature. Although this list is not completely comprehensive, it will address the major players.

1. Hypothermia
Patients often become hypothermic during surgery, and core temperature should be monitored intra-operatively, especially in small animals, debilitated animals, and during long procedures. If the affected section of bowel can be exteriorized, the retractors can be removed and the abdomen packed off and this can slow down heat loss. Using warmed fluids for abdominal lavage is beneficial. Careful but aggressive warming in the post-operative period with use of water blankets, foil covers, warm air huggers, etc., will ensure timely re-warming. Close monitoring to avoid overheating is also critical.

2. Pain
Adequate post-operative analgesia is critical for patients undergoing gastrointestinal surgery, especially in the first 12 – 24 hours. Options include epidurals or spinals (morphine), constant rate infusions (hydromorphone/lidocaine, fentanyl, ketamine/morphine/lidocaine), or repeat intravenous administration of opioid or other analgesics.

3. Gastroesophageal reflux and/or vomiting
Reflux or vomiting is can be noted (and sometimes present but not noted!) during or following gastrointestinal procedures, and may be related to pancreatitis, liver or bowel manipulation or pain. The pre-operative administration of intravenous esomeprazole and cisapride significantly reduces reflux during surgery and increases pH of gastric contents. Suctioning of the esophagus before recovery from anesthesia. If regurgitation is noted institution of an H2 blocker is recommended, along with NPO for 12 hours. Sucralfate is not indicated unless GI ulceration is present. Monitoring for aspiration pneumonia is also indicated in refluxing patients. In regurgitating and vomiting patients, an anti-emetic is indicated (e.g., metoclopramide, maropitant, ondansetron) either intermittently or as a constant rate infusion.

4. Renal hypoperfusion
It is very common to get behind on fluids during long or major abdominal procedures, and then fail to catch up in the post-operative period, especially if significant inflammation exists in the peritoneum. In most cases, renal perfusion can be gauged by measuring urine production through a urethral catheter (> 2 ml/kg/hour). In more critical cases, a central line (and sometimes arterial line) should be placed and central venous pressure measurements will provide feedback on vascular volume. If a patient’s urine production falls in the face of previously normal cardiac and renal evaluations, crystalloid fluids can be administrated as a bolus, usually as 500 or 1000 mls. Colloids such as hetastarch will also pull volume into the vascular space. Persistent hypoperfusion may require frusemide, or a pressor agent (dobutamine, dopamine). These agents should only be used when adequate vascular volume is assured. If systemic blood pressure stays below a mean of 60mmHg for more than 4 – 6 hours, permanent renal failure may ensue.

5. Pancreatitis
Surgical pancreatitis can occur from intraoperative retraction and handling of the pancreas (try to avoid this), especially following duodenal or hepatic surgery. Signs include cranial abdominal discomfort or pain, and vomiting, developing several days after surgery. Pancreatic enzymes may be elevated, but ultrasonography is usually typically used to confirm. Surgical pancreatitis is usually self-limiting and will resolve with several days on intravenous fluids and nutritional support. Occasionally, a fulminating necrotizing pancreatitis will develop, with a poor prognosis.
6. **Body wall dehiscence - herniation or evisceration**

If the body wall has not been securely closed, or if the suture material was inadequate, breakdown of the linea suture line and herniation of omentum and sometimes intestines will occur. Evisceration of abdominal contents can follow, along with self-trauma and rapid clinical deterioration. Incisional herniation is usually diagnosed on clinical presentation of a soft fluctuant swelling under the skin (unless strangulation or incarceration have occurred), which is usually reducible. Evisceration is self-evident and is an emergency. Immediate re-operation and resection is indicated, as well as aggressive management for presumed peritonitis.

7. **Intestinal suture line dehiscence and peritonitis**

One of the most critical of all abdominal surgery complications is the breakdown of an intestinal suture line, leakage of contents into the peritoneal cavity, and ensuing septic peritonitis. Gastric dehiscence is uncommon, due to the rich vascular supply and the typical two-layer closure. Most dehiscences will occur within 3 – 5 days of surgery. An initially improved post-operative patient will become lethargic, and inappetant. Heart rate and temperature may rise, and vomiting, abdominal pain and distention can (but will not always) develop. Younger animals can mask their clinical deterioration quite well, so close examination and lab values are indicated. Haematology values tend to show an increase in the WBC and percent bands, and decrease in platelets. Toxic changes will be seen associated with the left shift. With colonic dehiscence, marked deterioration will occur within hours. Diagnostics should include abdominal radiography, and abdominocentesis. Ultrasonography can be useful to determine presence of early abdominal effusion, and is useful to guide centesis. If abdominocentesis is not diagnostic, diagnostic peritoneal lavage is indicated. Remember that air can be present in the abdominal cavity for up to a week following abdominal surgery, as well as mature neutrophils and a few bacteria. The appearance of degenerate neutrophils and intracellular bacteria in the face of clinical deterioration are an indication to re-operate. Other possible differentials include fulminating pancreatitis, abscess draining into the peritoneal cavity, and generalized sepsis.

Treatment of intestinal dehiscence is immediate re-operation, with aggressive supportive therapy, including fluids, antibiotics, and any further drugs to maintain cardiovascular function. The animal now enters a high-risk category and has septic peritonitis. The original abdominal incision is re-opened, retractors placed, and thorough inspection of all abdominal contents is warranted. The appearance of the serosal surfaces within the peritoneal cavity can be variable, depending on how effectively the contamination has been localized by the omentum and anatomical location. Cases of any type of intestinal dehiscence require resection and anastomosis. The only exception might be in the proximal duodenum, where to resect would require a Bilroth II procedure. A serosal overlay is indicated, as the patient is now high-risk. A serosal overlay pexies two sections of healthy bowel over the suture line, carefully avoiding kinking of the jejunal festoons. An omental wrap covers the suture line with a ‘wrap’ of omentum, held in place with several tacking sutures. Both these techniques effectively reinforce the suture line and augment healing, but the jejunal overlay is considered superior. Copious, copious, lavage and suction, exit culture, placement of abdominal drains and placement of gastric decompression drains are performed, and possibly feeding tube placement. Intensive post-operate monitoring and support is instituted – cardiorespiratory support, vascular volume maintenance, maintenance of renal perfusion, appropriate antibiotics, nutritional support. Younger animals can cope with this insult quite well once the inciting cause has been addressed, but older or debilitated animals will require intensive nursing.

8. **Short bowel syndrome**

Short bowel syndrome is seen with the removal of 75 - 80% of the small intestinal tract. Maldigestion (due to decreased digestive enzyme production from proximal resections), malabsorption (due to decreased mucosal area and rapid transit time), bacterial overgrowth, bile salt and fatty acid loss into lumen will result in a clinically intractable osmotic diarrhoea, steatorrhoea and weight loss. Gastric hypersecretion can result in marginal ulceration and exacerbate the diarrhea.

The severity of the syndrome depends on:
- the amount resected,
- location of the resection,
- concurrent disease,
- the condition of the remaining bowel,
- the amount of time allowed for adaptation, and
- preservation of the ileocolic valve.
At least a month should be allowed for adaptation. During this time, hydration and electrolyte status should be monitored and intravenous fluids maintained as necessary. Parenteral nutrition may also be useful in the first week. Frequent, small offerings of a highly digestible diet with vitamin, mineral and enzyme supplements should be instituted. An elemental diet is preferred, with glutamine, if not already supplemented. If steatorrhoea is present, a low-fat diet can be given, but diets low in fat are not usually that palatable and have a low energy density. Gastric hypersecretion can be somewhat reduced with H2 antagonists, and antidiarrhoeal agents such as loperamide may help control the diarrhea. Bacterial overgrowth can be treated with antibiotics.

9. Inadvertent abdominal foreign body
These are the mistakes we have nightmares about, and why we have insurance. In human surgery, accidental surgical sponge retention is associated with prolonged, difficult or haemorrhagic procedures, or when the surgeon is rushed. Although metal instruments may not cause any signs, adhesions can eventually develop, causing some poorly defined signs, or intestinal obstruction. Needles sometimes cause a problem if migration and perforation of a hollow viscous occurs. By far the most common and serious object to accidentally leave behind is a surgical sponge (gossypiboma) - so use only large laparotomy sponges in the abdomen! An intense granulomatous inflammatory reaction can occur as the body tries to wall off the sponge. This can involve the GI tract, pancreas, ureters, kidneys, and also cause a draining tract through the retroperitoneal space to the skin (often the flank area). Reoperation is indicated and removal of the offending object and the adhesions (usually involving resections) are indicated. Leave plenty of time for these surgeries - they are a nightmare.

Less common complications…

Post-operative ileus is not often clinically encountered in small animals, unlike humans. When seen, it is usually associated with marked hypovolemia or developing peritonitis or pancreatitis. Poor technique such as drying of the intestines and aggressive handling will also contribute. It is a good idea to feed patients the day following surgery and keep them hospitalized until a bowel motion is passed. A prokinetic agent (e.g., metoclopramide) can be instituted if no feces are forthcoming in a few days, in an otherwise healthy post-operative patient.

Portal vein thrombosis can (rarely) be seen soon after surgery in hypercoagulable patients. This is manifested as rapid deterioration in the post-operative period, and signs of portal hypertension - abdominal effusion, pain, hemorrhagic diarrhea and cardiovascular collapse. If recognized early enough tissue plasminogen activator (tPA) may help prevent progression. Upon re-operation, marked bowel discoloration and distension may be evident, but not in all cases. Portal pressures should be taken, even if a thrombus cannot be palpated. Removal of part or all of the thrombus may be possible through a portal venotomy. Insertion of a portal vein catheter (via splenic or left gastric vein) to allow pulsing sprays of thrombolytic agents such as streptokinase or tPA may prove useful.

Permanent adhesions following gastrointestinal surgery are quite uncommon in small animals, especially if the principles of intestinal surgery are followed. Small animals have an active fibrinolytic system compared to humans and horses. There appears to be a small percentage of animals, however, that develop a sclerosing peritonitis, in which a fibrous dry sac encapsulates the viscera. This carries a poor prognosis, although some experimental studies with tPA have shown a decrease in adhesion formation.

Strictures are not common with appositional suture patterns. Inverting suture patterns in small bowel can lead to stricture formation and signs of obstruction. This is corrected by re-operation, resection and anastomosis.
WHAT DRAIN FOR THE SEPTIC ABDOMEN?

Bryden J. Stanley

Michigan State University, East Lansing, Michigan, USA

One of the principles of dealing with any infectious inflammatory processes is to provide drainage. This tenet holds just as true for septic peritonitis as it does for cutaneous wounds and abscesses. Drainage of a septic abdomen removes exudate brimming with inflammatory mediators, bacteria and residual foreign material from the peritoneal cavity. Additionally, drainage fluid volume and cytological analysis provides information to the status of the abdomen.

The steps in managing septic peritonitis include resolving of the cause of the peritonitis, exploring the entire cavity, removing gross contamination, culturing and copious lavage. Following these steps have been completed, the choices for providing ongoing drainage include:

1. complete closure without further drainage
2. gravity dependent drainage
3. active closed-suction drainage
4. combined irrigation and suction systems
5. open abdominal drainage
6. vacuum-assisted open abdominal drainage

The controversy arises over which of these techniques has the optimal outcome for small animal septic peritonitis. Most clinical veterinary researchers are reluctant to experimentally induce septic peritonitis in dogs and cats, and it is expensive and time-consuming performing randomized, controlled, clinical trials with such variable etiologies and signalments. Additionally, surgeon compliance can be less than ideal due to underlying bias and the desire to optimize outcome for every patient. So, we are dealing with a literature dotted with retrospective studies with less than ideal methodology, small numbers of patients and widely varying results. Nevertheless, we can eliminate some of these choices. It is generally accepted that to completely close an active peritonitis case without any type of drainage is not considered good clinical practice. (Although, a young and otherwise healthy animal may actually survive if the cause has been addressed and the cavity thoroughly lavaged). Likewise, gravity dependent drainage of the abdomen is considered ineffective, as the combination of abdominal wall and diaphragmatic excursions may even act to draw bacteria and microdebris into the abdomen. The remaining choices will be discussed.

Before instituting any type of drainage, the falciform ligament should be removed to decrease the risk of drain blockage. Complete omentectomy is controversial and not recommended, although damaged and compromised portions of the omentum should be resected.

Active closed-suction drains
Closed-suction drains are probably the most commonly used drains for peritonitis cases, typically consisting of one or more fenestrated silastic drains draining through polyethylene tubing into a compressible 100 ml grenade or a larger 500 ml box. These are functional for the 3-4 days that they are typically in place, and removal is based upon a decreasing volume of fluid (usually < 10 ml/kg/day), an improving cytological appearance of the fluid, and the ameliorating clinical picture of the patient. The biggest advantage of closed-suction drains is the ease of management – the abdomen is closed securely with no surgical revision or “second-look” planned. The chances of nosocomial infection is decreased compared to open abdominal drainage in a busy CCU. Disadvantages include the inability to drain the entire peritoneal cavity effectively, the need to frequently recharge the drains to maintain a reasonable level of suction, and obstruction of the drains. The risk of clogging of the fenestrated drains with omentum increases with length of time the drains are in place. This latter issue can be reduced by using fluted or channel drains, rather than fenestrated drains. We have also connected these drains to negative pressure pumps which prevents the frequent loss of negative pressure seen with grenade bulbs.

Combined irrigation and closed-suction systems
Combining intermittent instillation with an active drainage system was described many years ago in dogs but has not been widely reported (nor employed) since. The bathing of the inflamed serosae with buffered physiological
solution (with or without other additives) followed by its removal appears to be an excellent method of reaching all areas of the diffuse and convoluted intraabdominal region. This is a technique that should probably be re-evaluated in cases of severe peritonitis.

**Open abdominal drainage**

Open abdominal drainage comprises leaving the abdomen partly open by very loosely suturing the linea alba (2-3 cm gap between edges) and applying highly absorbable sterile dressings over the wound followed by a complete abdominal wrap. This technique provides an excellent drainage portal for septic peritoneal fluid, but is extremely intensive in its management. Bandages need to be change at least once daily, and maybe more than once if they start to strike-through. It is difficult to change the dressing aseptically (which is highly recommended) without fully anesthetizing the animal and returning to the OR. This significantly increases morbidity in an already sick individual, as well as escalating the cost of treatment. An advantage of open abdominal drainage, however, is the second-look laparatomies. Most open abdominal drainage techniques are closed on day 3, but it appears that this technique has largely been superceded in high-volume institutional and specialist practices by the placement of several closed-suction drains.

**Vacuum-assisted open abdominal drainage**

We have recently started using vacuum-assisted closure devices on open abdomens in cases of severe peritonitis. The abdomen is partially closed in the same manner as for the open abdominal drainage, but a fenestrated, petroleum-impregnated, wide-weave gauze is placed over the partial closure. Proprietary foam is placed in the wound, sealed with the adhesive drapes and the suction pad applied to a hole cut in the drape. Negative pressure at -125 mmHg is applied for 3 days, canisters being changed when full. Management of this system is much easier than open abdominal drainage as it forms closed drainage system with no chance of evisceration or strike-through. This is especially beneficial because it defines a second-look laparotomy, which is common in human trauma medicine. On day 3, the animal is re-anesthetized and taken to the OR for removal of the dressing, inspection of the abdomen, re-lavage and definitive closure (usually with a closed-suction drain).

There are commercial open abdominal drainage systems with more effective dressings than the previous description, but they are not yet widely available to the veterinary profession. At our institution, we will use multiple closed-suction drains (fluted catheters) for mild and moderate peritonitides, and vacuum-assisted open abdominal drainage for severe cases. There is clearly a need for carefully stratified, randomized, controlled clinical trials to determine optimal drainage techniques in small animals with septic peritonitis.

One thing common to all peritoneal drainage is the ongoing fluid losses and development of hypoproteinemia (and often anemia). Maintenance of adequate plasma volume in these patients is critical – crystalloid, colloid and other components should be carefully administered and parameters monitored (e.g., central venous pressures, urine output, arterial pressures). Additionally, enteral or parenteral nutrition should nearly always be administered to help counteract the massive protein loss.
ABDOMINAL BITE WOUNDS AND PENETRATING TRAUMA CASES

Bryden J. Stanley

Michigan State University, East Lansing, Michigan, USA

Dogs are more likely than cats to experience penetrating traumatic wounds, probably due to behavioural tendencies. Bite wounds are seen on a regular basis in small animal practice, and can cause punctures, lacerations, as well as physiologic and anatomic degloving injuries. Penetrating trauma from stick injuries typically occurs in the oropharynx, retropharyngeal tissues and thoracic inlet. At times, however, pets can sustain some quite spectacular thoracic and abdominal stick impalements. Other penetrating injuries occur from machinery trauma, hunting accidents (arrows, gunshot wounds), and occasionally malicious wounding. Be aware that owners are often very distressed when these types of injuries occur, in addition to the obvious discomfort to the animal. This seminar will concentrate on the overall surgical approach for penetrating abdominal trauma.

Bite wounds and abdominal skin trauma are usually obvious on presentation, but the extent of underlying damage may not always be initially apparent. Small skin penetrations from the canine teeth can cause significant trauma to the less pliable body wall musculature. There may be some distance between the skin interruption and body wall disruption. Additionally, even the full extent of cutaneous trauma can be hidden by a thick coat or matted fur. I have learnt the hard way that clipping of the entire trunk in very hirsute animals is advisable. (Incidentally, this holds true for burns as well).

It is of paramount importance to ensure the integrity of the body wall in all abdominal bite wounds, as the costs of not addressing penetrating abdominal wounds are high.

An accurate history can provide valuable information. Owners should be questioned in detail for any possible incident of wandering in the woods, stick throwing, fighting, hunting accidents. Determine what happened in the interim period between the trauma and presentation, and if the animal has been unconscious, experienced bleeding from any orifice, coughing, respiratory difficulties, ambulation issues, and if it has urinated.

Thorough physical examination is obviously warranted and typically some form of imaging is undertaken after intravenous access is obtained, bloods taken and intravenous fluids started. The following diagnostics are useful to ascertain extent of injury:
Radiography. Typically, plain radiography is unrewarding for localizing a penetration, unless there is a bullet or gunshot, buckshot or birdshot. However, radiographs will detect other conditions such as mediastinal, pulmonary or pleural involvement, and also will identify concurrent diaphragmatic disruption and orthopaedic damage.

CT. The sensitivities of these imaging tools, especially with contrast agents and other enhancing modes, make CT extremely useful, especially for stick impalements. Technology to reformat images in 3D greatly facilitates the surgery. Having the ability to view CT images in surgery is also useful.

Ultrasonography can locate a impalements and also injury to parenchymous organs.

Sinography. This tool, preferably with CT but also with fluoroscopy can prove quite useful when a open defect or draining tract exists, although is probably more useful for chronic foreign bodies within soft tissues (e.g., the neck), and has now largely been superceded by contrast CT.

Laparoscopy. Abdominal wounds can have disastrous consequences if the peritoneal cavity (and possibly bowel) has been broached and not addressed. It is therefore critical to ensure the full extent of injury when presented with a penetrating wound on the abdomen. If the abdomen wall appears intact on ultrasound and radiographs, a relatively quick way of reassuring its integrity is to perform single or 2-port laparoscopy and quickly examine the parietal peritoneal surfaces.

In many cases, injury is not limited to the abdominal cavity, thus thoracic wall and contents should be routinely evaluated for all trauma cases. Radiography and ECG should be the minimum diagnostic checks of the thorax, and the patient should continue to be monitored over several hours.

Be aggressive and prompt when dealing with acute penetrating injuries; it will avert subsequent problems.

Surgical approach to the bleeding abdomen

Hemoabdomen can be acute and severe if a major artery is lacerated, or slower with parenchymal or body wall penetrations. Three main arteries perfusing the splanchnic viscera are the celiac artery, cranial mesenteric artery and caudal mesenteric artery. Blood supply to and drainage from the viscera differ due to the portal system, which collects the oxygen-poor, nutrient-dense blood into the liver via the confluence of cranial mesenteric, caudal mesenteric and splenic veins, ultimately forming the portal vein. Thus, unlike most other areas in the body, not all arteries have a satellite vein. Take the time to learn the blood supply before operating, rather than learning it in a hurry at 2 o’clock in the morning.
The abdominal cavity in small animals is highly distensible, and can hold many liters of blood – a dog or cat can easily exsanguinate before adequate pressure builds to equalize the arterial pressure. If an animal has signs of hemorrhagic shock, aggressive crystalloid fluid therapy is instituted and baseline CBC, biochemistries, blood typing and blood gases are performed. Monitoring vitals and ECG and oxygen is set up. It is then crucial to ascertain if the animal continuing to bleed into its abdomen or thorax. A FAST (focused assessment with sonography for trauma) scan with abdominocentesis may provide a quick diagnosis. Packed cell volume of the fluid should be obtained. Cytology (save some for culture) of the fluid may also be prudent in cases of penetrating trauma. Some animals can sustain a certain amount of transient hemorrhage (spontaneous, traumatic or iatrogenic) that may respond to aggressive crystalloid fluid therapy. Resuscitative efforts will often include colloids, packed RBCs (if coagulopathy is suspected, fresh frozen plasma), and pressors. Non-responding animals should be instrumented with a central venous access, urethral catheter, and an arterial line (while you can still find one). Tight abdominal bandaging has been proposed by some, but to be effective they cause significant discomfort to the animal and take a long time to place. You are going to surgery anyway...

Prepare for surgical intervention when there is continued cardiovascular deterioration in the face of resuscitative efforts, even when there is no evidence of penetrating trauma. This is because the incident may have included a component of blunt trauma, causing shear or avulsion injury to a vascular pedicle (carnivores tend to shake their prey vigorously while biting). The sooner the bleeding is attenuated, the better. Although there are many hemostatic and vessel sealing devices available (hemoclips, ligacips, pressure enhanced ultrasound, bipolar, monopolar cautery, gelfoam, glues), the security that comes with precisely placed suture ligation is hard to beat.

Anesthesia needs to be performed with care - these animals often require less anesthetic drugs, and maintaining pressures during anesthesia can be challenging. Blood transfusion (whole blood or packed red blood cells) is commenced as soon as possible – the true hematocrit of the patient is invariably lower than what is seen at presentation, and restoration of vascular volume with fluids is continued. If the animal is stable enough, some criticalists will wait until bleeding has been attenuated before they administer blood components.

Nearly always, a ventral midline celiotomy is the procedure of choice. It is the quickest way to enter the abdomen and the exposure is excellent. An incision should be made from xiphoid to pubis, using electocautery once the skin is incised. Hemostasis on the way in is critical in these cases as they may be heading towards DIC and can ooz significant amounts from the subcutaneous tissues if they are, or become, coagulopathic. Self-retaining abdominal retractors will facilitate exposure. The abdomen is drained through a Poole suction tip taking care not to be rough with the tissues. Sterile, filtered autotransfusion can be performed if neoplasia is ruled out – although I can count the number of times I have done this on one hand.

The source of the bleeding may be readily identified by the presence of a large clot organizing around the lacerated vessel. Look for this first, as it enables 1) rapid anatomical localization, and 2) the opportunity to clamp the vessel(s) before removing the clot. In cases of traumatic avulsion of a major artery that is difficult to isolate
(e.g., renal) this could save 5-10 minutes of ongoing blood loss. If no obvious clot exists, then a systematic exploration should commence. Typically, the spleen is examined and exteriorized. An abnormal, hemorrhaging spleen is obvious as one enters the abdomen, whereas an unaffected spleen in the face of hemoabdomen tends to be small and contracted. Once the spleen has been examined, it can remain exteriorized and the descending colon used to dam the viscera off to inspect the left kidney, adrenal and body wall. Going cranially, the short gastric vessels (a common site of avulsion in gastric dilation volvulus), left liver lobes, the papillary process of the caudate liver lobe, and esophageal area can be identified. Moving through and examining the liver lobes from left to right leads one to the stomach and duodenum. The duodenum can be used to dam of the viscera and inspect the right kidney, adrenal and body wall. When a lacerated vessel is identified, clamping will temporarily control hemorrhage whilst inspection of the abdomen continues.

Severe hepatic bleeding may be attenuated somewhat by occlusion of the hepatic artery and portal vein (Pringle maneuver) - placement of an atraumatic clamp (e.g., Satinsky, Debakey bulldog) at the ventral border of the epiploic foramen. This will allow some time to perform a liver lobectomy, although leakage through the hepatic sinuses from the caudal vena cava can still be significant. Automatic stapling equipment and harmonic scalpel devices have greatly facilitated the removal of liver lobes and spleens, and are a worthwhile investments for the trauma surgeon. The kidney and ureter is generally removed by hand ligation of the artery and vein. The entire abdomen should be inspected before lavage and closure. Aggressive management and monitoring should continue into the post-operative period.

**Surgical approach for stable penetrations**

Even when the patient is stable, all penetrations need to be explored due to the risk of possible intestinal perforation, as well as the introduced contamination from teeth or soil. Acute peritonitis and risk of death will result if these wounds are not addressed early in the post-wounding period. Additionally, Actinomyces species and acid-fast organisms such as Nocardia and Mycobacteria species can cause long-term comorbidities, and be challenging to definitely manage. Early, aggressive cleansing and debriding to the full extent of the wounds will minimize late complications from these organisms.

A ventral midline surgical approach is most common when there is clear evidence of abdominal involvement, but often this is in combination with an exploration directly over the stick or wounded area. If it is unclear if the abdominal wall has been breached, then the wounded area is explored first, being prepared to enter the abdomen during the same procedure if needed (i.e., taken into the OR with a full abdominal prep and drape, separate instrument pack for abdomen). Occasionally, the abdomen can be explored by extending the penetration site, especially in the paracostal or flank area. But usually a combined approach is made - midline celiotomy as well as directly over the wound - especially with significant impalements. This minimizes the chance of organ disruption or vessel laceration which could occur with blind removal of an impaling structure. Once dissection has exposed all injuries and the full extent is realized, any foreign material is meticulously removed (bark is the worst), devitalized tissue debrided and the resulting wound can be copiously flushed. As much as possible, try to keep the superficial wound cleansing separate from the intra-abdominal surgery. Whenever the abdomen has been penetrated, a full abdominal explore is warranted. This is because bite wounds tear through distant tissues and cause shearing and avulsion injuries as the body is shaken; and impalements may have moved within the abdomen and caused further disruption.
The intestines should be examined very carefully along their entire length. It can be tricky to find small penetrating wounds in the mesenteric aspect of the bowel. (The worst type of penetrating injury in my experience is bird shot, due to the large number of tiny caliber missiles contained within one discharge). When possible, significant intestinal perforations should undergo resection and anastomosis. Proximal duodenum may be one exception to this rule: if the bile duct can be salvaged and a Bilroth II avoided by debriding and suturing, then do so. Another exception would be in the case of birdshot or buckshot wounds, where there are dozens of perforations. Stomach wounds can generally be debrided back to healthy tissue and sutured in two layers, due to its excellent blood supply, thick wall, and large lumen (hence lowered risk of stricture).

Abdominal wall closure is performed in most cases and some type of active abdominal drain is mandatory. More recent alternatives are open abdominal drainage with negative pressure therapy. The external wound is initially managed open and subsequently closed when healthy tissue is evident, either as a delayed primary closure or secondary closure. Negative pressure wound therapy is also useful in managing these wounds. Revisional surgery or a relaparotomy may be required, and this should be understood by the owners.

Uroabdomen: urinary tract rupture/avulsion:

If disruption to the urinary tract has been initially missed, diagnosis of uroabdomen can be delayed for several days by the non-specificity of clinical signs and the presence of other serious injuries. Remember that a palpable bladder and the ability to urinate does not preclude the possibility of a rupture.

The animal will develop haematuria (which may be transient), peritoneal effusion, elevated creatinine and urea, acidosis, hyperkalemia and become inappetant and lethargic. It may not always demonstrate abdominal or lumbar pain. There may be evidence of retroperitoneal or peritoneal effusion. Bladder rupture or urethral avulsion is more common than ureteral or renal rupture, although penetrating wounds to the kidney are not uncommon. Abdominocentesis and analysis of the fluid (creatinine, urea, potassium), urinary catheterization, and radiography (usually including positive contrast urethrocystography, and sometimes excretory urography for the upper urinary tract is diagnostic. Note, however, that the intravenous administration of iodinated contrast is not recommended in the unstable patient. Urine is extremely irritant and will cause severe metabolic and electrolyte disturbances. Within a few days, a patient can be quite metabolically and haemodynamically unstable. It is critical to stabilize these animals before rushing into surgery. Dehydration, hyperkalemia and azotemia will need to be corrected by aggressive fluid therapy with isotonic fluids, and drainage of the uroabdomen, and/or urine diversion if possible. ECG should be monitored and more aggressive management of the hyperkalemia may be indicated if life-threatening bradyarrhythmias exist. Drainage of uroabdomen can be performed by the placement of a multiple fenestrated peritoneal dialysis catheter, or a similarly fashioned thoracostomy tube (placed with stylet). These can be placed under local anaesthesia as many anaesthetic drugs will be poorly tolerated by the compromised patient. Urethral catheterization can still be performed sometimes following urethral disruption, or urinary diversion from the bladder can be done with a temporary cystostomy catheter. Following 24 hours of aggressive medical therapy, stabilized animals can generally be taken to surgery. Surgical intervention can include primary ureteral repair (with complications of leakage, dehiscence, stricture and calculus formation), placement of a SUB,
neoureterocystostomy, ureteronephrectomy, primary bladder wall debridement and suture, or urethral suturing. Urethral stenting is common after urethral surgery.

**Bile peritonitis:**

Trauma to the extrahepatic biliary tree is seen occasionally and can also have a considerable delay (i.e., weeks) to diagnosis. The gall bladder and biliary tree is somewhat protected by the rib cage. Bile duct rupture is more likely than gall bladder rupture following blunt trauma, but penetrating trauma is random. Clinical signs of bile peritonitis may be acute or chronic depending on whether infection is present. Although hyperbilirubinemia and other laboratory abnormalities are often found, diagnosis is confirmed by abdominocentesis. Although re-implantation and primary reconstruction of the common bile duct has been reported (usually with difficulty due to traumatised ducts and adhesion formation), most commonly ligation and cholecystoduodenostomy is performed.
CAESARIAN

Bryden J. Stanley
Michigan State University, East Lansing, Michigan, USA

Since the advent of anesthesia in the second half of the 19th century, surgery has become a more leisurely affair. However, there are times where urgency still needs to be impressed upon the surgeon…and delivery by caesarian is one of those times. There is general agreement that the earlier a truly distressed fetus is removed and support is instigated, the better the outcome.

Normal canine gestation is 64 days from ovulation. The most accurate ways of determining due date are: the date of the pre-ovulatory luteinizing hormone surge (parturition should occur 64-66 days later), the pre-ovulatory rise in progesterone (62-68 days following levels rising above 1.5 ng/ml and fetal ultrasonography before day 39. Closer to parturition, a drop in rectal temperature to less than 37.8 (labor should start within 24 hours), ultrasonographic measurement of specific fetal and placental dimensions, and transcutaneous uterine and fetal monitoring (placed 1 week before delivery) have been used. The most common late gestation monitoring is the drop in body temperature, and this is what we use for the rarely planned C-section (e.g., brachycephalic with history of previous dystocia) in the absence of pre-ovulatory data.

Normal feline reproduction is similar to dogs, but has been far less studied. The queen is an induced ovulator in most cases – coitus must happen for ovulation to occur and the corpora lutea to develop. Parturition is around 66 days after coitus, but can be quite variable, with breed differences.

Normal parturition:
Stage 1 labor consists of uterine contractions. The bitch may be anxious, restless, display nesting behavior, anorexia, shivering, occasionally vomiting and diarrhea. Stages 2 and 3 alternate as each fetus is expelled, with visible abdominal straining seen in Stage 2 as the fetus is delivered, and the placenta being expelled in Stage 3. Parturition in dogs may last from a few hours to up to 24 hours. As a general rule, active straining to expel a fetus should not exceed 30 minutes and the interval between puppies should not exceed 4 hours. The body temperature of the dam returns to normal about 12 hours after whelping, and the uterus takes about 4-6 weeks to involute. During the period of involution, a diminishing amount of lochia (dark red-brown, odorless vaginal discharge) is seen.

Cats experience the same stages of delivery as dogs, and are mostly done with their deliveries in less than 6 hours. The body temperature indicator of impending parturition is not as accurate in cats. While extremely rare, cats can appear to be finished with their deliveries, but then begin again after a day or so.

Antenatal care is not routinely performed as it is in humans and mares, so often the first time the vet has ever seen the animal is during dystocia. Once pregnancy is diagnosed, it is an excellent idea to provide an antenatal program for the bitch (or queen) and an education consultation for the owners, so that they know what to expect in the days leading up to and during a normal delivery. This will also establish a relationship between you, the owner and the patient, so that in the event of a dystocia, you are all more relaxed and prepared.

Dystocia:
Dystocia is the abnormally slow or difficult delivery of the fetus. The word derives from the Greek dystokia: dys-badly and tokos-childbirth. Says it all, really. Although the majority of dogs and cats will deliver normally, dystocia is seen regularly (estimates between 15-20%), with certain dog breeds over-represented - brachycephalics, and also some giant breeds. Dystocia is not as common in cats and has been reported to be about 6% - and again over-represented in pure and exotic breeds.

The causes of dystocia have been divided into maternal and fetal. Maternal causes include primary uterine inertia, small pelvic canal, and less commonly, uterine torsion, and vaginal septum or stricture. Fetal causes of dystocia are either fetal oversize (singleton, anasarca or other anomaly), or fetal malposition. Secondary uterine inertia is not a cause of dystocia, but is myometrial fatigue resulting from obstruction due to one of the causes listed above. Primary uterine inertia can be complete or partial, and is the most common cause of dystocia. With complete primary uterine inertia, no puppies or kittens are delivered. In partial primary uterine inertia, part of the litter is
delivered, but then the uterus fatigues before parturition is complete. The reasons for primary uterine inertia are thought to be:
- Very large or very small litter size leading to inadequate uterine stimulation;
- Systemic disorders
- Low plasma oxytocin
- Low prostaglandin/high progesterone levels

It can be challenging to recognize complete primary inertia. There are often no signs at all, or there can be a lack of Stage 1 transitioning to Stage 2. Certainly, a prolonged known gestational period, failure to deliver 36 hours after rectal temperature drop or signs of toxemia can indicate complete primary inertia.

Signs of partial primary inertia are prolonged (> 4 hours) interval between pups, and no significant abdominal straining.

**Diagnostics**
A well lubricated digital vaginal exam and also rectal examination can determine if there is a fetus in the birth canal, and the state of the vagina (with respect to tone, and contractions). Sometimes malposition can be detected. The two most valuable diagnostic tools, however, that aid decision-making are radiography and ultrasonography. Lateral and ventro-dorsal abdominal views will allow us to determine the number of fetuses and their position. Breech is considered normal in dogs and cats, but if the fetus is transversely presented, or breech with hips flexed or the neck is flexed, then the malposition can cause fetopelvic disproportion. Very large fetuses (e.g., singletons) and anasarcas can also be determined. Gas in the fetal sacs and fetus indicates fetal death and is evident as early as 6 hours following demise. Fetuses that have been dead for several days will show skeletal collapse. Ultrasound is not as accurate for determining the number of fetuses, but provides an excellent indication of fetal viability. Normal fetal heart rates in a conscious dam are around 220 bpm, and fetal limb movement is evident. The fetus is considered to be in distress if the fetal heart rate drops to less than 190 bpm in the conscious dam. Severe fetal distress (150-160) is an indication for immediate C-section.

**Treatment of dystocia**
Once dystocia is recognized, it should be treated as soon as possible. At our institution, **immediate C-section** is indicated if:
- there is obstruction to the birth canal, or
- there is unresolvable fetal malposition, or
- there is meconium staining in the vagina, or
- there is bloody or other abnormal vaginal discharge before the first pup, or
- the fetal heart rate is between 150 and 170, or
- the fetal heart rate is between 170 and 190, **AND** there is no movement, or
- it has been 4 hours since the last pup, or
- there has been more than 30 minutes of active abdominal straining, or
- the bitch has signs of systemic disease.

If, on the basis of your diagnostics, there is no obstruction to the birth canal, there is no fetal malposition or fetal monster, and fetal heart rates are normal or if they are between 170 and 190 but they are moving, and it has been less than 4 hours since the last pup delivered, then medical management can be considered. Medical management typically consists of fluids and electrolyte correction (animals are rarely hypoglycemic or hypocalcemic), and oxytocin 0.2 U/5kg IM or SQ. If a fetus is delivered, oxytocin can be repeated every 30-40 minutes. Most dogs, however, will go to caesarian...

**Caesarian**
The word caesarian derives from the Latin root *caedere* or *caesus*, to incise or cut. The following describes a team approach developed over many colony and client C-sections where delivery of a healthy pup and saving the dam were critical. The key to success with C-sections is in the **team**. Everything associated with prioritizing both fetuses and mother - anesthesia induction and maintenance, clipping and preparing for surgery, the surgical technique and neonatal resuscitation - all happen in very close concert. It is understood that not all facilities have a plethora of people to help at all times, so extra and willing folk (e.g., the owners, receptionist, kennel staff, delivery personnel) may have to be recruited. The time to removal of first fetus (often the most compromised) is critical.
A note on drugs: xylazine, methoxyflurane, ketamine, thiamylal and thiopentone have been clearly associated with decreased neonatal vigor. Alphaxalone should be an excellent choice.

**10 step MSU protocol for emergency delivery by caesarian:**

1. **Assemble team.** Round up folk and designate a resuscitation team leader. The anesthetist, surgeon (and assistant if possible) must never forget that time is crucial. Experienced anesthesia support greatly facilitates this mission.

2. **Teams split.** Anesthesia team: stays with animal and starts preparing animal (see Step 3.)

   **Surgery team:** immediately gets the instrument pack and drape pack together, and opens up packs with **extra** laparotomy sponges, hemostatic forceps (for umbilical clamping), and towels. Do not use 4x4 gauzes unless you have time to count them before the bitch arrives. Surgeon and assistant scrub, gown and glove and open up pack in the operating room (OR)…and wait. The surgical team should be ready and waiting to drape as soon as the bitch is in position. **Resuscitation team:** gets equipment together – see below under Neonatal Resuscitation.

3. **Preoxygenate, clip and prep.** Many laboring bitches can be clipped and even have an initial prep while conscious and receiving oxygen. Take care to avoid clipper rash and nipple damage – there is no need to clip too wide. As soon as the bitch is catheterized, clipped and vacuumed, she can be taken into the OR for induction.

4. **Move to OR, induce, and line block.** We use IV propofol induction followed by endotracheal intubation with administration of oxygen only. The bitch is maintained on IV Propofol only with no (or minimal) isoflurane until fetuses are removed. Dorsal recumbency is fine, supine hypotension is not an issue in cats and dogs. A generous line block with lidocaine is infused into both deep and superficial layers. The animal receives the final prep following line block.

5. **Drape and incise.** The surgeon needs to work quietly and surely, in unhurried movements, but not pausing – always be thinking of the next step in the procedure. It is probably slightly easier if surgeon stands on right side of dog. Towels are quartered around the midline, covering the nipples, and secured with towel clamps. The towel clamps should **not** penetrate through the skin. Barrier and fenestrated drapes follow. Incise firmly from 2-3 cm cranial to umbilicus to pubis (but drape up to xiphoid). Clamp any significant bleeders with hemostats but no other hemostasis – no electrocautery yet, no ligatures. Careful nick in linea in the middle of the incision length, then fingers protecting uterus and lifting linea, cut with Mayo scissors, cranial and caudal. The linea is usually quite wide and obvious in these girls.

6. **Deliver the first pup.** Gently bring body of uterus up, be careful of your fingertips on the broad ligament, as the uterine and ovarian vessels are ginormous. If there are only a few pups, you can also exteriorize both uterine horns. Pack off with a couple of laparotomy sponges on either side of the uterus. Transverse or longitudinal incision in body, with #15 blade, extend with Metzenbaum. Open sacs by lifting up with Debakey forceps and cutting with blade or scissors – pup will present immediately. Hold up with head down, two hemostats on umbilicus, leaving at least 2-3 cm of cord with pup. Cut between clamps and hand off onto sterile, warmed towel.

7. **Deliver the rest.** Immediately upon delivery of the first pup, the assistant should start applying gentle yet persistent traction on the placenta, while the surgeon starts to milk the next fetus down from the opposite horn. The placenta will slowly start to separate – if torn off too quickly, bleeding will ensue and some placenta may be retained. Each pup is delivered in a similar manner to the first, with the placenta being brought out immediately afterwards, alternating from one horn to the other. After one or two pups are delivered, the uterine horns are usually easily exteriorized. If there is no neonatal movement or if there are signs of meconium staining, these should be reported as the pup is handed off. The presence of a clearly dead fetus indicates culture and sensitivity. As soon as the pups are delivered, inhalation anesthesia can be started (sometimes a little is needed before this), and the urgency (of the surgical team) is lessened.

8. **Reconcile placenta, flush and suction.** Reconcile the number of placentae with the number of pups. Check that you have all fetuses extracted, and there is not a small, mummified fetus high in one horn. No more than a quick
flush and suction of the uterine horns is typically needed. By this time, you should notice some involution of the uterus beginning to occur.

9. **Close uterus.** The uterus can be closed in a snug, single layer, simple continuous suture pattern, using a 3-0 monofilament absorbable suture. The muscular organ starts to contract and longitudinal ridges appear in the body and horns. This will attenuate hemorrhage from the placentation sites, so it is important to note that it occurs. If the uterus remains flaccid, oxytocin should be administered.

10. **Close.** Following uterine closure, the abdomen can be lavaged and suctioned, using a new suction tip. A routine three-layer closure is performed, using an intradermal suture pattern in the skin. Finally, the abdominal skin is rinsed thoroughly with warm saline to rinse off any residual scrub or solution from the surgical prep.

**Neonatal resuscitation:**
The resuscitation team needs to gather equipment together beforehand: oxygen source, bulb syringe and/or gentle suction tube, umbilical clips, warm towels, radiant heat lamp or circulating water heating mat and epinephrine. Naloxone may be needed if an opiate was used on the dam. Try to have a person dedicated to each pup or kitten for resuscitation. The technique of swinging or flicking the neonate to clear the respiratory passages is no longer performed – this action can lead to intracranial hemorrhage and laryngeal edema. Holding in a head-down position while transferring the pup from the womb to the resuscitation table to facilitate drainage from the pharynx is a good idea. At the time of handing off, the resuscitation person should ensure that the hemostat on the umbilicus is not inadvertently poking into the abdomen. The hemostat can generally be removed in 10-20 minutes, with or without being replaced by an umbilical clip.

The oral cavity, pharynx and nares are gently suctioned to clear amniotic fluid from the area, and the pups should be kept warm and rubbed gently. They are very prone to burning with direct contact of heat sources, so radiant heat or circulating water mats are preferred. Healthy pups will generally start squeaking shortly after delivery. If the neonate is poorly responsive, then oxygen can be delivered by mask or careful intubation (not flow by), and more vigorous rubbing. Use of atropine and doxapram is controversial, as they increase myocardial oxygen consumption. The use of glucose under the tongue is also of unknown value. As a final resort for a non-vital neonate, 10ug/kg epinephrine can be administered through the umbilical vein, and gentle external cardiac compression commenced. Overall survival is variable and dependent on the condition of the fetuses at delivery.
**Chest Wall, Pleural Space, and Mediastinal Challenges**

Maurine Thomson, B.V.Sc, FACVSc. Veterinary Oncology Specialists at VSS

**Thoracic wall resection and reconstruction**

Typically this is performed for rib tumours though can have sarcomas of the soft tissue of the chest wall. Most rib tumours are sarcomas, with osteosarcoma (OSA) and chondrosarcoma (CSA) being the most common. Others include fibrosarcoma (FSA) and haemangiosarcoma (HSA). They are locally aggressive, and wide resection of 3cm is recommended. The role of surgery is to completely excise the tumour En Bloc, close the defect and re-establish an air tight seal to the pleural cavity.

General initial work up involves radiographs and a biopsy. Typically the swelling visible externally is the tip of the iceberg, with most of the tumour intrathoracic. CT is recommended after radiographs/instead of to allow a much more accurate idea of tumour size, to determine margins and chest metastases. Biopsy is generally performed from the centre of the tumour to minimize disrupting lateral margins, and requires excision with the definitive surgery.

Complete excision of chest wall tumours is prognostic for survival, so at least 1 rib caudal and cranial to the mass are removed, with grossly 3cm dorsal and ventral. Skin normally is not removed, except biopsy tract with 3cm around the incision. Reconstruction of the defect can be performed with autogenous latissimus dorsi muscle or myocutaneous flap, or when not suitable a prosthetic mesh. Autogenous tissue is always preferable if possible.

Patient placed in lateral recumbency. The initial skin incision is performed transversely over the length of the mass, and transversing 3cm around the biopsy tract.

Latissimus Dorsi Muscle Flap. Is based on the thoracodorsal artery arising at the caudal depression of the shoulder. It originates from the lumbosacral fascia of the thoracolumbar vertebrae, up to the 13th rib. It courses towards the shoulder and inserts on the teres tuberosity of the humerus. It is freed up ventrally with sharp and blunt dissection, and can be incised dorsally to allow rotation cranially, or detached from humerus and rotated caudally.

Omentum can also be placed in the defect by combining a flank incision and tunneling subcutaneously. Diaphragmatic advancement can be performed with caudal chest wall resections. The diaphragm is detached and advance to cover the level of the rib resection. This can be comfortably done to the level of 9-10th rib. After this lung lobectomy is likely to be required.

Mesh reconstruction: Most commonly used are Marlex (nonabsorbable polypropelene) mesh. A piece of mesh is cut larger than the defect and edges folded back 1cm to allow greater strength for suturing. It
is pulled quite tight as it is sutured with absorbable or nonabsorbable suture material. Mesh is considered to have >12x the complication rate of autogenous tissue, predominantly infection.

Sternectomy is performed for tumours arising from the sternebrae. The deep pectoral muscle can be rotated caudally, cranially or ventrally based on its segmental branches of the internal thoracic artery. Reconstruction of the sternum requires rigidity to reduce post-operative complications. This is performed with a marlex-methylmethacralate sandwhich, or spinal plates. Greater complication rate then rib reconstruction

Post operatively patients are monitored closely in ICU. Chest drain and local blocks prior to closure. Supplemental O2 usually required first 12-24 hours. Post op complications can be pleural effusions, seroma, infection

Prognosis. Of a recent paper involving 39 dogs, 25 tumours were OSA, 12 CSA and 2 HAS. Dogs with OSA treated with surgery and chemotherapy had a median survival time (MST) of 290 days. Those with elevated ALK Phos had MST 210 days vs 675 d. Tumour grade was not prognostic for survival. Dogs with CSA had a MST that was not reached, but >1300 days. Grade was not prognostic for survival. Overall the number of ribs resected was not prognostic, though local recurrence was 6x greater with incomplete excision.

CRANIAL MEDIASTINAL TUMOURS

THYMOMA

Pathophysiology

General Considerations

Thymoma is classified as invasive or non-invasive, most commonly is non-invasive and non-metastatic in both cats and dogs. Non-invasive thymoma (benign) are well-encapsulated while invasive (malignant) thymoma will invade adjacent structures such as cranial vena cava, thoracic wall and pericardium. They can also be cystic. Thymoma arises from thymic epithelium and has variable mature lymphocyte involvement which can predominate although the epithelium is the malignant component

DDx: thymic LSA, thymic carcinoma, thymic branchial cyst, ectopic thyroid and parathyroid neoplasia, aortic body tumour, metastatic carcinoma and rib and sternal sarcomas extending into mediastinal space
Medium and large breeds with Labrador Retriever and GSD over-represented, median age: 11 years. Previously thought hypercalcaemia was uncommon, but a recent paper shows 34% of 116 dogs were hyperCa. Mast cells detected in 85% of canine thymoma aspirates/pathology

Thymic carcinoma has been reported although rare and associated with more aggressive histological appearance and widespread metastases

Clinical Signs

Non-Invasive Thymoma
Asymptomatic or non-specific signs associated with large space-occupying thoracic mass. They may show exercise intolerance, coughing, dyspnoea, dysphagia and weight loss. Coughing and dyspnoea are due to pleural effusion or compression of the trachea or segmental bronchi.

Paraneoplastic Syndromes
Myasthenia gravis in up to 40% of dogs, and this may be either focal or generalised with megaesophagus and generalised weakness. The thymus is responsible for maturation of T cells and induction of self-tolerance, malignancies linked to thymoma include the loss of self-tolerance and autoimmunity, the ‘sick’ thymus may still generate T cells (but impaired). Thymic monocytes may become immunogenic resulting in formation of antibodies directed against acetylcholine receptors and resulting in development of myasthenia gravis (present with weakness and or megaesophagus +/- aspiration pneumonia)

20-40% of dogs with thymoma present with autoimmune disease such as immune-mediated anaemia, polymyositis and exfoliative dermatitis (in cats) or other non-thymic neoplasma

Diagnosis
Physical examination: clinical signs including caval syndrome and auscultation changes associated with pleural effusion, jugular veins may be distended, heart sounds may be more dorsal and caudal (cardiac displacement); smaller dogs and cats have reduced compressability of cranial mediastinum

Lymphocytosis (> 20000 cells/µL) and pseudohyperparathyroidism occasionally observed

Thoracic radiographs: space occupying mass with dorsal elevation of trachea and oesophagus, caudal displacement of cardiac silhouette, megaesophagus and aspiration pneumonia with paraneoplastic myasthenia gravis, pulmonary metastasis and minimal pleural effusion with non-invasive thymoma and pleural effusion which may obscure mass with invasive thymoma

Ultrasonography: mixed echogenicity with cavitation compared to homogenous hypoechochogenicity with LSA
FNA or needle-core biopsy: predominance of lymphocytes rather than epithelial cells may confuse diagnosis, ICC or flow will help differentiate (>10% CD4+CD8+)

Immunohistochemistry may be required for definitive diagnosis (cytokeratin)

needle-core biopsy can be non-diagnostic due to cystic thymoma and necrotic components

Thoracocentesis or FNA: mature lymphocytes rather than lymphoblasts seen with thymic LSA

**Treatment**

**Surgical Management**

Exploratory thoracotomy required to differentiate non-invasive and invasive thymoma

Median sternotomy required due to size of tumour although lateral intercostal thoracotomy can be used for smaller lesions or in cats (although adjacent rib resection sometimes required)

Non-invasive thymomas do not adhere to intrathoracic structures and removed using blunt-sharp dissection. Cranial vena cava and phrenic nerves are located along craniodorsal aspect of cranial mediastinal mass

Invasive thymomas usually invade vital structures and are difficult surgical candidates

Venous grafts are used in humans, and has been reported in the dog, for thymomas invading cranial vena cava

**Radiation Therapy**

**Can be used if invasive or not willing for surgery**

**Chemotherapy**

Ineffective but can be attempted in combination with corticosteroids . Response usually partial.

**Prognosis**

Recent paper of 116 dogs, 84 had surgery with a median survival time of 635 days compared to 76 days for those that did not. Dogs with myasthenia gravis or hypercalcaemia did not have a worse prognosis. About 17% were invasive at surgery, compared with 83% deemed noninvasive and resectable.
Mesothelioma

Pathophysiology
Is a rare tumour arising from mesothelial cells of pleural and peritoneal cavities

sites (dog): thoracic cavity, pericardium, abdominal cavity and vaginal tunic of scrotum

sites (cat): pericardium, pleura, peritoneum, abdominal with lung and mediastinal LN

Asbestos may be an aetiological factor in dogs (owners that work with it)

5 Golden Retriever Dogs developed mesothelioma after 30-54m of chronic haemorrhagic pericardial effusion – possible relation to chronic inflammation

Congenital form may also exist (7 week old)

Clinical Signs
Pleural (dyspnea), pericardial and peritoneal (distended abdomen) effusion most common presenting signs

Extensive effusion due to exudation from tumour surface and tumour-obstructed lymphatics

Acute tamponade and right-sided heart failure with pericardial mesothelioma

Sclerosing mesothelioma: restrictive disease present as a thick fibrous lining resulting in restriction of organs leading to vomiting and urinary disease

Diagnosis

Ultrasonography and radiography not usually useful as mass-lesion rarely evident (tumour cells cling to epithelial cells)

CT (thoracic) may be of benefit in identifying nodular lesions

Mesothelial cells can exfoliate under many circumstances resulting in difficulty differentiating physiological mesothelial cell proliferation from neoplasia, exfoliates with fluid accumulation, reactive hypertrophic mesothelial cells look neoplastic

Fibronectin concentration increased with neoplasia (sensitive but not specific), mesothelioma could be ruled out if fibronectin normal

Pericardiocentesis: hard to differentiate idiopathic pericardial effusion from mesothelioma as both serosanguinous often with mesothelial cells (reactive vs neoplastic) – need biopsy
Definitive diagnosis: histopathology (visually directed) – open/ thorascopic
- cytology not diagnostic, but can diagnose inflammation/ LSA

Treatment
Pericardecotomy may provide palliation for animals with cardiac tamponade
- 2 dogs; surgery alone, 4 and 9m (Kerstetter, JAVMA, 1997)
- 5 dogs; MST 13m (3 received chemotherapy – dox or mito) (Dunning, JAVMA, 1998)
- case; percardecotomy, intracavitary and iv cisplatin/ dox MST 27m
- 8 dogs; MST 2m, partial pericardecotomy (one survived 300d – had dox and cisplatin)

Intracavitary cisplatin/carboplatin: well-tolerated with decreased fluid accumulation, good for lining disease not bulky tumour – penetrates 2-3mm

Pleuralports very useful to drain chest and administer chemotherapy


Intracavitary cisplatin (dogs, 50mg/m2) or carboplatin (cats, 180mg/m2) in adition to piroxicam (0.3mg/kg)

Prolonged survival with reduced cavitary effusions, 6m cat, 8m-3yr in dogs

Mixed mesothelioma in 2 dogs and epitheliod in a cat


Reconstruction of chest wall defects after rib tumor resection:1 comparison of autogenous, prosthetic and composite techniques in 44 dogs. JM Liptak et al. Veterinary Surgery 2008:37:479487
Complications with Routine Bladder Surgery

Maurine Thomson B.V.Sc, FACVSc. Veterinary Oncology Specialists at VSS

Routine cystotomy is normally performed for the removal of calculi, trauma, biopsy, ectopic ureters and resection of neoplasms. I preferentially place a urinary catheter in all cases having a cystotomy. This allows the bladder to be empty when incising, allows me to keep the bladder empty, and monitor urine production post operatively.

A caudal abdominal incision is performed, the bladder identified and packed with moistened laparotomy sponges to isolate. Stay sutures are placed in the apex with 3-0 or 4-0 suture material to minimize traumatic handling of the bladder. An incision in typically made in the ventral aspect from apex to trigone, depending on the reason for the cystotomy.

Cystotomy closure requires a watertight seal to prevent urine leaking into the abdomen. Historically double layer closures have been recommended, as it was believed this offered a superior closure. In a study on rats, a single layer appositional continuous closure had rapid healing, and was biomechanically and histologically similar to an inverting pattern. The bladder heals rapidly, regaining almost 100% strength in 14-21 days. In a recent study of 144 dogs, these 2 patterns were assessed. 81% had a cystotomy for calculi removal, and others included ectopic ureters, biopsy and tumour resection. 55% had a simple continuous or simple interrupted closure with PDS or maxon. A double layer inverting pattern occurred in 45%. The mucosa and submucosa in 1 layer, then seromuscular layer, typically PDS or Maxon 3-0. Postop 45% had some minor complication, ie haematuria, incontinence, bruising. 1 in each group developed dehiscence (both associated with urethral obstruction prior). No difference in hospitalization or complications between 2 groups. Conclusions were that an appositional single layer technique, interrupted or continuous, is appropriate for clinical use in dogs and cats.

A recent study of 128 dogs undergoing a cystotomy for urocystoliths showed that up to 20% had failure of removal of all stones (only 34% were checked). This was most common in dogs which had bladder and urethra stones. Older literature also shows up to 20% of cases have stones remaining on post op imaging. Recommend catheter during surgery and flush both retrograde and normograde, with radiographs pre and post to identify urethroliths (double contrast more sensitive for non radiopaque stones).

Cystectomy is generally performed for resection of neoplasia or bladder necrosis. Up to 75% of the bladder can be resected if the ureteral papillae are not involved. Typically margins of 1cm are obtained, and closure with a 1 layered continuous suture of 3-0-4-0 PDS or maxon.

Ectopic ureters are usually treated with a ventral cystotomy, and visually observe the ureteral openings on the dorsal surface of the trigone, and catheterized. The bladder mucosa and
ureteral wall are incised at the level of the normal opening. The edges of the neoureterostomy are sutured to the bladder with 4-0-6-0 monofilament interrupted sutures and the distal ureter double ligated. Ureteronecystotomy is reimplanting the ureter in a new location, and can be performed for trauma, neoplasia or ectopic ureters. The ureter is tunneled submucosally and a small section of mucosa removed. The end of the ureter is spatulated and sutured to the bladder with 4-0-6-0 monofilament interrupted sutures.

Complications of bladder surgery, like all surgery, are best treated by AVOIDING. Treat any UTI first where possible, this decreases chances of contaminating the abdomen, or delaying healing/possibly increasing the dehiscence rate. The bladder is very easily traumatised, and the mucosa swells rapidly. Gentle tissue handling with stay sutures and small suture material is required, with careful apposition of sutures to encourage rapid healing with minimal granulation tissue. Surgical loups are very useful for any delicate surgery.

My personal preference is to place an indwelling urinary catheter before surgery and to maintain post op for 1-2 days. This allows accurate monitoring of urine production, and patency of the bladder to prevent overfilling immediately after surgery.

Calculi removal should have radiographs pre and post op to determine location of urethral stones, or count number of stones to be removed. Flush through the catheter to potentially remove any that may have fallen into urethra. Biopsy the bladder wall for culture or histology if required. There is a higher bacterial culture rate from biopsy than urine. Chronic inflammation can cause polypoid lesions or neoplasia.

It is possible to entrap a ureter (or accidentally incise) when performing surgery dorsally. I always triple check the location of the ureters when suturing dorsally following tumour resections.

Dehiscence post op can occur with infection, or bladder trauma. Cases in the literature have been associated with urethral trauma/stones. Also repeat manual expression of the bladder can result in rupture. Again a reason I leave a catheter in place post operatively to ensure the bladder is patent.

Complications post ureteral surgery include hydronephrosis/hydroureter. This occurs in at least 50% of cases, along with temporary loss of ureteral peristalsis. This is managed with monitoring urine production and riding it out. I typically will give IV dose of dexamethasone at 0.25mg/kg at time of surgery if I have to reimplant a ureter. Failure of urine production is life threatening, indicating renal failure, dehiscence or obstruction. Investigated with U/S, CT or re explore.

Accidental prostatectomy can occur when doing a cryptorchid surgery. Occurs more often than you would think! Necrosis of the bladder is managed by debriding edges where possible. Up to 75% of the bladder can be resected with a gradual return to normal urination over 2-3 months. A serosal patch from the intestine can be used to augment the repair?. A recent study looking at serosal patching for intestinal lesions did not reduce the peritonitis risk. Complete bladder resection with ureterocolonic, ureterourethral, and ureterovaginal repair have all been described.
Complications of treating bladder tumours can be seeding to the skin or rest of the abdomen. Occurs frequently with TCC. Surgery has little role in the treatment of bladder TCC, in one series of 67 dogs, only 2 had lesions that were resectable, with recurrence and metastases very common. Most TCC occur in trigone and urethra, effectively whole bladder is considered affected. Other tumours of the bladder can be cured with surgery, ie leiomyosarcoma or leiomyoma. Haemangiosarcoma can also occur primarily in the bladder.

So in summary most complications are best treated by avoiding, and practicing precise and careful tissue handling.

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Objective: To describe a case of peritonitis involving *Candida albicans*, which successfully responded to systemic antifungal treatment, is described.

Study Design: Case report

Case history: A 6-year-old male entire Jack Russell Terrier was presented for a strangulating scrotal hernia. Surgical exploration revealed devitalised bowel with partial thickness ulceration within the hernial sac, requiring intestinal resection and anastomosis. No gross evidence of peritonitis was present at the initial surgery. An intra-abdominal active suction drain was placed in order to monitor for the development of secondary peritonitis. Following the initial surgery the patient responded well to supportive treatment, however on the second day postoperatively the patient clinically deteriorated with clinical signs including emesis, anorexia and lethargy. An increase in the volume collected and change in consistency of the peritoneal fluid towards an exudate prompted an abdominocentesis and fluid analysis, which suggested a septic process. An exploratory laparotomy was performed, identifying gross peritonitis and dehiscence at the site of intestinal anastomosis performed two days earlier. Surgical repair of the dehiscence was performed, followed by copious lavage and closed management of the abdominal cavity. A mixed growth of *Candida albicans* and *Enterococcus spp.* was identified on culture of peritoneal fluid collected at the time of surgery. Systemic fluconazole was instituted postoperatively, in addition to broad-spectrum antimicrobial treatment and supportive therapy which included the administration of human serum albumin, gelofusine and total parenteral nutrition. Persistent, intractable vomiting was managed with intra-abdominal local anaesthetic infusion. The patient gradually improved and was successfully discharged 13 days after initial presentation.

Conclusions: The importance of performing cultures for yeast and fungi as well as bacteria in peritonitis cases is highlighted. These cultures allow for identification of all possible aetiological agents and therefore directly indicate potential therapeutic avenues. In this case, systemic antifungal therapy contributed to a successful outcome for the patient.
RESULTS OF SURGICAL TREATMENT OF INTERVERTEBRAL DISC DISEASE

W Park, D Cook, P Moses
Veterinary Specialist Services, Brisbane, Queensland

Objective: To describe the outcome of patients treated surgically for intervertebral disc disease (IVDD), and the prognostic factors that may influence that outcome. A positive outcome was defined as independent ambulation and the ability to voluntarily urinate.

Study Design: Retrospective case series.

Animals: 844 dogs that underwent surgery for confirmed cases of IVDD at Veterinary Specialist Services.

Methods: Medical records (2000 to 2013) on all patients that had surgically confirmed IVDD treated at the Veterinary Specialist Services Underwood and the Gold Coast Hospitals were reviewed. Records for patients that underwent surgery for IVDD were analyzed for signalment, location of lesion (cervical or thoracolumbar), neurologic grade (modified Frankel for thoracolumbar) at presentation, time from presentation to surgery, the use of physiotherapy in the aftercare program, experience of surgeon, and surgical site. Post surgical follow-up data collection was by clinical examination in the hospital or telephone contact with owners.

Results: Of 844 dogs with complete follow up records, 809 dogs had positive outcomes, and 35 dogs had negative outcomes. Of 65 grade 5 animals (no deep pain prior to surgery), 57 (88%) had positive outcomes. Of 763 animals with grade <5 (deep pain prior to surgery), 738 (97%) had positive outcomes.

Conclusions: Surgical therapy for intervertebral disc disease with intensive post operative physiotherapy offers a high chance of return to independent ambulation and voluntary control of urination. The prognosis for patients presenting with IVDD especially Grade 5 neurological status may be better than previously reported.
COARSE FRACTIONATED RADIATION THERAPY FOR THE TREATMENT OF MICROSCOPIC CANINE SOFT TISSUE SARCOMA

M Kung¹, V Poirier², M Dennis³, D Vail⁴, R Straw¹

¹Australian Animal Cancer Foundation, Brisbane Veterinary Specialist Centre, Queensland, Australia, ²Animal Cancer Centre, University of Guelph, Ontario, Canada, ³QML Vetnostics, Queensland, Australia, ⁴University of Wisconsin-Madison, Wisconsin, USA

Introduction: Soft tissue sarcoma (STS) is a common canine subcutaneous tumour that is characterized by local invasion. Metastatic rate is generally low and correlates with histological grade. Surgery with or without radiation therapy (dependent on surgical margins) is the current standard of care in dogs. Typical protocols for treating incompletely excised STS involve curative intent radiation with total dose in excess of 50 Gy.

Objective: To evaluate progression free survival (PFS), time to local failure (TLF) and overall survival (OS) for canine STS treated with a coarse fraction radiation therapy (RT) protocol.

Study Design: Retrospective clinical study.

Methods: Medical records of dogs that had incomplete resection of soft tissue sarcoma at a referring veterinary practice or at Brisbane Veterinary Specialist Centre (BVSC) followed by coarse fraction radiotherapy at BVSC were reviewed. Dogs were followed by examination at BVSC and by examination by referring veterinarians. Histopathology slides were reviewed by a single board certified veterinary pathologist. Histologically confirmed microscopically incomplete or inadequately excised STS confined to the primary site were treated with once weekly fractions of radiation (6 - 8 Gy/fraction) to a total dose of 24-32 Gy beginning approximately two weeks after surgery.

Results: Forty-eight dogs were included from 2007-2013. The age of dogs at diagnosis ranged from 3-15 years with a mean of 10.3 years and median of 11.0 years. Tumours were located on the head for 5 dogs, trunk for 7 dogs, and limbs for 36 dogs. Histologic grade was reviewed in 47 dogs (14 grade 1, 23 grade 2 and 9 grade 3, 1 rhabdomyosarcoma). Total radiation dose ranged from 24 Gy (n=2), 30 Gy (n=31), 32 Gy (n=15). Ten dogs (21%) developed local recurrence. Eleven dogs (23%) developed metastasis. Only 3 dogs had both local recurrence and metastasis. The median PFS was 698 days (with 1, 2 and 3 years PFS of 63%, 44% and 23%). The median TLF was not reached (with 1, 2 and 3 years TLF of 81%, 73% and 73%). The median OS was not reached (with 1, 2 and 3 years OS of 81%, 75% and 61%). Only histologic grade was prognostic for PFS and OS. Mean follow up time was 571 days (56 - 2376 days). Acute effects of RT lasted for a median of 14 days (range: 7-144 days) where sixteen dogs (35%) did not require any medical intervention, while the other 65% required minor medical treatment with antibiotics and pain relief. Two dogs (4.2%) developed late effects of RT (chronic lick granuloma and decubitus ulcer) after a median of 6.5 months (6-7 months) post RT.

Conclusions: Coarse fraction RT is a good option for treatment of incompletely resected STS where wide surgical margin may not be easily achieved by a second surgery. The low morbidity and favourable results with coarse fractionated adjunctive radiation therapy in this study presents a cost effective protocol likely to be a good consideration for treatment of older dogs with STS where wide-resection is not possible.
Developmental Anogenital Abnormality: A Case Report of Hypospadias and Bifid Scrotum in a 16 Week Old British Short Hair

W Basuki

Queensland Veterinary Specialists, Brisbane, Queensland, Australia

Objective: To describe the different type of anogenital congenital abnormalities and to describe the surgical correction of a hypospadias in a 16 week old British Short Hair.

Study Design: Case report.

Case History: Congenital anomalies of the urethra that have been reported previously in cats include urethral agenesis, urethral hypoplasia, urethra-rectal fistulas, urethral duplication, ectopic urethra, and hypospadias. Hypospadias is an uncommon congenital defect that results from failure of fusion of the urogenital folds and incomplete formation of the penile urethra. The abnormal urethral opening may be at any place along the shaft of the penis or may open into the scrotum or in our case report, perineum. A 16 week old British Short Hair was presented for a history of inappropriate urination and pollakiuria. Physical examination revealed an anogenital cleft and a bifid scrotum associated with hypospadias. This resulted in abnormal urination and subsequent urine staining of the perineum and hind limbs. Penile amputation, perineal urethrostomy, reconstruction of the ventral anus and castration were performed. The kitten was hospitalised for 5 days post-operatively and appeared to be able to urinate and defaecate appropriately. 2 weeks and 5 weeks post-operative revisit show good results.
TEMPORARY TRANSARTICULAR STIFLE EXTERNAL SKELETAL FIXATION IN DOGS AND CATS: 20 CASES

JM Kolichis, CA Preston

Pet Emergency and Specialist Centre, Malvern East, Victoria, Australia

Objective: To describe the use, outcome and complications of transarticular femorotibial external skeletal fixation in dogs and cats to augment primary reconstruction of a range of stifle pathologies.

Study Design: Retrospective clinical case study.

Animals: 20 stifle joints of 14 dogs and 5 cats.

Methods: Medical records (2005 – 2013) and radiographs of dogs and cats with severe traumatic stifle injuries or failed knee reconstructions that were supported by a transarticular external skeletal frame (TAESF) were reviewed. Following surgical exploration and primary repair of stifle injuries, a temporary transarticular external skeletal frame was applied across the stifle. Frame configuration was classified as type 1a uniplanar or type 1a biplanar. When pins were placed in the lateral femur and medial tibia (type 1a biplanar; 10/20 frames), the connecting bar or tubing was contoured around the anterior aspect of the limb. Stifles were immobilised in extension. Patients were reassessed regularly by veterinary examination and the frames were removed if fractures or tendons were healed, and if joints were considered stable from ligamentous repairs. Complications were recorded and addressed. Outcomes were determined by joint stability, limb use and owner perception.

Results: Stifle injuries included tibial crest and tibial tuberosity fractures/avulsions due to failure of previous repair (n=8), multiple ligamentous injuries of the stifle (n=6), patella alta due to patella tendon injuries (n=2), complex articular tibial and femoral fractures (n=3), and stifle instability due to MCL rupture after total knee replacement (n=1). Of the cases included, 13/20 had previous failed repair attempts and 9/20 had substantial polytrauma or concurrent orthopaedic pathology. Minor complications were common and included pin tract drainage, pin loosening and breakage of the pins and pin-connecting bar interface. Femur fractures occurred in 5/20 cases and appeared to be associated with clustering of pins in the distal femur (4/5 fractures). Frames were in place for an average of 6 weeks.

All stifles were considered stable at the time of frame removal. Outcomes for functional limb use were recorded as excellent (n=11), good (n=5), fair (n=3) and poor (n=1). Cases with type 1a biplanar frame configuration had significantly less recorded complications and 80% of cases with this frame configuration had an excellent outcome. All cats in the study had excellent outcomes. There was a significant association between multiple ligamentous injuries of the stifle and excellent outcomes. A significant association was found between patients weighing less than 20kg and having an excellent outcome.

Conclusions: Temporary immobilisation of the stifle joint using TAESF allows successful salvage of failed knee reconstructions and various traumas that might otherwise be managed with amputation or arthrodesis. TAESF carries significant perioperative morbidity including the risk of catastrophic long bone fractures. Femoral fractures may be associated with clustering of pins in the distal femur creating a ‘stress riser’, and may be avoided by placing...
proximal femoral pins at the level of the greater trochanter. In our study, use of a contoured lateral femoral medial tibial connecting bar reduced the major complication rate. This technique is simple to apply, inexpensive, effective and frame preparation requires no preoperative planning.
SMALL INTESTINAL FOREIGN BODIES: A RETROSPECTIVE STUDY OF 212 CASES

JSM Kim

Pet Emergency Room & Queensland Veterinary Specialists, Stafford Heights, Brisbane, Queensland, Australia

Introduction: Foreign objects are commonly ingested by cats and dogs, and frequently result in an obstruction within the gastrointestinal tract requiring veterinary intervention. A common anatomical site for the occurrence of foreign body obstruction is within the small intestine (duodenum, jejunum, and ileum).

Objective: To identify correlations between signalment and occurrence of small intestinal foreign body obstructions, and establish trends that exist between prognostic factors and the outcome of surgical intervention.

Study Design: Retrospective case series.

Animals: 212 dogs that underwent exploratory laparotomy for the presence of small intestinal foreign body

Methods: Records of exploratory laparotomies from 30 October 2004 to 30 January 2014 were reviewed to identify small intestinal foreign body cases, yielding 212 cases for the period.

Results: 33 (15.6%) were feline patients and 179 (84.4%) were canine patients. The mean age for cats was 4.1 ± 1.1 years and 3.6 ± 0.5 years for dogs. The most commonly presenting cat breed was Burmese (36.4%), and Labrador (19.6%) for dogs. In cats, males comprised 48.5% and females 51.5%. In dogs, males comprised 60.3% and females 39.7%. 13.3% of cats in this study presented for a linear foreign body compared to 13.9% for dogs, and had a relative risk of 26 and 2.7 respectively for intestinal resection. The most common anatomic location for a discrete foreign body lodgment for both species was mid-jejunum. In cats, the most common foreign body was a trichobezoar (26.7%), and in dogs this was stone/gravel/concrete material (13.3%). 33.3% of feline cases and 15.6% of dog cases had a history of a previous GI foreign body. Vomiting, inappetence, and lethargy were the most common presenting signs in both species. The most common physical examination finding of the abdomen in both species was pain upon palpation. The mean duration of clinical signs in cats before presentation was 2.7 ± 1.0 days and in dogs 2.8 ± 0.6 days. Intestinal resection was required in 2 cats (6.1%) and 24 dogs in this study (13.4%). The mean time from surgery to discharge was 1.9 ± 0.3 days for all feline cases and 2.0 ± 0.2 days for all canine cases; it was shown to be prolonged in resection cases (cats p=0.0005, dogs p=0.0006). One cat in the study was euthanised 3 days post-op due to septic peritonitis. One dog was euthanised 2 days post-op due to septic peritonitis, one dog died during surgery, and another dog suffered a cardiac arrest 1 day post-op with septic peritonitis. In cats, the mean ratio of body weight (kg) to foreign body size (cm) was 2.1 ± 0.5 (range 1.0 to 4.8), and dogs 6.7 ± 0.8 (range 1.1 to 18.2).

Conclusions: The jejunum is the most common anatomical site for a small intestinal foreign body to be lodged in cats and dogs. Vomiting was by far the most common presenting complaint. The duration of clinical signs before surgery was the most reliable prognostic indicator in dogs. The mean time from surgery to discharge was prolonged in both cats and dogs with intestinal resections. The ratio of body weight to foreign body size was shown not to be a reliable prognostic indicator for small intestinal foreign bodies in cats and dogs.
ASSOCIATION BETWEEN CLINICAL OUTCOMES WITH EPIDURAL METHYLPREDNISOLONE INFILTRATION AND MAGNETIC RESONANCE IMAGING FINDINGS IN DOGS WITH LUMBOSACRAL DEGENERATIVE STENOSIS

J King¹, D Cook¹, P Moses¹, P Gilbert¹, J Lunn¹, S Davies²

¹Veterinary Specialist Services, Brisbane, Queensland, Australia, ²Veterinary Imaging Associates, Sydney, New South Wales, Australia

Introduction: Lumbosacral degenerative stenosis may cause lumbar spinal pain, hind limb lameness or neurological deficits to the hind limbs, as well as urinary and faecal incontinence. Conservative management with oral analgesia and anti-inflammatory medications often improves symptoms but there is a high rate of recurrence with return to activity. Epidural infiltration of methylprednisolone acetate is a recently described non surgical treatment option which shows promise in alleviating clinical signs relating to pain. Clinical outcomes of epidural methylprednisolone injections have been described in 39 dogs, with 53% of dogs returning to normal activity and 79% improved. This study aims to correlate MRI findings with clinical results in a cohort of 27 dogs.

Objective: To correlate post treatment outcomes of epidural infiltration of methyl prednisolone acetate, with MRI findings and pre-operative clinical findings.

Study Design: Retrospective clinical study.

Animals: 27 dogs with lumbosacral degenerative stenosis.

Methods: Dogs included in the study presented to Veterinary Specialist Services between 2008-2013 for assessment of hindlimb dysfunction. All patients were ambulatory. Clinical examination findings were consistent with lumbosacral disease. Plain radiography and MRI was performed on all patients. Dogs had previously been treated with rest and NSAID therapy, which failed to alleviate clinical signs. Dogs were treated with 1 mg/kg epidural methylprednisolone acetate following confirmation of epidural location with contrast radiography or fluoroscopy. Instructions were given for strict rest and injections were repeated at 3 weeks and 6 weeks after initial injection. If clinical signs recurred in these animals, they either received further epidural injections, were admitted for decompressive surgery, or were euthanased at owner’s request.

Results: MRI changes did not correlate with clinical signs. Two dogs had no clinical improvement, 20 had clinical improvement, and 5 returned to be clinically normal. Sixteen dogs presented with neurological deficits while 11 had no neurological deficits. Dogs without neurological deficits were more likely to be assessed as clinically improved than those with neurological deficits (p=0.07). MRI findings of degree of intervertebral disc protrusion, evidence of foraminal stenosis, nerve root enlargement, or degeneration of the intervertebral disc did not have a significant effect on the clinical outcome post treatment. 16/27 dogs had protrusion of an intervertebral disc cranial to L7-S1, with associated spinal cord compression. These dogs had a significantly less successful clinical outcome post treatment (p=0.016). Two dogs received a second course of epidural injections, with the mean time after the initial treatment of 269 days. Two dogs were euthanased at owner’s request, at 28 and 90 days post treatment, due to severe deterioration in neurological condition.

Conclusions: MRI findings at L7-S1 in dogs with lumbosacral degenerative stenosis are unable to accurately predict clinical improvement following epidural infiltration of methylprednisolone acetate. There is evidence to suggest
that an intervertebral disc extrusion cranial to the lumbo-sacral space, and those that present with neurological deficits, are associated with a less successful clinical outcome.
CONTOURING A STANDARD TIBIAL PLATEAU LEVELING OSTEOTOMY PLATE AND PROXIMAL LOAD SCREW ANGULATION AFFECT OSTEOTOMY COMPRESSION

KR Mathis¹, SC Roe², KR Johnson¹

¹University of Sydney, Camperdown, New South Wales, Australia, ²North Carolina State University, Raleigh, NC, USA

Objective: To evaluate the effect of contouring a TPLO plate, and thus the associated angulation of the DCU relative to the long axis of the tibia and angulation of the screw relative to the DCU, on the osteotomy compression generated by load screws in a TPLO model.

Study Design: In vitro biomechanical study.

Study Population: Nine 3.5 mm TPLO plates and eighty one 3.5 mm cortical bone screws.

Methods: The distal portion of a Slocum TPLO plate was attached to a horizontally positioned polyoxymethylene rod that was attached to a load cell. A segment of synthetic cortical bone substitute was attached to the end mount of the testing frame and adjusted to conform to the angle of the proximal portion of the TPLO plate. A 3.5mm cortical bone screw was inserted in the proximal DCU and tightened to 1.5Nm. The peak load (N) was recorded.

Screw insertion and data collection was repeated for proximal plate angles of 0°, 5°, 10°, 15°, 20°, 25°, 30° 35° and 40°.

Results: A significant increase in the compression generated was observed as the plate angle was increased from 0° to 10°. The compression ceased to significantly increase until the plate was bent more than 20° after which a significant decrease in compression was noted. A marked reduction in the compression generated occurred at plate angles greater than 30°.

Conclusions: Angulation of the DCU and screw insertion angle can have deleterious effects on the magnitude of osteotomy compression.
EFFECT OF TPLO ON PATELLAR TENDON ANGLE: A PROSPECTIVE CLINICAL STUDY

S Sathya¹, P Gilbert², J Campbell¹

¹University of Saskatchewan, Saskatoon, Canada, ²Veterinary Specialist Services, Brisbane, Australia

Objective: To evaluate the effect of Tibial Plateau Levelling Osteotomy (TPLO) on the patellar tendon angle (PTA) in dogs with naturally occurring cranial cruciate ligament rupture.

Study Design: Prospective observational clinical study.
Animals: Dogs with naturally occurring cranial cruciate ligament (Cr CL) rupture that had TPLO (n=40). Methods: Pre-operative tibial plateau angle (TPA) and PTA were measured on radiographs of affected stifle joint at 90° and standing angle (135°) respectively. TPA and PTA were measured after TPLO was performed. Regression analysis was performed to evaluate the effect of pre-operative TPA and PTA and post-operative TPA on post-operative PTA. Linear regression analysis was performed to evaluate the correlation between post-operative TPA and PTA.

Results: The mean (± SD) pre op TPA and PTA were 26.5±3.8° and 105.7±3.8° respectively. The post op TPA and PTA values were 7.6±3.3° and 91.4±5.5° respectively. Regression analysis showed that higher pre operative PTA and post-operative TPA are associated with a larger difference between the post-operative PTA and 90°. There was a positive correlation between post-operative TPA and PTA.

Conclusions: TPLO alters the PTA to 90° in dogs with naturally occurring cranial cruciate ligament rupture similar to tibial tuberosity advancement (TTA). TPLO may be providing dynamic stability to the cranial cruciate deficient stifle by altering the TPA relative to the patellar tendon and creating a PTA of 90°. The biomechanical principle and mechanism of action of TPLO may be similar to TTA. It may be more appropriate to rotate a TPLO based on the PTA rather than the TPA.
INTESTINAL RESECTION: SMALL vs LARGE
GA Edwards
School of Animal and Veterinary Sciences, Charles Sturt University, NSW

Introduction: Resection and anastomosis of the small intestine is a relatively common and standard procedure performed in most veterinary practices. Historically however, there has been a greater concern regarding resection and anastomosis of the large intestine relative to the small intestine. This is largely as a result of perceived problems with slower healing, difficulty in exposure, problems with intestinal contents and the potentially devastating outcome of wound breakdown. Indeed the reported incidence of complications associated with large intestinal surgery in both humans and animals is relatively high and frequently associated with sepsis, wound breakdown, stricture formation or faecal incontinence.
For this reason a thorough understanding and knowledge of the relative healing processes and techniques used in both the small and large intestines is essential in successfully performing a resection of these structures.

Anatomical considerations: Small vs Large Intestine: Nearly all of the small intestinal arterial blood supply is supplied through the cranial mesenteric artery. It anastomoses proximally with a branch of the celiac artery along the descending duodenum and distally with a branch of the caudal mesenteric artery along the descending colon. From the root of the mesentery, the cranial mesenteric artery divides into 12-15 branches which course through the mesentery and anastomose with each other in a series or arcades from which short vasa recta extend directly into the intestinal wall.
In the large intestine the ileo-caecal branches of the cranial mesenteric artery supplies the ascending and transverse colon and the caecum. The rectum and descending colon are supplied by the caudal mesenteric artery with collateral circulation from the cranial mesenteric and caudal rectal branch of the internal pudendal artery.
The walls of the small and large intestines are both composed of 4 main layers.
1. The outer layer, or serosa is composed of connective tissue covered by a mesothelial layer, the visceral peritoneum.
2. The Muscularis Propria is composed mainly of smooth muscle with an inner circular layer, and an outer longitudinal layer.
3. The submucosa is principally composed of collagen (68% type I, 20% type II and 12% type V) and most of the tensile strength of the intestine comes from this layer. It has long been recognised that this is the critical layer to be included in placing sutures in the intestine.
4. The mucosa is composed of surface epithelium, a lamina propria (containing connective tissue, blood vessels and lymphatics) and a thin muscularis mucosa. The mucosa of the small intestine is folded into deep villi covered in epithelium. The deeper part of the mucosa is composed of intestinal glands, lymphoid tissue and single follicles. In dogs there are also approximately 22 areas of aggregations of lymphoid follicles (Peyer’s patches). The large intestinal mucosa on the other hand has no villi or aggregates of lymph nodules.

Surgical Approaches: Surgical access to the small intestine is best achieved via a ventral midline laparotomy. The entire small intestine, except for parts of the duodenum can be exteriorized and “packed-off” to decrease the risk of abdominal contamination.
Surgical access to the large intestine, and in particular the colorectum can be somewhat difficult, especially for lesions of the distal colon and rectum within the pelvic canal.
A number of surgical techniques have been developed to overcome these difficulties, the approach and method used being dependent on the location of the lesion.
The colorectum can be divided into 3 regions:
1. The colon and colorectal junction. These structures can normally be approached via the Ventral Abdominal Midline approach. Further access may be accomplished by an Ischial-Pubic Flap.
2. The middle third of the colon. This can be approached via a Dorsal Perineal Approach or an Abdomino- Anal Pull-Through approach.
3. The caudal third of the rectum. This area can be approached by a Caudal Rectal Pull-Through.

Dorsal Perineal Approach: The dorsal perineal approach allows excellent access to the colon and rectum.
The animal is placed in sternal recumbency and the tail elevated. Tilting the table with the head down slightly will also improve exposure. A purse-string suture is placed in the rectum and an inverted U-shaped incision is made around the dorsum of the anus from the level of the ischial tuberosities.

To expose the dorsal pelvic canal and rectum, the paired retrococcygeal muscles are undermined and transected near their attachment on the ventral surface of the coccygeal vertebrae. The blunt dissection is continued ventrolaterally between the external anal sphincter and the levator ani muscles. Care should be taken not to damage the pudendal nerve and vessels. If necessary the levator ani muscles can be transected to increase exposure, but is usually unnecessary.

The cranial rectal artery in the dorsal midline of the rectum is ligated, exposing the rectum as far cranially as the peritoneal reflection without difficulty. The pelvic nerve plexus, including the caudal rectal nerve and autonomic fibers, fan out along the lateral aspect of the rectum within the peritoneal reflection and is closely associated with the peritoneal attachment to the rectum.

Resection of the colon cranial to this reflection may result in nerve damage and incontinence. Studies of this technique indicate that up to 8cm of the rectum can be resected via this approach. Resections of greater than 4cm, however, result in a high incidence of post-operative incontinence. Experimental studies also indicate that greater than 1.5cm of intact rectum is also important for the maintenance of continence due to the presence of stretch receptors in the rectal wall, particularly in the distal wall which are responsible for a feedback mechanism to the external anal sphincter via the caudal branches of the internal pudendal nerve. This reflex results in increased external anal sphincter tone in response to rectal filling.

Faecal incontinence may therefore result from a decreased number of stretch receptors due to rectal resection or damage to either the efferent or afferent nerve fibers, particularly in the pelvic plexus.

Post resection, the retrococcygeal muscles may be reattached with mattress sutures. Penrose drains are inserted into the ischiorectal fossa, but not over the anastomotic site.

**Surgical techniques and an understanding of Small vs Large Intestinal healing:** Current methods and principles of intestinal surgery originated in the early 19th century, and have continued with the increased understanding of the mechanisms of healing of the intestine. Until then, most intestinal surgery was unsuccessful. Most intestinal wounds requiring surgical intervention were traumatic in origin, and carried a less than promising prognosis. Travers in 1812 made the astute observation that the divided ends of intestine needed to be in contact to heal properly! He was the first to use a small sewing needle to place multiple, full-thickness silk sutures at close intervals to prevent intestinal leakage and improve intestinal healing. He was also the first not to attach the intestine to the body wall.

In 1826, Lembert reported his technique to serosa-to-serosa apposition to improve rapid healing. His technique became a fundamental principle of intestinal surgery, which has continued to be adhered to in human surgery. Lister in 1867 was also important in the development of intestinal surgery when he described the principles of asepsis. The incidence of septic peritonitis and wound infections suddenly declined as a result of his work.

In 1887, Halsted reported on the importance of the submucosal layer in suturing intestine. The submucosa consists mainly of course, loosely woven collagenous and elastic fibers with a submucosal plexus of nerves, blood vessels and lymphatics.

In 1892, Connell introduced a single layer, continuous inverting suture pattern which was quick to perform. In the same year, Murphy described the use of an interlocking metallic button which created a sutureless, inverting, end-to-end anastomosis. When healing was complete the button would slough into the intestinal lumen and be passed in the faeces. It proved highly successful, but was replaced by hand-sewn techniques in the early 20th century.

By the beginning of the 20th century, the fundamental doctrines of intestinal surgery were firmly established. They included:

- Apposing the serosal surfaces using an inverting suture technique.
- Including the tough submucosa in the sutures.
- The use of aseptic technique.
- Maintenance of adequate blood supply.
- Avoiding tension on the anastomosis.

Healing within the gastrointestinal tract follows the same classical phases as described for all other tissues. Damage to the mucosa alone heals by epithelial migration. This also occurs across an anastomosis, usually within 3 days, if there has been good apposition of the intestinal ends.
In full thickness wounds the initial inflammatory phase (often referred to as the lag phase) involved the processes of haemostasis, vasconstriction and the diapedesis of neutrophils and macrophages into the injury site. Oedema of the subepithelial region may be present for 2 weeks, which makes it important not to place sutures too tightly. At the serosal surface, fibrin forms rapidly creating a watertight seal.

During this lag phase, studies in rats have shown decreases in anastomotic strength in the first 48 hours (Gastroduodenum – 64%, Small Intestine – 70%, Colon – 72%), due to collagenolysis. This is a clinically important period as dehiscense is most likely to occur in the first 48-72 hours.

Despite the small difference in the decrease in anastomotic strength between the small and large intestines found in rat studies, most surgeons still believe that the healing of surgical or traumatic wounds of the colorectum is relatively slow compared to the rest of the gastrointestinal system.

Factors which may further compromise healing include the presence of sepsis which results in greater collagenolysis activity. Shock will also significantly reduce vascular perfusion to the anastomotic site as blood is shunted to more critical organs (not a feature of skin wounds). The presence of shear stresses due to increased intramural pressure during peristalsis, and the presence of gas and ingesta in the intestinal lumen may further compromise the early phases of healing.

In the proliferative phase there is the development of granulation tissue. Collagen is produced by both fibroblasts and smooth muscle cells within the muscularis mucosa and muscularis propria. The majority of the collagen is in fact produced by the smooth muscle cells as type I and III, and unlike the skin, type V collagen.

Significant increases in strength will then occur with collagen synthesis, as long as there is no infection or dehiscence of the wound edges.

During the maturation phase, there is remodelling of the collagen and further increases in the tensile strength of the anastomosis.

From a wound healing perspective, the best healing results are therefore achieved with accurate approximation of the anatomic elements of the bowel wall, i.e with the use of appositional sutures, avoidance of close, tight sutures and anastomotic tension, and careful maintenance of the segmental blood supply is important.

Preoperative Considerations:

Preparation of the Bowel: In most cases, little is done to prepare the small intestine for resection other than stabilization of the patient as a whole.

Preparation of the large intestine on the other hand is controversial and when performed is aimed at trying to reduce the incidence of post-operative sepsis and wound breakdown by reduction of the bacterial load in the large bowel by two methods

a) Removal of faeces: The use of enemas is often not very effective in reducing potential contamination of the surgical wound. It is often better to isolate solid faecal material behind bowel clamps than to attempt to keep liquified faeces present following an enema, out of the operative site.

If enemas are necessary, 2 - 3 warm soapy enemas can be given 24 - 72 hours prior to surgery. Care should be taken not to traumatise diseased or compromised bowel. Laxatives, stool softeners and high calorific, low residue diet several days before surgery can also be useful. Food should be withheld for 24 - 36 hours prior to surgery.

b) Antibiotic Prophylaxis: The bacterial load in the large bowel is significantly higher than in any other part of the digestive tract. The majority of the bacteria are anaerobes (Bacteroides and Clostridium spp.). There are also some aerobes (Proteus, Pseudomonas and Strepts).

Classically, non-absorbable aminoglycosides such as Neomycin have been advocated to reduce the bacterial load. They are, however ineffective against anaerobes. Metronidazole is effective against anaerobes but must be administered for at least two days prior to surgery to be effective.

However the use of oral antibiotics has not been shown to be any more effective than the use of the prophylactic intravenous administration of a second generation cephalosporin which is effective against anaerobes and gram negative aerobes administered 1 hour prior to surgery, every 2 hours during surgery and immediately following surgery.

Surgical Principles: The normal surgical principles of isolating the bowel segment with moist abdominal packs to reduce contamination, keeping the tissues moist, haemostasis and lavage, all apply to surgery of the small and large intestines.

Configurations used to anastomose the ends of the small intestine include end-to-end, end-to-side and side-to-side techniques. Most resections and anastomoses of the large intestine however are repaired using the end-to-end technique.

The 3 principle types of suture patterns which can be used in the gastrointestinal tract are:
(1) *Inverting suture patterns:* These patterns produce serosa to serosa contact. The classical technique is the 2-layer inverting technique of a primary Connell layer followed by interrupted Lambert sutures. All sutures must penetrate the submucosa - this is a basic surgical principle as it is the only layer with any real holding power. Single layered closures are often used to reduce luminal closure. 

(2) *Approximating patterns:* These more accurately realign the anatomical layers of the bowel. Three types of sutures are used.

(i) Gambee sutures – First described in 1951 these penetrate the lumen and pass through the small segment of mucosa and submucosa on the same side increasing the strength of the suture.

(ii) Cutting sutures - these simple interrupted sutures are tied so that they cut through the mucosa, serosal and muscularis layers to just hold the submucosa in apposition.

(iii) Simple interrupted non-crushing sutures.

(3) *Everting suture patterns:* These are the easiest of the suture patterns to place as the intestinal mucosa naturally wants in evert when cut. These suture patterns include both horizontal and vertical mattress sutures.

There has continued to be much debate in both the human and veterinary fields as to the relative value of inverting and evertting techniques. The results were often contradictory, although it became apparent that evertting techniques narrowed the lumen less initially, they resulted in significantly more scar tissue associated with the anastomoses. In 1968, Poth and Gold reported that an appositional technique using simple interrupted crushing sutures to appose the layers of the intestine more accurately. However there are few reports in the human literature of appositional techniques, and none are currently recommended in human surgery textbooks (Gambee sutures are considered to be inverting in these texts).

In contrast to this, most veterinary literature recommends approximating techniques for end-to-end anastomoses. Again a large number of comparative studies have been undertaken in both dogs and cats with sometimes conflicting results. A critical examination of some of these studies have also shown that as a result of the difficulties encountered in creating accurate approximation of the layers within the intestinal wall, and the propensity of the mucosa to evert, some of the study results may in fact be flawed.

In general however these reports indicate that omental adhesions and mural fibrosis is greatest with evertting patterns, and least with approximating patterns, particularly when the modified Gambee suture was used. Evertting patterns are not recommended for use in the gastrointestinal tract.

Studies in both small animals and horses showed that inverting patterns significantly narrowed the lumen of the small intestine, predisposing the animal to intestinal obstruction (even in horses!).

Histologically, close approximation of the intestinal wall layers results in healing directly across the defect (primary healing), whilst inverting, evertting or overlapping the layers results in indirect bridging of the gap with increased amounts of collagenous tissue and neovascularisation (secondary healing).

A modified simple continuous pattern for closure of the small intestine is an acceptable alternative with the advantage of speed, decreased tissue handling, improved apposition of intestinal layers and a low rate of complications.

In the large intestine healing can best be achieved with a single layer of simple interrupted monofilament absorbable sutures. Generally sutures should be placed 2-3mm from the cut surface and 3-4mm apart.

To allow for more accurate apposition of the anatomical layers of the bowel, evertted mucosa may be resected, or a Gambee suture technique may be used to help invert the mucosa and submucosa and allow apposition of the seromuscular layers.

Two layered closures have and are still being used. One study of rectal anastomoses, however has shown an increased rate of anastomotic dehiscence with a 2 layered closure compared to a single layer.

Continuous suture patterns should be avoided in the large intestine as they favour increased collagenolysis in the early phases of wound healing.

Other factors shown to influence this include tissue handling, blood supply and the type of suture material used. **Staples** were originally used for intestinal repair in the USSR shortly after World War II.

They result in a rapid, secure, less tissue reactive and rapidly healing inverting anastomosis and have been used successfully in both large and small animals since 1981. A wide variety of stapling instruments are now on the market.

The primary limitations to the widespread use of these instruments are the cost and lack of familiarity with automated intestinal stapling techniques.

When fired the staples are bent against the anvil into a B-shape in a double overlapping layer. The staples compress the tissues, but as a result of their off-set configuration, do not reduce the micro-blood supply to the bowel edge.
Staple cartridges for reusable instruments or disposable stapling instruments are produced in 21, 25, 28 and 31mm diameters. Reported complications occurring subsequent to the use of staples include bleeding, poor tissue approximation, leakage and instrument failure. It is important for the surgeon to be fully familiar with the operation of the instrument.

A biofragmentable ring made from polyglycolic acid in a similar fashion to the Murphy button has also been used clinically in humans, but as yet, only experimentally in dogs.

Resections of the small and large intestines and especially enterocolostomies involving the removal of the ileocaecal valve may result in a size disparity between the ends of the bowel to be anastomosed. This may be overcome by either cutting the smaller of the bowel segments at an angle to create a larger lumen, making the antimesenteric border shorter, or by oversewing the extra colonic lumen at the antimesenteric border.
**Introduction:** Pyometra is an accumulation of pus within the uterus and in the bitch represents the final stage of the cystic endometrial hyperplasia-pyometra complex. It is a disease of the diestrous phase of the ovarian cycle while the corpus luteum is actively secreting progesterone and commonly affects middle-aged intact bitches with an incidence of 23-24% within 10 years. Pyometra is less common in cats as they are induced ovulators and therefore should only occur with sterile matings. As a result of luteal progesterone production the cervix closes and mucopurulent or purulent exudates accumulate within the uterus. It results in cystic endometrial hyperplasia and inhibits the leukocyte response facilitating bacterial colonization by a variety of bacteria, especially *Escherichia coli*. Management of the condition is, in most cases, achieved by ovariohysterectomy, and whilst the surgical technique is relatively straightforward the importance of good peri-operative care can significantly influence the outcome for the patient.

**Diagnosis:** Affected bitches are generally middle-aged (average age of 8 years) and present within 8 – 12 weeks of a previous season (4 weeks in cats). There is increased risk if exogenous oestrogen or progestagens are given (oestrogen increases the sensitivity of the uterus to progesterone). Cystic endometrial hyperplasia is present with chronic endometritis. Infection is not a primary cause of pyometra but is usually present secondarily. *E. coli* is most commonly isolated with *Streptococcus, staphylococcus, enterococci, Klebsiella, Proteus* and *Psuedomonas* also noted. Occasionally, anaerobic bacteria such as *Bacteriodes* and *Clostridium* with secondary toxema have also been reported. Pyometra results in systemic disease from bacterial endotoxins and the widespread release of inflammatory mediators which reduce cardiac output, increase vascular endothelial permeability with loss of fluid and proteins and lower systemic vascular resistance. Diagnosis may be obvious in cases of open pyometra where a typical purulent vaginal discharge is present. Closed pyometra is more difficult to diagnose and the clinical signs are less specific but include abdominal enlargement, anorexia/depression, vomiting/diarrhea, polyuria and or polydipsia (E. coli endotoxin affecting renal tubular function). Affected animals may be normothermic, hypothermic or pyrexic and vaginal discharge is variably present depending on whether is cervix is open or not. Gentle abdominal palpation may identify uterine distension in bitches which are not grossly obese. Clinic-pathologic data usually includes a finding of leukocytosis, with a left shift and toxic change. Anaemia may be present but is often masked by dehydration. Azotemia with a concurrently inappropriately low USG may also occur. Systemic inflammatory response syndrome has been associated with 57% of cases of pyometra. Diagnostic imaging is useful with radiographs revealing a soft tissue density in the caudoventral abdomen with concurrent displacement of intestinal loops. These changes can be less obvious in animals with abdominal effusion. Ultrasound provides a sensitive diagnostic tool giving an indication of uterine size, the thickness of the uterine wall and the presence of fluid within the peritoneal cavity.

**Management Options:** Pyometra may be managed both medically and surgically and clinical judgement is required in choosing an appropriate treatment modalities. Some owners may be adamant that the bitch will be used for future breeding which may preclude surgical therapy. Medical management involves appropriate supportive care to manage fluid and electrolyte imbalance, nutritional support and luteolysis with broad spectrum antibiotics. Luteolysis results in lowered progesterone levels which should open the cervix and allow drainage. Re-infection is likely and it is recommended that the dog be bred on the following mating. Surgery provides the mainstay of therapy for most affected dogs. Animals must be appropriately stabilized prior to anaesthesia and surgery. Ovariohysterectomy removes the septic focus and prevents recurrence. The reproductive tract should be handled carefully to prevent iatrogenic rupture and contamination of the peritoneal cavity. Isolation with moistened laparotomy sponges is recommended. Previously oversewing the uterine stump was recommended but lavage and omentisation provide increased drainage and prevent loculation of infected fluid and tissues. Reported complications include haemorrhage, peritonitis, incomplete removal of ovarian tissue and on-going uterine stump pyometra. Most of these complications can be avoided by careful tissue handling and good surgical technique.

**Post-operative care and management:** Good post-operative care and management of pyometra cases is essential in achieving a good outcome for the patient. Many of the post-operative complication can be avoided or minimized by good pre-operative stabilization and intra-operative care.
Patients should be closely monitored for 24-48 hours post-surgery for sepsis, shock, dehydration, and electrolyte or acid-base imbalances. Particular attention should be paid to any evidence of abdominal pain suggestive of peritonitis.

Affected bitches should receive intravenous fluids to correct hydration and acid-base deficits throughout the pre-operative, operative and post-operative periods of care. Severe hypoproteinaemia or anaemia should be managed by the administration of plasma or whole blood transfusions. Broad-spectrum intravenous antibiotics should be administered before or at the time of induction to counteract bacteraemia and possible peritoneal contamination as a result of handling the uterus. Broad-spectrum antibiotics such as cephalosporins or ampicillin should be administered intravenously and repeated every 90 minutes during the surgical procedure, and then post-operatively as the situation dictates. Some suggest that antibiotic therapy, based on culture and sensitivity results, should continue for 10-14 days following surgery.

The provision of analgesics and a warm comfortable environment during recovery is essential in a rapid return to homeostasis. When SIRS occurs, a more vigorous post-operative care protocol needs to be followed taking into account the extensive spectrum of systemic aberrations which may be taking place in these patients.

If contamination of the abdomen or a generalized peritonitis is recognized during surgery the abdomen should be lavaged with copious amounts of warmed sterile saline and drainage maintained with either closed suction drainage or open abdominal drainage.

In general, the prognosis following surgical management of pyometra is excellent, with a reported mortality rate of 0-5% in dogs. The mortality rate however significantly increases in the presence of a septic abdomen.
**Abdominal Wall Hernias**

**Peter Gilbert**

Veterinary Specialist Services, Brisbane, Queensland.

An abdominal hernia is defined as a full thickness defect or weakness of the abdominal wall that can allow protrusion of the contents of the abdomen.

Abdominal wall hernias can occur in many locations including the umbilicus, paracostal region, prepubic region, inguinal and scrotum as well as the abdominal wall itself. Hernias can be traumatic or congenital.

The overall prognosis is often more dependent on the degree of organ herniation or trauma than the repair method used.

The incarceration of organs causes impaired function of the organs involved. Incarceration can progress to strangulation of organs. Strangulation leads to organ devitalisation due to impaired circulation. Either the arterial circulation or venous circulation or both can be impaired. Usually venous obstruction occurs early on and causes reversible organ engorgement if treated early enough. If left unresolved arterial stagnation develops due to back pressure in the capillary beds.

There are four main principles of hernia repair.

1. Ensure viability of the hernia contents.
2. Return of viable contents to the abdominal cavity
3. Remove the redundant tissue of the hernia sac
4. Closure of the hernia defect primarily in a secure and tension free manner.
5. A thorough knowledge of the local anatomy is essential for hernia repair especially in challenging cases.

Large abdominal wall defects will often require reconstruction, using autologous and/or non-autologous methods.

Autologous are generally the method of choice and include: vacuum assisted closure, separation of anatomical components, partitioning of the abdominal wall and muscular flaps.

Non-Autologous methods include synthetic mesh repair and biological tissue grafts.

This lecture will present case studies of challenging hernia repairs going through diagnosis, management, complications and aftercare.
Prostatic Cysts and Abscesses

Peter Gilbert

Veterinary Specialist Services, Brisbane, Queensland.

Suppurative prostatitis is a common disease of the prostate gland in dog; infection is thought to occur via ascension from the urethra. Prostatitis may occur at any age but is most common from middle age onwards; it rarely occurs in castrated dogs, which may suggest a role for benign prostatic hyperplasia in the pathogenesis. Multiple cystic changes are usually evident throughout the parenchyma, which may indicate alteration in the flow of prostatic secretions and may allow bacteria to become established with E. coli being the most common bacteria isolated. Treatment is based upon the ablation of prostatic secretory function and antimicrobial therapy. Castration promotes involution of secretory tissue and is an essential part of treatment.

The term prostatic cyst generally refers to larger discrete cysts on the surface or within the prostatic parenchyma. Paraprostatic cysts do not arise from the prostate but have attachments to the capsule.

The prostate is usually approached surgically via a caudal midline coeliotomy, though occasionally the lesion location may require a perineal approach. A urethral catheter should be placed into the bladder to aid in identification of the urethra intraoperatively. Periprostatic fat must be carefully removed from the ventral surface of the prostate.

Many techniques have been reported for the management of prostatic cysts including ultrasound guided drainage, complete resection, marsupialisation, partial resection with omentisation and partial prostatectomy.

This lecture will look at surgical techniques for the treatment of prostatic cysts and abscesses in particular omentisation, the benefits, complications and effectiveness of treatment methods will be compared. A review of the latest literature will be presented along with case material.