Cystotomy, OVH for Pyometra, and GDV: What You Need to Know
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Cystotomy, ovariohysterectomy (OVH) for pyometra, and correction of a gastric dilatation and volvulus (GDV) represent three of the most common surgical procedures performed in an emergency setting in small animal veterinary practice. Successful outcome is dependent on meticulous pre-operative workup and stabilization, knowledge of proper surgical technique, having the necessary equipment to carry out the procedure, and having access to 24-hour care for post-operative observation and management.

Cystotomy
Indications
Cystotomy is most often performed for removal of urinary stones (uroliths). Other indications for cystotomy include congenital disease (vesicourachal diverticulae, patent urachus, and ectopic ureters), trauma (motor vehicular, iatrogenic, or secondary to urethral obstruction), and neoplasia (benign polypoid cystitis, transitional cell carcinoma).

Pre-operative diagnostics and stabilization
Diagnostics for urinary bladder disease include bloodwork, urine analysis and culture, and imaging as indicated by the underlying disease. Stones within the urethra may or may not be associated with signs of obstruction, and thus the preoperative diagnostic workup should include radiographs of the entire urethra. Other diagnostics to consider include contrast cystourethrography, abdominal ultrasound, cystoscopy, and catheter biopsy. Transabdominal fine needle aspirate or biopsy of suspected neoplastic lesions is not recommended due to the risk of seeding neoplastic cells into surrounding tissue. Catheter biopsy is achieved by applying suction with a syringe via a urinary catheter that has been advanced to the level of the mass. Alternatively, cystoscopy can be performed to examine and sample bladder mucosa.

If the patient presents with urinary obstruction or rupture, it is important to remember that surgery is not an emergency. A good outcome is dependent on successful preoperative urinary diversion and patient stabilization. Urinary obstruction or trauma may be associated with azotemia, electrolyte, and acid-base disturbances, with hyperkalemia the most common and life-threatening electrolyte abnormality. Urinary diversion is best established by dislodging stones from the urethra or passing with a small urinary catheter. If the stones cannot be dislodged or bypassed, then periodic cystocentesis can be performed until the patient is stable enough for anesthesia. Alternatively, in trauma patients with uroabdomen, an indwelling abdominal drainage catheter can be placed. Establishing urinary outflow allows fluid diuresis and correction of the metabolic disturbances, making the patient a better surgical candidate for definitive repair.

Concurrent with establishing urine outflow, the clinician should make every effort to correct metabolic disturbances associated with urinary tract obstruction or trauma (uroabdomen). Hyperkalemia can induce severe cardiac arrhythmias and bradycardia, and can be detected by characteristic ECG findings while bloodwork is pending. The most efficient technique to lower the potassium concentration is diuresis with isotonic crystalloid fluids such as Lactated Ringers Solution. If diuresis is not effective, insulin/glucose and/or bicarbonate can be used. Calcium gluconate may be necessary to protect the myocardium from the effect of potassium. Fluid therapy will also treat the metabolic acidosis and azotemia commonly associated with urinary tract obstruction and trauma.

When possible, urethral stones should be retropulsed into the urinary bladder due to the lower morbidity associated with cystotomy than urethrotomy. Retropulsion can be performed under heavy sedation or general anesthesia. Sterile saline is mixed with water-soluble lubricant in an approximately 3:1 ratio. A large urinary catheter is passed within the urethra steriley to the level of the obstruction without forcing it. A small quantity (1–3 ml) of lidocaine solution can be injected prior to the saline to help release local urethrospsm. A gauze sponge is used to pinch the end of the penis or the vulvar lips around the catheter by squeezing it with the thumb and forefinger. The saline/lubricant mixture should be forcefully injected under pressure while simultaneously moving the catheter back and forth against the stone (an assistant is required to properly perform this technique). For more difficult stones, an assistant can pass a gloved finger into the rectum to temporarily obstruct the proximal urethra with digital pressure. The assistant should remove the digital urethral pressure once sufficient urethral distention is palpable, allowing the stones to pass back into the urinary bladder. Always assess bladder size by gentle palpation prior to repeating retropulsion to avoid over-distending the bladder. Once the catheter can be passed into the urinary bladder, repeat a lateral (+/- VD) radiographic view to ensure all stones have returned to the bladder prior to surgery. Leave the urinary catheter in place to prevent migration of stones back into the urethra. Note that retropulsion can also be performed in surgery rather than before; however, it is more difficult to confirm radiographically that all stones have been removed from the urethra. If retropulsion is unsuccessful, urethrotomy or urethrostomy may be required.

Bladder surgery is considered a clean-contaminated procedure. Post-operative infection rate is approximately 5%. Perioperative antibiotics with a broad-spectrum antibiotic are recommended; however, post-operative antibiotics are given only if urinary tract infection (UTI) is present. A common question is whether the use of preoperatively-administered prophylactic antibiotics will alter...
intraoperative culture results. A recent study (Buote et al. *J Am Vet Med Assoc.* 2012) showed that preoperative administration of cefazolin had no effect on bladder culture results. Therefore, antibiotics should be given pre-operatively to establish effective prophylactic serum concentrations (not withheld until after the bladder has been sampled as previously recommended).

**Surgical technique**

The patient is placed in dorsal recumbency with the abdomen, prepuce and vulva clipped and aseptically prepared in all patients - dog, cat, male or female. It is very important to have access to the entire urinary tract at the time of surgery. Aseptic preparation of the prepuce or vulva is performed by lavage of a dilute betadine solution just prior to aseptic preparation of the abdomen. When draping, the penis or vulva should be included in the surgical field to facilitate urethral catheterization.

A standard caudal midline incision is made from umbilicus to pubis. This allows access to the bladder and the proximal urethra. The urinary bladder is identified, exteriorized and isolated from the remainder of the abdomen using saline-soaked laparotomy sponges. It is highly recommended to use sponges with radiopaque markers in them and to count sponges before opening and closing the abdomen to ensure no sponges are left behind. The ventral ligament of the bladder connects the bladder to the linea alba and may need to be transected. The surgeon should confirm the location of the lateral ligaments/ureters when planning the incision as they contain the ureters as well as the primary blood supply and innervation to the bladder. Stay sutures are placed in the apex and neck of the bladder to facilitate retraction, reduce urine leakage, and minimize traumatic tissue handling. Some urine leakage is expected but should be minimized. The bladder can be emptied prior to surgery with a transurethral catheter or during surgery with suction or a sterile syringe/needle. A scalpel blade is used to penetrate the ventral aspect of the bladder and enter the lumen. The incision is extended with Metzenbaum scissors. The bladder should be opened from apex to neck to allow proper visualization of bladder mucosa and easy retrieval of all stones. Stay sutures are placed on each side of the incision at its midpoint to facilitate visualization of the bladder interior. Use of cold saline, moistened swabs, and suction are essential to remove blood and urine and improve visualization. Cautery is avoided due to the potential for thermal damage and inflammation leading to delayed healing.

Dorsal cystotomy is not recommended since it has no advantage over ventral cystotomy when it comes to postoperative leakage or recurrent stone formation. A dorsal cystotomy results in an incision closer to the ureteral papillae, increasing the risk of inadvertent damage during opening or closure of the bladder. It also leads to 'kinking' of the urinary bladder neck during surgery, making stone retrieval difficult. A ventral incision allows optimal exposure with minimal spillage and contamination of the surrounding abdomen during bladder exploration and lavage. Further, it allows visualization of the ureteral openings and avoids damage or constriction of the ureters during closure.

Using a combination of suction, forceps, bladder spoons or curettes, the urinary bladder is gently cleaned of all visible stones. The bladder and urethra are checked for additional stones by passing a catheter normograde and retrograde and flushing with saline. Again, draping in the prepuce or vulva facilitates thorough flushing. For females, a catheter can be passed normograde from the bladder and out the urethra. The tip of the catheter is cut, and a second smaller catheter is wedged into the cut end of the first catheter and pulled back into the bladder. Alternatively, the 2 catheter tips can be sutured together before pulling the catheter tips back into the bladder. Flushing should be repeated several times until no stones are visible, the catheters and flush pass easily in both directions, and there is a high level of confidence that all stones have been removed. A small endoscope (cystoscope, arthroscope, laparoscope) can be used to assess the proximal urethra for presence of residual stones if necessary.

The interior of the bladder is examined for urachal diverticulae, masses, necrosis, etc. Traumatized or necrotic bladder tissue is debrided, and a piece of bladder mucosa is excised for culture and sensitivity testing. It has been shown that culture of bladder tissue is more reliable than culture of the urine. A sample of bladder tissue is submitted for histopathology if indicated.

The bladder is one of the quickest healing organs in the body, regaining 100% of its original strength within 2–3 weeks. Therefore, any shorter-acting absorbable suture material that maintains wound strength for 2-3 weeks is appropriate for bladder closure. Long-acting absorbable suture or nonabsorbable materials are not recommended as they can act as a nidus for stone formation or recurrent infection. In contrast to previous recommendations to avoid braided suture in the urinary bladder, a study of cystotomy practices in Ontario revealed the lowest rate of postoperative UTI with the use of Vicryl® suture compared to Monocryl® and PDS®. The rapid rate of suture dissolution was theorized as the possible explanation. In our hospital, we use Biosyn®, Vicryl®, and Monocryl® with regularity, the specific choice dependent on surgeon preference. Anecdotally, we have no difference in outcome or complications based on suture choice. Further studies are required in order to make firm recommendations for suture type used for urinary bladder closure. Bladder closure should be achieved with the smallest suture material possible, typically 3-0 or 4-0 (or smaller for delicate mucosal reconstruction).

Closure of the bladder is performed in one or two layers. A recent retrospective study (Thieman-Mankin. *J Am Vet Med Assoc.* 2012) of dogs and cats undergoing routine cystotomy showed no difference in complication rates between double and single layer, appositional or inverting suture patterns, and all complications that did occur were minor. An appositional pattern (vs. inverting) is generally preferred for thick, inflamed bladders due to the friable nature of the bladder wall. Inverting a thick bladder wall may compromise the size of the bladder lumen. Regardless of the suture pattern chosen, the surgeon should ensure accurate needle placement through the strength-holding submucosal layer. It has been previously recommended to avoid placement of the suture in the
bladder lumen; however, there is inconsistent evidence to support this recommendation. Further, avoiding the lumen is difficult to achieve in thin-walled bladders, especially given that engagement of the submucosa is essential. This author prefers to perform a two-layer closure with no attempt to avoid the bladder lumen. The mucosa/submucosa is closed in a simple continuous appositional pattern, and the muscularis is closed in either an inverting (Cushing or Lembert) or appositional pattern. Alternatively, if a single layer closure is chosen, full-thickness bites are recommended to ensure purchase of the submucosa. The incision should be inspected for potential areas of leakage. Additional interrupted sutures can be added if needed. The bladder is then locally lavaged, and the abdomen is closed routinely.

**Post-operative management**

A urinary catheter is not typically maintained postoperatively. In circumstances where the bladder integrity is poor or extensive cystectomy was performed, a soft catheter may be maintained (at the level of the trigone) for 1–3 days postoperatively and the bladder wrapped in omentum to promote healing.

Postoperative radiographs are taken in ALL cases involving urolith removal immediately after surgery (while under anesthesia) to both ensure and document that all stones have been removed. A recent study documented incomplete urolith removal in up to 20% of cases, and thus post-operative imaging is essential. For radiolucent stones, removal of stones is confirmed using positive contrast urethrocytogram. Should stones remain in the bladder or the urethra postoperatively, the recommendation is to return to surgery immediately for removal. Urinary stones should be submitted for analysis to ensure appropriate preventative measures are taken to prevent stone recurrence.

Patients should receive intravenous crystalloid fluids overnight to prevent blood clots from forming in the bladder that could result in urethral obstruction. Fluid support is also important for patients that were obstructed prior to surgery as they will be undergoing a post-obstructive diuresis phase. Fluid rate should be increased to maintain the hydration status of the patient. Discontinuation of fluids is typically based on patient recovery (appetite, urination, and pain management) as well as serum electrolyte and renal values.

Postoperative pain management should include a non-steroidal anti-inflammatory medication if azotemia was NOT present prior to surgery and there are no other contraindications. Opioids and other analgesics are administered as indicated by pain scoring.

Owners are advised that mild hematuria and pollakiuria may be present for 2-3 days but should resolve quickly. Antibiotics are continued only with a positive urine culture and are based on the culture and sensitivity results. If urosepsis is suspected in surgery, initial antibiotic therapy can be empirical, but should be altered once the culture and sensitivity results are available. Recommendations for dietary management of stone disease are made to prevent recurrence one results of the stone analysis are available.

**Complications and prognosis**

Complications following cystotomy include incisional complications, incomplete removal or recurrence of stones, UTI, dehiscence, and uroabdomen.

The prognosis following cystotomy is generally favorable depending on the underlying disease and preoperative management of concurrent issues. Successful treatment of azotemia and electrolyte management, successful retropropulsion of urethral stones into the urinary bladder, removal of all stones via cystotomy, and good surgical technique all lead to a more favorable outcome. Long term prognosis for animals with urinary stones is dependent on evaluation of stone composition, dietary management, management of UTI, and attention to urine pH.

**Minimally invasive urolith removal**

Minimally invasive laparoscopic-assisted cystotomy and percutaneous cystolithototomy have been recommended as alternative procedures to the standard open cystotomy. Reported benefits include a smaller incision in the abdomen and bladder (requiring less injectable analgesics) and increased visualization of the bladder and urethral lumen. On the other hand, however, laparoscopic-assisted cystotomy has been shown to be more time-consuming and expensive than open cystotomy. Transurethral cystoscopy with laser lithotripsy is also becoming more commonplace as a noninvasive option (no incision required) but has size and gender restrictions, depending on the equipment available. Three recent studies have shown laser lithotripsy to be safe and effective in removing both urethroliths and cystoliths; however overall procedure time is longer than for open cystotomy. When stones are isolated to the urethra, laser lithotripsy is significantly faster and urolith removal rate higher than when stones are present in the bladder +/- urethra. For all of the minimally invasive techniques, there have been no significant differences found in regard to uroliths removal rate when compared to open cystotomy. All of the minimally invasive techniques require potentially cost-limiting special equipment as well as a learning curve to become proficient in stone removal.

**Pyometra**

Pyometra, or cystic endometrial hyperplasia-pyometra complex (CEH-P) is the most common uterine disorder of older intact female dogs, reported in up to 23.24% of intact female dogs by 10 years of age. Dogs with pyometra may be classified as having a closed cervix (accumulation of purulent exudate within the uterine lumen with or without vaginal discharge) or open cervix (presence of purulent vaginal discharge). The pathogenesis of pyometra is not fully understood; however, it is thought that the influence of estrogen followed by prolonged progesterone stimulation, in combination with bacterial infection, is the likely cause of disease. The condition
typically occurs during the luteal phase (diestrus) within 9-12 weeks of ovulation. Dogs secrete ovarian progesterone for 60-70 days after ovulation irrespective of pregnancy. Progesterone stimulates the growth and secretory activity of endometrial glands, maintains closure of the cervix, and suppresses myometrial contractions, all of which create an environment favorable for bacterial growth. Progesterone also has an inhibitory effect on leukocyte function in the uterus. The most common bacterial isolate in dogs with pyometra is *Escherichia coli*, likely normal flora ascending from the vagina (though a hematogenous route is also possible). Infection is followed by endotoxemia, sepsis, and systemic inflammatory response syndrome (SIRS). SIRS is associated with a worse prognosis and longer hospitalization.

Clinical signs associated with pyometra include purulent vaginal discharge (more-so in the case of open pyometra), and varying degrees of lethargy, inappetence, vomiting, diarrhea, and polyuria/polydipsia (secondary to inability to concentrate urine). Closed pyometra may also have some degree of vaginal discharge, but will also have large volumes of purulent fluid within the uterus. Closed pyometra can rapidly progress to septicemia, dehiscence, hypovolemia, and death if left untreated.

Signalment and history raise the level of suspicion as to the diagnosis of pyometra. Abdominal palpation may reveal a tubular mass within the abdomen; however, care must be exercised not to rupture a friable uterus when palpating. Diagnosis is best made with ultrasonography, revealing an enlarged fluid-filled uterus. Some animals may also have a thickened, cystic endometrium (cystic endometrial hyperplasia, CEH), although CEH does not always precede pyometra. Radiographs can also be used to aid in the diagnosis of pyometra; however, a pregnancy of less than 40 days duration can be misinterpreted as pyometra on a radiograph alone. A biochemistry profile and complete blood cell count should be performed. Animals with pyometra will classically have a neutrophilic leukocytosis with a left shift. Concurrent findings may include anemia, prerenal or renal azotemia, electrolyte abnormalities, hyperproteinemia, and hyperglobulinemia. Supportive care should be initiated immediately to correct for dehydration, hypovolemia, acidosis, or electrolyte imbalances. If measured, serum progesterone levels generally exceed 2 ng/ml.

Pyometra can be treated by surgical or medical therapy. Medical medical treatment should be reserved for otherwise healthy younger dogs with an open pyometra that are intended for breeding. Several medical treatment protocols have been proposed, all with the intent of reducing the effects of progesterone in the uterus. Drugs used for medical treatment of pyometra include prostaglandin F2 alpha and analogues (dinoprost and cloprostenol), dopamine agonists (cabergoline), progesterone receptor antagonists (aglepristone and mifepristone), or different combinations of these drugs. Additionally, a broad-spectrum antibiotic is recommended to eliminate bacteria. Variable success rates are reported, and recurrence following medical treatment is common (up to 50%).

Complete OVH is the treatment of choice for pyometra. Drawbacks with surgery include the potential risk of anesthesia and that it renders the bitch sterile. Prior to surgery, the patient is stabilized with intravenous fluid therapy, and broad-spectrum antibiotics are initiated. Aggressive monitoring is recommended, and pressor support may be warranted. OVH is most commonly performed via an open ventral midline celiotomy. Though there have been previous recommendations to seal the end of the remaining uterus in a Parker-Kerr suture pattern, it is seldom performed due to the potential for creating a closed cavity of tissue and preventing drainage of infected material. It is this author’s preference to ligate the uterus by placing a single encircling ligature close to the cervix and separate transfixation ligatures around each uterine artery distal to the encircling ligature. A clamp is placed on the uterus to prevent leakage of infected material into the abdomen. The uterus is severed distal to the sutures and inspected for bleeding. The remaining uterine stump is lavaged locally and wrapped in omentum, and the abdomen is closed routinely.

Single- and multi-port laparoscopic and laparoscopic-assisted techniques have been described and successfully performed in dogs with both open and closed pyometra. Rupture of the uterus has been described with both open celiotomy and laparoscopic techniques, and thus care must be taken when manipulating the uterus. In reported cases of uterine rupture during a laparoscopic OVH, the surgical approach was converted to an open celiotomy to facilitate thorough lavage of the peritoneum. There is insufficient data available to determine if there is a threshold for size and weight of the infected uterus that would be better removed through an open celiotomy.

Uterine stump pyometra can occur in animals that have been spayed. This is a pyometra within the small stump of residual uterine tissue left during a spay procedure. The underlying cause is retained ovarian tissue and is typically due to technical error of the original surgeon. Treatment for stump pyometra should include excision of any retained ovarian tissue and removal of the infected uterine stump.

Potential complications following OVH include sepsis, septic shock, disseminated bacterial infection, peritonitis, and hemorrhage. Overall mortality following OVH for pyometra has been reported anywhere from 1-8%. Animals with septic peritonitis have a more guarded prognosis with mortality rates reported over 50% in some studies. A recent retrospective study was performed using records from 356 dogs diagnosed with pyometra in Sweden to describe complications of pyometra and investigate possible clinical indicators associated with peritonitis and/or prolonged hospitalization. 315 dogs were treated by OVH, 9 by medical management, and 32 were euthanized without treatment. In the surgically treated dogs, the most common complication was peritonitis (40/315), followed by UTI (19/315), wound infection (8/315), uveitis (6/315), and cardiac arrhythmia (5/315). Leukopenia and fever/hypothermia were associated with an increased risk for peritonitis (18-fold and 3-fold, respectively). Depression, pale mucous membranes, and leukopenia were associated with increased risk for prolonged postoperative hospitalization.
Gastric dilatation and volvulus (GDV)

GDV is the classic surgical emergency in veterinary medicine and is characterized by acute dilatation of the stomach and rotation on its mesenteric axis. The exact cause of GDV is unknown; however, a variety of predisposing factors have been documented including increased thoracic depth-to-width ratio, history of GDV in a first degree relative, eating a single large meal per day, small food particle size, and eating rapidly. Breeds at high risk include deep-chested dog breeds such as Great Danes, German Shepherds, Gordon and Irish Setters, Weimeraners, St Bernards, Doberman Pinchers and Standard Poodles; however, other medium sized breeds like the basset hound and shar-pei may also develop GDV.

Decompression results from accumulation of air, food, or fluid within the stomach. The stomach rotates in a clockwise direction from 90-360 degrees, with the pylorus moving ventrally and ultimately to the left craniodorsal aspect of the abdomen. The spleen is also often displaced or rotated resulting in gross splenic enlargement and possibly ischemia. The short gastric arteries are frequently avulsed from the greater curvature of the stomach, resulting in hemorrhage into the abdomen. A proportion of dogs will develop gastric necrosis due to vascular compromise and ischemia. Dogs affected by GDV may suffer from circulatory shock due to compression of the caudal vena cava by the dilated stomach. Cardiac arrhythmias commonly develop due to myocardial ischemia and reperfusion injury. Marked metabolic, electrolyte, acid-base derangements occur due to poor peripheral perfusion, decreased cardiac output, and fluid sequestration in the stomach.

The history and clinical signs vary depending on the duration and severity of the gastric volvulus; however, some of the more common signs include restlessness, retching, non-productive vomiting, hypersalivation, distended/painful abdomen, weakness, depression, and collapse. Common findings on physical exam include abdominal pain and distention, hypersalivation, pale mucous membranes, prolonged capillary refill time, weak pulses, tachycardia, tachypnea, dyspnea, arrhythmias, and collapse.

A presumptive diagnosis is made based on the history and physical exam findings; however, other differentials should include gastric dilatation, mesenteric torsion, pneumoperitoneum, septic peritonitis, abdominal effusion, and other causes of abdominal distention. The diagnosis of GDV is confirmed with an abdominal radiograph, typically a right lateral, revealing distention, displacement, and compartmentalization of the stomach (i.e. “double bubble” or “Popeye’s arm”).

The focus of preoperative management for dogs with GDV is hemodynamic stabilization. Generally fluid resuscitation is performed with a combination of crystalloid and colloids with the overall aim to rapidly increase and maintain intravascular volume. Two large catheters are placed for rapid fluid administration. The cephalic veins are generally preferred over the saphenous veins as venous return from the caudal half of the body may be compromised due to the distended stomach. Crystalloid fluids are administered at rates up to 90mls/kg in dogs, although these fluid rates should be chosen based on an individual patient’s clinical parameters. The volume status is reassessed every 15 minutes to determine response, and the volume is adjusted accordingly. Colloids may be necessary to maintain intravascular pressure and are chosen on an individual basis. Preoperative prophylactic antibiotics (e.g. cefazolin or Unasyn®) are started once the IV catheter is in place. The ECG should be monitored, and significant cardiac arrhythmias are treated (with lidocaine as first choice). H₂ antagonists may be given to protect the gastric mucosa. Analgesics (opioids and other synergistic drugs, not NSAIDS) should be given for both pain and preanesthetic sedation.

Decompression of the stomach should be performed as soon as possible after admission and can be achieved using either orogastric intubation or percutaneous placement of an over-the-needle catheter. If orogastric tube placement is chosen, the dog may be lightly sedated (this may not be necessary in cooperative dogs or those that are very sick) and a 2 inch roll of white tape placed between the incisors. A large-bore orogastric tube is then placed through the roll of tape and passed down into the stomach (A mark is placed on the tube prior to use to mark the length required to reach the last rib). Care should be taken as the tube passes into the stomach not to cause further compromise to the distal esophagus or stomach. Stomach contents will usually rapidly be evident draining in the tube, which is then held over a bucket until no further stomach contents are obtained. If the use of an orogastric tube fails or cannot be passed into the stomach, then percutaneous trocarization can be performed with a large-bore catheter, inserted into the stomach over the site of greatest gastric tympany (after aseptic preparation of the skin).

Once in the operating room, a standard ventral midline laparotomy is performed. Upon entry into the peritoneal cavity, a volvulus is confirmed by the presence of the superficial leaf of the greater omentum draped over the stomach. When the greater curvature of the stomach is twisted ventrally and over to the left, it drags the greater omentum with it. Derotation is facilitated by decompression and thus if adequate preoperative decompression has not been achieved, an 18-gauge needle may be inserted into a healthy area of the stomach wall and attaching suction to the needle. The stomach is then derotated by turning in a counter-clockwise direction. The surgeons hand is passed down the left body wall, and the antrum/lesser curvature of the stomach is grasped. Derotation may be facilitated by simultaneously pushing the fundus in a dorsal direction and to the left with the surgeon’s other hand as the antrum is being rotated ventrally. The hiatal region and cardia should be inspected after derotation to ensure that no twisting remains. The surgeon should confirm that the fundus is located on the left and the pylorus and descending duodenum are correctly positioned along the right side of the body wall.

The next step in intraoperative management is to assess the stomach and spleen for viability. It is imperative that the decision regarding organ viability is made after decompression and derotation have been completed and a full exploratory has been performed.
This allows time for blood flow to resume and venous congestion to resolve. The decision to resect stomach still largely relies on color, consistency and perfusion of the stomach wall. Techniques such as laser doppler flowmetry and intravenous fluorescein have been described to assess wall viability; however, these techniques are not practical in a clinical setting and are not widely used. Areas of stomach that are black, green or very dark red are generally ischemic and need to be resected. Areas that are an intense red or have patchy areas of darker red are more challenging to interpret. In general, color should be interpreted in conjunction with consistency. Any areas that are judged to be thin-walled are usually unhealthy and need to be resected. Thickened areas of stomach wall may be edematous, signifying persistent blood flow to these areas likely remains.

Once the surgeon has decided that gastric resection is necessary, the stomach should be packed off with moistened laparotomy sponges to avoid spillage of gastric contents into the abdomen. Partial gastrectomy is performed, removing the devitalized portion of the stomach with either an automatic stapling device or resection and closure with suture in a double layer closure. The use of surgical staplers may be quicker, but increases associated costs and requires experienced hands. A gastrointestinal stapler (GIA) has the advantage of having 4 lines of staples and a blade that cuts between them, thus sealing both sides of the stomach and minimizing spillage of gastric contents. The thoracoabdominal stapler (TA) can also be used for gastric resection with the disadvantage that the TA stapler does not seal both sides of the stomach and so contamination from the resected portion of the stomach can occur. Most surgeons still use a hand-sewn approach. When using a hand-sewn approach, stay sutures are placed circumferentially approximately 1 cm from the planned margin of resection. An assistant provides upward tension on the stay sutures to avoid gastric spillage, and the surgeon resects the devitalized tissue. Bleeding from the mucosal and seromuscular layers is assessed, and if adequate, a two-layer closure is performed. The submucosa is considered the holding layer and should be incorporated in the closure. The mucosa/submucosa is closed with a fine, 3-0 or 4-0, synthetic absorbable suture material, typically in a simple continuous pattern. A second inverting (Cushing or Lembert) layer of suture is placed in the seromuscular layer. In some cases, differential ischemia of the gastric wall layers can occur, with the mucosa significantly more ischemic and compromised that the seromuscular layer. This is due to a higher metabolic rate of the mucosa and sensitivity to perfusion impairment. If mild, the compromised mucosa can be resected. If extensive, it may be necessary to leave the ischemic mucosa in place with an assumption that mucosal sloughing and subsequent regeneration will occur in time. Experience with these cases has generally been positive.

The technique of gastric invagination was reported several years ago as an alternative to gastric resection with the supposed advantage that it may reduce surgical time. Clinical reports of significant case numbers managed with this technique have not emerged but the literature includes a case where the site of gastric inversion sloughed to become a large linear bleeding ulcer post-operatively resulting in severe lethargy, anemia and melena. The gastric invagination technique is not performed in our hospital.

Following gastric resection (if necessary), the abdomen can be lavaged with warm saline if contamination has occurred. A gastropexy is then performed to minimize risk of recurrence. Recurrence of GDV in dogs without gastropexy has been reported as high as 50% but is reduced to 0-5% (depending on the technique) if a gastropexy is performed. Failure to perform a gastropexy in patients treated for GDV patients could potentially be considered malpractice and grounds for legal liability. When performed in conjunction with surgical repair of GDV, gastropexy is performed as an open procedure. Minimally invasive techniques are described subsequently and are generally considered for dogs undergoing prophylactic gastropexy as an isolated procedure. Several open gastropexy techniques have been described, including tube gastropexy, circumcostal gastropexy, incisional gastropexy, belt loop gastropexy, ventral midline (incorporating) gastropexy, and gastrocolopexy. A recent publication recommended ventral midline gastropexy due to the rapid nature of the technique; however, this technique has garnered controversy due to the potential for complications upon subsequent abdominal surgery. Two separate studies have found no association between duration of anesthesia and survival in dogs with GDV. Therefore, it seems more logical to choose a technique shown to minimize the risk of complications and recurrence rather than a technique that minimizes anesthesia time alone. Some studies have recommended certain gastropexy techniques based on laboratory determined gastropexy strength measurements; however, it is not known what force the gastropexy is subjected to in vivo. There is no clear “gold standard” and thus surgeon familiarity and comfort typically influences the chosen gastropexy technique. This author prefers to perform an incisional gastropexy. A 4-7 cm incision is created in the right lateral abdominal wall through the peritoneum and transverse abdominis muscle, approximately 2 cm caudal to the last rib. A second incision is created through the seromuscular layer of the gastric wall, parallel to the long axis of the stomach between the lesser and greater curvatures at the level of the pyloric antrum. It is important that the incision in the stomach does not extend through the submucosa and into the gastric lumen. The incisions are sutured together in 2 simple continuous patterns starting dorsally and running ventrally. This author prefers to use a long-acting monofilament absorbable suture such as Maxon® or PDS®. Once the gastropexy is complete, the abdomen is lavaged with sterile saline if significant contamination has occurred. The abdomen is explored for any residual hemorrhage and is closed routinely.

After surgery, the patient’s vital signs are monitored to ensure adequate volume resuscitation and analgesia and to detect any potential complications. Packed-cell volume and total protein, electrolytes, and blood gas are monitored periodically as indicated by the patient. IV crystalloids, colloids, and blood products are administered as necessary. Antibiotic therapy is continued when ischemic injury or contamination during surgery are of concern. H2 antagonists are generally continued until the patient is eating well on its
own. An ECG is monitored for postoperative ventricular arrhythmias and treated if indicated. Food and water are introduced in small amounts, and the patient is monitored for vomiting. Antimetic or motility agents may be indicated for persistent vomiting, gastric dilatation, or ileus. Other possible post-operative complications may include hemorrhage, aspiration pneumonia, pancreatitis, peritonitis, sepsis, fatal cardiac arrhythmias, disseminated intravascular coagulation, or recurrence of gastric dilatation +/- volvulus. Recent attention has been placed on the association of GDV with SIRS and the potential for multi-organ dysfunction syndrome that leads to late morbidity and mortality. Reported organ dysfunctions in dogs with GDV include cardiovascular, respiratory, gastrointestinal, coagulation, and renal dysfunction. Astute monitoring is critical to detect complications early and facilitate early intervention to maximize the chance for successful outcome.

The prognosis for dogs with GDV is generally fair with a reported mortality rate of 10-33% depending on the study. Several studies have looked at various clinical and diagnostic parameters as potential prognostic factors in dogs presenting for GDV. The presence or absence of gastric necrosis is the main factor affecting survival (as well as time until surgery which is correlated with likelihood of gastric necrosis). Plasma lactate concentration is the only pre-operative parameter predictive of gastric necrosis and therefore survival. Dogs with an initial plasma lactate of <4 mmol/L have a greater chance of survival and a lower risk of complications. Dogs presenting with a lactate >6 mmol/L have a higher likelihood for gastric necrosis and greater associated treatment expense. One should be cautious, however, about recommending treatment based on the individual lactate concentration of a patient given the potential overlap between groups. Exploratory surgery should be recommended in all cases regardless of the plasma lactate concentration. Survival rates are poor in cases of prolonged hyperlactetemia where the lactate concentration does not fall to the reference range within 24-48 hours.

Recurrence of GDV is generally less than 5% if a gastropexy is performed. Gastropexy does not prevent distention of the stomach, and thus medical attention is indicated with recurrent gastric dilatation. It is generally recommended to feed the dog smaller more frequent meals, limit excessive amounts of water while eating, and avoid exercise after eating to reduce the rate of recurrence; however, success with dietary management in preventing recurrence is not clear.

Prophylactic gastropexy in dogs at high risk of GDV is commonly performed and can be performed using open surgical (described above) or minimally invasive techniques. Minimally invasive techniques include the grid approach (mini open approach), endoscopically-guided miniapproach, and laparoscopic gastropexy. In the grid (mini open approach), an incision is made caudal to the 13th rib on the right side and the gastric antrum is grasped. The gastropexy is performed as for an open approach, and the superficial muscle layers are closed individually with a simple continuous pattern. No special equipment is required. For the endoscopically-guided miniapproach, a gastroscope is advanced, and the stomach is insufflated. A stay suture is place with large (# 2) polypropylene suture by passing the needle through the right abdominal wall just caudal to the last rib and into the lumen of the stomach. The suture is passed through the body wall again and retrieved outside of the dog. An incision is then made in the abdominal cavity and pyloric antrum, and a gastropexy is performed as for the grid approach. This technique requires more equipment and skills to perform than the grid approach. Finally, with laparoscopic-assisted gastropexy or total laparoscopic gastropexy, 3 portals are inserted along ventral midline. A stay suture is passed through the body wall into the abdomen over the pyloric antrum. The needle is grasped intracorporally and passed through the pyloric antrum and exited back out the body wall. The gastropexy is then performed extracorporally (laparoscopic-assisted gastropexy) or intracorporally (total laparoscopic gastropexy). An intracorporal gastropexy is completed with either a suture-assist device or laparoscopic needle holder. Staples and barbed suture have also been used, negating the need to tie knots internally.

In a prospective case series of 23 dogs in which laparoscopic-assisted gastropexy was performed, there was no occurrence of GDV in any of the dogs within a year of surgery, and ultrasonography revealed an intact attachment between the stomach and abdominal wall. In a retrospective case series of 61 dogs that underwent incisional gastropexy either following gastric derotation for GDV (n = 34) or as a prophylactic procedure (n = 27), No dog experienced GDV in a median follow-up time of 717 days. The risk of GD alone was 8.8% for dogs with previous GDV and 11.1% for dogs treated prophylactically with gastropexy. Because the incidence of GDV varies by breed, a larger study comparing the incidence of GDV in dogs treated with prophylactic gastropexy to control dogs of the same breed is necessary to determine the true clinical benefit of prophylactic gastropexy.

References


All motor vehicle trauma patients are emergencies, even if the animal is seemingly “normal” after the accident. Motor vehicle trauma represents over 90% of blunt trauma patients presenting to veterinary hospitals. Dogs with blunt trauma tend to be younger (2-3 years of age) and medium to large breed. Some injuries are more common than others in dogs with blunt trauma with thoracic injury most common (70%), followed by injuries of the abdomen (50%), extremities (40%), and head (30%). Thoracic injuries may include pulmonary contusions, pneumothorax, hemothorax, rib fractures, pneumomediastinum, diaphragmatic hernia (DH), pulmonary bullae, and flail chest. Extremity injuries include superficial abrasions, degloving injuries, lacerations, fractures, luxations, and soft-tissue or ligament injury. The most common abdominal injuries are hemoabdomen, abdominal hernias, and rupture of the urinary tract.

Given the diversity of possible injuries, it is critical that the animal be thoroughly triaged upon presentation, prioritizing the most critical or life-threatening injuries first. The patient should be immediately assessed for level of consciousness, airway patency, breathing rate and effort, strength and rate of pulses or heart sounds, color of mucous membranes and capillary refill time, and examination for external abnormalities such as hemorrhage, sucking chest wounds, and abdominal distention. If the animal is deemed unstable, resuscitation and stabilization efforts are instituted immediately. A blood pressure, pulse oximetry measurement, and ECG reading should be obtained at this time. A CBC and biochemistry profile should be performed as part of the minimum database to establish a baseline for the patient; the blood is typically obtained at the time an intravenous catheter is placed. A staff member should remain with the owner during this time and obtain a history and permission to begin treatment.

As thoracic injuries occur in the majority of dogs experiencing trauma, thoracic radiographs should be obtained on all dogs with traumatic injuries; however, thoracic radiographs should wait until the dog is stable. Similarly, radiographs of fractures are not essential initially and should also wait until the dog is stable. Focused assessment using sonography for trauma (FAST) is a simple and rapid ultrasound exam that can be performed to detect intra-abdominal (or intra-thoracic) fluid suggestive of hemorrhage or urine leakage. With the animal in lateral, the ultrasound probe is used to assess for fluid just caudal to the xiphoid, on midline over the urinary bladder, and at the left and right flank regions. FAST can be performed on initial presentation as well as serially thereafter to monitor for the presence of fluid. Abdominocentesis is performed to determine whether the fluid is blood or urine.

In is important to note that the majority of dogs with hemoabdomens following trauma do not require surgery and can be managed supportively with rest and fluid resuscitation. Some of these dogs may require blood product transfusions; however, very few dogs will require exploratory surgery unless they have a liver or splenic laceration unable to be stabilized with supportive care.

If shock is suspected, one fourth of the patients’ estimated blood volume (~80-90 ml/kg) is given. The patient is reassessed every 15 minutes to determine if another fluid bolus is necessary. It is not necessary to withhold fluids from patients with head trauma, pulmonary contusions, or hemorrhage. Diuretics should not be given (and may actually be harmful) to patients with contusions as contusions are the result of vessel damage and not increased hydrostatic pressure.

Analgescics should be administered as soon as possible to patients with blunt force trauma. Non-steroidal anti-inflammatory drugs (NSAIDS) should be withheld for at least 12-24 hours and should not be given in animals with hypotension, shock, dehydration, severe hemorrhage, azotemia, and liver failure. Opioids are very safe to give to trauma patients, and if additional analgesia is needed, ketamine, lidocaine, gabapentin, or local anesthetics can be considered. Steroids are not recommended due to a potential detrimental effect in patients with head trauma.

Regardless of the problems identified at presentation, dogs must be monitored frequently while recovering from trauma, even though they may initially appear stable. It is quite common for new problems to develop or show delayed symptoms, and dogs can decompensate at any time during the first 24 hours of care.

Once the patient is deemed stable, the patient can be worked up for common comorbidities associated with motor vehicular trauma. There are many potential injuries for which surgical repair is the treatment of choice; however, it is critical to recognize that surgery can wait in the majority of cases until the patient is able to safely tolerate anesthesia.

**Diaphragmatic hernia (DH)**

Traumatic DH is thought to result from a sudden increase in pressure gradient between the abdomen and chest when an animal sustains major blunt trauma to the abdomen. Rupture of the diaphragmatic costal muscle is the most common consequence due to the inherent weakness of this tissue in comparison to the stronger fibrous portion, or central tendon, of the diaphragm. The tear may be circumferential or radial or a combination of both. Multiple tears are also possible. Any non-fixed organ may herniate into the chest cavity, with the most common including the stomach, small intestine, liver, omentum, and spleen.
Typical symptoms of DH include dyspnea (due to displacement of the lungs by prolapsed viscera) and discomfort in lying down. On physical examination, animals with DH may have muffled heart and/or respiratory sounds, possibly more evident on one side. Borborygmus in the chest or an “empty abdomen” appearance may also be noted. If the stomach is prolapsed through the hernia, dyspnea from lung compression may result in aerophagia, gastric dilatation, and progressive respiratory compromise. This requires emergency deflation of the stomach and surgery as soon as possible.

Radiographs are typically required for a definitive diagnosis but should be delayed until the animal is stable. Alternatively, ultrasound has been reported to be 93% accurate in diagnosing DH, and may be useful as a “bedside” test if the animals is not stable enough for radiographs. It is important to recognize that many animals may be either asymptomatic for DH, or signs may be masked due to shock or other concurrent musculoskeletal/organ system injuries. Global assessment of the patient is critical, and thoracic radiographs should be taken in all cases of blunt trauma so as not to miss the diagnosis of DH or other concurrent thoracic injuries. Classical radiographic signs consistent with DH include loss of a clear diaphragmatic outline and cranial displacement of abdominal organs. If radiographs are unclear, a pneumo- or contrast peritoneogram may be useful in demonstrating the diaphragmatic defect.

Currently, surgery is recommended as the treatment of choice for DH as soon as possible after hemodynamic stabilization and treatment of other life-threatening injuries has been performed. DH repair is typically done through a midline abdominal approach; however, if significant adhesions exist in the chest, the incision may need to be extended into a median sternotomy. Thus, the ventral thoracic area should be clipped and aseptically prepared for surgery in all cases in anticipation of a possible sternotomy. The clinician should only perform surgery for DH if he/she is prepared to perform a median sternotomy as well. In a recent study, sternotomy was necessary in 28% of dogs and cats with chronic DH.

Animals with DH can decompensate quickly after anesthetic induction and thus it is important to have trained personnel present with the plan for anesthesia, surgical preparation, and surgery laid out ahead of time. Supplemental oxygen is given before anesthetic induction, and rapid airway control via intubation is essential immediately after induction. Stress should be minimized. Mask induction is not recommended. Mechanical ventilation is mandatory and should be conservative (high respiratory rate with low tidal volume and peak airway pressure). Patient monitoring should include vital signs, temperature, ECG, blood pressure, capnography, and pulse oximetry. Arterial blood gas analysis is also indicated if available. Patient preparation is performed with the animal in lateral recumbency; dorsal recumbency is avoided until positioning for surgery. Positioning the animal with the head and thorax elevated (reverse Trendelenburg position) may minimize pressure on the lungs.

Upon entering the abdomen, the diaphragm is inspected to identify the location of the hernia. The herniated abdominal organs should be removed from the thoracic cavity without delay to improve ventilation and stabilization of the patient. The liver and spleen may be congested with blood and friable, and thus extreme care must be taken when handling these organs. Significant hemorrhage may result from tearing of the spleen or liver parenchyma with handling. Adhesions are broken down gently digitally or using electrocautery. If the organs can not be easily moved out of the thoracic cavity and back into the abdomen, the opening in the diaphragm can be enlarged, or alternatively, the abdominal incision can be extended cranially into the thorax.

One all herniated organs have been returned to the abdomen and hemostasis has been achieved, the defect in the diaphragm is closed. Prior to closure, a chest tube is placed either through the diaphragmatic defect for temporary evacuation of the pleural cavity, or separately through an intercostal space if prolonged thoracic drainage is anticipated or if hemorrhage is a concern. In simple radial or circumferential tears where apposition of the edges can be achieved without tension, primary apposition with 2-0 or 3-0 synthetic absorbable or nonabsorbable suture in a simple continuous pattern is recommended. An interrupted pattern is also sufficient. Radiographs should be taken in all cases of blunt trauma so as not to miss the diagnosis of DH or other concurrent thoracic injuries.

Occasionally, the defect in the diaphragm cannot be closed in a tension-free manner and reconstruction of the diaphragm is necessary. This has been done using a large variety of different materials, but most commonly with polypropylene mesh or an abdominal wall pedicle flap created from the transversus abdominis muscle. If mesh is used, the peripheral 0.5cm of the mesh is turned over on itself and sutured to the edge of the DH using simple interrupted 3-0 non-absorbable monofilament sutures (e.g. polypropylene). The free cut end of the mesh is oriented towards the abdomen to avoid the potentially sharp cut edges of the mesh damaging lung parenchyma. The abdominal side can be covered with omentum to cushion the sharp edges as well as to cover the defect.

Once the diaphragm is closed, the remainder of the abdomen is explored. Additional procedures (e.g. cystotomy or GI biopsies, etc.) are only performed if the animal is stable. Otherwise more elective procedures should be delayed to a later time when the animal has completely recovered. The abdomen and median sternotomy, if applicable, are closed routinely.

Air is typically evacuated from the thoracic cavity once the abdomen is closed. Temporary red rubber catheters placed through the diaphragm are removed at that time. There is a low risk for development of reexpansion pulmonary edema of chronically collapsed lung lobes following evacuation of the thoracic cavity, and thus some clinicians recommend slow sequential drainage of the thoracic cavity. Rather than evacuating the thorax to negative pressure, air is removed until a desirable reading on the pulse oximeter is
achieved. Though rare, reexpansion pulmonary edema can be life threatening and thus should be monitored for carefully in the postoperative period.

The mortality rate associated with diaphragmatic hernia is variable, approximating at 10-20% in recent studies. Anesthetic induction poses the greatest risk for animal with DH. Prognosis is generally much better if the animal survives surgery.

Occasionally animals with traumatic DH will present months to years after the initial injury, especially if the animal was acquired from a shelter, and the history is unknown. The DH may be found as an incidental finding in an otherwise asymptomatic patient (either when auscultating the thorax or taking abdominal or thoracic radiographs for another reason). Alternatively, the animal may present with mild to severe respiratory signs following decompensation for a variety of reasons. Even if the animal is apparently asymptomatic for the DH, surgery is still recommended, sooner rather than later, as there is a large potential for the animal to decompensate at some time point in the future. Despite concerns over these chronic cases having a greater incidence of adhesion formation and re-expansion pulmonary injury, survival has not been shown to be different compared to those diagnosed shortly after injury. In one large study of 1674 cases, mortality rates in dogs with acute and chronic DH were 27.8% and 26.2% whereas in cats those figures were 20% and 11.8% respectively.

**Traumatic hip luxation**

Coxofemoral luxation (CFL) accounts for 90% of all joint joint luxations in dogs, caused by motor vehicular trauma in 59-83% of cases. For disarticulation to occur, there must be disruption of the primary stabilizers of the hip joint, the ligament of the head of the femur and the joint capsule. As with other traumatic injuries, comorbidities are common requiring systematic evaluation of the entire patient. The grand majority of CFLs occur in a craniodorsal direction (78%), occasionally in a ventral direction (1.5-3.2%), and rarely in a caudodorsal direction.

The diagnosis of CFL can be made with a history of trauma, physical examination, and radiographs, but the diagnostic workup should also be focused on identifying concurrent injuries. With a craniodorsal CFL, the limb is typically non-weight bearing, externally rotated, and adducted. The limb appears shorter due to its dorsal positioning relative to the contralateral limb. CFL may be identified on palpation by placing a thumb in the ischiatic notch between the greater trochanter and the ischiatic tuberosity. When the limb is externally rotated, the thumb should be displaced from the ischiatic notch if the femoral head is normally seated in the acetabulum. If the femoral head is luxated, however, the thumb is not displaced with external rotation. In addition, the anatomic relationship between the pelvis and femur will palpate abnormally with CFL. The craniodorsal border of wing of the ilium, ischiatic tuberosity, and greater trochanter are typically positioned in a triangle. The greater trochanter should be distal to the other two points and closer to the ischiatic tuberosity than to the wing of the ilium. When luxated, the greater trochanter palpates more dorsal with a greater gap between the trochanter and the ischiatic tuberosity. A luxated hip is painful upon manipulation. Caudodorsal CFLs are rare and are likely craniodorsal in origin with severe disruption of the soft-tissues surrounding the joint and subsequent instability. Ventral CFLs are also rare and generally present with a limb that is “longer” than the contralateral side. Ventral CFLs are commonly associated with acetabular fractures. On physical examination, the greater trochanter is difficult to palpate due to medial displacement of the trochanter. Hip adduction and internal rotation may be constrained due to entrapment of the femoral head within the obturator foramen.

Although physical exam findings are generally diagnostic for CFL, pelvic radiographs are performed to confirm the presence and direction of CFL and also to identify concurrent orthopedic injuries. The coxofemoral joint is analyzed for articular fractures, osteoarthritis of the joint, and underlying hip dysplasia, any of which may preclude closed reduction and influence the chosen surgical option.

Closed reduction is generally the first line of treatment for CFL when no contraindications are present. Appropriate analgesia is initiated, with opioids preferred due to high efficacy and minimal side effects. NSAIDS are not used in the acute-trauma patient, as concurrent hypovolemia and shock significantly increase the risk of renal and gastrointestinal complications. General anesthesia is typically necessary to relax the muscles. Closed reduction may require more than one person in large dogs.

To reduce a craniodorsal or caudodorsal CFL, the patient is positioned in lateral recumbency. The affected limb is positioned uppermost, and the affected femur is externally rotated so that the patella is pointing to the ceiling. The limb is then distracted and lifted away from the body. A towel or rope placed under the leg may assist in distraction. The femur is then gently rotated internally as the femoral head is guided into the acetabulum. A “clunk” may be felt as the hip is reduced. Cranioventral luxations are manipulated into craniodorsal luxations and reduced in a similar fashion. Caudoventral luxations are reduced by applying traction to the limb and applying lateral force to the medial portion of the proximal femur in order to lift the head of the femur out of the pelvic canal and guide it back into the acetabulum. Once the hip joint is reduced, pressure is placed on the greater trochanter and the hip is put through the full range of motion. Failure rates of closed reduction are reported in 47-65% of CFLs reduced in a closed fashion. Intra-articular fractures, muscle contracture, intra-articular hemorrhage, inflammation of the ligament of the head of the femur, periarticular fibrosis, interposition of soft tissues, and preexisting conformational abnormalities increase the rate of failure.
Following closed (and sometimes open) CFL reduction, an Ehmer sling is placed on the limb for 10-14 days to prevent reluxation. The Ehmer sling flexes the hip joint and abducts and internally rotates the femur to position the femoral head within the acetabulum. Extreme care is taken when applying an Ehmer sling, as an improperly applied wrap can result in severe soft-tissue wounds. There is a newer commercially available vest and Ehmer sling system that is easy to apply, breathable, and less likely to cause sores. This system is currently utilized at the author’s hospital. Anecdotally, the sling is user friendly and allows daily maintenance and rehabilitation therapy. There is no published evidence indicating a difference in outcome between traditional Ehmer slings and the commercially available vest system. For caudoventral luxations, hobbles can be placed for 7-14 days to prevent splaying of the legs and reluxation of the hip during recovery; however, many ventral luxations are management successfully without hobbles. Radiographs are taken to ensure that the hip has not reluxated during application of the bandage. Animals placed in a sling or hobbles should be examined regularly to detect any potential problems early (sores and slippage). When the Ehmer sling is removed, hip stability is reassessed by putting the joint through a full range of motion and taking radiographs to ensure the hip is still within the joint. If the hip is stable, an additional 3-4 weeks of exercise restriction is recommended to allow full healing of the extraarticular soft tissue.

If closed reduction fails, or if immediate weight-bearing is necessary due to concurrent orthopedic injury in the contralateral limb, then open reduction with stabilization is recommended. Open reduction allows exploration of the joint, and removal of bone fragments, fibrous tissue, blood clots, and soft tissue (including remaining femoral head ligament) entrapped within the acetabulum. The joint capsule is then repaired if possible (capsulorrhaphy); however, the capsule is often too severely damaged to permit adequate stabilization of the joint alone. Several options for internal stabilization have been described including DeVita pinning (ischio-ilial pinning), prosthetic capsule technique (extracapsular sutures), tenodesis of the deep gluteal muscle, transarticular pinning, transposition of the greater trochanter of the femur, transposition of the sacrotuberous ligament, toggle rod stabilization, and stabilization using the TightRope system. Reluxation rates are significantly lower with open reduction and stabilization (1-17% depending on the chosen technique); however, additional complications include implant migration or failure, neurologic damage, joint infection, and injury to the articular cartilage. If reluxation occurs, it is generally within the first 2 weeks of surgery when stability of the repair is dependent entirely on the surgical implants. Triple pelvic osteotomy (TPO) has also been described for management of craniodorsal CFL, providing stability by rotating the acetabulum laterally to provide greater coverage of the femoral head. TPO may be more useful for dogs with recurrent luxations, dogs with hip dysplasia, or for CFL following total hip replacement.

For animals with significant preexisting hip dysplasia, severe articular fractures, or the owner is not willing to accept the risks associated with open reduction, salvage procedures including total hip arthroplasty or femoral head and neck excision may be warranted. Postoperative care for patients with CFL includes restricted activity for at least 4-6 weeks to allow soft tissue healing. Patients should be monitors for signs of reluxation, including lameness, hip pain, and reduced activity. Repeat radiographs are taken if there is concern for reluxation.

The prognosis following CFL is fair to good if reduction and stability are achieved soon after injury. Osteoarthritis progresses in the majority of patients after CFL, and thus osteoarthritis management should be instituted early in recovery and continued indefinitely. Nutraceuticals, NSAIDS (if no contraindications), and physical rehabilitation are recommended to promote an early return to function. Osteoarthritis following CFL is more pronounced in dogs that are overweight. Long-term weight-management, low-impact exercise, nutraceuticals, and a joint healthy diet are strongly encouraged.

Degloving wounds
Polytrauma cases in companion animals are frequently accompanied by shearing and avulsion cutaneous injuries of the distal limb, collectively designated “degloving injuries.” Depending on the location, degloving injuries may be associated with underlying orthopedic, neurologic, and vascular injuries. Though the injuries are unsightly and difficult to ignore, wound care is delayed until the animal has been thoroughly assessed systemically and stabilized. Significant hemorrhage should be controlled during the initial triage, and the wound should be covered with a light dressing (e.g. a non-adherent telfa pad secured with stockinette, a disposable “chux” pad, or a similar light wrap) to prevent further trauma and nosocomial contamination/infection; however, thorough wound assessment, cleansing, and debridement is delayed until the patient is stable. In addition to the challenges of medically and surgically managing degloving wounds, these cases require a large time, financial, and emotional commitment of the owner with significant uncertainty in regards to the overall cost and outcome. Successful management requires client education, prevention of further contamination or infection, restoration of a healthy wound healing environment through debridement and irrigation, regular reassessment of the wound, and choice of a wound closure strategy that maximizes normal function.

Multiple wounds are common in polytrauma cases, and each wound should be assessed individually in regards to the proper management strategy and costs associated. The odds of orthopedic injury are high with extensive cutaneous wounds, and thus a thorough orthopedic exam should be performed. Radiographs or CT scan should be performed on any areas suspicious for injury. A complete neurologic examination should also be performed for early detection of nerve and spinal injury. Immobility and opioid
medication may interfere with orthopedic and neurologic exam interpretation. Therefore, the animal should be reassessed with regularity to detect previously disguised orthopedic or neurologic abnormalities or to clarify previous findings.

Understanding normal the wound-healing process provides a framework for understanding factors that impair wound healing and for implementing effective wound management strategies. Normal wound-healing consists of 3-5 (depending on nomenclature) overlapping phases: Hemostasis (coagulation) phase, Inflammatory phase, Debridement phase (often combined with inflammatory), Repair (proliferative) phase, and Maturation (remodeling) phase. Formation of a fibrin clot during hemostasis initiates the inflammatory and repair phase through release of pro-inflammatory cytokines. Increased capillary permeability and infiltration of leukocytes occur during the inflammatory and debridement phase, resulting in bacterial phagocytosis and clearing of debris from the wound. Increased blood flow to the wound during this time results in the classic heat, redness, and swelling associated with inflammation. In a healthy wound, the proliferative or repair phase will begin in 3-4 days and is characterized by fibroplasia, angiogenesis, and epithelialization. A wound is considered “healthy” when bright red granulation tissue is present, comprised of fibroblasts, new capillaries, and fibrous tissue. Wound strength increases exponentially during this time. Maturation begins in a healthy wound approximately 1 week after injury, and is characterized by strengthening and remodeling of newly formed collagen. Inflammation resolves and new capillaries regress. Collagen aligns with the tension lines and forms cross-links. It is expected that skin will achieve approximately 80% of normal tissue strength at the end of the remodeling period.

The initial steps of wound management are critical in setting the stage for progression of healthy wound healing. The clinical relevance of wound healing is demonstrated in the recommended strategies for appropriate wound care. Timely surgical wound debridement and irrigation is recommended to remove debris from the wound and promote efficient transition from the inflammatory/debridement phases to repair/proliferation. Anesthesia or sedation is often required for at least the initial assessment and debridement. The clinician should wear sterile gloves whenever handling the wound to prevent further wound contamination and to prevent transfer of potentially resistant bacteria to other patients. The wound is first covered in a sterile water-soluble lubricant, and all surrounding hair/fur is removed. An initial irrigation is then performed with warm isotonic fluids to remove debris and gross contamination. Use of antiseptics (e.g. 0.05% chlorhexidine or 0.5% povidone-iodine) has not been shown to be advantageous. The literature suggests that low-pressure irrigation is superior to high-pressure irrigation to avoid injuring healthy tissue and seeding bacteria and debris more deeply into the wound. Adequate pressure (8-10 PSI) is achieved with a 35-60cc syringe and an 18-gauge needle.

The goal of debridement is to remove necrotic and devitalized tissue while preserving normal/ critical anatomic structures. Debridement is classified as either non-selective (removes both viable and non-viable tissue) or selective (maximizes removal of devitalized tissue, preserving normal tissue). Non-selective debridement includes surgical debridement and mechanical debridement (e.g. wet-to-dry bandages). Surgical debridement is typically the first type of debridement and is used to remove foreign material and obviously non-viable tissue. Surgical debridement should be performed conservatively, leaving any tissue of questionable viability for reassessment in 24-48 hours. Additional debridement can be performed once tissue has definitively been declared as necrotic. Preserving viable tissue allows for more rapid healing or easier closure at a later date. It can take 7-10 days for skin to declare itself in dogs and cats. After surgical debridement is complete, the wound is again irrigated thoroughly, cultured for antimicrobial sensitivity testing, and covered with a bandage.

It is ideal for debridement to continue even after the bandage is applied. Mechanical debridement is non-selective and includes wet-to-dry and dry-to-dry bandages. Contrary to previous recommendations, mechanical debridement is now considered controversial as it is painful, and removal of adherent gauze from the wound results in removal of granulation tissue and reparative cells along with the debris. Further, wet-to-dry bandages need to be changed every 12-24 hours in infected wounds. If performed, wet-to-dry bandages should only be applied during the inflammatory phase of healing to avoid damaging newly formed granulation tissue.

Selective debridement includes autolytic debridement and enzymatic debridement. Autolytic debridement is the natural process that occurs in a moist wound environment and is now generally preferred over non-selective mechanical debridement. Enzymes, cytokines, and growth factors in the normal wound fluid digest the necrotic tissue and stimulate granulation tissue formation and epithelialization. The process is facilitated by use of hydrophilic, occlusive, or semi-occlusive dressings (see below), allowing the wound exudate to maintain contact with the wound. Alternatively, commercial enzymatic agents are also available for topical use in wounds; however, they work slowly, are costly, and are not widely used in veterinary medicine.

The purpose of a bandage is to protect the wound from contamination and outside mechanical forces, manage wound exudate, eliminate dead space, immobilize injured tissue, provide support and comfort, and promote a healthy wound environment. The bandage has three essential layers:

1. Primary (contact) layer – This layer creates the wound environment. Potential roles of the contact layer include necrotic tissue debridement, medication delivery, exudate absorption, and formation of an occlusive seal to maintain moisture. Wounds heal better in a moist (not wet) environment. Non-adherent occlusive dressings are associated with faster, more cosmetic healing than adherent (e.g. wet-to-dry) dressings. Examples include traditional semi-occlusive dressings (telfa pads and petroleum impregnated gauze) or newer semi-occlusive and occlusive dressings (e.g. films, hydrogels, hydrocolloids,
employed in our hospital is the “tie-over” bandage. It is ideal for wounds of unique size, shape, or location, or wounds subject to significant motion. Large “belt-loop” skin sutures are placed circumferentially around the wound (2-3 cm from the wound edge) with veterinary medicine. Alcohol, hydrogen peroxide, Dakin solution, and acetic acid are all cytotoxic to normal tissue and should not be used.

Negative pressure, and removes exudate and infectious material from the wound. Microstrain/microdeformation causes cell stretch, Macrostrain (visible stretching) draws the wound edges together, provides direct/diffuse wound bed contact, provides uniform for managing large wounds with extensive contamination. With NPWT, a sealed foam or gauze dressing is applied to the wound and used. Secondary benefits include reduced frequency of bandage changes (every 48-72 hours), accelerated granulation tissue formation, and promotion of wound contraction. NPWT does not debride the wound, and thus foreign material and necrotic tissue must be surgically removed from the wound before NPWT application. NPWT is most beneficial during the early phases of wound healing and is generally not recommended beyond the time at which granulation tissue forms. Continued NPWT will actually delay epithelialization and wound contraction. NPWT has also been used in conjunction with free graft as a method to secure the graft to the wound bed and improve tissue survival.

Factors that negatively impact healing should be considered when planning the wound healing strategy. These factors include both systemic/host factors (age, body condition, nutrition, concurrent metabolic disease, and medications such as corticosteroids and chemotherapy) and local factors (infection, tissue perfusion/viability, hematoma, seroma, and mechanical factors such as tension, motion, and wound debris). The clinician should attempt to correct or accommodate for these factors when possible. Abiding by Halstead’s surgical principles (gentle tissue handling, asepsis, sharp dissection, hemostasis, minimizing tension and deadspace, and preserving blood supply) will help minimize negative local factors.

Wounds are generally classified based on the level of contamination:

- Class I (clean): 0-6 hours old, often surgically created and contaminated only by skin microflora.
- Class II (clean/contaminated): 0-6 hours old with minimal contamination. Often a surgical wound that may involve entry into a contaminated organ system (gastrointestinal, urogenital, or respiratory) without significant spillage, or may be associated with a minor break in sterility.
- Class III (contaminated): An open wound over 6-12 hours old with significant contamination/ bacterial introduction. It may be traumatic in origin and treated relatively early, or may be a surgical wound with a major break in asepsis.
- Class IV (dirty): Traumatic wounds with significant treatment delay (>12 hours), with gross contamination and colonized bacteria. Often contains foreign material, pus, necrotic tissue, or fecal material.
The class of the wound guides the recommended treatment plan. Primary wound closure (or first-intention healing) is generally reserved for class I wounds or wound that can easily be converted to a surgical wound. Second-intention healing is indicated for large defects that cannot be closed primarily of have significant contamination/infection. Second-intention healing requires formation of granulation tissue, wound contracture, and epithelialization. It is less risky than trying to close a wound that has residual infection or tension; however, it requires significant time, energy, finances, and may leave a scar. Delayed closure (or tertiary-intention healing) is a combination of primary and second-intention healing. It is ideal for heavily contaminated wounds, where the wound is treated as an “open wound” and then closed either before (delayed primary closure) or after (secondary closure) granulation tissue formation. If the decision is made to close the wound, sufficient skin should be available to close the wound without tension. Even a healthy wound is at high risk for dehiscence if closed under tension. Degloving wounds by definition are considered at least class III wounds, and often class IV. Therefore, the wound is treated as an open wound initially and then either closed primarily, closed with a skin flap or graft, or left to heal by second intention.

Degloving wounds are often accompanied by orthopedic injuries. Stabilization of the orthopedic injury and wound care are performed simultaneously and should influence the chosen method of stabilization. For example, external coaptation (cast), is not ideal for managing fractures with extensive soft-tissue injury, as the fracture will be destabilized with each bandage change. Internal or external fixation allows the wound to be managed while maintaining rigid stabilization of orthopedic injuries.

Finally, managing degloving injuries, especially in combination with orthopedic injuries, is costly, time-consuming, and often has an unknown endpoint or prognosis. For some owners, open wound management and orthopedic fixation is not a viable option. Similarly, degloving injuries may occur in conjunction with catastrophic injuries to the brachial plexus or sciatic nerve. In these cases, amputation is a reasonable alternative for animals with three remaining normal (or fixable) limbs. Amputation provides a less expensive option for cure with a shorter and more clear prognosis.

In summary, wound healing is a complex process controlled largely by cytokines. The process is really a continuum rather than individual, distinct phases. Clinical assessment of the patient and the wound determines the appropriate treatment strategy for a wound. Re-assessment is critical for changing the treatment strategy as needed. Many wound care products are available commercially, however, the efficacy and safety of their use has not been well-evaluate in veterinary medicine. Wound care requires a comprehensive approach, tailored to the individual patient, wound, and stage of healing. Most degloving injuries are Class III or IV wounds, requiring significant time, money, and energy to promote granulation tissue formation and ultimately either healing by second-intention or delayed primary closure. The wound should only be closed if it is free of infection, has a healthy granulation bed, and can be closed in a manner that is free of tension.

References
Complications are a potential risk of every surgery. It is important to anticipate all of the possible complications so that we may not only talk about them in advance with our clients when obtaining informed consent for a procedure, but also to prevent complications if possible, be able to identify them early if they occur, and be able to implement effective treatment to manage complications as soon as possible.

**Dehiscence**

There is a risk of dehiscence with every surgery in which sutures are placed and may be the result of any number of potential factors. It is the responsibility of the surgeon to take every precaution to avoid a dehiscence if possible, and to reflect on why it might have occurred if it happens. A dehiscence is occasionally the result of self-trauma by the patient, but in the majority of cases could have been avoided by taking extra precaution.

Technical errors are one of the most common reasons for dehiscence. These may include inappropriately tied square knots (either an incorrect pattern, number of throws, or failure to plasticize the suture when tightening), placing the suture in an inappropriate location (e.g. failure to incorporate the submucosa in the mucosal of the urinary or GI tract, or placement of the suture in the subcutaneous tissue rather than the linea alba), or accidentally traumatizing the suture with an instrument in surgery, leading to breakage of the suture postoperatively. Other technical errors may include placing the suture too close to the edge of the incision (within the zone of inflammation), placing too many or not enough sutures, tightening the sutures too much (strangulating the tissue), or not tightening the suture enough within the tissue.

Another potential cause of dehiscence is inappropriate suture pattern (either size or material). Many clinicians choose to close the linea alba with a short-acting monofilament absorbable suture, such as Monocryl®, Biosyn®, or Monomend®. While this may be sufficient for a young, healthy animal undergoing an elective surgery (e.g. ovariohysterectomy), it may be insufficient for an animal with potential for delayed healing. Most short acting absorbable sutures will retain tensile strength for 2-3 weeks – the initial peak in strength for a healing abdominal wall occurs at approximately 2 weeks. Thus, a slight delay in healing may lead to an abdominal wall dehiscence around 2 weeks or so. It is of the author’s opinion that a longer acting absorbable suture (e.g. Maxon® or PDS®) should be used for the abdominal wall in any surgery other than an elective procedure in a juvenile patient. Maxon® and PDS® retain tensile strength for up to 2 months and are a safer choice for slower healing tissues such as the abdominal wall and other tendinous tissue.

Some animals with concurrent metabolic, immunosuppressive, or neoplastic disease may experience significantly delayed healing and will rely upon the suture material for far longer than 2 weeks (or even 2 months!). Examples include animals with chronic renal failure, Cushing’s disease, neoplasia, immunosuppressive disease (for which corticosteroids are likely part of the treatment), or poor nutrition/ hypoalbuminemia. In these patient’s, peak healing may likely take months, and a non-absorbable suture is recommended for the linea alba. In our hospital, we use polypropylene to close the linea alba for all of these patients, including patients with suspect neoplasia that may undergo adjuvant chemotherapy or radiation therapy in the future. In mucosal organs, PDS® or Maxon® may be indicated (rather than a short acting absorbable suture) for this patient population.

Finally, tension is a leading cause of dehiscence. When performing large mass removals, closing large skin wounds, or extensive excisions in mucosal organs, the key to success is eliminating tension. The tissues should be undermined and released until they lie in proximity of each other without tension. Suturing the strong supportive layers together first (muscle, submucosa, etc.) will help to relieve tension on the epithelium. Other tension relieving techniques (skin sparing techniques, mattress sutures/stents, hobbles, bandages, etc.) may also help to relieve tension, but every effort should be made to relieve tension before suturing the epithelium to reduce the rate of wound dehiscence.

When a dehiscence occurs, surgery should be performed as soon as possible if the animal is stable. Any damaged tissue is cleaned and debrided, and the tissue is reapproached taking care to avoid any mistakes that may have occurred during the first surgery. Antibiotics are generally warranted for the majority of wound dehiscences, aside from potentially an isolated linea dehiscence in which the skin remained intact.

A dehiscence of the GI tract or urinary tract are severe consequences to surgery of these organs. The result is abdominal effusion and septic or non-septic peritonitis. In additional to technical error, leading causes of dehiscence with in the abdomen include trauma to the tissue, pre-existing peritonitis, and in the case of GI surgery, hypoalbuminemia. When performing GI tract or urinary tract surgery, the patient should be monitored closely post-operatively to identify complications early if they arise. If the patient is lethargic, inappetent, painful in the abdomen, vomiting, etc., dehiscence should be high on the list of differentials. Patients with
urinary tract dehiscence may or may not be urinating after surgery, and thus the clinician should not rely too heavily on urination to make a diagnosis. A FAST (focused assessment with sonography for trauma) scan to look for abdominal fluid is the fastest way to make a diagnosis of dehiscence within the abdomen, sampling any fluid present. GI tract dehiscence is characterized by intracellular bacteria and increased amounts of degenerate neutrophils. Urinary tract dehiscence is associated with elevated creatinine and potassium in the abdominal fluid. In both cases, the fluid is cultured, the animal is stabilized, and broad spectrum antibiotics are initiated. Once stable, the abdomen is explored, the dehisced wound is debrided and closed, a thorough abdominal lavage is performed, and the abdomen is close routinely. The author prefers to place a closed-suction drain in the abdomen after surgery to prevent peritonitis. Before undergoing surgery for an intraabdominal dehiscence, 24-hour care and monitoring must be available.

In summary, prevention of dehiscence is far better than treatment. The critical elements of wound closure are apposition of the holding layer (typically muscle fascia or the submucosa of mucosal organs), tying secure square knots, and making sure to place the sutures snug, but not too tight so as not to create tissue necrosis. Always make sure to have good visualization of the holding layer during closure, and place the suture bites outside of the inflammatory zone of the wound (~ >3mm from the edge). Finally, some animals are at high risk for dehiscence due to underlying disease. In animals with expected delayed healing, use longer acting suture materials (or even nonabsorbable in muscle fascia or tendon), and provide enteral nutrition to maximize the chance of success.

Hemorrhage
Hemorrhage is also a risk of any surgery, including elective ovariohysterectomy (OVH) and castration. The bleeding can come from any number of locations including the subcutaneous tissue, muscle bellies, small and large vessels, or other organs that may not have even been involved in surgery, such as the spleen, omentum, liver, etc. Preventing hemorrhage is clearly better than managing it if it occurs; however, management should involve both identifying the underlying cause if possible and initiating supportive care to avoid systemic consequences of hemorrhage.

Preventing hemorrhage
The majority of hemorrhage can be avoided with proper planning and meticulous surgical technique. The preoperative patient workup should be sufficient to identify patients with a potentially increased risk for bleeding. This includes patients with low platelet counts, von Willebrand’s disease, breed-associated risk, and coagulopathies (including those associated with hepatic insufficiency, rodenticide toxicity, sepsis, DIC, etc.). A thorough pre-operative work-up allows the clinician to anticipate an increased risk for bleeding and to take proper precaution.

The clinician should think about the surgical procedure itself and what surgical steps will be necessary to avoid and control hemorrhage during the procedure. For example, in the majority of invasive procedures, cautery should be available. If there are any large vessels in the surgical field, suction and vessel clamps should be open and on the instrument table in case of inadvertent damage to the vessel. When performing surgery or biopsy of the liver, it is helpful to have Gelfoam® (absorbable gelatin sponge) available to promote clotting of the liver parenchyma. For large tumor dissections, it is helpful to have a variety of tools available to quickly ligate multiple small vessels supplying the tumor. Examples include suture material on a reel (such as chromic catgut), multiple small mosquito hemostats, cautery, (Hemoclips®), or in larger referral hospitals, an electrical vessel sealing device such as the LigaSure™.

Once in the operating room, the surgeon should take care to practice good surgical technique, avoiding inadvertent damage to vessels and surrounding organs. It is recommended to not perform surgery on any patient with an increase risk for bleeding if electrocautery is not available, as even small subcutaneous vessels can bleed excessively in a patient unable to form a sufficient clot.

To avoid inadvertent damage to surrounding organs, the surgeons should enter the abdomen carefully, lifting the linea alba away from the abdominal organs and avoiding downward movement of the scalpel blade during entry. All motions in surgery should be planned, taking care to exercise control of the instruments at all times and ensure there is adequate visualization of the tissue being dissected. Mistakes commonly occur when the surgeon has inadequate visualization, improper instruments, or is not prepared for the procedure.

As a rule of thumb, the surgeon should ensure that all bleeding has ceased before closing the incision. This includes examining ligated pedicles and all potential sources of hemorrhage. The mesentery and omentum should be examined, as well as other abdominal organs that may have sustained injury. The linea alba, falciform fat, and subcutaneous tissue are also examined for bleeding, taking care to either cauterize or ligate any actively bleeding vessels. It’s important to recognize that the majority of patients experience some degree of hypotension during surgery, and thus even minor intraoperative bleeding may become more profuse once the animal is awake and normotensive.

Managing the bleeding patient
The underlying cause of hemorrhage will, in part, determine how hemorrhage is managed in the postoperative period. In general, going back to surgery to find the bleeding vessel is rarely recommended as this can be very difficult and may put the patient at greater risk than managing the hemorrhage conservatively.
When bleeding is visible, management may be significantly more straightforward. The clinician may see active hemorrhage from the incision, bruising, or a swelling under the incision line. In these cases, cold-packing the incision and applying external pressure is recommended to stop or slow the bleeding. The packed cell volume (PCV) and total protein (TP) is monitored, as well as the blood pressure and heart rate and treated accordingly. If the bleeding continues, the clinician should consider evaluating the patient for disorders of primary and secondary hemostasis including thrombocytopenia, platelet dysfunction or coagulation disorders. Screening tests include a complete blood cell count with platelet count, buccal mucosal bleeding time to evaluate platelet function, and a coagulation panel or activated clotting time. Treatment is directed at controlling or managing the underlying cause, maintaining adequate volume and packed cell volume, as well as local wound care. Bleeding wounds are prone to infection and should be covered at all times.

When hemorrhage occurs inside a body cavity, diagnosis and treatment may be more challenging. The PCV and TP do not drop right away, and thus signs of hemorrhage may be non-specific (tachycardia, hyper- or hypotension, tachypnea, depression, etc.). It is important to differentiate tachycardia caused by hypovolemia or anemia from tachycardia induced by pain. An animal with pain will not show improvement from a crystalloid bolus, whereas a hemorrhaging patient will show at least transient improvement in vital parameters from a fluid bolus. Hemorrhage may be confirmed by performing a FAST scan of the surgical area and sampling and fluid present. A PCV of the fluid is also measured to confirm that the fluid is blood and not serosanguineous discharge.

Once hemorrhage in a body cavity is confirmed, conservative treatment is initiated. Volume support in the form of crystalloids and colloids are provided. If tachycardia continues or the PCV drops to a clinically significant level, the clinician should consider treatment with packed red blood cells and/or fresh frozen plasma (FFP). In the grand majority of cases, hemorrhage will eventually stop with conservative medical management. If the animal continues to bleed or decompensate despite aggressive medical management, surgery should be considered. It is important to recognize that it can be very difficult to locate bleeding vessels in surgery. In addition, anesthetizing an unstable bleeding patient can result in significant hypotension and further tissue trauma and inflammation, increasing the risk for acute renal failure, multi-organ dysfunction, disseminated intravascular coagulation (DIC), and death. If surgery is deemed necessary to stabilize the animal, the anesthesia and surgical team must work cohesively and efficiently, preparing the patient as much as possible before surgery, planning out how the vessel will be located, and providing aggressive monitoring, fluid support, and pressor support as necessary. Prognosis is guarded if surgery is required to control postoperative hemorrhage.

**Thrombocytopenia**

There are several conditions for which increased bleeding may be anticipated in surgery. Thrombocytopenia, or a low platelet count, is a disorder of primary hemostasis, formation of the platelet plug. There are several underlying causes of thrombocytopenia, including hereditary disorders (Cavalier King Charles Spaniels), reduced production, DIC, immune-mediated thrombocytopenia, etc. Thrombocytopenia may cause spontaneous, immediate, excessive and prolonged bleeding. The risk for bleeding is inversely proportional to platelet count. When >100,000/µL, the risk for bleeding is generally not increased. When 50,000-99,000 µL, there may be an increased risk for bleeding in surgery. When less than 50,000 µL, the patient is at risk for spontaneous bleeding. Other concurrent problems and coagulopathy will increase the risk for hemorrhage.

Treatment of thrombocytopenia includes addressing the primary cause, gentle handling, transfusion (whole blood, platelet-rich plasma, FFP, or cryoprecipitate), thrombopoietic drugs and prothrombotic drugs.

**Von Willebrand’s Disease (vWD)**

vWD is a congenital extrinsic platelet defect resulting in dysfunction in primary hemostasis (formation of the platelet plug). Reference laboratory blood results for vW assay (factor) are reported in percent, with normal ranging 70-180% in dogs and cats. Dogs at 50-60% are considered borderline. Clinical signs are generally not seen until vWF is less than 20%, but dogs less than 35% are at greater risk for bleeding episodes. vWD can be typed; however, 90% of dogs are Type I (partial quantitative deficiency of all vWF multimers), and the type is unlikely to influence treatment.

Though it is ideal to avoid surgery in all vWD patients, this is not practical. In our hospital, we routinely provide vWD patients with FFP (or cryoprecipitate if available) and desmopressin acetate (DDAVP) prior to surgery to reduce the risk of intra- and post-operative hemorrhage. DDAVP is a synthetic polypeptide that causes dose-dependent increased release of plasma factor VIII, plasminogen factor, and vWF from storage sites. If DDAVP is not stocked in the hospital, it should be ordered when planning surgery for a vWD patient. DDAVP takes 30 minutes to work and is effective for 2 hours.

A buccal mucosal bleeding time (BMBT) can be used to both screen for and monitor bleeding risk in patients suspect for vWD. As it is not 100% sensitive in identifying patients at increased risk for bleeding, we tend to use a combination of the patient’s breed, history of bleeding, BMBT, and vWD factor assay, if available, in determining whether or not to treat a patient prior to surgery. DDAVP and cryoprecipitate (or FFP) are continued into the postoperative period, if necessary, if seeping from the incision continues after surgery.
DIC
Disseminated intravascular coagulation (DIC) is a common component of Systemic Inflammatory Response Syndrome (SIRS), which can happen as a consequence to major trauma, sepsis, inflammation, or surgery. If suspected, a blood smear is evaluated for decreased platelets and fragmented red blood cells. Activated clotting times should be monitored. Specific tests for fibrin degradation products (FDPs) and antithrombin II (ATIII) may help guide therapy. Therapy is directed toward decreasing microthrombi (heparin, heparinized plasma) providing missing clotting factors (FFP), and improving perfusion (fluid/colloid support). A postoperative patient in DIC has a grave prognosis.

Delayed hemorrhage in Greyhounds
Delayed postoperative bleeding is common in retired racing Greyhounds, despite normal results of routine coagulation assays. Following surgery, Greyhounds may experience catastrophic bleeding, leading to increase hospitalization, increased cost, multiple transfusions of packed red blood cells and FFP, and sometimes death. One study evaluating complications of amputation in Greyhounds compared to other breeds showed that 36% of greyhounds had severed delayed (2-4 days) postoperative bleeding. Studies show that this is not due to a defect in primary (formation of the platelet plug) or secondary (coagulation) hemostasis, but rather is likely due to increased fibrinolysis or dysfunction of clot maintenance.

The lysine analogues, epsilon aminocaproic acid (EACA) and tranexamic acid, are currently recommended in human trauma patients to inhibit fibrinolysis and support clot maintenance. EACA is the most studied in veterinary medicine, with one recent paper looking at both EACA and tranexamic acid. The largest clinical study compared the effects of EACA and placebo in 100 greyhounds that underwent elective ovariohysterectomy or orchietomy at The Ohio State University. They found that 30% of the greyhounds in the placebo group had delayed postoperative bleeding beginning at 36-48 hours after surgery, whereas only 10% of the greyhounds in the EACA group experienced the same complication. TEG parameters demonstrate significantly different clot formation times between the groups.

In our hospital, we now routinely use EACA in greyhounds in the perioperative and postoperative time periods. Side effects are rare and outweigh the risks of not using it in Greyhounds. It is also relatively inexpensive in comparison to treating post-operative bleeding if it occurs. The current dose recommendation is 500 mg (or 15mg/kg) EACA orally every 8 hours for 5 days post-op. EACA is available in both injectable and oral formulations. In the limited studies available, EACS appears safe with no increased risk for thrombosis reported.

Other causes of “oozing”
There are several reasons that an incision may “ooze” or have persistent drainage after surgery in addition to hemorrhage. Other causes of incisional discharge are discussed below.

Serosanguineous discharge
Serosanguineous fluid will often accumulate beneath a wound in the form of a seroma. In some cases, the fluid will exit through the incision if there is not a tight seal in the skin. The serosanguineous fluid develops and accumulates as a result of excessive tissue trauma, excessive undermining, and ineffectively closing dead space. Seromas (and drainage of serosanguineous fluid) are typically self-limiting; however, when draining through the incision, there is a high risk for infection if bacteria are able to colonize the wound. Therefore, a draining wound should always be covered with a sterile wrap to prevent the wound from becoming infected. If drainage continues beyond 2-3 days postoperatively, the wound should be cultured to rule out infection. A belly wrap or other compressive bandage may be helpful to compress the dead space. For a seroma, aseptic drainage prior to a belly wrap is recommended. If the seroma recurs, placement of a Penrose or closed suction drain may help minimize the chance of recurrence. Prevention involves minimizing tissue trauma by carefully planning and executing each surgical move, minimizing undermining, and effectively closing dead space (or placing a drain).

Surgical site infections
Surgical site infections (SSIs) are acute postoperative infections that develop within 30 days of surgery (or within 1 year if an implant is used), which produce bacterial growth when cultured. Veterinary studies show that SSIs develop in 2.5-5% of clean and clean-contaminated surgeries and up to 10% for contaminated and dirty surgeries. The rate of SSI may be lower with minimally invasive surgery, but there is insufficient evidence to prove this yet in veterinary medicine. SSIs will present with purulent discharge from the incision, pain or heat around the wound, dehiscence, or an abscess beneath the wound. SSI is confirmed with cytology and culture.

It is a good idea to keep track of the SSI rate within a hospital. If the rate is higher than what is expected, methods of decreasing SSI should be explored. Reducing SSI relies on good operating room management, atraumatic surgery, competent anesthesia and careful postoperative management. Prophylactic antibiotics are recommended for clean surgery extending over 90 minutes, surgery where an implant is used, surgeries where infection would be catastrophic, compromised patients (anemic, diabetic, immunosuppressed, etc.), clean-contaminated surgeries where contamination occurred, and contaminated/dirty surgeries. Antibiotics are administered 30-60 minutes before the skin is incised and repeated every 90-120 minutes. There is no strong evidence that there is benefit in maintaining antibiotics postoperatively unless an established infection is present.
Gloves are punctured in 20-30% of soft tissue surgeries and up to 60% of orthopedic surgeries by one hour into the procedure. The majority of glove punctures are not recognized by the surgery. Double gloving should be considered for longer orthopedic surgeries.

Hair clipping should wait until the animal is anesthetized as there is a 3x risk of SSI when clipping is done before induction.

During patient and surgeon skin aseptic preparation, there is some evidence that 0.5% chlorhexidine and alcohol are more effective in decreasing bacterial colony forming units (CFUs) than the iodophors. In addition, brushing the skin aggressively may lead to microabrasion and increased colonization of bacteria. Contact time of the antiseptic agent is the critical component in surgical asepsis.

The surgeon should make every effort to minimize traffic and the number of people in the operating room. For every person in the operating room, the SSI rate increases 1.3-fold.

Finally, the suture material chosen is important in minimizing SSI. The chosen suture material should be absorbed once wound support is no longer necessary and of a suitable size. Triclosan-coated suture may prevent formation of biofilms and SSI; however, there is insufficient data in veterinary medicine, and conflicting results in human medicine.

When a wound infection occurs, it should be cultured, flushed, and debrided. Any suture material in the wound that is no longer needed or providing benefit should be removed. The wound should be left open to allow active drainage and covered with a semi-occlusive dressing and a bandage. Broad-spectrum antibiotics are initiated until the culture and sensitivity results are available. The wound should not be closed surgically until there is a healthy bed of granulation tissue present and no evidence of infection. The wound should be recultured if at any point healing slows or incisional drainage resumes or changes character.

**Persistent incision drainage**

Occasionally, an incision will continue to drain (or develop recurrent drainage) chronically. The wound will likely culture positive at some point and warrant antibiotic treatment. Though the drainage may subside while the patient is on the antibiotics, drainage resumes after antibiotics are discontinued.

In these cases, the clinician should reevaluate the patient and the wound prior to restarting antibiotics (unless inappropriate antibiotics were chosen or for a less than ideal time period). Reevaluation should include culturing the wound, imaging if indicated (e.g. if a retained surgical sponge is a possibility) and potentially explored. This is a common scenario when foreign material is retained in the wound and colonized with bacteria. In these cases, if it has been at least 2-3 weeks since surgery, the clinician can remove any visible suture material as they are likely coated with a biofilm. If the wound has not healed yet or if the implant is an orthopedic implant, the patient is treated with antibiotics until healing is sufficient to remove the implant.

**Summary**

When doing surgery, complications will occur; however, prevention is always better than management. A thorough preoperative patient workup, meticulous tissue handling, secure ligatures, secure body wall closures, and minimizing dead space will all help to minimize complications. When complications do occur, however, do not panic. Work through the complication in a thorough, logical approach.
Obstruction of the upper airway can present from chronic or acute causes. Common causes in small animal are laryngeal paralysis and Brachycephalic Obstructive Airway Syndrome (BOAS). Other causes are laryngeal, oropharyngeal, tracheal, and nasal lesions.

**Primary signs**
Animals presenting with obstructive airway crises typically have respiratory symptoms comprised of increased respiratory effort with prolonged inspiration and increased noise. Orthopneic stance is typical.

Presentation may include severe hyperthermia as a result of the increased work and heat generated by the work of breathing through an obstructed airway. This is a rare occurrence in felines. Some animals will present after developing a heat stroke crisis and the obstructive airway phase may not be witnessed by the owners if the victim is comatose. Heatstroke crises can be associated with SIRS and MODS. Those features are beyond the scope of this lecture but cannot be underscored. Increased inspiratory effort is most common with obstructive upper airway disease.

**History**
Historical information can be useful in identifying at-risk patients. Important questions to ask are regarding previous anesthesia problems, loud or labored breathing (at rest or with exertion), exercise tolerance, change in voice, cyanosis, collapse, gastrointestinal symptoms (vomiting, regurgitation, hacking or gagging when eating or drinking, spitting up foam, difficulty eating due to poor nasal breathing). When taking a history, look for signs of respiratory compromise and interference with glottis, esophageal, and laryngeal function.

**Planning**
Initial exam should always be based on patient stability. Abbreviate the exam and provide airway support or intubation if in clinically warranted. Stable patient may be electively worked up after appropriate pre-anesthetic testing. Age-appropriate ASA guidelines should be followed with the addition of thoracic and possibly cervical radiographs. Set up with a wide variety of endotracheal tubes and have several undersized tubes available. Use of a pair of laryngoscopes is often helpful to move tissues of the oropharynx and larynx as well as provide more light. Malleable retractors can also be helpful in retracting the tongue or soft palate. Pre-oxygenate patients to avoid hypoxia. I routinely use anti-emetic and gastroprotectants to minimize the incidence of nausea, vomiting, or regurgitation. I recommend setting up for potential tracheostomy prior to sedating or anesthetizing.

**Diagnosis/examination**
Start by watching the patient breathe at rest and without direct interaction. Make observation about respiratory effort and noise. Is the typical nasal stertor heard? Stertor is defined as “a low-pitched heavy snoring inspiratory sound” and is contrasted by stridor as being “a high-pitched noisy sound”. I will then perform my routine exam and then return to focus of the face and head. Some animal will resent this and more handling thereafter may not be tolerated. Examine for airflow from the nares (independently). Also, look at the nares and evaluate for medial displacement of nasal wing during inspiration. If the patient does not nose breath on its own, close the mouth and observe for changes in effort and noise. If these increase, nasal or nasopharyngeal obstruction is suspected. Increased inspiratory effort is typically seen with the obstructive airway diseases. Some animals will also have cardiac or lower airway disease concurrently. **If the patient is in distress, provide supportive care (see below).**

 Routinely, per os visual exam can be performed to evaluate the components of the upper airway. I typically do this under a very light plane of anesthesia to allow a functional laryngeal exam and then use a deeper plane if the exam is hampered by patient motion or resentment. In cases where lower airway disease is also suspected, bronchoscopy may be indicated.

**Initial therapy**
Animal that are distressed need gentle handling and avoiding further stress. Providing supplemental Oxygen by flow-by or mask. Providing mild sedation may decrease anxiety and the extra respiratory effort that is driving the crisis further. Placing an IV catheter is helpful for sedation, IV fluid therapy, induction of anesthesia, and delivery of other rapid-acting medications. If IV catheter stress is deemed too stressful (use judgment), initial parental medications may be given IM or SQ. Fluids are helpful for treatment of hyperthermia. In some cases, pulse oximetry or arterial blood gas analysis may be very helpful but, if this is very stressful, use clinical judgment to avoid further stress.
In the distressed patient, start with light sedation with medications such as butorphanol and low-dose acepromazine. Vasodilation from alpha–blockade may further decrease patient stability. Oxygen support is tolerated better in some patients after sedation. If swelling is thought to be part of the crisis, low doses (anti-inflammatory) of corticosteroids may be given. Ensure adequate hemodynamic stability prior to administration.

In more severe crises, or if the above situation worsens, induction of anesthesia may be required. It is almost always possible to intubate orally in BOAS crises. Have a variety of tubes available and expect to markedly undersize the tube. Rapid induction and airway acquisition are essential as these critical moments can be life-saving.

If the animal is unable to be intubated, a small catheter (such as a urinary catheter) can sometimes be passed into the trachea in a temporary effort to provide Oxygen support. A transtracheal or transcricoid through the needle catheter can be used similarly. These small lumens seem to have a very short period of support and must not be relied upon other than a momentary stop-gap method to either intubate or perform a tracheotomy.

Patients often need to be maintained on inhalant anesthesia or continuous infusions (such as Propofol) at this time. Establish a safe plane of anesthesia and take care to avoid unintentional waking and possible unsafe, unscheduled extubations. Stability provided by anesthetizing compromised patients can allow safer diagnostic procedures such as blood collection and diagnostic imaging. Additionally, anesthesia can be useful in cooling hyperthermic patient.

**Surgical decision-making**

In many cases, attempting to wean from anesthesia after a period of stabilization is performed. It is important to assess the patient carefully. Some patients are clearly not candidates for this attempt and should have a tracheotomy performed instead to avoid another crisis. In some patients, this is not as clear and may not wean well and “prove” their need for tracheotomy. During the weaning process, the patient needs to be closely attended by the team as rapid decompensation may occur and immediate re-intubation may be required. Provide nasal or flow-by Oxygen support during this time. If the weaning is successful, continued oxygen support may be needed in the form of nasal, flow-by, or Oxygen cage therapy. Again, close observation is required in these patients.

Tracheotomy may be needed to place a temporary tracheotomy tube for emergency management of an obstructive crisis, postoperative re-obstruction, or as a pre-emptive procedure during airway surgery. This is also useful in mechanical ventilator patients. Permanent tracheotomy is indicated for animals with end-stage BOAS disease (laryngeal collapse) or that have failed treatment (often have laryngeal collapse). Other indications are neoplastic processes, failed laryngeal paralysis treatments.

Loss of lumen diameter and decreased tracheal rigidity makes **tracheal collapse patients less favorable candidates**.

**Set up and equipment**

Rapid and concerted efforts by your team are required for success. If this is not currently occurring in your practice, institute protocols for crashing patients, CPR, etc. Perform drills to improve response time and efficiency. **Teams are most effective when everyone has a job and responsibility and is aware of their role.** Do not waste too much time performing an airway exam in a crisis. After establishing a patent and secure airway and ensuring patient stability, then a more thorough exam can be performed (and the findings documented).

Make sure a sterile instrument pack is readily available for tracheotomy (and similar procedures). I prefer to have “just the essentials” in such a pack for these purposes to limit fumbling with unnecessary instruments. Having suture available for use a stay sutures, drapes, blades, sterile gloves, etc is also essential. Non-sterile umbilical tape is needed for tying tubes in place. Create a tube cleaning station with dilute chlorhexiderm solution, cotton tipped applicators, pipe cleaners, and suction catheters (red rubber catheters work). A suction device will be needed also.

Have a wide array of tube sizes available. Cuffed tubes are necessary for positive pressure ventilation and maintenance of inhalant gas anesthetics (to avoid unnecessary gas exposure to clinic personnel)- otherwise, do not inflate these cuffs. **Double lumen tubes are preferable** as the inner tube can be removed and cleaned without removal of the outer tube- thus minimizing the chances of loss of airway maintenance. Small tubes are not available in double lumen models. Cutting standard ET tubes is a less favorable option.

**Surgical procedures- tracheotomy**

Having the patient anesthetized with an orally-placed ET tube is ideal. Clip, prep, and drape the ventral cervical region from mandible to the cranial sternum. It is important to place the patient in dorsal recumbency with the neck extended (usually over a small rolled towel). Obesity can make ensuring positioning more difficult.

A ventral midline cervical incision is created over the cranial cervical trachea (caudal to the larynx). Incised through subcutaneous tissue and platysma muscle (usually together). Identify the paired sternohyoideus muscles and dissect between them on midline. There are small anastomosis veins that can be separated bluntly. I highly recommend use of **self-retaining retractors** (such as Gelpi or Weitlaners) or **an assistant**. The trachea lies beneath these muscles and is covered in loose peritracheal fascia. Important to note is the position of the **paired recurrent laryngeal nerves** that run dorsally adjacent to the trachea. In severely obese animals, fat occlusions may occur and some subcutaneous fat may need to be excised.
In the current edition of Tobias and Johnston there is not a specified ring location for tracheotomy incision. Previously, incisions between the 4th and 5th ring were recommended. It is important that the site is superficial. I typically incise between the 3rd and 6th rings. I prefer a tranverse tracheotomy incision. Prior to incision into the trachea, place a stay suture through the ring immediately cranial and caudal to the proposed annular ring incision. I tend to place the needle through the ring in an oblique orientation to make sure I can avoid severing the suture. Use a large suture size (such as 0) on a large taper needle. These stay sutures need to be clearly labeled after completing the surgery. Stabilize the trachea- I prefer to apply traction on one of the stay sutures- and make a full-thickness incision with a #10 or #15 blade on the annular ring between the stay sutures. Make sure the ET is placed distal to this location to avoid incising the cuff or losing airway control. Make the incision less than 65% (I typically make around 50%) to minimize the chance of stricture postoperatively. The paired recurrent laryngeal nerves must be avoided.

When the tracheotomy tube is to be inserted, alert the anesthetist. Be prepared with the proposed tube and maintain a secure grip on the caudal stay suture. Have the anesthetist deflate the tube and slowly retract the tube past the incision in the trachea. Insert the tracheotomy tube once there oral tube is out of the way. Gently insert the tube while hold the stay suture. Many commercial tubes have an obturator which makes insertion easier. This obturator must be removed immediately after the tube is in place as it completely obstructs the tube lumen. If this attempt fails, have the anesthetist reposition the ET tube. Decrease tube size and try again. Once the tracheotomy tube is in place, the other tube can be removed.

Reconnect the anesthetic circuit to the tracheotomy tube. If inhalant anesthetic is to be continued, inflate the cuff using standard protocol. No closure is required. Clearly label the stay sutures! Tie the tube in place using umbilical tape around the neck. Recovery the patient and proceed to postoperative care and tube management.

Postoperative care
Care of the tube and site is very important. Tube care entails keeping the area around the incision clean and applying a triple antibiotic around it. The tube will need to be changed 1-2 times per day unless secretions are very copious – in this case, it needs to be changed more frequently. The tube can be changed more easily if it is a double-lumen. Use the stay sutures to manipulate the tracheotomy incision and to keep the lumen open during the changes. Clean the tube with dilute Chlorhexiderm soaks and rinse with saline. A dedicated cageside station should be created. Instill 0.25-1.0 ml sterile saline into the tube 4-6 times per day to compensate for airway drying. Suctioning of tube is performed several times per day. The patient must be preoxygenated for a few minutes prior to suctioning. Each suctioning attempt is less that 10 seconds and oxygen is provided again thereafter to recover. Patients oversuctioned can have severe atelectasis and hypoxia. Vagal responses may also be induced and can be manifests as bardycardia, gagging, retching, or vomiting. EKG monitoring is advised during suctioning. Small tubes more prone to occlusion with secretions must be evaluated frequently. Plugging is the most common complication. Keep extra tubes of smaller sizes in case of emergency as they can be changed more easily.

When the patient is deemed stable or improved, try removing the tube under a controlled situation. Remove the tube and cover the site with an occlusive dressing (such as a Telfa pad) while observing respiratory effort. If the patient is improved, leave the tube out and observe in the ICU. If the tube removal trial fails, try again in 24 hours or re-investigate for other treatment options if the recovery is not as expected- such as re-evaluating the operated or diseased sites.

Surgical procedures- permanent tracheostomy
Permanent tracheostomy is indicated for end-stage upper airway diseases. It is imperative that owners are aware of potential complications and the need for long-term care by the owners. Many pet owners are not going to be willing to elect to proceed in my experience. Acute obstruction is the most common postoperative immediate complication. Stenosis is common and expected-therefore adequate stoma size must be created at surgery. The site must be cleaned frequently after surgery to avoid crusting that can irritate the stoma and cause stricture or obstruction. Long-term, cleaning is less intense but the hair around the site must be kept short. Excess skin folds can irritate or obstruct and sometimes need to be resected surgically. Patients cannot swim and must be kept in clean environments. Neck leads are abandoned and harnesses are used.

Procedure tenets common to all successful stoma surgery are providing a tension-free anastomosis, creating skin-to-mucosa apposition, and minimizing motion or other irritation of the stoma.

The patient positioning and prep are the same as for tracheotomy. Prior to surgery, evaluate the skin of the ventral neck. If the skin is loose or saggy, plan to remove an ovoid section of skin to compensate. Otherwise, the skin folds will cover or obstruct the stoma. If possible, place an orotracheal tube with the tube tip caudal to the proposed tracheostomy site for anesthetic maintenance. Initial surgical approach is also the same. Excise the ventral half of the tracheal cartilage over 3-4 rings. Incise the mucosa left behind. Sutures between the subcutaneous or dermis and the cartilage can stabilize and minimize tension and motion. The mucosa is excised to create a window that allows suturing the skin to the mucosa using a fine monofilament suture in either a simple interrupted or continuous pattern. Recovery and postoperative care is similar to tracheotomy patients.
Brachycephalics: How Can We Protect Them?
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Brachycephaly is defined as having a “short wide head”. The ratio of skull length: width is calculated and if <1.44, brachycephaly is defined. Selective breeding has caused breed-specific airway problems.

The Brachycephalic Obstructive Airway Syndrome (BOAS) is defined by multiple lesions. The primary lesions are stenotic nares, elongated and thickened soft palate (traditionally only palate length was considered), tracheal hypoplasia, and caudally displaced turbinates. The commonly considered secondary or acquired lesions are eversion of the laryngeal sacculae and laryngeal collapse. There are several other lesions that will be discussed.

The breeds commonly affected are English Bulldog, French Bulldog, Pug, Boston terrier, Pekingese, Shih Tzu, Pomeranian, Boxer, and the Persian cat. The English Bulldog is the only one commonly affected by tracheal hypoplasia.

Airflow concepts are important to understand in regards to respiratory physiology. Poiseille’s law is a fluid dynamics physics equation describing fluid flow through a tube. Basically, air (a fluid) can be viewed as flowing through various parts of the respiratory system using this equation. The equation is:

\[ Q = \frac{\pi P r^4}{8 n l} \]

- \( Q \) is flow rate
- \( P \) is the pressure in the tube
- \( n \) is the fluid’s viscosity
- \( r \) is the radius of the tube
- \( l \) is the length of the tube

Important concepts to take away from this equation is that changes in a tube’s radius size has a dramatic effect on airflow. Changes in the radius affect flow to the 4th power. For example, a decrease in the radius by a factor of 2 (half the radius) decreases the airflow by a factor of 8! This is more apparent in the smaller patients as the small airways can experience more dramatic changes in lumen size. This increases pressure and these pressure changes stress respiratory system’s physical structure and can damage or collapse them. The areas of the most flow are in the small passages such as the nares or larynx.

Primary components
The nares are the entrance of airflow into the body. These areas are often very affected in brachycephalics. This is a commonly overlooked and undertreated part of BOAS. The alar folds are medially displaced and either partial or complete close the nasal meatus. This can be a static or dynamic lesion. In some animals, the nasal wing can be seen to actively medially move during inspiration in response to negative pressure and pinch the nares.

The soft palate length affects respiration by obstructing the nasopharynx and rima glottidis and interfering with closure of the epiglottis. The former is a cause of airway obstruction and the latter can cause aspiration and explains some of the coughing and gagging clinical manifestations. More recently, the thickness of the palate has been studied in CT studies by Grand and Bureau. The palates in clinically affected animals were significantly thicker than unaffected patients. Cross et al examined histologic specimens of resected palates and found salivary hyperplasia, palatine muscular atrophy, and lamina propria atrophy.

Caudally displaced nasal conchae (also referred to as “nasopharyngeal turbinates”) have been noted in affected animals. They occur in about 20% of brachycephalics and 82% of those were pugs (Ginn et al.). This displacement causes a caudal obstruction of the nasopharynx. This may be a previously underdiagnosed reason for poor recovery in some animals treated with conventional means.

Tracheal hypoplasia is primarily a disease occurring in English Bulldogs. The common method of diagnosis is from lateral thoracic radiographic projections. In this view, the dorsoventral thoracic inlet height is compared to the tracheal diameter. The ratio is calculated and normal ratio is 0.20. A ratio of 0.16 is typical in the brachycephalic breeds and most Bulldogs are at 0.11-0.10. There is currently no treatment but should be recognized and can cause marked respiratory compromise.

Secondary components
The sequelae to breathing through undersized airways, is physical damage to structures of the larynx. These changes are permanent and may occur early in disease (reported as early as 6 months of age). This is the laryngeal collapse component. This is diagnosed on sedated or anesthetized per os laryngeal examination. Laryngeal collapse is described in stages. Stage I is comprised of eversion of the laryngeal sacculae. The sacculae evert out of their crypts and then obstruct the ventral rima glottidis. Initially, they are translucent and soft. With chronic eversion, the sacculae become firm and fibrotic. Often, sacculle eversion is described as an entity unto itself, but is the first stage of collapse. Medial tipping of the corniculate processes of the arytenoid is stage II. Stage III is defined by contact of the opposing corniculate processes and loss of the dorsal arch of the rima glottidis. This can be diagnosed in young animals and is not a reversible condition. In pugs, the cartilage seems to be softer and may actually be a primary condition. Caccamo et al compared rima
glottis indices between English Bulldogs, French Bulldogs, and Pugs. Their study found pugs to have the smallest laryngeal openings overall.

Several other conditions and markers of disease have been studied. Increased circulating inflammatory markers such as Tumor Necrosis Factor, Interleukins, and Cardiac Troponins have been identified in affected dogs. Also, gastrointestinal lesions such as gastroesophageal reflux, esophagitis, pyloric mucosal hypertrophy, and hiatal hernias may occur secondary to chronic upper airway obstruction. Chronic hypoxia will induce pulmonary hypertension. Additionally, bronchial collapse is reported in some dogs that have laryngeal collapse.

Presentation and diagnostics

Historical information can be useful in identifying at-risk patients. Important questions to ask are regarding previous anesthesia problems, loud or labored breathing (at rest or with exertion), exercise tolerance, cyanosis, collapse, gastrointestinal symptoms (vomiting, regurgitation, hacking or gagging when eating or drinking, spitting up foam, difficulty eating due to poor nasal breathing). When taking a history, look for signs of respiratory compromise and interference with glottis, esophageal, and laryngeal function.

Initial exam should always be based on patient stability. Abbreviate the exam and provide airway support or intubation if in clinically warranted. Start by watching the patient breathe at rest and without direct interaction. Make observation about respiratory effort and noise. Is the typical nasal stertor heard? Stertor is defined as “a low-pitched heavy snoring inspiratory sound” and is contrasted by stridor as being “a high-pitched noisy sound”. I will then perform my routine exam and then return to focus of the face and head. Some animal will resent this and more handling thereafter may not be tolerated. Examine for airflow from the nares (independently). Also, look at the nares and evaluate for medial displacement of nasal wing during inspiration. If the patient does not nose breath on its own, close the mouth and observe for changes in effort and noise. If these increase, nasal or nasopharyngeal obstruction is suspected. Increased inspiratory effort is typically seen with the obstructive airway diseases. Some animals will also have cardiac or lower airway disease concurrently.

In patients with little clinical signs, medical management may be recommended. This typically consists of weight reduction and environmental modifications to avoid heavy exertion and exposure to hot and humid clients. Antacids, anti-emetics, and gastroprotectants therapy may be initiated and evaluated for response. These patients can have airway examinations electively- this is very reasonable to plan coinciding with elective neutering. Animals with clinical signs should be evaluated further.

Stable patient may be electively worked up after appropriate pre-anesthetic testing. Age-appropriate ASA guidelines should be followed with the addition of thoracic and possibly cervical radiographs. Set up with a wide variety of endotracheal tubes and have several undersized tubes available. Use of a pair of laryngoscopes is often helpful to move tissues of the oropharynx and larynx as well as provide more light. Malleable retractors can also be helpful in retracting the tongue or soft palate. Pre-oxygenate patients to avoid hypoxia. I routinely use of anti-emetic and gastroprotectants to minimize the incidence of nausea, vomiting, or regurgitation. I recommend setting up for potential tracheostomy prior to sedating or anesthetizing.

Routinely, per os visual exam can be performed to evaluate the components of the upper airway. I typically do this under a very light plane of anesthesia to allow a functional laryngeal exam and then use a deeper plane if the exam is hampered by patient motion or resentment. In cases where lower airway disease is also suspected, bronchoscopy may be indicated. To evaluate the nasal conchae, CT scan and possibly rhinoscopy is recommended.

The soft palate should not extend past the caudal borders of the tonsils and should not interfere with the epiglottis. Look for inflammation and thickening of the palate. Avoid applying over-vigorous traction on the tongue, as it will displace the larynx and epiglottis rostrally, which could affect palate length assessment. The larynx and sacculles are evaluated for collapse and inflammation.

Surgical treatments

Nares resection is typically the first procedure I perform. It is the least demanding technically. For some reason, this procedure is overlooked and underutilized. These small airways can create a lot of resistance and are the entry point of the respiratory tract. I typically use a vertical wedge resection technique in the majority (maybe 90%) of routine cases. In very small patients (and cats), I prefer Trader’s technique (wing amputation) for improved cosmesis and less complicated healing. Horizontal wedge resection, punch technique, and alapexy have all produced successful results.

Soft palate reduction (staphylectomy) procedures are typically aimed at reducing length of the palate to an imaginary line at the caudal border of the tonsils or to provide minimal or no contact with the epiglottis. It is important to pay attention to patient positioning for adequate visibility. Use of a head mounted lamp is advantageous. Long-handled instruments are very helpful. Make sure the patient is at an adequate plane of anesthesia to avoid inducing vomiting during manipulation. Do not underestimate the amount sensory stimulation produced by manipulating the soft palate! I prefer to place the patient in sternal recumbency with the head elevated by suspending by the maxilla and using a mouth speculum. Alternatively, the lower jaw may be taped or tied down to keep the mouth open. The tongue needs to be tractioned gently rostrally. Some surgeons perform this procedure with the patient in dorsal recumbency.
Shortening of the palate may be accomplished in the following manners:

- by cutting with scissors and suturing (so called “cut and sew” technique)- my preference
- vessel sealing devices (Ligasure and Harmonic scalpel)
- CO2 laser
- Diode laser
- Electrosurgery

All can produce satisfactory results. There is significant postoperative inflammation with the use of vessel sealing devices, lasers, and electrosurgery. Diode laser seems to produce more complications than the other methods. Despite being the slowest method, cut and sew is my preference. When using the other techniques, minimizing power to decrease delayed thermal injury and necrosis.

More recently, a technique call “folding flap palatoplasty” has been described by Findjie and Duprie. This method both decreases palate thickness and length. It also has an advantage of not leaving a cut mucosal edge exposed at the edge of the palate. The procedure incises the oral palatal mucosa and dissects the palatal muscle. A flap is developed with a caudal base extending to the caudal palate. The flap is retracted rostrally and the resection length is determined once the folding creates the desired length. The edge is resected and the flap sutured in place. This technique worked well in their study and is likely to gain wider use and acceptance.

Everted saccules are resected when they are deemed obstructive. I am much more likely to remove chronic appearing saccules than acutely everted saccules. Removed saccules can regrow. They are typically removed by gasping them and excising them at their base. Once I have removed saccules, I am much more observant for potential need for tracheostomy placement in the postoperative period.

Laryngeal collapse carries a guarded prognosis and there are no universally accepted treatment techniques other than permanent tracheostomy. Arytenoidectomy, vocal cordectomy, and arytenoid lateralization techniques have all been attempted with varying success. Permanent tracheostomy is a palliative measure that provides successful outcomes in selected cases.

Laser-Assisted-Turbinatectomy (LATE) has been reported by Schuenemann et al to remove the obstructive turbinates in affected animals. These animals had excessive contact between adjacent turbinates. After removal, regrowth is expected but a more “clubbed” pattern occurs and results in less contact, which is less obstructive.

**Postoperative care**

Attention to analgesia and relaxation is important to minimize stress and respiratory effort. Oxygen support is provided as needed. There is a delicate balance that must be struck between adequate levels and avoiding over-sedation and potential aspiration. Cooling with a fan is helpful in some patients. In some patients, they are calmed by the noise and airflow provided by the fan. I advise aggressive antiemetics, gastroprotectants, and promotility agents to minimize aspiration risks. These patients must be closely observed as they may rapidly deteriorate. Airway re-obstruction is the most concerning complication and must be treated with re-intubation and possibly tracheostomy (see my other lecture) when severe. I typically hospitalize for at least 24-48 hours. In patients that are more severely affected with clinical signs, I expect longer hospitalizations and am on-guard for complications.

In patients with poor recoveries, I evaluate for aspiration pneumonia, laryngeal collapse, eversion of resected saccule edges, postoperative swelling of the palate, and nasal obstruction (swelling or blood).
Gallbladder Mucocele: Incidental or Surgical?
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Indications
Surgery of the extrahepatic biliary system is relatively common in small animal referral practice. The most common indications are obstructive or inflammatory lesions of the biliary tree such as pancreatitis, cholelithiasis, tumors, and gallbladder mucocele. Other indications are traumatic ruptures (either external trauma or iatrogenic). Most indications for biliary surgery are for acquired lesions. The goals of surgery are to confirm a diagnosis and establish biliary patency.

Pertinent anatomy
It is paramount to have a detailed understanding of hepatobiliary anatomy prior to further discussion of disease. For meaningful interpretation of imaging or surgical findings, this fact cannot be understated. It is wise to refer to anatomy texts as needed.

The lobar ducts exit the liver lobes as the hepatic ducts. These converge and continue as the common bile duct (CBD) with the cystic duct exiting to the side ending at the gallbladder. The point where the cystic duct arrives is the end of the hepatic ducts and is henceforth called the CBD. For size reference, this structure is approximately 2.5 mm in diameter in a medium-sized dog. The gallbladder resides between the quadrate and right medial liver lobes in the hepatic fossa.

The CBD continues to its termination at the major duodenal papilla (MDP). The CBD enters the mesenteric side of the proximal duodenum and courses 1-2 cm in the wall until it emerges at the MDP. The MDP is located about 3-6 cm aboral to the pylorus. In the dog, the pancreatic duct joins the CBD at the MDP but in the cat the CBD and the pancreatic duct join prior to emptying together at the MDP. Also, a minority of cats possesses a minor duodenal papilla (emptying of accessory pancreatic duct). Hence, pancreatic obstruction is very common with obstructive feline biliary disease. The gallbladder and CBD derive blood supply from the left branch of the hepatic artery. Damage to this vessel can cause ischemic necrosis of these structures.

The CBD courses with the portal vein and hepatic artery at the epiploic foramen. This foramen is bounded ventrally by the aforementioned structures, dorsally by the caudal vena cava, and medial to the caudate liver lobe. Digital occlusion of the portal vein and hepatic artery produces inflow occlusion known as the “Pringle maneuver”- this maneuver is used as an emergency procedure to arrest hemorrhage from the liver.

Clinical presentation and diagnostics
Symptoms of extrahepatic biliary disease are generally vague and nonspecific. Vomiting, anorexia, and lethargy are common complaints in patients with mucoceles. Like many other diseases in small animal practice, many animals may present late in the course of their disease. In many reports, Shetland Sheepdogs, Cocker Spaniels, Miniature Schnauzers, Pomeranians, and Chihuahuas are overrepresented.

Clinically detectable icterus develops with serum bilirubin concentration at 1.5-2.0 mg/dl and higher (Eddlestone). In humans, there is significant interobserver variability in this ability with about one-third of cases in one study of examiners missing “clinically detectable” icterus (Ruiz, et al., Mil Med 1997). Patient skin color, ambient lighting, and the presence of anemia may affect the detection of icterus. Observation of acholic feces with icterus is highly suspicious for bile duct obstruction but, unfortunately owners may not note this and anorexic animals do not produce much feces. Bilirubinuria should prompt further investigation, as it can be a very early sign of bile duct obstruction.

Diagnostic testing
Comprehensive laboratory testing such as complete blood counts, chemistry profiles, pancreatic enzyme testing, and coagulation profiles are indicated. Blood typing and assessing the availability of compatible blood products is advised especially if surgery is planned. Based on availability and recent data (see below), point-of-care blood lactate testing should be considered. Laboratory findings with biliary disease are typically elevation of liver enzymes, bilirubin, and cholesterol. Bilirubinuria and bilirubin crystals are noted in urinalysis. Prothrombin Time (PT) elevation takes time to occur – about 10-14 days after complete biliary obstruction due to short half-life of Factor VII.

Imaging is indicated in animals with suspected liver disease. Radiographs are indicated of thorax based on age-appropriate for ASA-standards, if cardiopulmonary disease is suspected, or if malignancy is suspected. Abdominal ultrasound is very useful in assessing the liver and biliary tract as well as for obtaining ascites fluid or aspirating masses. Due to the widespread availability and non-invasive nature of testing, this is the most widely used modality to assess the liver in both human and animal medicine. Ultrasound was used to confirm mucoceles in ~75% of cases (Malek et al.) with a classic appearance of a stellate or striated
appearance and immobility of the bile. Biliary obstruction can be diagnosed via ultrasound early and before onset of clinical icterus. Repeating ultrasound may be warranted in stable cases.

Ascites fluid is important to evaluate and analyze if present. This is facilitated with ultrasound guidance especially if there are only small volumes present. Elevation of fluid bilirubin concentration greater than twice that of blood levels is diagnostic for bile peritonitis (Owens et al., Ludwig et al.) Bile peritonitis tends to produce a large volume of ascites fluid due to the hyperosmolar nature of the bile salts and may contribute to hemodynamic instability. It is paramount to determine if bile peritonitis is sterile or septic - the latter requires emergency surgery and carries a significantly less favorable prognosis (see below)

**Prognostic indicators**

Preoperative elevations in GGT, phosphorous, bilirubin, PT and azotemia and decreased albumin are risk factors for mortality with biliary surgery (Mehler et al). Based on blood count data, non-survivors of mucocele surgery had significantly higher leukocyte and band counts.

If septic bile peritonitis is diagnosed, emergency surgery is needed and this also has a negative impact on mortality when compared to sterile bile peritonitis (27-45% survival compared to 87-100%).

Based on several studies, collectively, extrapleural biliary tract surgery mortality ranges from about 28-63%. Approximately 80% of patients survive in the series by Pike et al. In the 2013 Malek et al study that focused only on mucoceles, there was only a 7% immediate (<2 weeks) mortality rate with cholecystectomy surgery. In this study, postoperative hypotension, anemia, and elevated serum lactate were found to be significant risk factors for mortality. More specifically, hypotensive patients were 20 times more likely to die and animals with elevated serum lactate were 30% more likely to die for each 1 mmol/L increase of lactate. The MST was never reached in this study- this means that after the initial loss of about 25% of the patients, the decrease in surviving patients was so slow, they never reached a MST for the study duration. This implies that survival past the postoperative period carries a good prognosis. There is a paper that suggests that the mucocele can be treated medically using ursodiol, antioxidants, and H2 blockers (Walter et al.) but there were only two dogs in this study.

**Initial treatment**

Patients that are severely debilitated warrant very thorough evaluation and stabilization. Failure to assess patients thoroughly preoperatively can result in very poor anesthetic and postoperative outcomes.

Severe dehydration is common needs to be corrected with intravenous fluid therapy. Unless there is a need for emergency surgery, this is corrected gradually. Electrolyte and acid-base abnormalities need to be addressed. Anemia and hypoalbuminemia are common and will be worsened (especially in the dehydrated patient) after fluid resuscitation especially if crystalloids use is overzealous. Use of colloids (Vetstarch, Hetastarch, albumin products), Fresh frozen plasma (in coagulopathic patients), or erythrocyte transfusions may be needed. Vitamin K1 supplementation is indicated with obstructed patients, especially with chronic obstruction or prolonged PT. Establishing hemodynamic stability is important to potentially avoid the above stated postoperative complications that lead to poor prognosis. Nutritional support is very important and should established early in treatment.

**Surgical conditions and treatments**

Recommendations are highly variable and no universal agreement exists on timing or rationale for surgery except with septic bile peritonitis being a “true” emergency. In general, the mucocele patient should be taken to surgery for once diagnosed. Cholecystectomy and bile duct catheterization is typically performed. If biliary patency cannot be confirmed, permanent diversion is needed (cholecystoenterostomy) is needed. Depending on the clinical signs and clinician preference, an enteral feeding tube may be needed. Placing a tube distal to the pancreas is may be needed to avoid further stimulation of the pancreas in cases of severe pancreatitis.

With gallbladder mucocele, the gallbladder mucosa becomes hyperplastic and over-secretes mucus which, over time becomes an inspissated, firm mass. This increased bile viscosity prevents normal emptying and promotes bilious accumulation. The mucus can become obstructive in the CBD or hepatic ducts. This mucus needs to be flushed as thoroughly as possible at surgery. The gallbladder was ruptured in 37% of cases- this was found during surgery or evidence of previous rupture (Malek et al.). Rarely, large mucocoeles are found free in the abdomen at surgery. Rupture of the gallbladder does not preclude a positive outcome but septic bile peritonitis carries a more guarded prognosis. The gallbladder bladder wall can become quite thin and friable. Cholecystoenterostomy has been used successfully (if needed due to lack of bile duct patency) but concerns exist for recurrence due to the abnormal mucosa that caused the mucocele remaining in the patient.

In all cases, bile or tissue should be submitted for culture. The sample should be collected at the time of incision (if possible) because additional contamination is likely during the procedure as enterotomy is typically part of the surgery. Samples of liver, gallbladder bladder, and small intestine are usually collected for histopathologic exam. Other tissues can be collected, as indicated. Most cultures from mucoceles are negative but perioperative antibiotic use may preclude positive culture. Perioperative antibiotic use has shown decreases in morbidity and duration of hospitalization in humans (Lippert and Gastinger).

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Procedures
For successful biliary tract surgery, good lighting and delicate instrumentation must be available. Use of magnification is also helpful especially with cats and small dogs. Attention to anatomy and careful assessment of the initial findings as well as the response to intraoperative maneuvers is imperative for success. Also, allow time for these surgeries, as they can be time-consuming.

Mobilization of the gallbladder from the hepatic fossa is needed for cholecystectomy, cholecystostomy, and cholecystoenterostomy. In human medicine, vagal stimulation-induced bradycardia and collapse are reported with relatively minor manipulations of the gallbladder—thus, it is sensible to gently manipulate an inflamed or distended gallbladder. Distended gallbladders are typically removed more easily than a ruptured one. Omental adhesions may need to be transected or removed. A small incision between the gallbladder and the parenchyma of the hepatic fossa is started with small hemostats, scissors, or cotton-tipped applicators (CTA). The dissection is continued with blunt dissection using blunt instruments (suction tip, CTA, the back end of a scalpel blade handle, fingers, etc.). It is important not to stray into the parenchymal as much more bleeding will occur. Not surprisingly, this hemorrhage seems to be much more problematic in small dogs and cats. The dissection must continue to the cystic duct junction. This is needed to mobilize the gallbladder for tension-free enterostomy or proper cholecystectomy.

Once the gallbladder is mobilized, an incision is made on the apex and suctioning and sample collection is performed. Stay sutures of fine (4-0 to 6-0) or Babcock forceps are used in combination with accurate suctioning and pre-placed laparotomy sponges. This is much easier with an assistant. Mucocele contents can be very difficult to suction and control due to the viscosity of the contents. In cases of mucocele with CBD obstruction, it is worth initially catheterizing the MDP to ensure some patency and then excising the gallbladder with the mucocele still inside (to avoid the big mess) and then flush extensively. However, it can be more difficult to suture the stump this way. This is not recommended when evidence of biliary obstruction exists because diversion may be needed and is not reasonably possible once the gallbladder has been removed. With choleliths, they are vigorously lavaged. They can sometimes be palpated with fingers or by their obstruction to passing of catheters. Flushing should not be overly vigorous as damage to the duct could occur. Cholecystectomy is performed with double ligation of 1-2 nonabsorbable sutures. Placement of a closed drainage system is advised with peritonitis or significant intraoperative contamination.

Evaluation of the MDP and CBD is recommended in most procedures. A sharp incision into the duodenum on the antimesenteric surface approximately 3-6 cm distal the pylorus is needed. I typically will collect a duodenal biopsy by excising a full-thickness sample after the enterotomy. In cases with choleliths or masses at the MDP, it is relatively easy to follow the CBD to where it dives into the wall of the duodenum. With higher obstructions or other disease (like a mucocele), it may not be so obvious. It is important to gently handle the intestines as well as avoiding traumatizing the adjacent pancreas. Appropriate sized catheters in cats and small dog and cat are 3.5 to 5 Fr but can be quite large in dogs. Passing catheters from the gallbladder side (normograde) is more difficult.

It is advised with peritonitis or significant intraoperative contamination. For successful biliary tract surgery, good lighting and delicate instrumentation must be available. Use of magnification is also helpful especially with cats and small dogs. Attention to anatomy and careful assessment of the initial findings as well as the response to intraoperative maneuvers is imperative for success. Also, allow time for these surgeries, as they can be time-consuming.

Mobilization of the gallbladder from the hepatic fossa is needed for cholecystectomy, cholecystostomy, and cholecystoenterostomy. In human medicine, vagal stimulation-induced bradycardia and collapse are reported with relatively minor manipulations of the gallbladder—thus, it is sensible to gently manipulate an inflamed or distended gallbladder. Distended gallbladders are typically removed more easily than a ruptured one. Omental adhesions may need to be transected or removed. A small incision between the gallbladder and the parenchyma of the hepatic fossa is started with small hemostats, scissors, or cotton-tipped applicators (CTA). The dissection is continued with blunt dissection using blunt instruments (suction tip, CTA, the back end of a scalpel blade handle, fingers, etc.). It is important not to stray into the parenchymal as much more bleeding will occur. Not surprisingly, this hemorrhage seems to be much more problematic in small dogs and cats. The dissection must continue to the cystic duct junction. This is needed to mobilize the gallbladder for tension-free enterostomy or proper cholecystectomy.

Once the gallbladder is mobilized, an incision is made on the apex and suctioning and sample collection is performed. Stay sutures of fine (4-0 to 6-0) or Babcock forceps are used in combination with accurate suctioning and pre-placed laparotomy sponges. This is much easier with an assistant. Mucocele contents can be very difficult to suction and control due to the viscosity of the contents. In cases of mucocele with CBD obstruction, it is worth initially catheterizing the MDP to ensure some patency and then excising the gallbladder with the mucocele still inside (to avoid the big mess) and then flush extensively. However, it can be more difficult to suture the stump this way. This is not recommended when evidence of biliary obstruction exists because diversion may be needed and is not reasonably possible once the gallbladder has been removed. With choleliths, they are vigorously lavaged. They can sometimes be palpated with fingers or by their obstruction to passing of catheters. Flushing should not be overly vigorous as damage to the duct could occur. Cholecystectomy is performed with double ligation of 1-2 nonabsorbable sutures. Placement of a closed drainage system is advised with peritonitis or significant intraoperative contamination.

Evaluation of the MDP and CBD is recommended in most procedures. A sharp incision into the duodenum on the antimesenteric surface approximately 3-6 cm distal the pylorus is needed. I typically will collect a duodenal biopsy by excising a full-thickness sample after the enterotomy. In cases with choleliths or masses at the MDP, it is relatively easy to follow the CBD to where it dives into the wall of the duodenum. With higher obstructions or other disease (like a mucocele), it may not be so obvious. It is important to gently handle the intestines as well as avoiding traumatizing the adjacent pancreas. Appropriate sized catheters in cats and small dog and cat are 3.5 to 5 Fr but can be quite large in dogs. Passing catheters from the gallbladder side (normograde) is more difficult.

If there is significant inflammation or pancreatitis is present, placing a temporary stent into the CBD is recommended. This is accomplished by suturing a catheter that has been placed through the MDP into the CBD in place. A section of catheter is cut off (I typically bevel the end slightly) and sutured into place using a fine absorbable suture through the side of the beveled edge of the catheter and into the submucosa of the duodenum caudal to the MDP. A few centimeter of the catheter are exiting into the bowel lumen and the proximal edge should reside cranial to the area of concern. Additional fenestrations can be made in the catheter. The catheter should not fit tightly as flow is thought to be around stents and not through the lumen. If permanent stenting is needed, non-absorbable suture is used. The technique has better results in dog than cats (Mayhew et al.). It is less technically demanding than biliary diversion.

Cholecystoenterostomy is recommended when biliary patency cannot be established or confirmed. Ideally, the duodenum should be the site chosen for the enterostomy, as it is more physiologic. The gastric acid needs to be buffered by the bile as it exits the stomach as soon as possible, otherwise, duodenal ulcers will develop. This procedure is typically used with pancreatitis, post-pancreatitis fibrosis, and tumors. The gallbladder is mobilized as previously described and a cholecystotomy and duodenotomy (over the MDP) are performed. The incisions should be similar in size. Samples of both structures are collected. A simple continuous appositional suture pattern using fine monofilament suture is placed on the “far” side first, followed by another similar closure on the near side. The stoma size should be more than 2.5 cm in length. Use of fine taper point needles is recommended. Additional sutures are recommended near the “crotch” of the anastomosis to relieve tension. Two-layer closures have been reported but likely further reduce the stoma size. A technique described by Morrison et al. used an EndoGIA30 (Covidien) for rapid anastomosis. This technique works well and is quickly performed. A few sutures are needed to close the distal end of the anastomosis and again for the “crotch”. This is a bit more expensive due to the cost of the staplers, but saves significant surgical time especially with less experienced surgeons.

Postoperative care
Care of these patients is often prolonged and intense. Typically, this consists of fluid therapy, pain management, gastroprotectants, anti-emetics, and nutritional care in all patients. Close monitoring of patient stability with close attention to blood pressure and blood lactate are important as previously stated.
Types of modalities include thermal packs, therapeutic ultrasound, range of motion, massage, aquatic therapy, neuromuscular electrical stimulation, and laser.

Cryotherapy is used for 24 to 72 hours after injury, after exercise during rehabilitation and before laser sessions. It needs to be applied for 15 to 25 minutes several times daily. It penetrates deeper than heat. The Potential Benefits are that it reduces inflammation, Edema formation, Muscle spasms, and Pain. Precautions should include always placing insulation between cold pack and skin and inspect skin every few minutes.

Superficial Heat is most often used after acute inflammation has resolved. It can be used before exercise to reduce joint and muscle stiffness. It is generally used for 15-20 minutes and penetrates approx. 2cm. Potential Benefits include that it reduces pain, inflammation, muscle spasms and relaxes muscles. It also increases blood flow. Precautions include monitoring the site of hot pack before, during and after use and use some type of insulation, like a thin towel.

Muscle stiffness. It is generally used for 15-20 minutes and penetrates approx. 2cm. Potential Benefits include that it reduces pain, inflammation, muscle spasms and relaxes muscles. It also increases blood flow. Precautions include monitoring the site of hot pack before, during and after use and use some type of insulation, like a thin towel.

Dogs should never be left alone when using any type of heat application.

Therapeutic Ultrasound has sound waves are produced within a transducer along with heat to produce local heating of deeper tissues. The typical duration of treatment is short, approx. 10 minutes. However, hair must be clipped. Potential benefits include causing vasodilation, increased oxygen and nutrients to the area, as well as flushing of cellular waste products. Precautions: you can overheat or burn deep tissues. Indications: Tendonitis and bursitis, Joint contracture, Sprain or strain, Pain and muscle spasms, and Edema.

Massage uses physical touch for physical and emotional well-being. Usually it lasts 10-15 minutes each session up to 2-3 times a week. Potential Benefits: Improved circulation, Relaxation and tension relief, Helps drainage, Emotionally bonding, Pain relief from chronic pain through endorphin release. Precautions: Massage around NOT directly on a painful joint.

And Deep massages should be followed with cryotherapy.

Passive Range of Motion Patient should be relaxed and comfortable. The movement should be gentle to not create pain or discomfort. Should be performed 2-6 times daily. Potential Benefits: Decreases pain, Helps to prevent joint contracture, Improves synovial fluid production, and Enhances blood and lymphatic flow. Indications: Most commonly used immediately post-op.

Aquatic Therapy has several positive unique benefits; Buoyancy, Great for dogs with neurological conditions or obesity, Decreases loads on injured tissues, Less painful than land exercises. Precautions: Never leave dog unattended. Use a life vest in pools, Discontinue if dog thrashes. Indications: Muscle endurance, Strength, Range of motion, Agility, Psychological well-being.

Electrical Stimulation (Estim or TENS) is really multiple modalities and strengths depending on the settings and how the electrodes are placed. You must shave hair, +/- Muzzle or slight sedation during acclimation. If you have multiple channels you can do flexors & extensors in one session.

When using e-stim for neuromuscular dysfunction the goal is to depolarize a motor nerve to cause a muscle contraction. When using e-stim for pain management the goal is to depolarize sensory nerves to suppress pain. Precautions: DO not use over pacemakers, in animals with seizure disorders, over infected areas, over the trunk during pregnancy or any time active range of motion is contraindicated. Also, be cautious in areas of skin irritation or damage. Indications:

Muscle atrophy, Muscle strength, Range of motion, Edema, Chronic/Acute Pain.

Laser, aka Low-Level Laser Therapy should have a cold pack prior to treatment. Most units contact skin with handheld probe, perpendicular to the lesion. Hair absorbs 50-90% of light and should be considered when creating protocols. It should be applied in a grid-like fashion with the dose prescribed. In general it is controversial with minimal research to-date with regards to the optimal wavelength, intensities and dosages. Potential Benefits: Cause cellular oxygen production, Increase cellular permeability, Increase cellular metabolism and growth, May increase endorphin release, May block pain transmission to brain. Indications: Wound healing – stimulates fibroblasts, Pain. Is has been described to stimulate muscle trigger points and acupuncture points. There are good OA studies in humans show improvement 2 months to 1 year after a 10-14 day protocol.

Benefits include increased blood flow, reduced inflammation, reduced muscle atrophy, pain control and reduced periarticular contracture. Caution must be used to remember discomfort counteracts the goals of PT. Also owner compliance will diminish if pain is perceived. All rehabilitation should be in a controlled setting, on a short leash, with good footing. Animals should never be left unattended in pool/bathtub. Assessing outcomes should be performed regularly with objective measurements including measuring joint flexion and extension and muscle mass. Body condition, pain (lameness, touch, Glasgow or Rankin) should also be documented. Despite best treatments, some conditions are so serious complete recovery cannot be expected Rehabilitation goals need to be realistic and protocol adjusted if needed.
Postoperative Care for the Neurologic Patient
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While we care for all our patients, neurologic patients have special circumstances that require special attention. They often need help ambulating into and around the hospital. While they may be able to walk outside with good traction, slick hospital floors are often very difficult for them. Whether you need to use a gurney, sling or carry the patient, be prepared before surgery.

Common neurologic conditions include disc rupture, fractures, nerve or brain tumors and seizures. Depending on the type of disease, stage of healing, type of surgery and size of your patient, the intensity of your patient care will vary. Being able to adequately assess your patient, so you can advocate for them is critical. Knowing the proper order of losing and regaining nerve function is paramount. You need to also realize control of ambulation and urination, usually happen together. Meaning, if they cannot walk, it is unlikely they have control of their bladder. Also being confident in your pain assessment is important. When you pinch the toe and they pull the leg back, was there a conscience response or was it simply a withdrawal reflex? Since pets without deep pain have a much different prognosis and need more care, this is a critical assessment for improvement or worsening status.

When patients cannot walk, they usually cannot urinate on their own. They need their bladder expressed frequently and completely to avoid it overstretching and to prevent infection. If they bladder cannot or should not be expressed (ie Pelvic fractures) a urinary catheter should be placed. Bladder expression can often be difficult for us. That means it is even harder for the owner. Properly overpowering the bladder with a slow but steady pressure from your flat hand is vital to success. The bladder should be emptied completely at least 2-3 times a day. Also using the right drugs when needed to help with tight sphincters and to coordinate the detrusor muscle. Often as the animal improves or the owner gets better at expressing the bladder, the medication can be decreased or discontinued. But in order to gain owner confidence and compliance, I usually use diazepam, phenoxybenzamine and bethanecol earlier to avoid a therapeutic delay and creating owner frustration. A frustrated owner with a paralyzed pet than cannot urinate can lead to rash and permanent decisions.

There are many commercially available carts and slings for pets that are paralyzed or simply need a little help balancing. If an owner is resistant, showing them a current patient or some UTube videos will often alleviate their concerns. Neurologic dogs are often happy and ready to play, they just need some help. And by having the proper tools, the owner’s back can be saved with big dogs, or even very short ones. Since carts are custom and often nonreturnable, I suggest you picking a brand or two and offering as a service to measure the pet for the proper cart. When the cart is delivered, have them come in for a fitting before the pet is allowed to use the cart. This will avoid any rubbing spots or frustration from to owner not being able to get the dog into it by themselves. Many pets first walk backwards in the carts, but can usually be trained quite well with either food or a toy to walk forward, turn and even run or retrieve in a wheelchair.

Once the pets are up and about in a wheelchair, or perhaps you are assisting them in a sling, you need to watch their feet. Since they may have an issue with proprioception; knowing where their feet are in space. This makes them more likely to have scratches, cuts or wounds on their feet. There is also a lower than normal circulation in neurologic extremities, so they will be slower to heal once a wound has formed. Prevention is the best option with booties, wraps and avoiding walking on abrasive surfaces. For instance, encourage walks in the grass versus on the sidewalk.

Seizures are also something that can happen postoperatively in a neurologic patient. There may be diagnostic reasons, like a myelogram, or perhaps the patient already had a history of seizures. Knowing your patient, their medications and how to react are critical. First, stay calm. You should call their name to look for a response, move any loose objects away from them and quiet the room. You should also look at a clock to note the time, how long the seizure lasts and if you noticed any triggers that set the animal off. Once the seizure has finished, also watch to see how long before the animal looks normal. The recovery period afterwards can vary. How you medically treat the seizure will depend on the condition and the animal’s current medications. But there are several options for idiopathic seizures and a combination approach is often used to reduce potential side effects like sedation, or liver damage.

When neurologic patients are totally recumbent, balls and hoists can help you lift them to keep them alert, feed them and help them obtain a more normal posture for defecation. Getting them up and outside not only helps them mentally but also helps prevent lung atelectasis and bed sores. Bedding and cleanliness to prevent pressure sores and urine scald are vital in these more severely affected patients. Just cleaning their bedding it not enough. Cushions between their legs, flipping sides down and moving them around helps their skin, joints and attitude. They should be cleaned regularly with a dry shampoo and bathed every few days. Knowing the hips, elbows, tail bone and hock are the most common places for pressure sores should be known by all. The best way to treat a bed sore is to prevent it. It starts with simply warm skin, then once it becomes red you need to start treating it as soon as possible. If you have hair loss or discharge from the skin, you are losing the battle. Pressure sore can become deep enough to have exposed bone which can result in systemic infection and death. Once you have a pressure sore, you need to release the pressure, but also treat the sore itself.
The depth, size, severity and placement of the sore will dictate the treatment. But you need to make the attending doctor aware of it immediately.

Neurologic patients can take a lot more care and time than a healthy elective surgery case. But with proper care and recognition of problems and progress then can improve in days and weeks. The first several days and weeks are often the hardest and require the most attention. Proper communication and training of the owner to care for their pet at home will be critical to keeping everyone happy and healthy.