The peritoneal cavity is the potential space between the visceral and parietal peritoneum. The surface area of the peritoneal cavity is approximately 150% of the skin surface area. It is a bi-directional semipermeable membrane that allows exchange between peritoneal fluid and plasma, exudation/transudation of fluids, and absorption. There is also active lymphatic drainage from the peritoneal cavity.

Peritoneal defense is largely through the innate immune response and complement. Peritoneal injury or contamination causes an intense inflammatory reaction that, in turn, causes the influx of protein rich fluid, macrophages, neutrophils, humoral opsinins, antibodies, and complement. Peritoneal injury may also cause mast cell degranulation and immunoglobulin production. The end result is a massive fluid and protein movement into the peritoneal cavity.

Primary (spontaneous) peritonitis is an infection of the peritoneal cavity with no identifiable intraabdominal source of infection or history of a peritoneal penetrating injury. In veterinary medicine, primary peritonitis has been documented in patients suffering from FIP, and several recent papers have also retrospectively documented and analyzed data from patients that have spontaneous bacterial peritonitis. Sources of bacteria have been speculated to be from hematogenous or lymphogenous spread, transmural bacterial migration from the GI tract, and bacterial passage from the fallopian tubes during ovulation.

Secondary peritonitis occurs after inoculation of the peritoneal cavity with bacteria, bile, urine, foreign bodies or parasites. Secondary septic peritonitis is defined as peritonitis from intra-abdominal bacterial contamination. These infections are generally polymicrobial with Escherichia coli and Bacteroides fragilis being the most commonly cultured organisms. Clinical signs in patients suffering from septic peritonitis include anorexia, vomiting, depression, malaise, fever, abdominal pain, and shock.

Common causes of septic peritonitis in small animals include leakage from the GI tract such as can occur with GI perforation, perforated tumors, and dehiscence of previous GI surgery sites. Other sources of contamination leading to septic peritonitis are the urinary tract (in the presence of urinary tract infection), the reproductive tract such as after a ruptured pyometra or prostatic abscess, ruptured pancreatic abscesses, and hepatic abscesses or necrotizing hepatitis. Peritonitis can also be seen after penetrating abdominal wounds such as can occur with vehicular trauma or dog bites.

Patient workup
Patients with evidence of gastrointestinal disease should have a complete physical exam followed by appropriate blood work and imaging. Abdominal radiographs are very helpful when imaging GI disease patients and are the best modality for diagnosing foreign bodies. Barium studies can be performed but it is important to remember not to use barium for imaging if perforation of the gastrointestinal tract is suspected. Abdominal ultrasound can also be used but is very operator dependent.

An abdominocentesis or diagnostic peritoneal lavage should be performed if a perforation and septic peritonitis is suspected. The presence of intracellular bacteria in an abdominal fluid sample is pathognomonic for septic peritonitis.

Perioperative considerations
Perioperative antimicrobials should be used if contamination is expected or suspected or if the surgical procedure will last more that 90 minutes. Antimicrobial choice depends on the area of the intestine being operated. At the author’s institution Cefazolin at 22 mg/kg is the antimicrobial of choice for stomach and small intestinal surgery while cefoxitin is given at 30 mg/kg for large intestinal surgery. These medications are given at induction and every 90 minutes during the procedure but are not continued beyond the time of the procedure unless there was pre-existing infection, gross contamination, or the animal has a compromised immune system.

Balanced electrolyte solution should be administered before and during surgery to ensure the patient is properly hydrated. Normosol-R, Lactated Ringers and Plasmalyte are all reasonable fluid choices. Other fluids to consider would be colloids, such as hypertonic saline or hetastarch if the patient needs colloidal support, as well as blood products or plasma.

Abdominal surgery is painful, so pain medications should be administered pre, peri and postoperatively. Opioid pain medications are safe and effective.

Timing of surgery
Planned gastrointestinal surgeries are performed for biopsy and possibly mass removal. With these surgeries there is time for a full workup and they are performed in a stable patient. Emergency surgeries are performed in a potentially unstable patient with maybe minimal workup. Examples of emergency gastrointestinal surgeries include patients with an acute abdomen, septic peritonitis, penetrating abdominal wounds, gastric dilatation and volvulus, and patients with acute ischemia (mesenteric or colonic torsion).
**Surgical procedures**

Enteric biopsy, enterotomy, and intestinal resection and anastomosis are surgical procedures commonly performed in private and referral practice. Enterotomies may be performed for foreign body removal or biopsy, while resection and anastomosis are performed for foreign body removal, tumor resection, and removal of devitalized bowel, treatment of intussusception, biopsy, and treatment of penetrating abdominal wounds. Dehiscence with leakage of intestinal contents from an enteric incision is the most serious potential complication of intestinal surgery, and is associated with high morbidity and mortality due to the development of septic peritonitis. Mortality rates for dogs and cats with septic peritonitis are ∼30–70%.

Risk factors for leakage after intestinal surgery have been described in various papers. The most frequently acknowledged factors include, but are not limited to, preexisting peritonitis, foreign body, trauma, preoperative bowel obstruction, sepsis, hypoproteinemia, and low serum albumin (< 3 g/dL).

The most common cause of septic peritonitis in dogs and cats is gastrointestinal tract leakage. Due to the morbidity and mortality associated with septic peritonitis, perioperative strategies for prevention of leakage have been widely sought after in human and veterinary medicine. Halstead’s principles, gentle tissue handling, strict aseptic technique, sharp anatomic dissection of tissues, careful hemostasis, obliteration of deadspace, and avoidance of tension, are the foundation for perioperative strategies to prevent dehiscence after intestinal surgery.

**Principles of GI surgery**

Tissues should be gently handled during gastrointestinal surgery. Stay sutures, DeBakey forceps and Babcock forceps are all atraumatic, and can be used to manipulate bowel, although the use of instruments to grab or manipulate tissues should be minimized. If an assistant is not available to provide digital occlusion of the bowel during enterotomy or resection and anastomosis, Doyen intestinal forceps which are atraumatic should be used. Strict aseptic technique should be adhered to during preparation and surgery.

Perioperative peritoneal contamination can be minimized by milking intestinal contents from the segment of bowel to be operated and packing off the bowel with saline-moistened laparotomy sponges. Before returning the operated segment of bowel to the abdomen, local lavage with warm sterile saline should be performed. The abdomen should be copiously lavaged at the end of the procedure.

Bowel should be dissected sharply using a scalpel blade or Metzenbaum scissors, so as not to crush tissues to be sutured. Careful and very exact hemostasis is imperative to allow visualization of tissues, while preventing overzealous ligation or cautery use which could compromise the blood supply to the segments of bowel to be sutured. The segments to be sutured or anastomosed should not be under any tension, as it increases the chances of dehiscence postoperatively. Any tissues that is deemed non-viable, or appears questionable at the time of surgery should be resected.

In small animals, the submucosa is the holding layer of the intestine. The submucosa is collagen rich, has a good lymphatic and blood supply, and is the strongest of the intestinal layers. It must be incorporated into the intestinal closure to prevent dehiscence. Both interrupted and divided continuous suture patterns engaging the submucosa can be used for enteric closure. Appositional, non-crushing suture patterns are most commonly used in small animal surgery. Sutures should be placed 2 mm from the cut edge and spaced approximately 2-3 mm apart. Absorbable suture materials such as polydioxanone, polyglyconate, or poliglecaprone 25 with a swaged-on taper needle are generally recommended for closure, while catgut should be avoided due to its rapid degradation. In severely hypoalbuminemic animals, non-absorbable sutures such as nylon or polypropylene may be considered. Various stapling instruments have also been used successfully in human and veterinary gastrointestinal surgery. While they add expense to the surgery, they have been shown to significantly decrease operating times. No significant differences in complication rates have been found between sutured and stapled anastomoses in humans or small animals.

Once the intestinal closure has been performed, a leak test should be used to assess intraoperative enteric suture line security. It is performed by injecting an appropriate volume of saline intraluminally into an occluded intestinal segment, while the enteric suture line is observed for leaks. The volume of saline necessary to achieve peristaltic pressure during leak testing of canine small intestinal biopsy sites has been determined. Normal peristaltic pressure in the canine jejunum ranges from 20-34 cm of water, and volumes were determined for each of these pressures. With digital occlusion, the volume of saline needed to achieve 20 and 34 cm water intraluminal pressure were 10.9–13.6 and 16.3–19.0 mL, respectively with digital occlusion and 8.5–11.1 and 12.1–14.8 mL, respectively with Doyen occlusion.

Testing may impact the number of sutures used to close an enteric incision, hopefully limiting such number to that appropriate to achieve secure closure. Potential negative consequences of superfluous suture placement during enteric wound closure are excessive foreign material and potential damage to the vasculature. Findings during leak testing should help minimize the use of excessive sutures.

Dehiscence of enteric incisions most commonly occurs 3-5 days post operatively, which coincides with the lag phase of healing. Leak testing should be performed at the time of surgery, since during the lag phase of healing the integrity of the enterotomy or resection and anastomosis site is almost entirely depended on the sutures placed by the surgeon.
The omentum is invaluable for healing after gastrointestinal surgery in dogs and cats. It functions as a physical seal to the anastomotic or enterotomy site, and also provides blood vessels, nutrients, and lymphatic drainage to the surgical site. The omentum should be gently placed over the enterotomy or resection and anastomosis site at the end of surgery. Some surgeons may prefer to place several fairly loose sutures using suture material such as 4-0 poliglecaprone 25 to “tack” it in place although this is generally not necessary. An alternative to using the omentum is to perform a serosal patch. A serosal patch should be considered if the closure integrity is questionable, in septic animals after dehiscences are repaired, and in systemically ill animals that may be slow to heal, such as patients with intestinal cancer, Cushing’s disease, severe hypoalbuminemia, or diabetes mellitus. A serosal patch can be placed in an effort to prevent contamination, even if the surgical site leaks, and may also aid in healing of the surgical site. To perform a serosal patch, the antimesenteric border of an adjacent loop of intestine is sutured over the suture line of the enterotomy or resection and anastomosis, either in a simple interrupted or simple continuous pattern.

In animals with a history and clinical signs suspicious of septic peritonitis, the diagnosis is made using various modalities. Abdominal radiographs may show decreased serosal detail due to free fluid accumulation, obstructive patterns in the intestines, or ileus. Pneumoperitoneum with no history of recent (within the last 14 days) GI surgery is indicative of hollow organ rupture and warrants emergency exploratory surgery. If a contrast study is deemed appropriate, such as for diagnosis of a foreign body or intussusception, and perforation of the bowel is suspected, iodinated contrast agents should be used rather than barium.

Abdominal ultrasound can be used to locate free fluid within the abdomen and to obtain a fluid sample for cytology and culture. Ultrasound may also aid in the diagnosis, if a foreign body, intussusception, or other cause of perforation is suspected. Bloodwork should be performed in animals suspected of having septic peritonitis. A complete blood count may be indicative of inflammation or infection, with an increased white blood cell count, and possibly a left shift. Later on in the disease process, leukopenia may be seen as the animal becomes septic or suffers from SIRS (systemic inflammatory response syndrome). Abdominocentesis or diagnostic peritoneal lavage (DPL) and cytology are the gold standard for diagnosing septic peritonitis. If cytology indicates the presence of intracellular bacteria, the diagnosis of septic peritonitis is made and emergency surgery is warranted.

At the time of surgery, a sample of fluid should be obtained for aerobic and anaerobic culture and susceptibility. The abdomen is explored and the source of intra-abdominal contamination is located and corrected. The abdomen may be closed, with or without drain placement, or left open for peritoneal drainage, depending on the degree of contamination, the patient, the hospital facilities, and the surgeon. Vacuum assisted wound closure (VAC) has also been employed in patients with septic peritonitis. Aggressive antimicrobial therapy is warranted in any septic patient, as well as colloid support, good nutritional support and vigilant nursing care. Pain management with opioids is important for patient comfort and may decrease the incidence of post-operative intussusception. Patients should be fed within 12-24 hours after gastrointestinal surgery. Some patients may require metoclopramide post-operatively, if they are suffering from ileus or continuing to vomit after surgery.

References