Additional information on this topic can be found in the textbook ‘Small Animal Surgery’ edited by Teresa Fossum, published by Elsevier. If you would like an instructive DVD of this topic, go to www.ivseminars.net and click on Video Vet.

Key Points
• Serosal patching is used to fill visceral gaps
• Don’t let the sun set on a GI obstruction
• Enteroplication will prevent recurrence of intussusception
• Tumors of the small intestine can be treated surgically with a reasonable prognosis
• Whenever you explore a patient for chronic vomiting/diarrhea take multiple GI biopsies

Serosal patch
A technique has been described for successfully treating hollow viscous organ perforation and leakage and for reinforcing areas of potential leakage. The technique involves suturing the surface of a loop of healthy bowel (generally jejunum) over the leaking or devitalized area to form a serosal patch.

In the small intestine, serosal patching is most helpful when debridement and closure of an intestinal defect would result in significant lumen compromise. A typical example would be a gunshot or dog bite wound to the duodenum in the area of the pancreatic and bile duct papilla. Resection and anastomosis would be difficult due to the presence of the duct systems as well as location of pancreas. Serosal patching would allow closure of the defect, preservation of lumen diameter, preservation of pancreas, and avoidance of pancreatic and bile ducts.

Serosal patching is also indicated for support of an enterotomy or intestinal anastomosis that is of questionable viability. It is effective in preventing leakage even if the anastomosis breaks down as the patch seems to retain its integrity in the face of peritonitis or protein-calorie malnutrition.

Use of a serosal patch may also be indicated to support enterotomy closure in patients with protein losing enteropathy undergoing full thickness, multiple intestinal biopsies.

Technique: When using a serosal patch to cover a defect, the defect is first debrided to healthy bleeding margins and irrigated. A loop of jejunum is brought into apposition with the defect and sutured using a simple continuous apposing pattern of 4-0 or 5-0 polypropylene (Prolene) suture. Sutures are placed 2-3 mm apart and about 3 mm from the edge of the defect; be sure sutures are in viable bowel wall. Polypropylene suture is used for its nonreactive properties as well as its continued tensile strength in the face of peritonitis, hypoproteinemia, and prolonged illness. Sutures are placed 360° around the defect making sure to suture submucosa of both structures with each bite.

Examples of serosal patching in supporting an intestinal anastomosis and enterotomy or for patching leaks in other abdominal viscera are shown in the following figures.

Advantages of serosal patch over omentum include: its strong subserosal layer, it withstands higher intralumen pressures, and it holds sutures well. It may also help to "support" the anastomosis during healing. When defects in the duodenum and colon are patched with a loop of jejunum, the serosal surface becomes lined with mucosa similar to the organ repaired.

Mesenteric Volvulus: Mesenteric volvulus is an uncommon but often fatal disorder in dogs; it is rarely diagnosed in cats. Clinical presentation is a young to middle age, male, medium sized to large breed dog (German Shepherd Dogs appear to be most commonly affected), presenting with an acutely distended and painful abdomen, hematochezia, +/- vomiting, and rapid onset of shock. The abdomen is moderately distended and tympanic. Abdominal distention occurs rapidly; generally less than 6 hours. Presumptive diagnosis is based on history, clinical presentation, physical examination, and radiographs. Abdominal radiographs reveal distended loops of small
intestine suggesting obstruction or adynamic ileus. The stomach is generally not distended with air. Differential diagnosis includes GDV, intestinal obstruction, parvovirus, garbage gut, and generalized adynamic ileus. Treatment is emergency surgery. A xyphoid to pubis midline abdominal exploratory is performed. Adequate exposure is necessary to visualize and evaluate the volvulus for appropriate derotation. As in any strangulation obstruction, endotoxin is released to the systemic circulation when the vascular occlusion is relieved. Pretreatment with shock dose of polyionic isotonic fluids, glucose, broad spectrum antibiotics, and corticosteroids or flunixin meglumine are recommended. As these patients are also experiencing reperfusion injury, specific drug therapy shown to improve patient outcome should be considered (at this time no drug has been shown clinically effective in treating dogs with reperfusion injury).

**Intussusception**

Intussusception is a sign not a disease. It most frequently occurs in young animals with a history of GI upset; generally secondary to parasitic infestation, parvovirus, etc. In older patients it may be associated with intestinal foreign body or GI neoplasia. Classic history is that of vomiting, diarrhea (with or without blood), and abdominal cramping or pain when lifted by the abdomen. Clinical signs are as with any gastrointestinal obstruction however, in puppies and kittens, the signs may "come and go". This is thought to be due to the effects of an intussusception that comes and goes (i.e., sliding intussusception). Physical examination generally reveals an easily movable, slightly painful, sausage-like abdominal mass.

Diagnosis is based on history, clinical signs, palpation of an abdominal mass, and pain on abdominal palpation. Radiographs may reveal an obstructive pattern. A barium enema may outline the intussusception but is rarely necessary for the diagnosis. Be appreciative of the sliding intussusception that presents with periodic signs of an abdominal mass that seems to "come and go".

Treatment of intussusception in the dog and cat is generally surgical. Barium enemas rarely reduce the intussusception and maintain its reduction. Laparotomy generally reveals either an ileoceccocolic, jejunal, or rarely a colonic intussusception. A thorough abdominal exploratory for multiple intussusceptions, foreign bodies, or other causes of GI obstruction should be done in all cases.

When attempting to surgically reduce an intussusception, very gently push distally and pull proximally (don't pull hard).

Frequently, intussusceptions can be reduced without serosal tears. Once reduced, examination of the bowel for intestinal foreign bodies, masses, etc. is performed (remember, intussusception is a sign not a disease). If the intussusception is reducible but there is questionable viability, inject fluorescein dye and make viability assessments as previously described.

If no obvious abnormality exists to explain the presence of the intussusception, an enteroplication should be performed.

**Enteroplication:** *Technique.* Enteroplication is performed by exteriorizing the small intestine from the proximal jejunum to the ileum. The bowel is placed in an accordion-like manner and sutured together to form permanent adhesions. The seromuscular/submucosal layer (do not penetrate into the lumen) of one loop of bowel is sutured to the seromuscular/submucosal layer of the adjoining bowel using simple interrupted sutures of 4-0 Vicryl, Dexon, PDS, or Maxon.

The plicated bowel is replaced into the abdominal cavity and closure is routine. The planned adhesions prevent bowel from re-intussuscepting. Plicated bowel remains adhered for at least two months postoperatively and no abnormal gastrointestinal signs or nutritional disturbances result. Recurrence is essentially eliminated.

If reduction of the intussusception results in seromuscular tears or if bowel viability is assessed as poor, serosal patching or resection and anastomosis should be considered. Serosal patch and anastomotic techniques have previously been described. Any of the appositional techniques may be successfully used. If resection and anastomosis is performed, the resected bowel should be examined carefully to determine a possible cause. If there is no evidence of a foreign body, mass,
etc., the remainder of the bowel should be plicated as described above. Postoperative treatment for patients with intussusception is as previously described for any intestinal foreign body.

**Rectal prolapse or prolapsed intussusception?** Whenever a patient presents with a rectal prolapse, the clinician must first rule out the possibility of a prolapsed intussusception. This can easily be done by placing a finger or instrument (e.g., thermometer, forceps) between the prolapsed bowel and the anocutaneous junction. If the finger passes easily between the two structures the diagnosis is prolapsed intussusception; if resistance is met immediately the diagnosis is rectal prolapse.

**Linear foreign bodies**

**Clinical presentation:** Linear foreign bodies (e.g., string, plastic bags, tinsel, tape deck tape, yarn, thread) occur in the dog and cat. The classic presentation is a patient four years of age or less with persistent vomiting, anorexia, and depression. These signs are common with many gastrointestinal disturbances and linear foreign body should be included in your differential diagnosis. Occasionally, patients are presented late in the course of the disease and may have a history of intermittent vomiting with anorexia, depression, and weight loss as the major presenting signs.

**Diagnosis:** A thorough physical examination should be performed with emphasis on oral examination and abdominal palpation. Oral examination often reveals the linear foreign body around the base of the tongue in cats. The foreign body itself may be seen or an area of inflammation may be present at the junction of the base of the tongue and frenulum. Abdominal palpation may reveal "bunched-up" small intestine due to the plication. When this finding is made, the clinician should be very gentle with further abdominal manipulations so as not to encourage bowel perforation.

**Radiography:** Definitive diagnosis is based on characteristic findings on survey and contrast radiography. Survey radiographs may reveal plicated bowel bunched up in one quadrant of the abdomen. Due to its plicated nature, air accumulation in the bowel lumen forms a characteristic "tapered enteric gas bubble". Three or more tapered gas bubbles are diagnostic for linear foreign body. Evidence of peritonitis (i.e., ground glass appearance), free gas in the abdominal cavity, ileus, or the presence of a needle are findings that may be present on survey radiographs. Patients with subtle changes or questionable findings should have an upper gastrointestinal contrast study (e.g., barium 6.6-11 ml/kg). The typical plicated appearance of the bowel is diagnostic for linear foreign body. If your index of suspicion is high that perforation exists, Gastrografin (1,900 mOsm), iohexol (520 mOsm), or another water soluble contrast material should be used as barium is difficult to remove from the peritoneal cavity and is a significant irritant. Because of its low osmolality, iohexol is recommended as the water soluble contrast agent of choice in evaluation of GI disorders where barium is contraindicated. The possible disadvantage of iohexol is its cost @ $0.80/ml.

**Contrast dosages:** Gastrografin: 1.1-2.2 ml/kg (0.5 - 1 ml/lb) Iohexol at 240 mg/iodine/ml preparation: diluted with water (1:1 or 1:2) and given at a rate of 10 ml/kg [1:1 dilution with water gives 120mg/ml or 1:2 dilution with water gives 80 mg/ml]. Radiographic views should be taken at 0, 30, and 60 minutes.

**Presurgical treatment:** Surgery for the removal of linear foreign bodies should be accomplished as soon as possible. Presurgical preparation of patients diagnosed early and in good health include an intravenous catheter, maintenance fluids (22 ml/kg TID), replacement of fluid loss from vomiting and dehydration, and antibiotics prior to abdominal exploratory. Patients that present in septic shock (i.e., perforation, peritonitis, severe dehydration) should be treated with a shock dose of fluids (90 cc/kg IV), antibiotics (gentamicin and ampicillin), shock dose of steroids (2-4 mg/kg IV) or banamine (in dogs only @ 1 mg/kg IV), and have a blood glucose level taken and fluids supplemented with 2 1/2% dextrose as needed. Electrolytes (chloride, potassium, sodium) and acid-base evaluation are helpful in presurgical management. When fluid losses have been replaced and shock therapy instituted the patient is anesthetized for abdominal surgery.

**Surgical treatment:** After celiotomy, the plicated bowel is gently exteriorized from the abdominal cavity.
In order for a linear foreign body to result in intestinal obstruction and clinical signs, it must be lodged somewhere in the proximal gastrointestinal tract. Common areas include: base of the tongue (i.e., string is often looped around the base of the tongue), stomach or pylorus (i.e., a ball of string is often lodged at the pylorus), or duodenum (i.e., the string becomes impacted in the descending or ascending duodenum). The surgeons first task is to locate the area in which the foreign body is lodged and release it. If it is lodged under the tongue it should be cut at the time of exploratory laparotomy; if it is lodged in the stomach or pylorus, it is released via a gastrostomy; if it is lodged in the duodenum, it is removed via enterotomy.

Once the proximal end is released, the extent of the linear foreign body is evaluated, and 2-3 subsequent jejunal enterotomies are performed to remove the remainder of the foreign body.

Care is taken to remove the linear foreign body in segments short enough that further cutting of the mesenteric border of the intestine does not occur during removal, yet long enough to perform a minimum number of enterotomies. These numbers and distances vary with the type and length of linear foreign body involved. All linear foreign bodies should be removed to the level of the ascending colon. Colotomies are **not** necessary, as once the linear foreign body is in the colon it can be passed with little danger of causing obstruction. Colonic surgery should be avoided whenever possible.

An alternate technique for removal of a linear foreign body is to identify and release the obstructed proximal aspect of the foreign body and attach the released end of the linear foreign body to the flanged end of a 12 - 18 French red rubber catheter/feeding tube. Pass the blunted end of the catheter into the gastrostomy or enterotomy and pass it aborally through the entire length of the intestinal tract and out through the anus. As the catheter is passed, it pulls the linear foreign body out of the GI tract and releases the bowel from its plication. This technique eliminates the need for multiple enterotomies to remove the foreign body. Difficulty can arise when attempting to pass the catheter through the small intestine. Care should be taken not to encourage further trauma to the mesenteric border while passing the catheter.

After the foreign body has been completely removed, a close examination of the mesenteric border is made for evidence of perforation. Any perforation should be debrided and sutured. If multiple perforations occur, a resection and anastomosis may be necessary. Serosal patching may be considered to protect an anastomosis or enterotomy site in a compromised patient. Serosal patching is not recommended to patch mesenteric perforations as suturing the patch may result in vascular compromise to the affected intestinal segment.

Patients with multiple mesenteric perforations that cannot be sutured without severely compromising bowel viability should undergo massive bowel resection. Remember, you can successfully resect 60 - 70% of the small intestine and have a nutritionally acceptable animal. If the client is willing to treat their dog or cat with an acid blocking agent, this resection can be expanded to a 75 - 80% small intestinal resection.

The abdominal cavity is lavaged with copious quantities (e.g., 200-300 ml/kg) of sterile physiologic saline solution prior to closure. Placement of a enterostomy feeding tube should be considered in severely debilitated patients. Postoperative management (i.e., fluids, antibiotics, feeding) is as previously discussed.

**Prognosis:** Prognosis for patients with linear foreign body is directly related to the presence or absence of bowel perforation at the time of surgery. Patients without preoperative perforation have an 85% chance of survival while those with preoperative perforation have only a 50% chance of survival. This survival rate further reinforces the importance of early diagnosis and surgical treatment.

**Massive bowel resection**
A question often asked is: "How much small bowel can I resect and still have a nutritionally functional pet?" Experimental surgical studies reveal that dogs with 75-80% of the small bowel removed usually die within 90 days of emaciation, cachexia, and massive diarrhea with undigested
food in the stools when fed standard diets. However, dogs with 50-60% of the small bowel removed will eventually undergo enough intestinal villous adaptation that a nutritionally sound diet can be expected. Although this work has not been studied in cats, it is presumed to be similar.

Recently, it has been shown that dogs undergoing 75 - 80% small bowel resection (i.e., leaving 18 inches from the descending duodenum and 18 inches from the ileum in a 25 kg dog) will be nutritionally functional if given an H₂ receptor blocker or other acid blocking agent (i.e., cimetidine, ranitidine, famotadine, prilosec). This is probably due to the fact that massive small bowel resection results in gastric acid hypersecretion and lipid malabsorption. The cause of gastric acid secretion is unknown (possibly increased gastrin levels), but it results in a decreased pH of the small intestine. This acid intestinal environment inhibits lipase activity and the emulsification process. The use of H₂ receptor blockers improves patient response by decreasing acid production, increasing digestibility of lipids by 40%, and accelerating intestinal adaptation by increasing villous length, width, and numbers. It is recommended that patients with massive bowel resection (60% or greater) be placed on acid blocking agents.

**Ileoceccolic and ileocolic valve resection**
If bowel resection results in removal of the ileoceccolic valve (cat) or the ileocecal and ceccolic valves (dog) malabsorption syndrome and chronic diarrhea may result. These valves function to control bacterial numbers in the small and large bowel. The small bowel has a relatively low bacterial count, and the large bowel a high bacterial count. If the valve is removed in an intestinal resection (i.e., ileoceccolic intussusception), reflux of bacteria from the colon into the ileum may occur. Overgrowth of bacteria in the small intestine results in an increased deconjugation of bile acids and hydroxylation of dietary fatty acids as well as production of bacterial metabolites toxic to epithelial cells. The absorptive capacity of the epithelial cells is then decreased, resulting in malabsorption. The toxic effect on villi result in inflammation and edema causing fluid secretion into the lumen and further malabsorption resulting in chronic diarrhea. Treatment with intestinal antibiotics may help control the overgrown small bowel bacterial population.

A similar syndrome can occur with chronic partial obstructions (i.e., mural neoplasms, chronic intussusception, intestinal stricture) that result in decreased movement of intestinal contents and subsequent overgrowth of aerobic and anaerobic bacteria; also called stagnant loop syndrome.

**Closure of the peritoneal cavity in patients with peritonitis**
Prior to abdominal closure, especially in cases with peritonitis secondary to intestinal perforation, the peritoneal cavity should be lavaged with copious quantities (200-300 ml/kg body weight) of sterile physiologic saline solution. The use of rubber drains for postoperative drainage and/or lavage of the peritoneal cavity is a controversial subject among surgeons. Several types of drains can be used, the most common include Penrose drains, single lumen fenestrated tubes, and double or triple lumen sump drains. Although these drains may be efficient for the first 12-24 hours, omentum quickly and effectively seals them off, precluding further drainage. Patients with generalized suppurative peritonitis should be treated with open peritoneal drainage and intermittent lavage. Abdominal wall closure is generally performed using absorbable or nonabsorbable monofilament suture material in a simple continuous pattern.

**Open peritoneal lavage**
Generalized peritonitis occurs frequently in small animal practice. The major causes include bacterial, chemical, and miscellaneous (i.e. neoplasia, parasitic, secondary to foreign bodies). Generalized peritonitis secondary to gastrointestinal disorders may also occur. This is commonly a result of perforated bowel from penetrating trauma, iatrogenic contamination at the time of surgery, an ischemic bowel segment secondary to torsion or volvulus, or breakdown of a previous intestinal procedure (e.g., anastomosis or enterotomy). In each instance, bacterial contamination and subsequent infection lead to generalized suppurative peritonitis.

Appropriate therapy for patients with generalized peritonitis of any etiology includes careful preoperative, operative, and postoperative planning. Prior to operative intervention, the patient should be stabilized; this generally involves appropriate therapy for septic shock (i.e., fluids, broad spectrum antibiotics, glucose, nonsteroidal antiinflammatories, steroids). After proper medications
have been given, and a shock dose of fluids administered, the patient is considered "stabilized", is anesthetized and prepared for aseptic surgery.

Wide exposure through a ventral midline abdominal incision from xiphoid to pubis will allow thorough exploration of the abdominal cavity. Samples of peritoneal fluid are taken for cytology and culture and susceptibility testing. All visceral adhesions and fluid-filled pockets are carefully broken down using sharp and blunt dissection to allow proper drainage of purulent material. Careful examination of all visceral structures is performed in order to find the source of contamination. Any GI perforations are debrided and repaired with monofilament nonabsorbable suture (Prolene, Nylon, Novafil) or synthetic absorbable suture (PDS, Maxon, Vicryl, Dexon). Following appropriate exploration and surgical repair, peritoneal lavage with copious quantities (i.e., 200-300 ml/kg body weight) of body temperature sterile physiologic saline solution is performed. The lavage encourages mechanical removal of purulent material, dilution of bacterial numbers, and dilution of endotoxins.

The question of continued postoperative drainage in patients with severe generalized peritonitis has always been controversial. It is virtually impossible to "drain" the entire peritoneal cavity with any soft rubber drain tube (i.e., Penrose, tube, sump), yet closure of a contaminated or infected cavity is contraindicated. It has recently been shown that open peritoneal drainage and intermittent lavage in patients with generalized peritonitis doubles the chance of survival. It is therefore recommended to "leave the abdomen open" to allow appropriate drainage.

One of the major problems associated with this procedure is patient cooperation. The following technique has resulted in the best patient tolerance and drainage efficiency in the author’s experience.

a. Loops of monofilament nonabsorbable suture (e.g., prolene, nylon, novafil) are placed 2-3 cm apart on each side of the abdominal incision along its entire length.

b. Sterile 1/8" to 1/4" umbilical tape is threaded through the loops of suture in a "shoe lace" fashion and tied. This allows gentle apposition of wound edges, acts as a "net" to prevent evisceration, and allows adequate drainage of peritoneal fluid.

c. Several sterile laparotomy pads are then secured to the open incision. Umbilical tape is passed through the previously placed suture loops and tied over the laparotomy pads to hold them in place. The presence of laparotomy pads acts to absorb peritoneal fluid.

d. Several sterile surgical towels are placed over the laparotomy pads to increase absorptive capacity of the bandage.

e. Sterile absorbent cotton is placed over the towels and secured with plastic Steri drapes, kling, and elasticon in a snug belly bandage.

f. An inexpensive and effective aternative to "e." above is use of a disposable diaper (i.e., nappy). The diaper is secured around the patients abdomen to cover the sterile towels.

Postoperative therapy includes intravenous fluids, antibiotics, periodic blood-glucose analysis (i.e., monitor sepsis), and bandage management. At 24-48 hour intervals the patient is anesthetized and bandage removed. A sample of fluid is taken from the peritoneal cavity for cytologic evaluation, the area prepared for aseptic surgery, umbilical tape removed, abdominal cavity lavaged, and bandage reapplied.

Closure of the abdominal incision is dictated by cytologic evaluation at each lavage. As the PMN's become healthy and bacterial numbers decrease (i.e., approaching a serosanguinous exudate) abdominal closure is considered.

Generally, if a positive response to therapy is going to occur, it will be seen by the second or third lavage session. Patients requiring open peritoneal lavage beyond 4 or 5 days often develop complications such as anemia, electrolyte abnormalities, and hypoproteinemias. These complications coupled with generalized peritonitis often result in an unfavorable to grave prognosis.

If routine abdominal closure can be performed by day 4 or 5, the prognosis is guarded to favorable.
In conclusion, patients with severe generalized peritonitis should be treated with appropriate lavage and drainage in the immediate postoperative period. It has been found that open peritoneal drainage and intermittent lavage results in an increased recovery rate for patients with generalized peritonitis.