PRINCIPLES OF GI SURGERY
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Key Points
• Pay attention to basic surgical principles
• Submucosa is the layer of strength
• Use synthetic absorbable suture materials
• Appositional techniques are best
• Identify breakdown via abdominal tap

General principles of small intestinal surgery

The small intestine is a very forgiving organ system when considering surgical intervention. It has an excellent blood supply with many collateral mesenteric vessels. If the blood supply can be preserved during surgical manipulations, small intestinal incisions can be expected to heal rapidly, gaining almost 70% of its original unwounded tensile strength in 14-21 days. It should be remembered that the small intestine is a low pressure conduit system that contains primarily liquid contents and has a relatively low bacterial content proximal to the ileocecocolic valve. These properties make surgical manipulations of the small intestine predictably successful if basic principles of tissue handling, preservation of blood supply, and hemostasis are followed.

Principles of intestinal surgery include:
1) Incorporation of the collagen laden submucosal layer in the surgical closure.
2) Minimize trauma and contamination.
3) Maintain good blood supply to the surgical site.
4) Avoid tension across the suture line as this may enhance leakage and/or breakdown.
5) Pay attention to detail when suturing intestinal defects.

Preoperative preparation

Preoperative assessment should include a thorough historical and physical examination. This can often be helpful in localizing the problem to an upper versus lower GI obstruction, complete or partial obstruction, or strangulating versus nonstrangulating obstruction. Minimum data base should include complete blood count, electrolytes (i.e., sodium, potassium, chloride), glucose, and BUN. If available, blood gas analysis should be done on patients with severe vomiting, dehydration, or possible sepsis.

Criteria for Use of Prophylactic or Therapeutic Antibiotics

Prophylactic antibiotics should be considered in the following situations:
1. Old age (e.g., >7 years old), debilitated patient
2. Likely to open devitalized bowel
3. Estimated surgical time greater than 90 minutes
4. “Break” in aseptic surgical technique

Therapeutic antibiotics should be considered in the following situations:
1. Non GI associated infection that cannot be treated prior to surgery (e.g., severe dental disease, pyoderma)
2. Gross peritoneal contamination at surgery
3. Operation involving strangulation obstruction
4. Operation in patient with existing peritonitis (e.g., gun shot wound to abdomen with bowel perforation)
5. Reoperation of intestinal surgical breakdown with peritonitis

**Operative Considerations**

1) Proper “packing off” of the surgical field using moistened laparotomy pads should be performed around the *exteriorized* bowel to prevent accidental abdominal contamination from intestinal contents.
2) Keep abdominal contents warm and *moist* throughout surgery with a warm, balanced electrolyte solution.
3) Handling abdominal viscera should be kept to a minimum. Gentle manipulation of intestine with moistened gloves or stay sutures is helpful in preventing unnecessary tissue trauma. *DeBakey* forceps are the most atraumatic forceps for handling abdominal visceral organs.
4) The collagen laden, tough *submucosa* is the layer of strength in the small intestine; this layer must be incorporated into any small intestinal closure (i.e., enterotomy, anastomosis).
5) It may be difficult to visualize the submucosal layer due to *mucosal eversion*. Visualization of submucosa may be enhanced if everted mucosa is trimmed away.
6) Intestinal contents should be "milked" away from the anastomosis or enterotomy site. *Intestinal clamps* (e.g., Doyan clamps, rubber shot Doyens, *Alice* tissue forceps with sponges a rubber feeding tube interposed, hair clips and, or *Penrose* drains) may be used to prevent intestinal contents from contaminating the surgical site whilst manipulating intestine during anastomosis or enterotomy.
7) The enterotomy or anastomosis should be *irrigated* prior to its return to the abdominal cavity and instruments and gloves changed prior to abdominal closure.
8) *Abdominal lavage* with 2-3 liters of body temperature, sterile, physiologic saline solution should be accomplished prior to closure. The objectives of repeated abdominal lavage include dilution of bacteria and endotoxin and mechanical removal of fibrin and necrotic debris. The fluid of choice is body temperature, sterile, physiologic saline solution. Lavage solution is poured into the abdominal cavity using a sterile stainless steel bowl, the abdominal viscera gently agitated, and fluid and debris suctioned out with a suction device and a sump suction tip.

**Suture Material**

**Absorbable suture**

*Catgut*. Catgut is not recommended in contaminated, infected, hypoproteinemic, or debilitated cachexic patients. Its unpredictable absorption and rapid loss of tensile strength in such situations may result in an unacceptably high number of anastomotic breakdowns. Use of catgut suture in gastrointestinal surgery is not recommended.

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

*Biosyn and Monocryl*. These sutures have similar properties to Dexon, Polysorb and Vicryl however they are monofilament. They were developed to overcome the problem of tissue drag and knot slipping found in the braided synthetic absorbables. Their predictable hydrolytic absorption is unaffected by their immediate environment (i.e., infection, contam-
ination, hypoproteinemia). They retain high tensile strength for a long period of time (2-3 weeks) and have very good handling characteristics. These suture materials are ideal for use in gastrointestinal surgery. These sutures are the authors choice for gastrointestinal surgery. PDS and Maxon. PDS and Maxon, are synthetic absorbable monofilament suture materials with similar properties to that of Dexon and Vicryl. They have been shown to retain approximately 70% of their tensile strength at 3-4 weeks, and are absorbed by hydrolysis (unaffected by infection, contamination, hypoproteinemia). These suture materials are ideal for use in gastrointestinal surgery. Possible disadvantages include stiffness, a tendency to kink and prolonged absorption time.

Nonabsorbable suture
Nylon, Polypropylene, Polybutester. Monofilament, nonabsorbables are excellent suture materials for use in contaminated or infected surgical sites. They have a high tensile strength, are relatively inert in tissue, noncapillary, and do not act as a nidus for infection. These materials pass through tissue with essentially no tissue drag and have excellent knot tying security at sizes 3-0 to 5-0. For their properties, effectiveness, and cost, these are the author's nonabsorbable sutures of choice for intestinal anastomosis and enterotomy closure. Possible disadvantage of these materials is their memory.

Silk, Mersilene, Bronamid, Vetafil. In general, stay away from burying multifilament or braided nonabsorbable suture material. These sutures may harbor infection for years and may result in suture related abdominal abscesses or draining tracts. They should never be used in gastrointestinal surgery.

Suture size
For the majority of small intestinal surgical procedures in dogs, 3-0 or 4-0 size suture material is adequate; in cats, size 4-0 or 5-0 is recommended. The tensile strength of this size suture is greater than the tensile strength of the tissues that are being sutured (i.e., intestinal wall). Larger size suture may contribute to anastomotic failure by increased trauma to tissues and its effect on the blood supply of tissue margins.

Needles
Swaged-on "atraumatic" reversed cutting, narrow taper point, or fine taper-cut needle can all be used for gastrointestinal surgery. The author prefers a narrow taper point needle.

Suture Placement
When suturing intestine, sutures should be placed 3 - 4 mm from the cut edge of the intestine and no more than 2 - 3 mm apart and. It is important to recognize the everted mucosa and be sure the 3 - 4 mm bite is not in mucosa but in the submucosal layer.

Suture Patterns
There is considerable controversy regarding specific suture pattern for use in small intestinal surgery. Everting, inverting, and appositional suture patterns have been used experimentally and clinically for suturing enterotomies and anastomoses. Appositional patterns are recommended as they cause little lumen compromise postoperatively. The following figures of everting and inverting suture patterns described below illustrate the lumen compromise caused when using either of these suture patterns.

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

Inverting: In small animals, adequate lumen diameter is an important consideration with any technique. Inverting patterns result in substantial lumen compromise of the small intestine and are not recommended in dogs and cats.
Appositional*: Anatomic apposition of individual layers of the bowel wall (i.e., mucosa, submucosa, muscularis, and serosa) result in primary intestinal healing. This technique is superior to inverting or evertting techniques because apposition of intestinal margins eliminates lumen compromise. This is the author's preferred technique for suturing all hollow viscus organs in the abdominal cavity. Suture patterns of choice include:

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

2) Simple continuous apposing. This technique is similar to the simple interrupted appositional technique, however, a continuous suture pattern is used rather than an interrupted pattern. Advantages include faster anastomosis, equal suture tension over the entire anastomosis, watertight seal, and mucosal eversion is minimized.

Commonly performed small intestinal surgical procedures

Key Points

- Intestinal sutures should be 3 - 4 mm into submucosa and 2 - 3 mm apart
- Handle bowel wall with atraumatic technique
- Examine integrity of anastomosis visually
- 75-80% of small bowel can be resected

Enterotomy: An enterotomy incision may be necessary for removal of intraluminal intestinal foreign bodies (e.g., balls, rocks, toys, linear foreign bodies), intestinal biopsy, exploration of the bile duct papilla or intestinal lumen, or rarely intestinal decompression. The segment of bowel to be incised should be removed from the abdominal cavity and packed off with moistened laparotomy pads. An incision parallel to the long axis of the bowel (i.e., longitudinal) or perpendicular to the long axis of the bowel (i.e., transverse) may be made on the antimesenteric border, preferably in healthy bowel (i.e., the aboral side of the foreign body). Closure is performed using any of the appositional techniques previously described (i.e., simple continuous or simple interrupted). Omentum can be placed over the enterotomy, but need not be sutured.

Transverse closure: If a large full thickness piece of intestine must be excised (i.e., mural mass), longitudinal closure may result in stenosis. To prevent this, transverse closure of the linear incision is recommended. This ensures adequate lumen diameter without the need for intestinal anastomosis.

Intestinal anastomosis: Intestinal anastomosis is indicated for resection of nonreducible intussusception, necrotic bowel wall secondary to complete intestinal obstruction, intestinal volvulus, stricture secondary to trauma, and intestinal neoplasia (e.g., leiomyoma, leiomyosarcoma, adenocarcinoma). After a complete abdominal exploration, the affected length of bowel is delivered from the peritoneal cavity and isolated with the use of moistened laparotomy pads. If possible, the intestinal anastomosis should be performed on a water resistant surface (e.g., plastic drape, crib towel) to prevent 'strike' through contamination. Once the level of resection has been determined, the appropriate mesenteric vessels are ligated, and the portion of intestine to be resected is isolated by clamping the bowel at a 60° angle away from the mesenteric border. This angle ensures adequate blood supply to the antimesenteric border.

Bowel lumen diameters: In cases where the oral end of the bowel is dilated and the aboral end is of normal size (i.e., distal end), several options exist to create intestinal lumens of equal diameter:
1) Increase the angle of resection on the smaller diameter segment of bowel (i.e., aboral segment). This will increase the orifice size by 5-10 mm depending upon bowel width (e.g., dog vs cat).

2) In larger lumen size discrepancies the antimesenteric border of the smaller diameter stoma can be incised longitudinally to enlarge the lumen diameter.

3) An end-to-side anastomosis can be performed by closing the larger diameter stoma of the intestinal resection with a single layer continuous apposing suture pattern then anastomosing the smaller diameter segment of bowel to an appropriate size enterotomy made in the antimesenteric border of the larger diameter segment of bowel.

4) If the smaller diameter segment of bowel cannot be enlarged, the larger diameter segment can be made smaller using the following technique. First, cut the larger diameter segment at a 45° angle. Then, beginning at its antimesenteric border, suture the larger diameter segment using simple interrupted appositional sutures until its lumen diameter equals the diameter of the smaller segment. Finally, complete the anastomosis using a simple continuous or simple interrupted appositional pattern. 

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

The following tips may prove helpful when performing an intestinal anastomosis (see the anastomosis video clip for detailed description of tips below):

1) First, place a stay suture to hold the mesenteric border of each segment of bowel in apposition. Tie this suture, leave the ends long, and place a hemostat on the suture end end without the needle.

2) Place a second stay suture to hold the antimesenteric border of each segment of bowel and bring the ends of the intestinal segments into apposition. Place a hemostat on the ends of this suture.

3) Place gentle traction on the mesenteric and antimesenteric stay sutures to bring the two intestinal segments into apposition.

4) Using the needled segment of suture from the mesenteric stay suture, begin a simple continuous appositional anastomosis being careful to get a 3 mm bite in the submucosa and placing each suture no more than 2 - 3 mm apart (2 mm apart in cats). When the anastomosis is complete, tie the suture to the mesenteric stay suture.

5) If a simple interrupted apposing suture pattern is used, be careful to get a 3 mm bite in the submucosa and place each suture no more than 2 - 3 mm apart.

The author’s preference for evaluating the integrity of anastomotic closure is to visually examine each suture to be certain that suture placement is no more than 2 - 3 mm apart and that each suture has a 3 mm bite in the submucosa.

**Postoperative care**
Intravenous fluids to maintain hydration and ensure renal function are continued postoperatively, until the patient begins to eat and drink. Intravenous fluids should then be tapered over a 24 to 48 hour period.
Systemic antibiotics are continued postoperatively for 5-7 days; 10 - 14 days in cases with peritonitis and/or sepsis.

**Feeding:** Early return to enteral feeding is best for the overall health of the intesting. Feeding the postoperative gastrointestinal surgical patient is generally based on the following criteria:
a) preoperative condition of the patient  
b) the condition of the bowel at the time of surgery  
c) surgical procedure performed (i.e., enterotomy, anastomosis, pylorectomy)  
d) presence or absence of peritonitis  
e) postoperative condition of the patient.  
The earlier patients can be returned to oral alimentation the better.

Complications  
The most common postoperative complication of small intestinal surgery is leakage; leak is either associated with breakdown of the anastomosis or improper surgical technique (i.e., improper suture placement, inappropriate suture material, knot failure, sutures to far apart, inappropriate bite in the collagen laden submucosal layer, suturing nonviable bowel).  
A presumptive diagnosis may be accomplished by the following:  
1) Body temperature (may be up if acute or down if moribund).  
2) Abdominal palpation: periodic, gentle abdominal palpation for pain (gas or fluid?).  
3) General attitude (depression-anorexia).  
4) Incision: examination of the patients incision for drainage (look at cytology if drainage is present)  
5) CBC: leukocytosis followed by leukopenia (sepsis), or a degenerative left shift may imply breakdown.  
6) Glucose: low glucose generally implies sepsis (this occurs early in sepsis and may be used as a screening test).  
7) Abdominal radiographs: generally not helpful, they are difficult to critically assess due to the presence of postoperative air and lavage fluid. It can take 1 - 3 weeks for peritoneal air to diffuse from the abdominal cavity after routine abdominal surgery. Time variation is dependant upon the amount of air remaining in the abdominal cavity postoperatively (i.e., large deep chested animal vs a small obese animal).  
8) Abdominal tap (paracentesis): a four quadrant abdominal tap is accomplished by aspirating fluid using a 5 cc syringe and 20 gauge needle or placing a plastic IV catheter into the peritoneal cavity and allowing fluid to drip onto a slide.  
9) Peritoneal lavage (if paracentesis is not productive): infuse 10-20cc/kg of sterile physiologic saline solution into the abdominal cavity, then gently palpate the abdomen and repeat the four quadrant paracentesis. This technique increases the sensitivity of paracentesis to 90%. Once fluid has been obtained, a smear should be stained and evaluated microscopically. Depending upon the cell types seen, a determination of the presence of leakage can be made. Below are examples of expected cytology in patients with and without leak.  
1) Healthy PMNs with few degenerate PMNs and a moderate number of red blood cells: This cytology may be expected in any postoperative abdominal procedure (e.g., OHE, abdominal exploratory, cystotomy). Your index of suspicion for anastomotic breakdown should be low. However, if clinical signs continue to deteriorate, repeat paracentesis (2 - 3 times daily, if necessary) to determine the "trend" of the abdominal fluid cytology is recommended.  
2) Healthy polymorphonuclear leukocytes with bacteria located intra or extracellularly, degenerate PMNs with intracellular bacteria, free bacteria, or food particles--imply breakdown. Exploratory laparotomy is indicated.

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

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