“The Labrador and the Corn Cob!”
A *Tale of Practical Advice to Improve Intestinal Surgery Success*

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The Labrador and the Corn Cob - A Tale of Practical Advice to Improve Intestinal Surgery

Foreign bodies can cause partial or complete obstruction of the gastrointestinal tract. The degree of intestinal obstruction influences the severity of presentation, ranging from intermittent vomiting or diarrhoea to profuse vomiting, complete anorexia, abdominal pain, depression or in severe cases hypovolemic shock. Achieving a diagnosis ranges from simple to challenging due to the inherent variation in objects that are ingested. A diagnosis should be based on multiple parameters including history, clinical signs and abdominal radiographs and / or ultrasound.

Clinical presentations that make me extremely suspicious of intestinal obstruction

Patients with intestinal obstruction present with a combination of clinical signs. The more orad and complete the obstruction the more severe acute is the clinical presentation. The following are highly suggestive of intestinal obstruction.

1) Anorexia
2) Vomiting closely associated with feeding
3) Vomiting ‘faecal’ material
4) Persistence of vomiting despite fasting
5) An absence of defecation
6) Abdominal pain

Diagnostic investigation for intestinal obstruction

1) Palpation under sedation – sedation and relaxation of the abdominal wall greatly facilitates foreign body palpation
2) Radiographs – Can see radio-opaque foreign bodies. For non radio-opaque foreign bodies dilated loops of small intestine filled with gas can be observed in circumstances of complete obstruction. Small intestine dilation is > 1.6 times L5 has a high correlation with bowel obstruction. Bowel dilation is less obvious with very proximal obstruction however the stomach might be dilated. If intestinal obstruction is suspected, radiographs should be closely scrutinized for gas bubbles and objects that are not round or oval objects (not many objects are square or triangular in the abdomen). For linear foreign bodies bowel plication located in cranial to mid-ventral abdomen can be visualized. The hallmark of bowel plication is clusters of eccentric intra-luminal gas bubbles. Partial obstructions are better detected by contrast studies. Barium should enhance a proximal obstruction within 6h and a distal obstruction within 24h.
3) Ultrasound is very rapid and an adjunct to radiography. Beware that in the hands of a specialist veterinary radiologist sensitivity is only 85% and specificity 94%. Beware of ‘ultraguess’! Intussusceptions are accurately diagnosed with ultrasounds by observing a double layer of intestinal wall as either concentric rings in transverse (bull’s eye) or parallel lines in the longitudinal plane.

**Key instrumentation for intestinal surgery:**

1) Abdominal retractors
2) DeBakey tissue forceps

If instruments are used, they should be designed for use on abdominal organs e.g. DeBakey tissue forceps. Toothed forceps should never be used on GI tissues.

3) Doyen bowel clamps

When cross clamping of the intestinal tract is needed, an assistant can grasp the tissue between index and middle fingers. Although this may cause some leakage of intestinal contents it is the least traumatic technique. An alternative is to use Doyen bowel clamps. These are atraumatic intestinal forceps. They are applied so that the bowel is placed at the tip of the clamp and the clamps are closed to one ‘click’. Crushing forceps are only placed on tissues that are to be resected.

4) Large abdominal swabs
5) Suction

**Key principles to improve intestinal surgery technique:**

1) Halstead’s principles

When performing any surgery the surgeon should always follow Halsted’s principles:

- Aseptic technique
- Gentle tissue handling
- Sharp dissection of tissues
- Good haemostasis and preservation of blood supply
- Accurate tissue apposition with avoidance of tension and closure of dead space
- Removal of devitalised tissue

During abdominal surgery, exposure and handling of tissues will result in desiccation and abrasion. Poor tissue handling causes an increased amount of inflammation and a greater risk of adhesion formation, ileus and peritoneal fluid production. Even with careful attention to surgical technique, myo-electrical activity of the gastrointestinal tract is decreased for 24 hours post surgery.
2) Stay sutures
Where possible, stay sutures (full thickness) are used instead of instruments for mobilisation and to increase exposure.
3) Moist swabs
If intestine is manually retracted, it is covered with a moistened swab.

**Key steps for improving access:**
1) Make a bigger abdominal incision and use retractors
2) Use large abdominal swabs to pack other organs out of the surgical field
3) Abdominal oesophagus/cardia – extend into median sternotomy
4) Stomach – transect hepatogastric ligament (rarely required) Pylorus & proximal duodenum – transect paraduodenal peritoneum (complex and challenging anatomy) Distal duodenum - cut the duodenocolonic ligament

**What antibiotics should I use and when?**
Broad spectrum antibiotic, intravenously at the time of induction and then every 1.5 – 2 hours until closure of the skin is achieved. There is no benefit in continuing antibiotics beyond surgery unless an existing infection is present.

**Background**
Factors that influence the risk of postoperative infection:
1. Duration of surgery; 1.5 hours infection rate 1.6%, > 1.5 hours infection rate 8%. Risk doubles for every 30 minutes over 1 hour procedure
2. Total duration of anaesthesia; for every minute beyond 60 minutes 0.5% increase in risk
3. Administering propofol; Animals receiving propofol 3.8 times more at risk than those that don’t
4. Surgical sites clipped before anaesthetic induction 3 times more likely to develop post op infection
5. Older animals (>8y) or animals with high or low body scores at greater risk
6. Animals with concurrent endocrinopathies

**Peri-operative antibiotics**
Peri-operative antibiotics are recommended for:
- Clean-contaminated procedures that last for more than 2 hours
- Contaminated procedures
- Dirty procedures e.g. septic peritonitis, intestinal ischaemia or strangulating obstruction (these are associated with bacterial overgrowth) and colorectal surgery
• If the animal is at increased risk for developing post-operative infections (e.g. distant infection, prior irradiation of the surgical site, elderly, debilitated or immune-compromised)
• Disease associated with severe mucosal insult, haemorrhagic diarrhoea, pyrexia or leucocytosis\leucopoenia

Antibiotics are administered before contamination or infection occurs. The aim is to achieve and maintain antibiotic concentrations above the mean inhibitory concentration of bacteria at the surgical site. This is achieved by intravenous administration of antibiotic approximately 30 minutes before surgery starts, as there is a predictable lag between the peak serum and wound fluid concentrations of antibiotic. Elimination half-life studies recommend additional doses of the antibiotic every 3 hours, however, it is routine in veterinary soft tissue surgery to repeat antibiotics every 1.5 - 2 hours. The optimum duration of antibiotic is unknown in veterinary patients. In humans, the same infection rate was seen if antibiotics were used for less than 24 hours or for 5 days after clean, clean-contaminated and contaminated procedures. I do not routinely administer antibiotics beyond the end of surgery except for dirty procedures.

A broad-spectrum antibiotic should be used. Good choices of antibiotic are cefuroxime (Zinacef) or amoxycillin clavulanate (Augmentin) both of which are given at 20 mg/kg IV. If intravenous antibiotics are not available then Clavulox either S/C or I/M 20 minutes prior to surgery will provide bacteriocidal serum concentrations of antibiotic at the time of surgery. It has been shown that, in clean procedures, infection rates are higher in animals in which an inappropriate peri-operative antibiotic protocol was administered than in animals that got no antibiotics. An example of an inappropriate peri-operative antibiotic would be s/c long acting amoxycillin.

**How can I assess intestinal viability?**

The easiest method is to make small stab incisions in the serosa and assess for bleeding. In the stomach 1/3 of blood flow is to the serosa and 2/3 to the mucosa. Hence if it is bleeding at the serosa it is likely to have a blood supply to the mucosa. In the small intestine viability is best assessed by evaluating serosal colour, bowel motility and evaluation of jejunal arcades for arterial pulsing. Fortunately large regions of the small intestine can be resected.

Ischaemic necrosis of the intestine may occur secondary to dilatation, obstruction or strangulation. It may be difficult at surgery to assess whether intestines will recover from ischaemic injury. Following a period of obstruction or dilatation, the gastrointestinal wall may be swollen and oedematous and have suffered intramural haemorrhage, which may make it appear non-viable. There may be obvious necrosis with a thin black-purple wall and a clear line of demarcation between viable and non-viable tissue, but signs of ischaemia are more subtle. It
is worth re-assessing the tissue 10-15 minutes after de-rotation of volvulus or removal of foreign bodies, as the tissue often looks worse initially. Assessments should be made of colour, thickness of tissue on palpation, texture, peristalsis, vessel pulsation or bleeding of the cut surface. It has been shown that clinical assessment of viability does not always correlate with histopathological evidence of ischaemia and necrosis. If in doubt, it is safer to assume tissue is necrotic and resect it, than leave necrotic tissue in situ. Objective measures of tissue necrosis, e.g. fluorescin and pulse oximetry, are not be more accurate than subjective assessments, and are rarely available.

**Which suture material should I use?**

A synthetic absorbable monofilament suture material is recommended. I use PDS, 1.5 metric (4/0) in cats and small dogs and 2 metric (3/0) medium and large dogs for all gastrointestinal surgery. Synthetic materials that are broken down by hydrolysis and have a predictable initial tensile strength and loss of strength over time should be used. There is no place for catgut in GI surgery – breakdown by phagocytosis is unpredictable, especially in an inflammatory environment, and the swelling that occurs when it is wet results in poor knot security. Monofilament sutures are preferred over multifilament sutures – they have less tissue drag, create less inflammation and potentiate infection less when used in contaminated tissues. Non-absorbable sutures are rarely indicated, and are avoided in full thickness or mucosal gastric sutures as they may result in ulcer formation.

The ideal suture material has a similar tensile strength to the tissue it is used in and loses tensile strength at the same rate that the tissue gains tensile strength. For GI surgery, the suture needs to maintain adequate tensile strength for 20 days e.g. Biosyn / PDS. Suture should be 1.5 or 2 metric (4/0 or 3/0) – smaller sutures are preferred. Monocryl is commonly used for gastrointestinal surgery by many surgeons. I prefer PDS as Monocryl losses 90% of its tensile strength by 14 days.

Needles should be swaged on rather than eyed. Taper or tapercut needles are preferred for gastric sutures as they are easier to pass through submucosa than round-bodied needles. Round bodied or tapercut needles are preferred for small intestine.
Which suture pattern should I use?

**Stomach**
Closure of gastric incisions is normally performed in two layers however a single layer closure is acceptable. It is very important that the submucosa is included as this is the layer with the greatest tensile strength. Many different suture patterns have been described for closure of the stomach wall, with many texts recommending an inverting pattern. Unlike other parts of the gastrointestinal tract there is little concern of stricture formation in the stomach. I generally close the stomach in two layers unless the stomach is grossly thickened. When the stomach is grossly thickened I use a single layer closure of simple interrupted appositional sutures. For two layer closure the first layer should include the mucosa and submucosa. The second layer includes the muscularis and serosa. I generally use a simple continuous suture pattern in both layers. An alternative is to use an inverting pattern such as a Cushing or Lembert in the second layer.

**Small Intestine**
For small intestine, an appositional pattern is preferred as it causes less intestinal lumen narrowing than the inverting pattern, and less adhesions than the everting patterns. Simple interrupted sutures cause less intestinal narrowing and are more secure than continuous patterns, and are easier to adjust tension and distance between sutures. Continuous patterns are less strong than interrupted sutures, but they do provide enough strength for intestinal repair. They are potentially quicker to place, provide a better watertight seal and leave less foreign material at the surgical site. Eversion may occur if excess tension is applied to the suture line. It is important to include the submucosa in the suture as this is the strength holding layer. Sutures should be spaced approximately 3 (cat) to 4 (dog) mm apart and 4 to 5 mm from the edge of the intestine wound. I prefer a simple interrupted suture pattern for closure of enterotomies and for intestinal anastomosis.

Simple continuous patterns are described for performing small intestine anastomoses. Closure is with two simple continuous sutures, one starting at the mesenteric border and one starting from the antimesenteric border. Each suture line closes half the circumference of the bowel. Skin staples have been used to create rapid end to end small intestinal anastomoses. An alternative to hand sutured anastomosis is functional end to end anastomosis using surgical staplers. This is extremely quick and may be particularly useful in very unstable animals.
How can I reinforce my suture line?
Using either the omentum or performing serosal patching techniques. The omentum can provide gastrointestinal surgery sites with a good blood supply, as well as promoting lymphatic drainage and controlling infection. It adheres to surgical sites and areas of inflammation. It is wise to wrap the surgical site in omentum. The omentum does not need to be sutured to the surgical site. Experimental studies have shown that omentum can re-vascularise areas of intestinal ischaemia and prevent perforation.

Serosal patching is more secure then omental patching but is rarely needed. It does not provide an additional good blood supply or promote lymphatic drainage. It can be used to reinforce intestinal suture lines and can seal even infected perforations. The anti-mesenteric borders of healthy jejunum are sutured either side of the suture line in question. Multiple patches may be necessary.

Maximise enterotomy and resection / anastomosis technique

**Enterotomy**
This may be performed for biopsies, removing foreign bodies and examination of the intestinal lumen. The affected area of intestine is isolated from the rest of the abdomen using laparotomy swabs, the intestinal contents are milked away, and intestinal clamps or an assistant are used to clamp off the intestine proximal and distal to the proposed incision. If there is a foreign body, the incision is made distally on the anti-mesenteric border so that sutures are placed in healthy intestine, as the proximal intestine is usually oedematous and may have suffered ischaemic injury. A longitudinal incision is made to enter the lumen of the bowel. Closure can either be longitudinal or transversely if compromise of intestinal luminal diameter is a concern. The intestine is carefully evaluated for necrosis, which would require a resection to be performed instead.

**Resection and anastomosis**
Enterectomy is performed for ischaemia, necrosis, neoplasia or irreducible intussusception. The arcade of vessels (from the cranial mesenteric artery) supplying the area of intestine to be resected, and the terminal vessels at the mesenteric border, are ligated. The intestine is occluded with two pairs of intestinal clamps proximal and distal to the area to be resected and placed 1.5 - 2cm away from the incision site, so that there is enough tissue to place sutures. Crushing forceps can be placed on the portion of the intestine that will be resected. Some healthy tissue is resected and slightly more intestine is resected on the anti-mesenteric border to ensure a good blood supply. Sutures are placed approximately 4-5mm from the edge of the
wound and 3-4mm apart with extra-luminal knots. Serosa is engaged further away from the edge of the wound than mucosa to avoid mucosal version, or everted mucosa can be trimmed as necessary.

Size disparity is corrected by cutting the smaller diameter intestine at a 45-60° angle (anti-mesenteric border is shorter than mesenteric border to ensure a good blood supply) or by placing sutures closer together in the smaller intestinal segment. Alternatively an incision can also be made on the anti-mesenteric border of the smaller segment (not my preferred option), but it should be noted that if the larger segment is due to dilation then this may not be necessary as the size disparity would be corrected when oedema resolves. The larger segment should never be reduced in size as it may result in obstruction.

Sutures are placed in the mesenteric border first as this is the site that is most difficult to place sutures in due to the presence of mesenteric fat, therefore it is more prone to leakage. Sutures can either be continued up to the anti-mesenteric border or the second suture can be placed at the anti-mesenteric border. The suture line is checked for leakage and additional sutures are placed as necessary. The mesentery is sutured to avoid bowel entrapment and strangulation and the suture line is reinforced with omentum.

Common errors when performing enterotomy closure or anastomosis

1) Excessively large diameter suture material – interferes with blood supply to intestinal wound edge
2) Too many sutures – interferes with blood supply to intestinal wound edge
3) Sutures too close to wound edge – interferes with blood supply to intestinal wound edge
4) Poor placement of mesenteric border sutures – failure to include submucosa and hence suture pull out

Practical tips to avoid and recognise of complications

How much can I safely resect?

In most instances a large length of the intestine can be removed with little long term consequences. However, removal of an excessive amount of the small intestine (70-85%) can lead to short bowel syndrome. Whether an animal will develop clinical signs depends on many factors, including the location and amount resected (loss of duodenum or ileum increased risk), whether the ileocolic valve is resected (increased risk) and the health and adaptation of the remaining intestine.
Clinical signs of watery diarrhoea and weight loss are seen due to malabsorption and maldigestion, secondary to decreased mucosal surface area, hyper-secretion, bacterial overgrowth and decreased gastrointestinal transit time.

Short-term medical treatment involves providing intravenous fluid therapy +/- total parenteral nutrition. The key to management is providing enteral nutrition that is easily digestible and high in fibre fed in small meals 6-8 times daily. Tinned pumpkin is anecdotally suggested as a good fibre source for short bowel syndrome. Anti-diarrhoeal drugs and antibiotics for bacterial overgrowth may help those animals in which dietary management is not working. Most cases eventually reach a stable weight or increase to approximately three quarters of the animal’s original weight.

What should I not touch?
Keep away from the colon in particular. Colotomy to remove foreign bodies and surgical colonic biopsy are almost never indicated. Although the large intestine heals in a similar way to the small intestine, healing is slower and therefore dehiscence is more likely. The biliary and pancreatic ducts and the proximal duodenum should also be avoided.

How much do I panic if I spill intestinal contents?
It is important to avoid spilling intestinal contents, as doing so will increase the risk of post-operative infection. Risks are potentially higher following spillage of colonic contents and faeces. However if the abdomen is thoroughly lavaged with several litres of sterile saline and the lavage solution removed with suction then this increase in risk is probably theoretical. Where possible, the part of the GI tract involved is exteriorised from the abdomen. It should be isolated using moistened, large laparotomy swabs. Layering 3-4 swabs allows removal of any swabs that become contaminated during the procedure and decreases the risk of contamination. Stay sutures can be placed to manipulate the intestine, and can be lifted by an assistant to avoid spillage when the lumen is entered. Before making an incision, the intestinal contents are milked away from the incision site. Finally, local irrigation of the incision site and general abdominal lavage prior to abdominal closure will dilute contamination. It is important to utilise suction to remove all lavage fluids, as cells of the immune system cannot move across fluid. Lavage should not be excessive as proteins are removed with the lavage fluid.

How can I tell that dehiscence of my intestinal surgery is occurring?
The clinical sign of vomiting is the hallmark of peritonitis. Other clinical signs are abdominal pain, lethargy and depression and anorexia. Following intestinal foreign body removal dogs should have a rapid return of appetite (within 24 hours) and defecate within 48 – 72 hours. A
return of appetite and the passing of faeces generally indicate that the development of intestinal dehiscence and peritonitis is unlikely. Any dog vomiting, or with persistent abdominal pain after intestinal surgery should be evaluated for peritonitis. A simple and reliable technique is abdominocentesis and cytology of abdominal fluid.

Two studies have identified a relatively high risk of dehiscence associated with gastrointestinal surgery at large referral hospitals. In a study of 66 dogs with gastrointestinal biopsies 10.6% of the dogs died as a result of septic peritonitis due to dehiscence of the biopsy wounds. Another study examined the outcome for 90 dogs and 25 cats following intestinal anastomosis and found that 14.4% of dogs suffered leakage from the anastomosis compared with 0% of the cats. Interestingly a study of foreign body removal in dogs and cats at a busy charity hospital 4.9% of dogs were euthanased or died as a result of peritonitis compared with 0% of cats.

Wound dehiscence usually occurs 2-5 days post-operatively, when fibrinolysis results in decreased wound strength. Wound failure secondary to failure of sutures is rare if the correct surgical technique has been used. Clinical signs include acute onset vomiting, depression, anorexia and abdominal pain, and are more severe for colonic wounds than small intestinal or gastric wound breakdown. The animal may start to show evidence of hypovolaemic shock. Radiographs are difficult to interpret as the presence of fluid and gas is not unusual in post-operative patients. Contrast radiography may not help as barium may not leave the stomach if there is ileus associated with recent surgery or peritonitis. Ultrasonography is useful to facilitate collection of fluid. Definitive diagnosis is made on the basis of cytology – neutrophils are degenerate with intracellular bacteria, and there may be foreign material. It is important to be able to differentiate sepsis from the cytology of a normal post-operative patient, which contains higher numbers of macrophages and non-degenerate neutrophils than a normal animal. Comparison of glucose levels in the peripheral blood compared with the fluid is supportive for a diagnosis of septic peritonitis if there is a blood: fluid glucose gradient of >1.5mmol/l.

In some animals, it may not be possible to confirm dehiscence and peritonitis, but surgery is warranted in postoperative patients that show clinical signs of an acute abdominal crisis. A period of stabilisation, using high dose crystalloid +/- colloid therapy, is performed prior to anaesthesia. At surgery, the site of dehiscence is either reinforced with extra sutures or resection and anastomosis is performed. Copious peritoneal lavage, and omental or serosal patching is mandatory, and in severe instances it may be necessary to place a drain or perform open peritoneal drainage.

Risk factors for developing dehiscence include the presence of pre-operative peritonitis, low serum albumin concentrations, intestinal trauma, intestinal foreign bodies and multiple intestinal
procedures. Dogs are more likely to suffer dehiscence than cats. Mortality rates following intestinal dehiscence and peritonitis are between 50 and 80%.