Surgical Management of Abomasal and Small Intestinal Disease

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KEYWORDS

- Bovine • Surgery • Abomasum • Duodenum • Jejunum • Ileum • Caecum • Colon

KEY POINTS

- The right para-lumbar fossa is not always the ideal surgical approach to treat abomasal problems, such as ulcer and impaction.
- Minimally invasive procedures have the advantage of decreasing the need for perioperative antibiotics.
- The sigmoid flexure of the duodenum should be systematically evaluated in case of proximal intestinal obstruction.
- Hemorrhagic bowel syndrome remains a difficult condition to treat.
- Partial cecal amputation should be considered in cases of recurrent dislocation/dilatation.

INTRODUCTION

A bovine practitioner should master abdominal exploratory surgery (laparotomy). Several gastrointestinal (GI) problems require surgical correction to save the animal's life and to keep it in production. Time, from the onset of the clinical signs to the surgery, is a key factor in the success of the procedure. Clients need to be educated to rapidly recognize clinical signs of GI obstruction anorexia, colic, decreased fecal output, change in color of feces (melena, fresh blood, mucus). The veterinarian should evaluate cows presenting such signs as early as possible. At the farm, the tools described in Gilles Fecteau and colleagues' article, "Diagnostic Approach to the Acute Abdomen," in this issue, should be used to determine if surgery is needed (surgical abdomen). Depending on the most probable diagnosis, the attending veterinarian should then quickly decide whether or not the surgery can be performed at the farm, if he or she needs to call for help (assistant or a more experienced surgeon), or if the cow has to be euthanized because of the poor prognosis.

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This article first reviews the surgical preparation of the abdomen and the preoperative treatments. The following part is divided in 2 sections: abomasal and intestinal surgery. For the abomasal surgery, the different surgical approaches according to suspected problems will be presented. Finally, postoperative care, including management of postoperative ileus, is presented.

PREOPERATIVE TREATMENTS

Cattle in shock should be stabilized before the surgery (fluids and blood transfusion). Preoperative antibiotics (beta-lactam) are needed when the abdomen is manually explored in a field setting. When the GI tract is open, a broad-spectrum antibiotic effective against gram-negative bacteria should be given. A nonsteroidal antiinflammatory drug (NSAID) (flunixin meglumine or meloxicam), if not already given by the owner, should be given before the surgery with the exception of when an abomasal ulcer is suspected.

Depending on the procedure, the cattle remains standing (most procedures) or is placed in dorsal, lateral, or sternal recumbency. The authors have come to prefer sternal recumbency when it is highly probable that the animal will go down during the procedure (pain or weakness). A key element when choosing this position is to provide enough padding for the down leg to avoid peroneal paresis (seen even more frequently in hypotensive animals). The upper leg should be pulled back and secured to clear the para-lumbar fossa (Fig. 1). Compared with the left lateral recumbency position, sternal recumbency allows better exteriorization of the jejunum and the exploratory seems easier to perform.

If a recumbent position is required, the animal will most likely need to be sedated. A ketamine stun given intravenously (IV) (butorphanol 0.025 mg/kg, xylazine 0.05 mg/kg, ketamine 0.5 mg/kg) combined with casting ropes (Fig. 2) is usually sufficient to get the cow to lay down safely without significantly compromising the cardiovascular system.[1,2] For the more frantic cattle, the dose of ketamine can be increased to 1.1 to 2.2 mg/kg.

PRINCIPLES OF SURGICAL PREPARATION AND ANESTHESIA
Patient (Cattle)

After identifying a clean area with appropriate lighting to perform the surgery, the animal should be brushed to remove dirt and hairs from the back and flank. Then, the

Fig. 1. Adult cow in sternal recumbency. The upper leg is pulled backward to expose the para-lumbar fossa. (*Courtesy of* Sylvain Nichols, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

Fig. 2. Casting rope passed around the neck, the thorax, and the abdomen. By pulling on the rope, the abdomen and the thorax are squeezed. The leg ropes help to flip and secure the cow in dorsal recumbency. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

surgical site is clipped using a clipper with a No. 40 blade. Using a cordless clipper removes the hassle of finding a power outlet. The razor blade has no advantages over the clipper blade and causes more skin irritation.[3] The clipped area should be a least twice the length of the incision vertically and horizontally.

The second step of the surgical preparation is cleaning. An antiseptic soap with a detergent is needed to remove all organic material from the surgery site. At least 3 rounds of cleaning and aggressive brushing should be done before anesthesia and the aseptic scrub.

Local anesthesia
Local anesthesia of the surgical field within the para-lumbar fossa may be obtained through multiple techniques. For ventral surgery, local anesthesia can only be obtained through a line block using 2% lidocaine.

The proximal and the distal paravertebral blocks have the advantage of completely anesthetizing the para-lumbar fossa. They are somewhat more challenging to perform than the line block and the inverted L. They have the negative reputation of not being efficacious 100% of the time. The percentage of failure lowers over the years of experience.

Proximal paravertebral block The nerves anesthetized are T13, L1, and L2. They are located respectively behind the same numbered vertebrae. The site is at the junction of the axial third and the middle third of the length of the vertebra's transverse process. The closer the block is performed to the spine, the more efficient it is. At this location, 30 to 60 mL of 2% lidocaine is infiltrated in 3 sites (1 cm below, at the level, and 1 cm above the transverse process) with an 18-G, 3.5-in (9 cm) spinal needle. The depth of the transverse process is evaluated by walking off the process with the needle. Before injection, aspiration is performed to check for air (needle in the peritoneum) or blood. The last transverse process to be palpated before the ilium wing is L5. Knowing this, L2 is located to start the block.

Distal paravertebral The nerves anesthetized are T13, L1, and L2. They are located above and below the tip of the vertebral transverse process of L1, L2, and L4.

At this location, 20 to 40 mL of 2% lidocaine is infiltrated in 2 sites (above and below the distal end of the transverse process) with an 18-G, 1.5-in (3.8 cm) needle. Before injection, the site is checked for air (needle in the peritoneum with the ventral injection) or blood (do not inject IV). The last transverse process to be palpated before the ilium wing is L5. Knowing this, L4 is located to start the block. The authors find that the distal paravertebral block does not have the same reliability as the proximal block. However, it is easier to perform and does not create the scoliosis caused by the proximal block.

Segmental epidural block This block is more challenging to perform. It is done at the level of L1-L2 or T13-L1. A 16-G, 12-cm in length Tuohy needle is used. After aseptic preparation, the needle is inserted in the epidural space. A hanging drop technique is used to confirm the proper placement of the needle. Air is allowed to enter the space for 1 minute before the needle is inserted 0.5 cm deeper to avoid injection in the epidural fat. A fixed volume of 4 mL of 2% lidocaine or 1 mL of xylazine (20 mg/mL) and 3 mL of 2% lidocaine is injected. The xylazine speeds up the onset of anesthesia and provides a mild sedative effect. When successfully performed, the abdominal wall is anesthetized bilaterally.[4,5]

The aseptic scrub is performed using an antiseptic soap and detergent. The shaved area is divided in 3 sections: central, mid, and external sections. The central section is located precisely where the incision line will be performed. The aseptic scrub is initiated in this area. It is scrubbed for 90 seconds before moving to the midsection. At this point, the brush should not come in contact with the central section. Another 90 seconds of scrubbing is performed at this location before moving to the external section. At this point, the brush should not come in contact with the mid and central sections. The external section is the junction between the clipped and unclipped part of the animal.

The final step of the surgical preparation is the alternating swipes of alcohol and antiseptic in a circular motion from the anticipated incision line to the outside of the prepared area. This step should be performed just before cleaning and scrubbing the surgeon's hands. Three swipes of each product are performed. The last swipes should be done with the antiseptic. The gauze is inspected to evaluate the cleanliness of the surgical field.

Commonly, iodine- (povidone-iodine) or chlorhexidine-based (4% chlorhexidine gluconate or 2% chlorhexidine diacetate) products are used for surgical preparation. It is important to use the same product throughout the preparation. Chlorhexidine is superior to iodine in the face of organic material. It also has a residual effect that iodine products are lacking. However, studies were not able to demonstrate a difference between the 2 products in regard to surgical site infection.[3–6]

Surgeon

Practitioners doing on-farm surgery are often multitasking to get the animal ready in a timely fashion. They are the anesthesiologist, technician, and surgeon at the same time. After the aseptic scrub, just before the aseptic swipes, the surgery table is set. Visualizing the procedure while opening the instrument packets is a useful review of the material that might be needed. Then, the final aseptic swipes are done just before the surgeon's preparation. The hands and forearms are thoroughly cleaned with an antiseptic and detergent soap, which is followed by a 5-minute scrub.

An impermeable surgical gown (sterile or not) and sterile gloves should be worn for all abdominal procedures.

Drapes

Sterile drapes can be used for standing or recumbent surgery. Ideally, they should be impervious. They extend the aseptic surgical field and help keep the suture material and the surgeon's hands sterile. They are held in place with towel clamps. Those clamps are essential to avoid sliding of the drapes, which will bring dirt in the surgical field. Care must be taken not to contaminate the scrubbed area when setting the drapes. Remember that the back of the drape is in contact with the unclean area so if it moves toward the prepared and aseptic site, contamination occurs.

ABOMASAL PROBLEMS/DISEASES

The most frequent problem involving the abomasum is the displacement. Two displacements have been described: the left (left displaced abomasum [LDA]) and the right side (right displaced abomasum [RDA]) displacement. The RDA is less frequent. However, this displacement can lead to a more serious condition: abomasal volvulus.

LDAs are frequently seen after calving. The cause is multifactorial. Small rumen after calving, electrolyte calcium imbalances, and any other concomitant diseases (retained membranes, mastitis, metritis) causing a decrease in food intake and reduce abomasal motility may predispose to LDA.[7–9]

The RDA can be seen at any time during the life of the animal. When an RDA progresses to a volvulus, the animal rapidly goes into cardiovascular shock (increased heart rate, severe dehydration, pale mucous membrane, slow capillary refill time).[10–12] In this case, surgery is needed as soon as possible to correct the condition and obtain a better outcome.

Other conditions affecting the abomasum are ulcers,[13,14] motility dysfunction leading to impaction,[15] and pyloric outflow obstruction caused by an intraluminal (bezoar) or an extraluminal/intramural (lymphoma, abscess) mass.

ABOMASAL SURGERIES

Multiple surgical approaches to the abomasum have been described. Some are minimally invasive (laparoscopically), and others are performed through an abdominal incision. Each technique has its pros and cons. It is important to realize that not all surgical approaches are suitable for all abomasal problems. Other factors that influence the choice of a procedure over another are surgeon experience, client budget, the value of the cow, and the environment where the animal is kept.

The blind techniques (toggle and blind stitch) are not discussed in this article.

Surgical Techniques Performed Through Laparotomy

The main advantages of laparotomy over laparoscopy are the possibility to explore the abdomen more thoroughly and to palpate the structures. However, having the abdomen open in a farm setting increases the risk of surgical wound infection and peritonitis compared with the noninvasive technique. Therefore, perioperative antibiotics are more often needed and justified with laparotomy.

Right or left paramedian (abomasopexy)

This technique became less popular when the standing right flank omentopexy was developed. It creates a strong adhesion between the abomasum and the body wall.[16] With this technique, the abomasum is secured in its normal anatomic location.

This technique is the ideal surgical technique when ventral adhesion or abomasal ulcers are suspected because it is the only technique that allows exteriorization of the greater curvature of the abomasum through the incision (Fig. 3). All the

Fig. 3. Greater curvature exposed through a right paramedian incision. (*Courtesy of* André Desrochers, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

displacements can be corrected through this approach. The main disadvantages of this technique are the need for dorsal recumbency and the risk of postoperative abdominal/abomasal herniation.[17] The latter is reduced by performing a left paramedian approach with a right paramedian pexy next to the incision instead of directly in it. This technique does not allow a thorough abdominal exploration.

Abdominal surgical approach A 15- to 20-cm skin incision is performed 5 to 8 cm caudal to the sternum and lateral (right or left) to the midline. The incision is made through the skin, subcutaneous tissue, caudal deep pectoral muscle (cranially), the external sheet, the rectus abdominis, the internal sheet, and the peritoneum.

Abdominal exploration and abomasopexy The abomasum should be located right below the incision. If the abomasum is not in its place, it is located and brought back to the right side. If it cannot be replaced, adhesions should be suspected. Fibrinous adhesions can be broken down manually. Fibrous adhesions need to be sharply dissected. When the abomasum is freed, it is brought out of the incision. Any perforations or ulcers are sutured. The greater curvature and its omental attachment are identified. Caudally, the pylorus and cranially the reticulo-abomasal ligament are palpated. The abomasopexy is performed midway between those two landmarks, 2 to 4 cm lateral to the omental attachment.
   Two techniques have been described:

1. The first technique incorporates the abomasal wall into the abdominal wall closure. The serosa and the muscular layer of the abomasum are attached to the peritoneum and the internal sheet of the rectus abdominis muscle with a simple continuous pattern using nonabsorbable suture material. Care should be taken not to penetrate the lumen of the abomasum by slipping the mucosa away at each bite.
2. The second technique secures the abomasum away from the incision. It reduces the risk of postoperative abomasal herniation. Three pieces of absorbable or nonabsorbable suture material are preplaced through the peritoneum, internal sheet, and rectus abdominis muscle lateral to the incision (Fig. 4). Then they are placed within the abomasum wall (same location as in the previous technique) making sure not to penetrate the lumen. The sutures are tightened before abdominal wall closure.

Abdominal surgical closure The abdominal incision is closed in 3 layers. The peritoneum and the internal sheet are closed in a simple continuous pattern (already done if the abomasopexy is located in the abdominal incision). An interrupted suture pattern
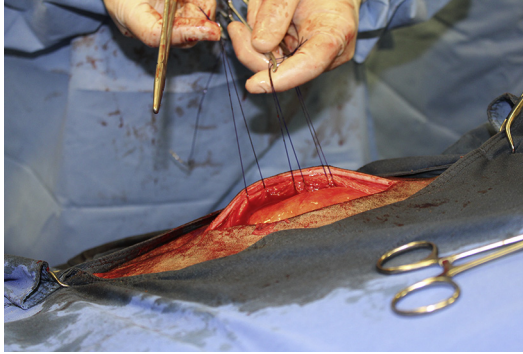
Fig. 4. Paramedian abomasopexy. Three strands of PDS 2 have been placed through the peritoneum, internal sheet, and rectus abdominis muscle before being placed within the abomasal wall. (*Courtesy of* André Desrochers, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

(cruciate or simple interrupted) is then used for the rectus abdominis and the external sheet (holding layer). Finally, cruciate sutures are used for the skin.

Left para-lumbar fossa (abomasopexy)

This technique can only be used with an LDA. It is commonly performed on cattle with displacement while in late gestation. It is also used when adhesions and ulcers are suspected up high in the flank.

Surgical approach The flank approach closer to the last rib (3–5 cm) and more ventrally on large cattle is used.

Abdominal exploration and abomasopexy The left para-lumbar approach allows the surgeon to palpate the reticulum, the rumen, the spleen, the displaced abomasum, the uterus, and the left kidney. Fibrinous adhesions should be carefully dissected. With fibrous adhesions, it is safer to dissect the parietal peritoneum with the adhesions to avoid rupturing the abomasum. The parietal defect left by this technique will heal quickly.

The omental attachment is identified, and the greater curvature of the abomasum is pulled out of the incision (Fig. 5). A continuous pattern (Ford interlocking) is placed 2 to 3 cm lateral to the omental attachment, midway between the reticulo-abomasal ligament and the pylorus. A long strand (2 m) of nonabsorbable suture material of US Pharmacopeia (USP) 4 is used. The length of the suture line, on the abomasum, is 5 to 6 cm. The cranial and caudal ends of the suture are kept long.

The abomasum is partially deflated. Using a 3-in straight needle or a straightened S-curve needle, the cranial end of the suture is pulled toward the pexy site making sure not to grab the omentum on the way down. An assistant can identify the pexy site by pushing on the abdominal wall with hemostatic forceps (15-20 cm caudal to xyphoid and 5-10 cm on the right side of midline). The pexy site can be identified by palpating the xyphoid intra-abdominally. The needle is pushed through the abdominal wall and grabbed by an assistant. The same process is performed with the caudal end of the suture. It is important that the length of the suture line on the abomasum is the same as the distance between the exit points on the abdominal wall. The abomasum is fully deflated (not always necessary) and pushed down into normal position (not pulled down by the assistant otherwise tearing will occur). The

Fig. 5. Greater curvature of the abomasum exteriorized through a left para-lumbar fossa incision. (*Courtesy of* Marie Babkine, DMV, MSc, DECBHM, Université de Montréal, Québec, Canada.)

abomasum is held down while an assistant attaches the suture ends together through a roll of gauze.

Abdominal surgical closure and specific postoperative care The abdominal incision is closed in 3 layers (peritoneum and transverse muscle, external and internal oblique muscles, and skin). The ventral stitch is removed 14 to 21 days after the procedure. If the cow is not doing right early in the postoperative period with clinical signs of proximal GI obstruction, it is recommended to cut the ventral suture and perform another type of abomasal fixation. The authors have seen omental/intestinal incarceration and kink of the abomasum at the pexy site causing total outflow obstruction.

Right para-lumbar fossa (omentopexy/pyloropexy)
This technique can be used for all types of displacement. It is the ideal surgical approach for abomasal volvulus.

Abdominal surgical approach The standard right flank approach is used (8–10 cm below the transverse process and 8–10 cm caudal to the last rib).

Abdominal exploration and omentopexy The right flank approach allows for the most thorough abdominal exploration.

The abomasum is deflated and brought back to its anatomic location. The omentum and pylorus (not to be confused with the cranial duodenum) are pulled out of the incision (**Figs. 6** and **7**). The fixation site is located 10 cm caudal to the pylorus. The sow's ear (an omental fold) is rarely at this location. This should not be used as a landmark for the pexy. However, when identified, you know you are close. Allis forceps are used to mark the site.

Retention sutures are placed at the cranial and caudal aspect of the incision to enlarge the size of the adhesion. Absorbable suture material of USP 2 is used. The cranial suture is passed from outside in through all the muscle layers and peritoneum at the lower end of the incision. Then 2 to 3 large bites of omentum are taken from the bottom to the top in regard to the Allis forceps. The suture is passed through the body wall from the inside out at the top of the incision. The same manipulations are repeated on the caudal aspect of the incision. The suture ends are held together with hemostatic forceps. They will be tied before skin closure.

Fig. 6. Pylorus exteriorized through a right para-lumbar fossa incision. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

The omentopexy is performed with absorbable suture material of USP 2 in a simple continuous pattern. The suture line includes the peritoneum, the transverse muscle, and the omentum (large bits). It starts at the bottom of the incision. Care should be taken not to incorporate the descending duodenum while closing blindly the top of the incision. The internal and external oblique muscles are then closed together with a simple continuous pattern. The retention sutures are tied before skin closure with a Ford interlocking suture pattern.

Pyloropexy A *pyloropexy* is performed when the omentum is friable, overly fat, or torn (**Fig. 8**). Several techniques have been described. The antrum can be incorporated in the suture of the ventral aspect of the flank incision when an omentopexy cannot be performed. If the omentum is still usable, a single horizontal mattress suture can be placed through all of the muscle layer of the flank and the serosal and muscular layer of the pyloric antrum at the ventral and cranial aspect of the incision. It is important to avoid the lumen of the abomasum to avoid postoperative complications (leakage

Fig. 7. Duodenum exteriorized through a right para-lumbar fossa incision. It is important to note the difference with the structure shown in **Fig. 6**. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

Fig. 8. Pylorus, pyloric antrum, and part of the body of the abomasum exteriorized through a right para-lumbar fossa incision. The omental attachment has been torn from the greater curvature during an abomasal volvulus. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

causing peritonitis or outflow obstruction). Slowly, absorbable suture material can be used. Although somewhat infrequent, in the authors' opinion, the complications are maybe more serious with this technique if they occur.

Abomasal volvulus A large fluid-filled abomasum in volvulus can be difficult to replace. By lifting up and forward the body of the abomasum, it loosens the knot at the pylorus allowing the fluid to drain into the duodenum. This movement is repeated until the volvulus can be corrected by pushing back and down the pylorus and the greater curvature. However, if no progress is noted after several attempts at lifting the heavy abomasum, drainage is indicated. A purse string suture with an internal diameter of 5 cm is placed on the greater curvature before the incision and insertion of a gastric tube. It is not uncommon to remove more than 5 gal of abomasal fluid with this technique. When the drainage stops, the purse string is closed before being buried with an inverting suture pattern. The empty abomasum is then easily replaced in a normal anatomic position before being pexied.

Para-costal flank approach (abomasopexy or abomasotomy)
This approach is performed with the animal in lateral recumbency. From the left side, it allows the safe release of a chronically displaced abomasum adhered to the body wall. In a referral center, on anesthetized cattle, the rib cage can be lifted up to expose the adhesions (Fig. 9).

From the right side, it allows exteriorization of the pyloric antrum and part of the body of the abomasum to perform an abomasotomy to empty an impacted abomasum or to safely remove an abomasal foreign body.

From both sides, an abomasopexy using the transfixation technique described through the left flank approach can be used to secure the abomasum in place.

Surgical Techniques Performed Through Laparoscopy

The main advantage of laparoscopy over laparotomy is the minimal invasive approach needed to perform the procedure, thereby decreasing postoperative morbidity. However, the technique requires specific equipment and training and can only be used to correct LDA.

Fig. 9. Right para-costal approach to release a dilated abomasum from its abdominal adhesions. The rib cage has been lifted to improve exposure. (*Courtesy of* Marie Babkine, DMV, MSc, DECBHM, Université de Montréal, Québec, Canada.)

Two-step laparoscopic toggle pin placement (Janowitz)

The procedure starts by placing a double-strand toggle pin within the abomasum through a standing left flank laparoscopy.[18,19] Two 10 cm × 10-cm squares are shaved and prepared for the introduction of the laparoscope and instruments. The laparoscope is introduced just behind the last rib and ventral to the transverse process of the lumbar vertebras. Room air is allowed to enter the abdomen. The instrument portal is located at the 11th or 12th intercostal space at the same level or slightly ventral compared with the laparoscope portal. A long trocar and its cannula are introduced through the instrument portal into the abomasum. The trocar is removed, and the toggle pin is introduced within the abomasum. The abomasum is deflated, and the toggle ends are left in the abdomen.

The second step requires that the cow is placed in dorsal recumbency. Two 10 cm × 10-cm squares are shaved and prepared for the introduction of the laparoscope and instruments. The laparoscope is introduced 10 cm lateral (right) to midline and 30 cm cranial to the umbilicus. The instrument portal is introduced 10 cm lateral (right) to midline and 10 cm cranial to the umbilicus. The toggle ends are brought out of the instrument portal with laparoscopic forceps introduced through the instrument portal. The instruments are removed, and the cow is placed in right lateral recumbency. The sutures are tied over a roll of gauze until the markers are visualized (5 cm from the pin).

One-step laparoscopic toggle pin placement standing procedure (Christiansen)

This procedure requires a special instrument named a spieker to push the toggle ends through the ventral abdomen from a standing left flank approach.[20] Two 10 cm × 10-cm squares are shaved and prepared for the introduction of the laparoscope and instruments. The laparoscope is introduced just behind the last rib and ventrally to the transverse process of the lumbar vertebras. Room air is allowed to enter the abdomen. The instrument portal is located at the 11th or 12th intercostal space at the same level or slightly ventral compared with the laparoscope portal. A long trocar and its cannula are introduced through the instrument portal into the abomasum. The trocar is removed, and the toggle pin is introduced within the abomasum. The abomasum is deflated, and the toggle ends are kept outside the abdomen. They are passed through the push rod within the spieker. This unit is then introduced in the abdomen through the instrument portal and directed in the cranial right paramedian part of the abdomen. The tip of the spieker is felt or seen before pushing the rods

through the abdominal wall. Finally, the toggle ends are tied over a roll of gauze until the markers are visualized (5 cm from the pin).

With this technique, it is possible to damage abdominal structures when the rod is pushed blindly outside the abdomen and cause GI obstruction or septic peritonitis. Therefore, if the cow is not doing right after the surgery, it is recommended to cut the ventral suture, do a complete physical examination, and modify the treatments according to the findings.

One-step laparoscopic toggle pin placement dorsal procedure (Newman)

This procedure is performed with the cow in dorsal recumbency. The ventral abdomen is prepared aseptically. The first portal is created near the umbilicus to avoid penetrating the abomasum. Because no pneumoperitoneum is created, it is more challenging to insert the cannula. Insufflation through the left para-lumbar fossa before placing the cow in dorsal recumbency can be useful to avoid inappropriate placement of the cannula. The abomasum is visualized (**Fig. 10**) and the trocar and its cannula are introduced into the abomasum in the right paramedian area (same location as the previous technique). The trocar is removed, and the toggle pin is introduced in the abomasum. The toggle ends are kept outside the animal. The abomasum is deflated. The remainder of the procedure is like the 2-step technique. With this technique, no laparoscopic forceps are necessary.[21]

Ventral laparoscopic abomasopexy (Babkine)

This technique is a minimally invasive way to perform a right paramedian abomasopexy.[22,23] The cow is positioned in dorsal recumbency. A laparoscope, grasping laparoscopic forceps, and a laparoscopic needle holder are introduced into the abdomen. The abomasum is deflated before being grasped with the laparoscopic forceps. A needle of USP 2 (polydioxanone [PDS II, Ethicon, Somerville, NJ] or polyglactin 910 [Vicryl, Ethicon, Somerville, NJ]) is straightened and introduced in the abdomen through a stab incision in the skin at the pexy site. The needle is grasped with the needle holder, and the suture is introduced in the abomasum wall. The needle is then stabbed back out where it is retrieved by an assistant through the stab skin incision. The manipulations are repeated 2 to 3 times to create the abomasopexy (**Fig. 11**). The sutures are tightened subcutaneously only when they are all in position.

Fig. 10. Abomasum seen from a ventral laparoscopic approach. A trocar to insert the toggle within the abomasum is inserted in the abdomen (*top center of the picture*). The greater curvature with the omental attachment are seen on the right side of the abomasum. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)
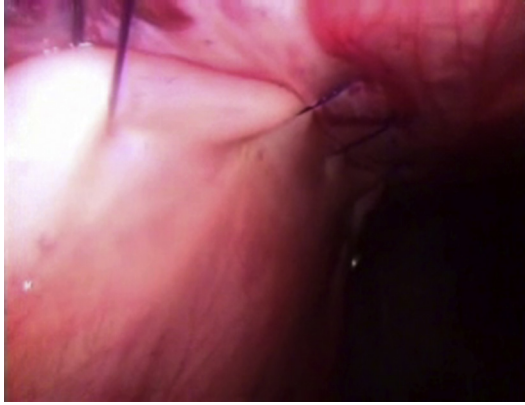
Fig. 11. Four stitches have been placed laparoscopically to perform the abomasopexy. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

This technique is more challenging than the other laparoscopic procedures described previously. An assistant is needed to assist the surgeon technically.

In all the minimally invasive techniques, the skin incisions are closed with cruciate sutures. The toggle stitches are cut 14 to 21 days after the procedure.

Laparotomy Versus Laparoscopy

The 2-step laparoscopic abomasopexy seemed to improve abomasum motility when compared with the right flank omentopexy.[24] However, when the peritoneal fluid was analyzed, the laparoscopic technique seemed to create more inflammation than the right flank omentopexy.[25] It is thought that inflammation was caused by puncture of the abomasum with the toggle. The overall success rate (milk production and culling rate) are not different between techniques.[26] The main advantages of the laparoscopic technique are the rapidity of the surgery and the decreased use of antibiotics.[27]

INTESTINAL SURGERIES

Intestinal surgery can be challenging in cattle. The short mesenteric attachment of the intestinal tract (with the exception of the cecum) makes exteriorization of the devitalized segment difficult. Because most procedures are performed with the animal standing, the pain elicited increases the probability that the animal will go down, usually at the least desirable moment. Frequently, by the time the animal is evaluated, the condition has progressed to a point where the lesion has become friable and necrotic. Therefore, many cattle with intestinal problems will be euthanized before or during exploratory laparotomy.

This section is divided according to the localization of the lesion: the small intestine versus the cecum and colon. For the preoperative treatments and the surgical preparation, the reader is referred to the beginning of this article.

Small Intestines

Duodenum
Duodenum sigmoid flexure volvulus This condition is caused by a dorsal displacement followed by a counterclockwise volvulus (as seen from the top of the cow) of the duodenal sigmoid flexure (**Figs. 12–14**).[28] The cause of this condition remains unknown. Prior omentopexy seems to be a risk factor.
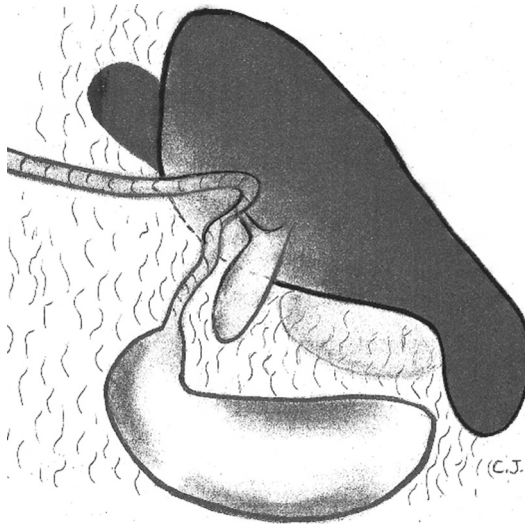
Fig. 12. The normal anatomy of the abomasum and duodenum. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

This condition is diagnosed mainly on dairy cattle of any age and at any stage of lactation. The clinical signs are similar to those of an abomasal volvulus. However, the ping location and diameter are different. A high-intensity ping associated with a positive succussion will be located at the 11th and 12th ICS. Classic hypochloremia, metabolic alkalosis, and hypokalemia are present but much worse than with an abomasal volvulus. Ultrasound evaluation of the right ventral and dorsal abdomen shows a large fluid-filled abomasum and cranial duodenum. During surgery, similarly, a fluid-filled abomasum and cranial duodenum and a gas-distended duodenal sigmoid flexure are palpated. The sigmoid flexure is located cranially, just under the caudate
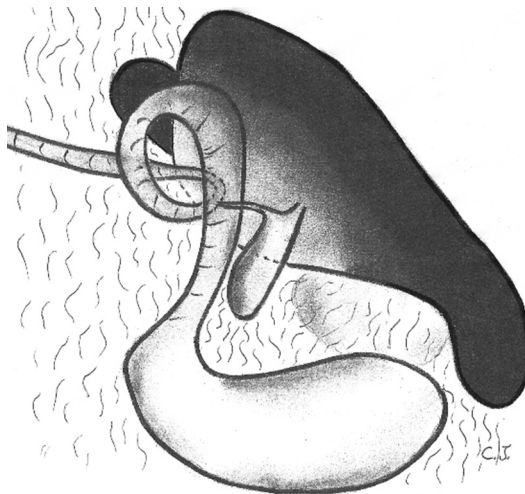

Fig. 13. The dorsal displacement of the duodenal sigmoid flexure before the volvulus. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)
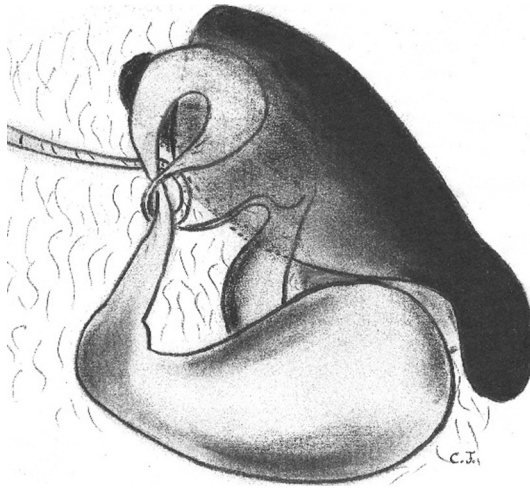
Fig. 14. Duodenal sigmoid flexure volvulus. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

lobe of the liver. This area is often neglected during abdominal exploratory. A twist is often palpated at the sigmoid flexure. An empty descending duodenum is a constant finding. The volvulus is resolved by flipping the gas distended duodenum ventrally and caudally. On correction of the volvulus, the descending duodenum starts to fill with ingesta. No pexy of the duodenum is performed.

In chronic cases, peritonitis surrounding the duodenum may be present, complicating replacement of the sigmoid flexure. In this situation, a side-to-side anastomosis of the cranial duodenum to the descending duodenum is necessary.[29] This technique is not described in this section.

The abdomen is routinely closed without performing an omentopexy. It is thought that it could be a risk factor for duodenum sigmoid flexure volvulus (DSFV), because most cases had an omentopexy before presentation. In addition, the pexy creates pain because the large fluid-filled abomasum is pulling on it.

Intensive fluid therapy, systemic antibiotics, and NSAID are needed in the postoperative period. The prognosis is good with the exception of the cows with extensive peritonitis at the time of surgery.[28]

Gallbladder malposition Duodenal obstruction caused by malposition of the gallbladder shows clinical signs of proximal gastro-intestinal obstruction similar to those seen with duodenal sigmoid flexure volvulus. The obstruction is caused by a displacement of the gallbladder above the cranial duodenum. The condition is resolved by returning the distended gallbladder to its normal anatomic position.[30]

Jejunum
Hemorrhagic bowel syndrome Hemorrhagic bowel syndrome (HBS) has been recognized in veterinary medicine for more than 2 decades. It affects mostly dairy cattle in lactation consuming a high-energy diet.[31] The cause remains unclear. Clostridium perfringens type A containing the beta2 toxin is thought to be involved in the disease.[32]

The cattle are usually in shock. A blood clot in the lumen or in the intestinal submucosa creates a GI obstruction. Moderate to severe abdominal distension will be present. Bloody feces and distended loops of bowel are a frequent finding on transrectal examination. Ultrasound evaluation reveals distended jejunum. In some cases, blood

clots within the intestinal lumen can be seen, as in Gilles Fecteau and colleagues' article, "Diagnostic Approach to the Acute Abdomen," in this issue.

Treating cattle with HBS is always challenging. The first reports of HBS showed that the prognosis after either surgical or medical treatment was poor.[33,34] Better understanding of the disease seems to improve the prognosis. However, after the encouraging report by Peek and colleagues,[35] it seems that the prognosis remains guarded at best (authors' clinical impression). The treatments have not changed drastically over the year with the exception that pain is better control nowadays. However, the authors think that the current cases are more challenging than they were. The single-clot obstruction is rare. Enormous clots, multifocal clots, and ruptured bowel (Fig. 15) at surgery are seen more frequently.

When the animal is still passing feces, medical therapy is indicated. Broad-spectrum antibiotics, including a beta-lactam, NSAID, or other analgesic, such as lidocaine, and aggressive fluid therapy, including blood transfusion, are appropriate. It is the authors' opinion that mineral oil (1 gal orally) is extremely useful to move the clot aborally. If fecal output or if the general status of the animal does not improve or worsens during medical therapy, a right flank laparotomy is warranted. Massaging (Fig. 16) the clot, when possible, has been shown to carry a better prognosis than resection and anastomosis.[35] Relapses have been reported with this disease after clot massaging or resection and anastomosis.
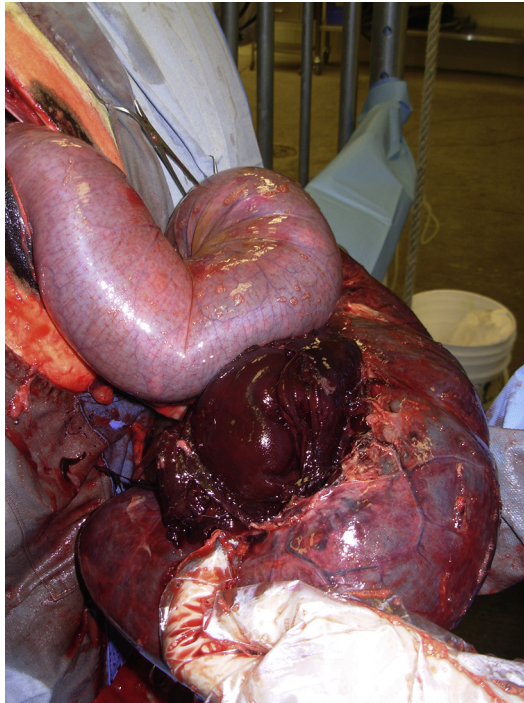

Fig. 15. Loop of jejunum suffering from hemorrhagic bowel syndrome exteriorized through a right para-lumbar fossa incision. The massive blood clot had ruptured the jejunum before the surgery. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)
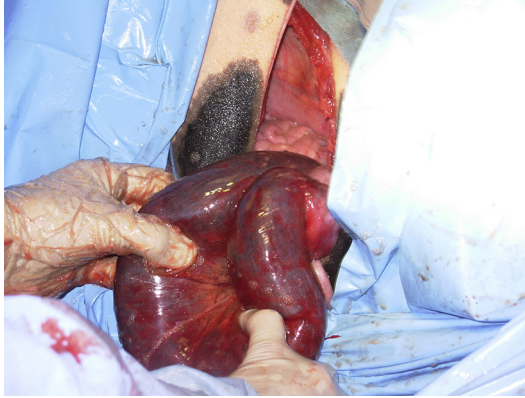
Fig. 16. Loop of jejunum suffering from hemorrhagic bowel syndrome exteriorized through a right para-lumbar fossa incision. The clot is carefully broken down and pushed in the empty jejunum. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

Volvulus A volvulus is defined as a rotation of the viscera around its mesenteric attachment. Two types of intestinal volvulus are recognized in cattle: mesenteric root and jejunal flange volvulus. The flange refers to the distal portion of the jejunum, including the ileum. It has a longer mesenteric attachment that can rotate on itself and create a volvulus. Both types of volvulus are uncommon and may be present in cattle of all ages.

The mesenteric root volvulus causes a rapid obstruction of the mesenteric vein and artery of the small intestine, cecum and ascending colon with the exception of the duodenum and descending colon. The cattle show acute and severe signs of abdominal pain. They become rapidly in shock and may die suddenly. The transrectal examination reveals distended bowel with tension bands.

Cattle with jejunal flange volvulus also have acute signs of abdominal pain. However, their general status deteriorates progressively when compared with mesenteric root volvulus, which is rapid and sudden.

With both conditions, the abdomen is explored through a right flank approach. When a mesenteric root volvulus is present, discolored jejunum segments are seen in the abdomen. The mesenteric root is palpated by sliding the hand cranially to the left kidney within the supraomental recess. The volvulus is located, and the direction of the twist is determined. The jejunum is then carefully untwisted to prevent spontaneous rupture of a fragile devitalized segment. Because the jejunum cannot be completely resected, the animal should be euthanized if the jejunum is determined to be nonviable.

When a jejunal flange volvulus is diagnosed, the affected segment of bowel is gently exteriorized while reducing the volvulus. The bowel is inspected for viability. Resection and anastomosis of the devitalized segment is possible (**Fig. 17**).

The prognosis for both types of volvulus is guarded to poor. Dairy cattle seem to have a better outcome because the farm staff recognize the condition earlier.[36]

Intussusception An intussusception is a segment of bowel (intussusceptum) penetrating another segment (intussuscipiens). Several predisposing factors have been identified (diarrhea, intraluminal mass [granuloma, abscess, tumors], drugs affecting GI motility) (**Fig. 18**). It can affect cattle of all ages, but it seems more frequent in calves

Fig. 17. Jejunal flange volvulus in a 1-year-old heifer. The affected segment has to be re-sected. An end-to-end anastomosis will be performed. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

less than 2 months of age.[37] The segment most frequently affected is the jejunum. Seldom, it can affect the ileocecal junction and the spiral colon. Compared with other types of intestinal obstruction, the clinical signs appear slowly and will evolve over several days. Colics are mild and present only in the early stage. The production of feces decreases until it stops, and only fibrin and mucus are expulsed. Distended loops of the bowel are palpated during a transrectal examination, and fluid-filled jejunum is seen on ultrasound. Rarely, the supposed typical bull's eye sign is observed during ultrasound evaluation.

Through a right flank approach, the abdomen is evaluated quadrant by quadrant until the intussusception is localized. Frequently, fibrinous adhesions are present around the obstruction site. It is gently exteriorized to perform a resection and anastomosis. The authors have never been able to reduce the intussusception without a resection. It is, however, described in other species.
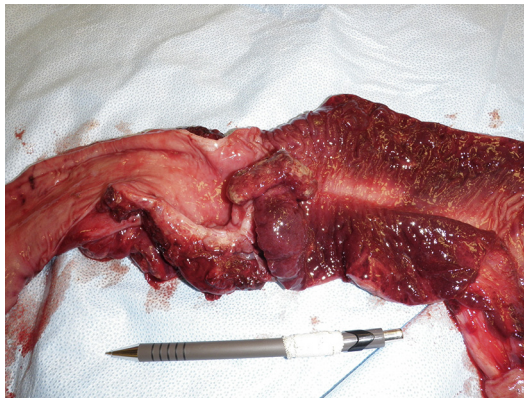

Fig. 18. A loop of jejunum suffering from an intussusception has been resected. The intus-susception has been reduced to expose a granuloma of unknown origin within the lumen of the jejunum. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

The prognosis remains guarded because the long-term outcome was estimated at 35%.[37]

RESECTION AND END-TO-END JEJUNAL ANASTOMOSIS

Challenge of the procedure
1. Exteriorization (short mesentery)
2. Pain control during the procedure (difficult to anesthetize the mesentery)
3. Hemostasis (localization of vessels difficult because of the abundant fat within the mesentery)

When the affected segment is localized, it is carefully pulled out of the abdomen. Wet towels are used to isolate the bowel and protect the abdomen from any leakage during the procedure. The site of resection is determined (healthy jejunum). The mesenteric vessels are ligated (blindly) or transected using a sealing device (eg, Liga-Sure, Medtronic, Minneapolis, MN). The mesentery is cut parallel to the bowel to be resected.

The lumen is occluded with Penrose drains on the healthy section to anastomose. On the section to be resected, any type of obstructive clamps or forceps can be used (Doyen, Rochester forceps).

The aboral section is cut with a 60° angle to increase the lumen diameter. The oral portion is cut at 90°. Each side of the jejunum should be held by an assistant. The anastomosis is started at the mesenteric side. It is more difficult to obtain a tight seal at this location. Two or 3 simple continuous or Lembert sutures are made to complete the anastomosis. Absorbable suture material (Vicryl, PDS) of USP 2.0 or 3.0 is used. The Penrose drains are removed allowing the ingesta to progress through the anastomosis. The site is evaluated for leakage. The mesentery is closed with a simple continuous pattern. Absorbable suture material of USP 0 is used. The surgery site is thoroughly rinsed before being carefully replaced in the abdomen.

Internal herniation Internal herniation is diagnosed sporadically in cattle. The clinical signs are similar to other types of intestinal obstruction (abdominal distension, colic, distended loops of bowel on transrectal examination and ultrasound evaluation) and ileus. Nonresponse to medical therapy (NSAID and fluids) justifies right flank laparotomy. The abdomen is carefully evaluated quadrant by quadrant. Finding empty loops of bowel helps to localize the site of obstruction. The jejunum can be trapped through a rent in the broad ligament, the omentum, the mesojejunum, or the mesoduodenum. When the hernia ring is located, it is determined if the bowel can be pulled out safely. In most cases, the ring has to be enlarged manually. The entrapped segment is then exteriorized to evaluate their viability. If necessary, a resection and anastomosis are performed. If accessible, the rent is closed after being refreshed. If not accessible, it is enlarged to avoid further entrapment. The prognosis is good if the jejunum is viable at the time of surgery.[38]

Ileum
Impaction Ileal impaction seems to be uncommon in North America. However, it is a more frequent cause of intestinal obstruction in other parts of the world.[39] No predisposing factors have been identified other than the condition occurs more frequently during winter time. The clinical signs are more subtle than other types of obstruction (eg, intestinal volvulus). Distended loops of bowel and in some cases a firm mass (the impaction) can be palpated during a transrectal examination. A right flank laparotomy allows the localization of the obstruction, which can be broken down and massaged within the cecum. The long-term outcome following surgery is good.[39]

Cecum

Cecum dislocation After abomasal displacements, cecal dislocation is the most frequent condition affecting the GI tract. It has been associated with hypocalcemia and a diet rich in rumen-resistant starch causing an increase in carbohydrate fermentation in the cecum and large colon.[40] It is usually diagnosed in dairy cattle during their lactation.

The cecum can be dilated, retroflexed (ventral or dorsal volvulus), or twisted. The dilation will be recognized on transrectal examination. The apex of the cecum is found in the pelvic canal. With a 180° retroflexion, the apex is typically located cranially in the abdomen. This flexion can evolve to a 360° volvulus. Then, only the body of the cecum is palpated transrectally. The cecal torsion is a twist within the long axis of the organ. This presentation is less common.

Usually, with cecal dislocation, a distended structure is seen in the para-lumbar fossa. A positive percussion and succussion is present. Depending on the type of dislocation, the vital parameters will be affected with more or less severity.

Cattle with cecal dilatation without significant systemic repercussion and still passing feces are treated medically with IV fluids and NSAID. The fluids are complemented in calcium because hypocalcemia has been shown to be a predisposing factor to cecal problems.[41]

Cattle with cecal dilatation with systemic repercussion, cecal retroflexion or cecal torsion has to be treated surgically. A right para-lumbar fossa approach allows to safely mobilize and exteriorize the cecum (**Fig. 19**). A typhlotomy is performed to empty the cecum and the proximal loop of the ascending colon. If the cecum has necrotic patches or in recurrent cases, partial resection is indicated (**Fig. 20**).

The prognosis following cecal surgery is good. It is important to note that the recurrence rate of cecal dilatation is relatively high.[41–43]

TYPHLOTOMY AND PARTIAL TYPHLECTOMY

1. Typhlotomy

    The apex of the cecum is easily exteriorized after correction of the retroflexion or torsion. A typhlotomy is performed to empty the contents. An assistant holds the cecum exteriorized. The abdomen is protected with a wet sterile towel. At the apex of the caecum, a 5-cm stab incision is made (**Fig. 21**). The ingesta within the cecum and proximal loop of the ascending colon is massaged out. The typhlotomy is closed with 2 inverting layers (Cushing) with absorbable
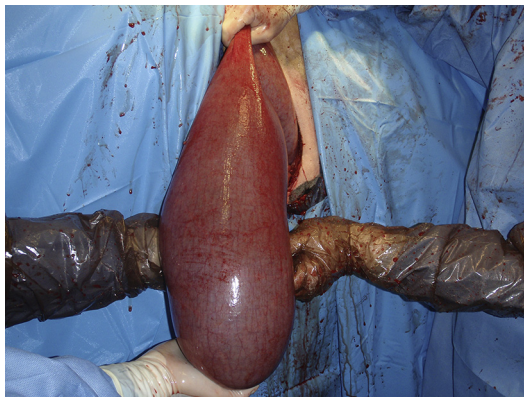

Fig. 19. Dilated cecum exteriorized through a right para-lumbar incision. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

Fig. 20. Dilated cecum with necrotic patch following a volvulus exteriorized through a right para-lumbar incision. The apex of the cecum will have to be amputated. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

(Vicryl, Braided Lactomer [Polysorb, Covidien, Mansfield, MA]) suture material of USP 0. The possibly contaminated part of the cecum is rinsed thoroughly before being returned in the abdomen at its normal anatomic location (apex pointing back in the right dorsal quadrant of the abdomen).
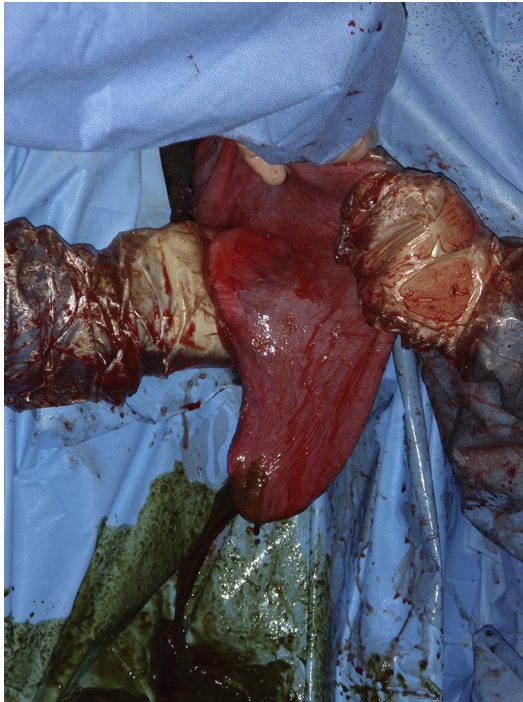

Fig. 21. Dilated cecum being drained by a typhlotomy through a right para-lumbar incision. The fluid within the proximal loop of the ascending colon has been massage back to the cecum and out by the typhlotomy incision. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

2. Partial typhlectomy

> This surgery is performed when the cecum is devitalized or in recurrent cases. The cecum is exteriorized and isolated from the abdomen with wet sterile towels. A typhlotomy is performed to empty the cecum and ascending colon. The ileocecal ligament is dissected toward the ileocecal junction, and the blood vessels are ligated along the way. Two Doyen forceps are placed across the cecum (**Fig. 22**). The cecum is amputated at least 3 cm away from the forceps. The cecum edges are rinsed before being closed with 2 inverting layers (Cushing) with absorbable suture material (Vicryl, Polysorb) of USP 0. The cecum is rinsed thoroughly before being returned in the abdomen.

Colon

Mechanical obstruction of the colon is uncommon in adult cattle. Adhesions, volvulus, intussusception, and phytobezoars have been described. Abdominal distension with moderate signs of colic are a common feature. No feces and distension of the cecum and part of the jejunum are present on transrectal examination.

Medication given through the peritoneal route is a risk factor to colonic adhesion.[44] Through a right para-lumbar fossa laparotomy, the obstruction is located. Most of the time, the bowels are distorted and difficult to recognize. A side-to-side anastomosis would have to be performed to bypass to obstruction.

Intussusception of the spiral colon is more frequent in calves (**Fig. 23**).[37,45] The fat surrounding the loops of colon are thought to protect against this condition in older cattle. Dissection of the intussusception within the spiral colon is difficult. The authors have come to think that the diseased segment should be left in place and a side-to-side anastomosis should be performed. Some cases can spontaneously heal and slough the intussusceptum.

A phytobezoar can be found within the spiral colon. It is usually a single mass causing a complete obstruction. The obstructed colon is pulled out of the abdomen to perform an enterotomy (**Figs. 24** and **25**). An assistant is needed to hold the spiral colon exteriorized. The incision is closed with a single inverting layer (Cushing) with absorbable suture material (Vicryl, Polysorb) of USP 0.
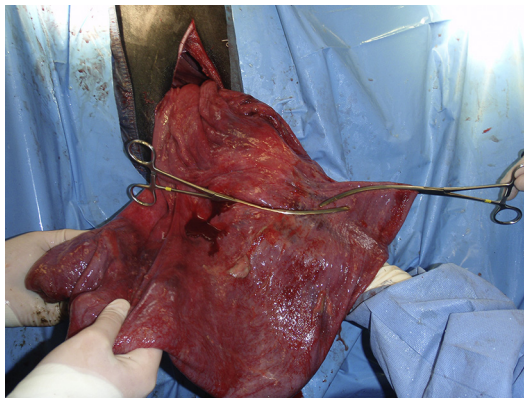

Fig. 22. Curved Doyen forceps are placed on the cecum to perform a partial typhlectomy. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)
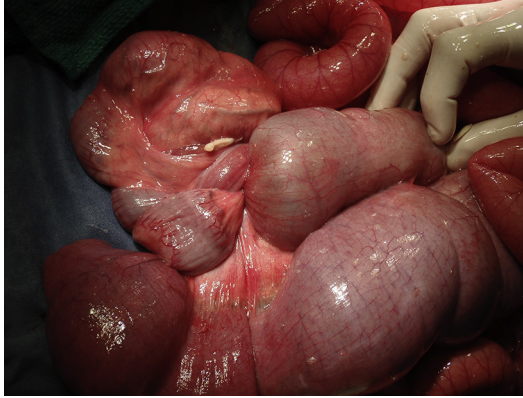
Fig. 23. Intussusception within the spiral colon of a 3-month-old calf. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

POSTOPERATIVE TREATMENTS

The postoperative period can be as challenging as the surgery itself. Fluids and systemic antibiotics are frequently needed for an extended period of time. Serum electrolytes are followed to avoid functional ileus from hypocalcemia or hypokalemia.

Fig. 24. Fecalith within the lumen of the spiral colon exteriorized through a right para-lumbar fossa incision. Wet sterile towels have been placed around the lesion to avoid abdominal contamination during enterotomy. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

Fig. 25. Fecalith removed from the spiral colon in Fig. 23. (*Courtesy of* Sylvain Nichols, DMV, MS, DACVS, Université de Montréal, Saint-Hyacinthe, Québec, Canada.)

To allow the GI tract to regain its motility, pain control is essential. NSAIDs are used judiciously to avoid abomasal ulceration. Opioids should also be used carefully because they may decrease GI motility.[46] Butorphanol, a κ agonist and a μ antagonist, seems to affect GI motility to a lesser extent than other morphinics.[46] It may be used during the early postoperative period as repeated injections (0.025–0.05 mg/kg IV, intramuscularly [IM], subcutaneously) or as a continuous drip (0.01–0.02 mg/kg/h).

If a functional ileus remains despite adequate therapy, prokinetic drugs are used. Erythromycin (8.8 mg/kg IM) has the best prokinetic effect on the abomasum[47,48] and the jejunum. Neostigmine and bethanechol have been used for cecal atony.[49] Neostigmine should be used carefully because it causes anarchic contractions. Erythromycin has been shown to increase the myoelectric activity of the spiral colon.[50]

Lidocaine drips have been used in cattle based on studies performed in horses.[51] The prokinetic effect is uncertain. It is thought that the analgesic effect might explain the positive clinical result perceived during lidocaine infusion. It is important to note that cattle may be more sensitive than horses to lidocaine. Therefore, the initial bolus is not routinely given in the authors' institution to avoid the possible neurologic side effect.

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