Surgical Management of Abomasal Disease

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KEYWORDS

• Abomasum • Abomasopexy • Laparotomy • Displaced abomasum
• Abomasal ulcers • Abomasotomy • Abomasal obstruction

KEY POINTS

- Abomasal disease is common in ruminants and frequently requires surgical intervention.
- The most common surgical abomasal disorder is abomasal displacements.
- Abomasal displacements can be corrected with conventional surgical techniques as well as minimally invasive techniques.
- Other abomasal diseases such as intraluminal abomasal obstruction and abomasal ulcers may be treated by surgery.

Conditions affecting the abomasum can result in a severe and potentially life-threatening situation for the affected animal. Some of these conditions may not be amenable to surgical therapy, whereas others may be exacerbated by surgical intervention. However, surgical management of abomasal disease remains a treatment option for several of these conditions. Surgical therapies for various abomasal conditions are reviewed herein. Abomasal disease can be divided broadly into disorders that result in altered abomasal outflow and those that result in loss of abomasal wall integrity. Abomasal outflow alterations include abomasal displacements, intraluminal abomasal obstruction, abomasal wall lesions that obstruct flow of abomasal ingesta, and extraluminal masses that obstruct the flow of ingesta. Conditions that result in the loss of abomasal wall integrity include abomasal ulceration and abomasal fistula formation (Fig. 1).

ABOMASAL DISPLACEMENTS

Surgery to correct abomasal displacements likely accounts for the majority of nonelective surgical procedures in cattle, but is uncommon in small ruminants.

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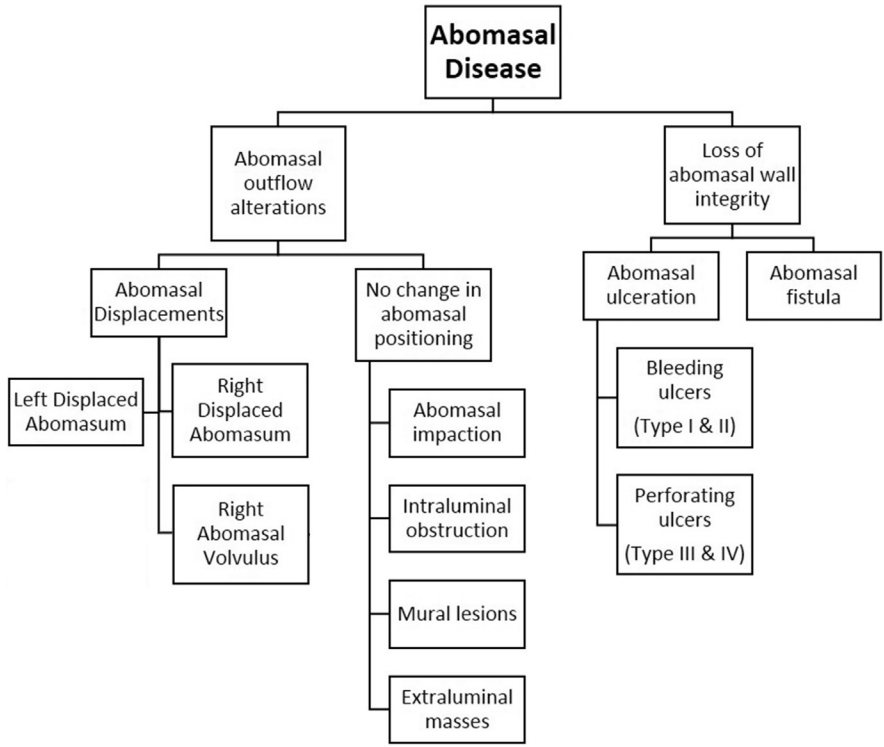

Fig. 1. Relationship between various conditions affecting the abomasum.

The most common surgical procedures performed on the abomasum in cattle are for correction of a left displaced abomasum followed by correction of other abomasal displacements (right abomasal dilatation/displacement and right abomasal volvulus [RAV]). Multiple surgical procedures have been advocated for repair of the displaced abomasum ranging from blind techniques (closed abdomen) to open laparotomy techniques to minimally invasive procedures. Most of the techniques are associated with a good outcome, depending mostly on the perioperative status of the patient.

PATHOGENESIS OF ABOMASAL DISPLACEMENTS

An abomasal displacement is an abnormal positioning of the abomasum within the abdominal cavity, and is divided into 3 broad categories: left abomasal displacement (LDA), right abomasal displacement (RDA), and RAV. In the healthy bovid, the abomasum lies to the right of the rumen against the ventral abdominal wall. Abomasal positioning changes during gestation. As the gravid uterus expands cranially, the abomasal length decreases and the length increases resulting in a more transverse oriented abomasum that gets pushed leftward on the ventral abdominal wall.[1]

The etiology of abomasal displacements is multifactorial. It is thought that the genesis of all abomasal displacements is abomasal atony. Abomasal atony leads to gas accumulating within the abomasum creating a gas-filled viscus. This gas-filled viscous is buoyant within the abdomen and floats dorsally. If it floats up on the left side of the

rumen, an LDA is formed; if it remains on the right side, an RDA is formed. An RDA can twist again, creating a RAV or can involve the omasum forming a right abomasal omasal volvulus. The direction of the twist is counterclockwise as viewed from the hind (RDA), and counterclockwise as viewed from the top (RAV). It is thought that all cases of RAV begin as RDAs.

Any concurrent diseases or conditions that cause gastrointestinal (GI) atony can lead to formation of a displaced abomasum. Infectious diseases such as mastitis, metritis, enteritis, and peritonitis, as well as noninfectious causes such as hypocalcemia, hypokalemia, and ketosis, can lead to stasis of the GI tract and subsequent GI and abomasal atony. Abrupt changes in diet can also cause upsets that can cause GI atony. Cattle that have recently calved are at a much higher risk for developing a abomasal displacement. In addition to physically changing the position of the abomasum in late gestation, an abrupt void created within the abdomen after parturition has been speculated to predispose to displacements in the early postpartum period, but this is likely a minor contributing factor. Also, recently fresh cattle are at a much higher risk for development of other conditions such as metritis, mastitis, hypocalcemia, and ketosis. Eighty percent of LDAs occur within the first month after parturition and 57% within the first 2 weeks.[2] In the author's practice, the median number of days after calving for cases of LDA was 14 and the median age of cows was 4.2 years.[3]

An LDA occurs when the abomasum becomes displaced to the left of the rumen and floats up between the rumen and the left body wall, and owing to the buoyancy of the gas-filled abomasum, it becomes trapped on the left. An RDA occurs when the abomasum becomes gas distended and floats dorsally but remains along the right side of the rumen, sliding along the right body wall. If the RDA flips along its long axis, then an RAV occurs. The abomasal volvulus may include the omasum within the twist, becoming a right abomasal omasal volvulus.

An LDA and RDA create a partial outflow obstruction to abomasal contents. The abomasum is usually only mildly to moderately distended and the animal is typically not colicky. The animal will usually be depressed in feed intake and, if a lactating dairy cow, the animal will generally drop in milk production over the course of the disease. The signs of a RAV are generally more severe. The onset of clinical signs is more acute with an RAV. The abomasum is typically severely distended and the luminal pressures can reach upwards of 30 mm Hg.[4] Signs of colic are common with elevated heart and respiratory rates. As the luminal pressure increases, the abomasal perfusion decreases.[5] The abomasal tissue may be totally devitalized, resulting in necrosis of the abomasal wall. Signs of shock and endotoxemia may result. RAV is an emergency condition. If the omasum is involved within the twist, the condition is worsened with a poorer prognosis.[6]

PROGNOSIS

Much of the recent research in the realm of abomasal displacements investigates predicting outcome based on preoperative and postoperative factors. In general, cattle with abomasal volvulus have more hemodynamic compromise, leading to a poorer prognosis than cattle with simple displacements. One study found that prognosis to return to a productive life averaged 81.2% for RDAs and 67.3% for RAVs.[7]

Historically, poor prognosis of cattle with RAV have been associated with preoperative findings of tachycardia, poor hydration status, and a longer period of inappetence[8] than cattle without these findings. Intraoperative findings of omasal involvement, large

abomasal fluid volume, venous thrombosis, and dark abomasal color before decompression were associated with a poor prognosis.[6] Anion gaps of 30 mEq/L or greater were a poor prognostic indicator for cattle with abomasal volvulus. This same study showed that anion gap measurements was a more accurate prognostic indicator then either serum chloride or base excess values.[9] Preoperative blood lactate concentrations are a better predictor of outcome in cows after right abomasal disorders (RDA and RAV) than heart rate; however, the best predictor of outcome has been shown to be the combination of blood lactate concentrations with heart rate together. More recent studies investigating the correlation between blood lactate and outcomes found that lactate concentrations of 2 mmol/L or greater were associated with a favorable outcome, whereas lactate concentrations of 6 mmol/L or greater were associated with a poor outcome.[10] Another study showed that postoperative blood lactate could be useful to predictor of outcome in cattle with RDA or RAV; however, the change in blood lactate (difference between preoperative and postoperative values) was not predictive of outcome.[11] In a review of 106 cases of right-sided abomasal displacements, 1 study found that a heart rate of 90 bpm or greater, blood urea nitrogen of 10 mmol/L or greater, potassium of 3.3 mmol/L or less, and a chloride of 85 mmol/L or less were associated with a nonproductive outcome. High γ-glutamyl transferase was a preoperative indicator that could be used to differentiate an abomasal volvulus from an RDA.[7] An early report looked at base excess as a predictor of outcome and as a biomarker to preoperatively differentiate RDA from RAV. This study found that the survival rate decreased as the base excess decreased and the lowest survival rate was found in cattle with base excess of -0.1 mEq/L or greater.[12]

In general, cows with LDAs have a good prognosis for returning to a productive life after surgical replacement. It has been shown that, in cows that have fatty liver disease with LDA, the prognosis after surgical correction of the LDA was related inversely to the severity of the fatty liver. Therefore, it is useful to be able to predict the severity of the hepatocellular damage. One study found that there was a strong correlation between serum levels of ornithine carbamoyl transferase and hepatocellular damage during cases of fatty liver disease. These results support the use of these compounds use as clinical anylates in cases of cattle with abomasal displacements and fatty liver.[13] Dermal carotenoids (a reflection of the animal's antioxidant status) were investigated in a more recent study. In a group of cattle that had an LDA surgically repaired, it was found that cattle with a favorable outcome had an increase in dermal carotenoids over time, whereas the dermal carotenoids decreased over time in cattle with a poor outcome. Although dermal carotenoids are not routinely used clinically as a prognostic indicator in cattle suffering from LDA, these may prove to be useful to prognosticate cattle with LDA.[14] Higher magnesium levels and, counterintuitively, higher β-hydroxybutyrate levels, have been found to be protective for herd survival in cattle with LDA. No association between surgical procedure and longevity in herd was found. Dystocia before LDA and β-hydroxybutyrate of less than 1.2 mmol/L were associated with decreased herd survival.[15] Although abomasal displacements in beef cattle are rare, 1 study looking at beef cattle with LDA showed increased serum glucose and decreased serum insulin concentrations compared with cattle without abomasal displacements, suggesting that cattle with LDA had altered glucose metabolism. Beef cattle with LDA that did poorly postoperatively had significantly lower serum insulin concentrations compared with cattle that did well.[16]

Diagnosis

Diagnosis of abomasal displacements is made based on clinical signs and auscultation and percussion of the abdomen. Auscultation and percussion over the displaced

abomasum reveals a hyperresonant "ping" either on the left (LDA) or right (RDA and RAV) abdomen over the gas-distended abomasum. The rectal examination is likely to be normal, but a distended abomasum may be felt in the right paralumbar fossa with large RDAs or RAVs or in the left paralumbar fossa with very distended LDAs. An LDA pushes the rumen away from the left body wall, which may be appreciated on routine rectal examination.

Although cattle having a simple right displacement generally are not regarded as having a surgical emergency, they should be operated on immediately given the difficulty in distinguishing preoperatively between cattle with RDA and RAV on physical examination. In a study investigating base excess in cattle with right-sided displacements, all cows that had a base excess of −5.0 mEq/L or less had an abomasal volvulus rather than a simple displacement.[12] Ultrasound examination of the abdomen is occasionally used to differentiate RDA and RAV. Cattle with an RAV have an abomasum that is more distended, and typically pushes the liver medially away from the right body. However, ultrasonographic visualization of the liver, omasum, and intestines has been shown to be more difficult in cattle with right abomasal disorders compared with cattle without, and the usefulness of ultrasonography in distinguishing between RDAs and RAV is questionable.[17]

MEDICAL THERAPY

Medical therapy is seldom used alone for treatment of abomasal displacements, but is combined frequently with surgical correction. Goals of medical therapy include correction of the underlying cause of the abomasal atony, promotion of GI motility, and correction of metabolic derangements. The restoration of abomasal motility should result in gas being expelled and allow it to return to its normal anatomic position.[2] Oral or systemic calcium to correct hypomotility owing to hypocalcemia may be useful. Promotility agents such as parasympathomimetic agents can help to stimulate GI motility. Dehydrated animals or animals that suffer from severe electrolyte imbalances may benefit from oral or systemic fluid therapy.

Postoperative ileus and abomasal hypomotility can be a complicating factor in cattle undergoing surgical correction of LDA. Preoperative erythromycin can increase the postoperative abomasal emptying rate in these cattle.[18] Preoperative erythromycin has been shown to be effective at ameliorating postoperative abomasal hypomotility in cattle undergoing RAV correction via right flank omentopexy.[19]

Cows are in a state of negative energy balance after freshening. If severe, ketosis can ensue and lead to appetite suppression as well as hypomotility and be a cause of GI atony predisposing to a displaced abomasum. An abomasal displacement can further exacerbate the negative energy balance by decreasing appetite and nutrient assimilation. Mild ketosis may resolve after correction of the abomasal displacement and an increase in appetite; however, severe cases of ketosis should be treated. Intravenous dextrose, insulin therapy, oral niacin, and oral propylene glycol can be used for treating ketosis.

Metabolic derangements are common in cattle with abomasal pathology. Hypochloremic, hypokalemic, metabolic alkalosis typifies the metabolic abnormalities in cattle with functional, proximal GI obstructions. Fluid therapy is beneficial in these animals to correct electrolyte and acid–base abnormalities. Cattle with abomasal volvulus suffer from severe hemodynamic compromise. Hypertonic saline administration has been shown to improve hemodynamic function in these patients.[20]

SURGICAL THERAPY

Surgical correction of abomasal displacements is one of the most commonly performed surgeries in cattle by food animal surgeons.[21–23] Several surgical techniques are available for correction of abomasal displacements (**Box 1**). The chosen technique depends largely on surgeon preference, available facilities and equipment, assistance available, value and purpose of the cow, direction of displacement, presence of adhesions, and prior displacement with surgical correction. Cattle having surgical correction of the uncomplicated abomasal displacements have a good to excellent prognosis for return to productivity.[3,24–27]

Many surgeons prefer right flank techniques because they can be done standing, allow versatility in working with different abdominal structures, and allow the surgeon to perform a thorough abdominal exploration. Right flank techniques are also preferred because they allow the surgeon to work alone.[21] The right flank omentopexy is a procedure by which the greater omentum attaching to the greater curvature of the abomasum is fixed to the right body wall holding the abomasum in near anatomic position.[1] It is critical that the correct positioning be achieved and that sutures are placed through the omentum in close proximity to the pylorus. If this is not achieved, the omentum can stretch and the abomasum can displace again.[5,23]

The pylorus usually serves as a landmark and is brought to the level of the flank incision to assure correct positioning of the abomasum (**Fig. 2**).[21] With this technique, no suture is placed in the abomasal wall decreasing the likelihood of developing leakage of abomasal contents, which can result in peritonitis or fistula formation.

Disadvantages of the right flank approach include inability to visualize and work with adhesions of the abomasum to the left body wall which may occur in cases of chronic or recurrent LDA or cases of LDA complicated by abomasal ulcers or peritonitis. Correcting an LDA in cattle in late gestation can be challenging. These conditions make a left flank approach (left flank abomasopexy) preferable. The greater omentum is friable and can stretch or break down allowing for redisplacement of the abomasum, after an omentopexy. Many surgeons advocate adding a "pyloropexy" to the omentopexy to increase the strength of the fixation. Owing to possible complications of pyloric stricture and secondary abomasal outflow problems, it is best not to pass suture through

Box 1
Techniques for correction of abomasal displacements

- Right flank omentopexy
- Right pyloricantropexy ("pyloropexy")
- Left flank abomasopexy[a]
- Right paramedian abomasopexy
- Rolling[b]
- "Roll and tack"[b]
- "Roll and toggle"[b]
- One-step laparoscopic abomasopexy[b]
- Two-step laparoscopic abomasopexy[b]

[a] Only an option for left abomasal displacements.
[b] Minimally invasive techniques. Only advised to correct left abomasal displacements.

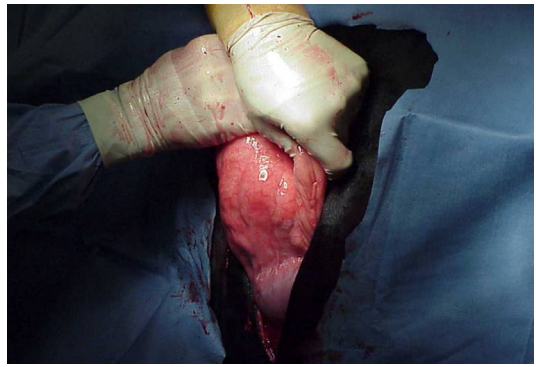

Fig. 2. Exposure of the greater omentum during a right flank omentopexy on a cow. Note the paler pink area at the bottom of the incision representing the pyloric area of the abomasum. Visualization of this landmark indicates to the surgeon that the abomasum has been replaced to its correct anatomic position. (*Courtesy of* Dr Jen Ewoldt, Eldridge, IA.)

the muscular pylorus, but rather through the pyloric antrum of the abomasum, approximately 3 to 5 cm orad to the pylorus (pyloricantropexy). It can be used as a standalone procedure, or it can be combined with an omentopexy to increase the security of the omentopexy. Although providing added security to the pexy, there is greater risk of abomasal perforation and fistula formation. Indications for performing a pyloricantropexy are those situations where the surgeon feels that an omentopexy may not provide enough security to hold the abomasum in place. In overconditioned cattle, the fatty omentum is friable and tears easily. Cases where omentum tears as the abomasum is being replaced has weakened omentum and is a candidate for omentopexy failure.[28] Although intuitively we feel that standalone omentopexies are a relatively weak method of abomasal fixation, studies have found that recurrence rates of LDAs are approximately equivocal[29,30] for correction via omentopexy (4.0%[30]) versus techniques like paramedian abomasopexy, which are thought to have a very secure fixation (2.4%,[31] 3.6%,[32] and 4.3%[33]). Another study comparing the right flank omentopexy, right flank omentoabomasopexy (pyloricantropexy), and the left flank abomasopexy found that all techniques could be successfully used for returning cattle to normal milk production after left displaced abomasum; however, a small but statistically significant poorer outcome (milk production) was noted in cattle with LDA corrected with an omentopexy combined with a pyloricantropexy. It is noted that this difference may be owing to case selection and the retrospective nature of the study.[3]

The left flank abomasopexy technique is performed by laparotomy incision in the left paralumbar fossa. Although there have been methods described preventing a left displaced abomasum via left flank approach,[34] in general, the left flank approach can only be used for the correction of left displaced abomasum, which is a clear disadvantage if the veterinarian is unsure of a diagnosis. Owing to blockage by the rumen, the left flank approach also limits the surgeon's ability to perform a complete exploratory of the peritoneal cavity. Another disadvantage of performing a left flank abomasopexy as compared with the right flank approaches is that the left flank abomasopexy requires an assistant to guide the needle through the ventral abdominal wall so as to achieve correct positioning of the pexy and to avoid vascular structures.[35] One indication for performing a left flank abomasopexy in cases of an LDA where adhesions are present between the abomasum and the left body wall. These adhesions can be visualized and

subsequently broken down through a left flank approach. Other forms of abomasal pathology like gastric ulcers or perforations can be oversewn from the left flank approach.[21] Surgical correction of LDAs during late stage pregnancy may be difficult to perform from the right flank owing to the large gravid uterus preventing replacement of the abomasum; these cattle may be good candidates for a left flank abomasopexy.

A small, 10- to 15-cm square should be prepared on the ventral abdomen of the standing cow before left flank abomasopexy. The ideal location for fixation of the abomasum has been determined to be 20 cm caudal to the xyphoid and 5 to 10 cm to the right of midline.[1] These landmarks should be identified and a permanent marker can be used to mark the area so that an assistant can help to guide suture placement. Two paramedian marks, approximately 5 cm apart in a sagittal plane, should be identified centered over the previously described landmarks. Care should be taken to identify the milk veins so that they are not inadvertently punctured. A left flank laparotomy, approximately 15 cm in length, is made in the left paralumbar fossa. A left flank exploratory should reveal the left displaced abomasum lateral to the rumen (**Fig. 3**). The laparotomy should be started approximately 5 to 10 cm ventral to the transverse processes of the lumbar vertebrae. A long piece of continuous, nonabsorbable suture (#3 Braunamid) is required. The length of the suture should be approximately 2 times as long as the surgeons "wingspan." The left displaced abomasum is visualized, and multiple continuous bites of a nonabsorbable suture (#3 Braunamid) are placed in the greater curvature of the abomasum. The ends of the suture should protrude from the abomasum equally at the ends of the suture line. The ends of this suture are passed ventrally along the left body wall, cross the midline, and emerge through the right paramedian abdominal wall at the locations previously identified on the external abdomen. An assistant is needed to guide the surgeon. Both suture ends are passed thought the ventral body wall before the abomasum is replaced to normal positioning. The abomasum is pushed ventrally by the surgeon as the assistant pulls the excess suture tight. Deflation of the abomasum is useful during this step. Once the abomasum has been successfully replaced, the assistant ties the sutures externally to fix the abomasum in position.[21]

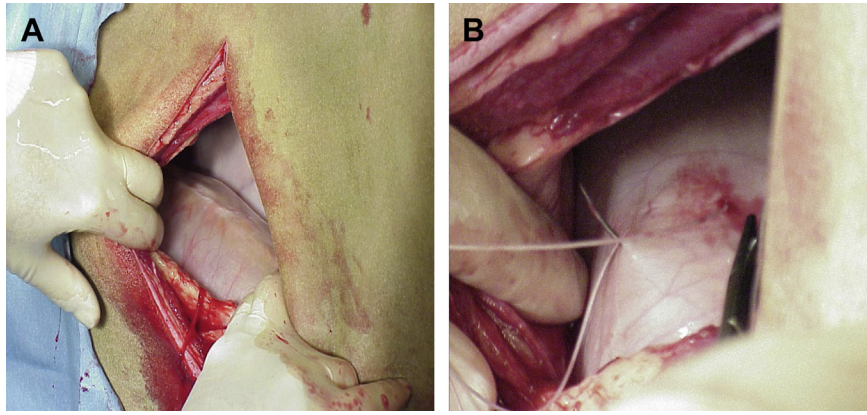

Fig. 3. (*A*) Left flank exploratory in a cow before performing a left flank abomasopexy. Note the left displaced abomasum in the foreground and the rumen medial to it. (*B*) A #3 Braunamid suture is placed through the greater curvature of the abomasum. This suture will be passed ventrally to perform the abomasopexy. (*Courtesy of* Dr Jen Ewoldt, Eldridge, IA.)

If nonabsorbable sutures are used, sutures must be removed after formation of an adhesion. It is recommended to remove the sutures at 14 days postoperatively. Failure to remove these sutures may result in abomasal fistula formation.

An abomasopexy can also be performed from a right paramedian approach. With this approach, the cow is placed in dorsal recumbency. An incision is created parallel to and 3 to 4 cm to the right of midline, extending caudally from a point 4 to 5 cm caudal to the xyphoid (**Fig. 4**). The incision should be approximately 15 to 20 cm in length (see **Fig. 4**).[2]

After repositioning of the abomasum, the seromuscular layer of the abomasum is sutured to the peritoneum and the internal rectus fascia. Some surgeons suture the abomasum with the incisional closure and others describe pexying the abomasum to the body wall remote from the incision. Potential advantages of this approach include achievement of a stronger adhesion as well as the ability to work with prior abomasal adhesions. Complications with this technique include complications with maintaining the cow in dorsal recumbency during surgery, abomasal fistula formation, and herniation of abomasal leaves.

Minimally Invasive Approaches

Minimally invasive approaches capitalize on the buoyancy of the distended, gas-filled, abomasum. When the cow is rolled on her back, the abomasum tends to float to the ventral abdomen. If the cow is tilted slightly onto her left side (putting the right abdomen in a nondependent position), the abomasum floats into a right paramedian location. In this manner, by laying a cow down on her right side and slowly rolling her through dorsal recumbency and slightly onto her left side, an uncomplicated left displaced abomasum can be replaced. Rolling should only be performed for cases of LDA because it is thought that an abomasal volvulus can result from rolling a cow with an RDA. Advantages of minimally invasive techniques include less expense on average compared with traditional open approaches. The procedures are generally faster, cattle have shown a decreased need for antimicrobials, and cattle have shown a faster recovery and return to milk production compared with traditional open approaches.[26,27,36,37] Even though all methods of abomasal displacement correction results in sterile inflammation within the abdominal cavity, minimally invasive techniques

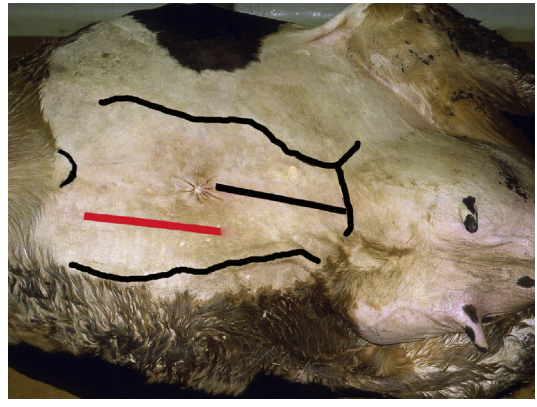

Fig. 4. Ventrum of a cow illustrating the correct placement of the paramedian incision (*red line*) for a paramedian abomasopexy. The xyphoid, milk veins, and midline are outlined in black. (*Courtesy of* Dr Bruce Hull, Columbus, OH.)

have been shown to result in less muscle damage compared with traditional surgical techniques.[38]

Multiple methods of abomasal fixation can be performed after rolling of the cow to replace the displaced abomasum. First described by Hull in 1972,[39] the "blind stitch" abomasopexy technique is the first and the simplest of the minimally invasive techniques and involves passing a large gauge, large diameter needle (and suture) through the skin, body wall and abomasal wall fixing the abomasum to the ventral abdomen. Although auscultation and percussion can and should be used to determine the relative location of the distended abomasum, the primary disadvantage of this technique is that the surgeon cannot be certain that the abomasum has been penetrated, decreased confidence in proper anatomic repositioning of the abomasum, and the possibility that other structures have been trapped between the abomasum and the body wall.[40] In 1982, Grymer and Sterner published a technique that replaced the "blind stitch" technique and has become the basis for percutaneous (minimally invasive) abomasopexy today.[41] The Grymer-Sterner method involves placing a pair of bar sutures (toggle sutures) into the lumen of the abomasum and the attached suture passes through the abdominal wall and is tied externally. The primary advantage of this technique is the verification of abomasal penetration by analysis (odor/pH) of the gas/fluid that is obtained after penetration of the viscus. This technique has remained popular through today and has been associated with equivocal outcomes compared with open techniques.[27,42]

Laparoscopy has been combined with the general principles of the Grymer-Sterner method and has been described as either a 2-step[42] method or as a 1-step[43] laparoscopic abomasopexy. Laparoscopic viewing of the abomasum ensures accurate penetration of the abomasum while avoiding other abdominal structures.

The 2-step laparoscopic abomasopexy was described by Janowitz[42] in 1998. This technique uses a specialized bar suture with two 80-cm-long sutures attached to its midpoint with a dyed present marker used to indicate that the abomasum has been pulled adjacent to the body wall. Placement of the toggle pin suture within the abomasal lumen and deflation of the abomasum is first accomplished with laparoscopic guidance via the left paralumbar area in a standing cow, followed by laparoscopic suture retrieval via the right paramedian area after the cow has been rolled into dorsal recumbency.[42,44] Similar to the sutures of the left flank abomasopexy, the suture is cut 2 to 3 weeks postoperatively. A retrospective study investigating the outcome of cows who underwent an LDA surgically repaired with a 2-stage laparoscopic repair technique found that the cows had a good outcome. There was no difference in 305-day milk yield between control cows and LDA cows after laparoscopic repair.[24]

The disadvantages of this procedure include the additional cost of the laparoscopic equipment, the necessity to reposition the cow during the procedure, and the need for 2 separate surgical preparations. The main advantages of the 2-step laparoscopic abomasopexy is the ability to confirm the diagnosis of the LDA and the ability to evaluate adhesions between the abomasum and body wall or rumen.

The main disadvantage of the 2-step laparoscopic abomasopexy is the need to reposition the cow during the surgical procedure. This has led to the evolution of the 1-step laparoscopic abomasopexy.

Multiple versions of the 1-step laparoscopic abomasopexy have been described and can be performed with cattle either standing[45] or in dorsal recumbency.[25,43] Advantages of the 1-step laparoscopic abomasopexy procedures compared with the 2-step include fewer surgical preparations, fewer incisions, and no need to reposition the cow midway through the procedure, resulting in less operative time.

The original 1-step technique developed by Christiansen[45] involves placement of a bar suture within the abomasal lumen under laparoscopic guidance via the left paralumbar area in a standing cow (similar to step 1 in the 2-step laparoscopic abomasopexy). The suture ends are then passed ventrally against the left body wall using a specialized tool ("spieker"; TR-78–766, Fritz LLC, Veterinary Endoscopy America, Louisville, KY). The spieker tip is a long instrument used to advance the suture ventrally to exit the right paramedian area. Excess suture material is withdrawn by an assistant (similar to the left flank abomasopexy). Advantages of this technique include confirmation of the LDA, ability to evaluate adhesions, and the ability to perform this surgery while the animal remains standing.

The 1-step procedure developed by Newman[43] involves placement and suture retrieval with laparoscopic guidance via the right paramedian area in a dorsally recumbent cow. Placement of the bar suture within the lumen of the abomasum is similar to the technique described by Grymer and Sterner.[41] A reported complication of this technique was accidental placement of the cannula for the viewing portal into the omental bursa before insufflation of the abdomen in one cow. This complication was immediately corrected and did not cause any long-term complications.[43]

Ventral laparoscopic abomasopexy utilizing intracorporeal suturing rather than the bar suture principle has been described.[25] This technique was used successfully in 17 LDA cases and 1 RDA case. Follow-up laparoscopy at 90 days postoperative indicated good adhesion formation of the abomasum and the body wall. Unlike the laparoscopic techniques using the bar-suture principle, this ventral laparoscopic abomasopexy technique requires more intraabdominal laparoscopic maneuvers and therefore is more technically challenging. It also requires the need for a surgical assistant and therefore its use may be limited to hospital settings.[25,46]

POSTOPERATIVE COMPLICATIONS OF ABOMASAL FIXATION

As with any surgical procedure, complications include incisional infections, abscessation, and dehiscence. Catastrophic complications are rare. Techniques that perforate the abomasal lumen could result in peritonitis from leakage of abomasal contents from the lumen. Abomasal fistulation is also possible and most commonly result from ventral abomasopexy procedures that penetrate the abomasal lumen. Failure to remove the abomasopexy suture in a timely manner is associated with the development of abomasal fistulation.

Duodenal sigmoid flexure volvulus has been reported in cattle. Affected cattle present with clinical signs similar to abomasal volvulus or duodenal obstruction: a dorsal right-sided ping, succussable fluid, and a severe hypochloremic, hypokalemic metabolic alkalosis with high bilirubin. Cattle that have had previous history of surgical fixation of the abomasum are overrepresented with 20 of 29 cattle having a previously performed omentopexy or pyloropexy. Timely surgical intervention generally yields a fair to good prognosis.[47]

ABOMASAL ULCERS

Abomasal ulcers, similar to gastric ulcers of other species, are erosions of the abomasal wall. Abomasal ulcers are divided into 4 categories based on the depth of the ulceration. Types I and II are nonperforating ulcers. Types III and IV are perforating ulcers with localized and diffuse peritonitis, respectively. Animals with type I ulcers present with vague clinical signs including decreased appetite, weight gain, and rumen motility. Fecal occult blood may be positive. Type II ulcers commonly bleed and cause melena from digested blood. If blood loss is great, the cow may be anemic

with pale mucous membranes and very low packed cell volume. Surgical management of type I and II ulcers is not indicated and may be contraindicated in anemic patients. Type III ulcers are perforating ulcers that result in localized peritonitis because the omental sling contained the abomasal leakage. Type IV ulcers are perforating ulcers that result in diffuse peritonitis.

Although management of type I and II ulcers are generally focused on medical management, reduction of stress, treatment of concurrent diseases, and correction of metabolic disturbances, surgery may be indicated for perforating ulcers; however, the prognosis is often poor and depends on the location and size of the ulcer, as well as the extent of peritonitis.[48] One report indicates that surgical resection of perforating abomasal ulcers was successful in 4 out of 10 calves.[49]

Often ulcers or secondary changes (peritonitis, adhesions) are found on exploratory surgery performed for correction of a displaced abomasum. If encountered during surgery, or if performing surgery to correct a perforating abomasal ulcer, the ulcer can be resected or oversewn to close the defect. The low pH of abomasal contents confers a relative sterility to the contents of this viscus as compared with that of other parts of the GI tract. Therefore, leakage of abomasal contents into the abdomen causes a self-limiting chemical peritonitis rather than a septic peritonitis. This may explain the surprisingly good outcome experienced by cows with perforating abomasal ulcers. Most abomasal ulcers are thought to be predisposed by stress. Stressors include environmental stress (transport, heat stress, etc), stress from high metabolic demands (high milk production), or stress induced by concurrent diseases (mastitis, metritis, ketosis, etc). Abomasal lymphosarcoma can also cause abomasal ulcerations. The prognosis for abomasal lymphosarcoma is poor and treatment is generally not warranted, although exploratory laparotomy with abomasal biopsy may be needed to confirm the diagnosis. Ultrasound imaging has been shown to be useful in diagnosing cows affected with abomasal lymphosarcoma. Enlarged lymph nodes caudal to the reticulum[50] and a thickened pylorus were visualized by ultrasonography in cattle affected by abomasal lymphosarcoma.[50,51] In addition, transabdominal ultrasonography can be a useful diagnostic tool in cattle presenting with signs of pyloric outflow obstruction caused by abomasal lymphosarcoma to avoid the time and expense incurred by exploratory laparotomy.[51]

Other Abomasal Surgery

Abomasal impaction can be treated by abomasotomy, abomasal massage, or pyloromyotomy. This study showed that abomasal massage with mineral oil delivered orally can be an effective treatment of abomasal impaction.[52] A case report of an abomasotomy for removal of a bezoar in a 4.5-year-old standing Holstein cow indicated that the cow was doing well and had integrated well into the milking herd with a similar milk production as the herd average at 6 months postoperatively.[53]

Midline body wall defects occasionally entrap the abomasum. This is especially true in young ruminants, where the abomasum is the largest of the gastric compartments. Adhesions of the abomasum to the body wall or to omentum in these young ruminants may need to be broken down. Care should be taken to avoid accidental abomasal perforation. If adhesions are present, part of the abomasal wall may need to be resected and oversewn.

A Richter's hernia is a hernia where only the antimesenteric wall of a viscus protrudes through the hernia. Although it is unlikely that the entire abomasum will become herniated owing to the size of the viscus, it is possible that 1 wall of the abomasum can protrude through a ventral hernia and become strangulated. This may necessitate resection of the strangulated portion of the abomasum (**Fig. 5**).

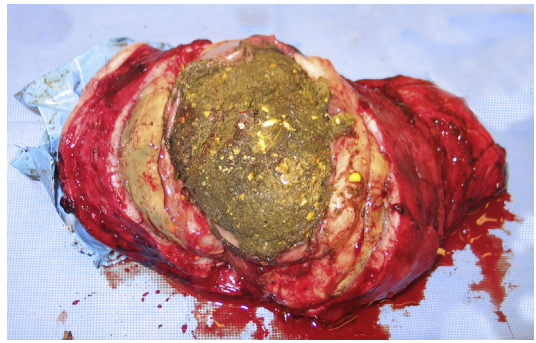

Fig. 5. Richter's hernia after resection from a 3-month-old calf. The open abomasal lumen can be visualized where it was resected from the rest of the body of the abomasum.

SUMMARY

The majority of abomasal surgeries are performed to correct abomasal displacements in cattle. Many different procedures for abomasal displacement correction and fixation exist in veterinary surgery. It is important to have an understanding of the techniques, their indications, contraindications, prognoses, and potential complications. Surgery to correct other abomasal disorders such as abomasal obstruction and perforating abomasal ulcers in cattle and small ruminants do exist, but are far less common.

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